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Papers

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A New Resource Recommendation Method for Experiential Leaching Based on the Completion Degree of Online Learning Tasks

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Short Papers

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Predictable Factors that Help Students Engage in Online EFL Classroom and their Relationship to Self-Management

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Abstract—Online teaching has become a decisive factor to keep growing in higher education settings. The present analytical correlational study examined the predictable factors that would help EFL Jordanian students engage in online learning in English courses after COVID-19 pandemic. To achieve the objective of the study, a validated and a reliable survey was administered to investigate the students' perceptions toward various factors that would affect their success and engagement in online EFL classroom. Additionally, the relationship among some factors was investigated. Fifty-nine EFL students in an English Language Skills course in a technical university college in Jordan were randomly selected to respond to a questionnaire which was adapted from Bernard [7]. Data of the study were analyzed using the descriptive statistics (means and standard deviations) and Person Correlation Coefficient. Findings of the study confirmed that relationship among some factors has uncovered the importance of having basic skills in building other skills. A positive relationship was also found between the factors that help students engage in online learning and self-management. Findings of the study would be helpful for teachers, instructors, and course designers when designing and delivering online courses as well as policy makers.

Keywords—EFL, interaction, online learning, self-confidence, self-management

1 Introduction

Unprecedented rapid global changes in the educational systems have occurred as a response to COVID-19 where the World Health Organization declared it as a pandemic. COVID-19 has caused the change of the educational systems. It has forced all the educational institutions in most countries to shift to remote learning in all its different kinds whether synchronous or asynchronous. It has been affirmed by the United Nations Educational, Scientific and Cultural Organization (2020) that 1,186,127,211 learners were affected across the world, approximately about 67.7% of the total enrolled learners from 144 country-wide closures [3].

The rapid migration from conventional learning to online has raised many questions regarding the preparedness of the educational institutions generally and uncovered the importance of utilizing technology in various sectors. Before COVID-19, the utilization of technology was not clear enough to the extent that enables these institutions deploy the emergent technologies appropriately. However, it has been noted that the negative effects of this pandemic on people all around the world have increased the value of investing in technology as a sustainable method of teaching. This pandemic has opened new doors to several institutions. Thus, all policy makers and educators have started thinking that migrating to online education is not a temporary solution and it should be looked at as the most sustainable method of learning. Meanwhile instructional activities should become more blended considering the challenges experienced during the pandemic and transform them to opportunities, people should be prepared positively toward adapting to the use of technology as an essential partner in the process of learning [2].

Online courses delivery has imposed big challenges on both teachers and students. Teachers need intensive training that enable them to shift successfully to online environments. Similarly, students are not familiar to this new emergent kind of education particularly in the Arab world. Online learning necessitates students to put great efforts in the learning process because they have to be independent learners. Thus, meetings the challenges together could help both teachers and learners discover the factors that make the learning process flexible, understandable, effective, beneficial and feasible.

During the pandemic, many universities around the world have fully digitalized their operations understanding the dire need to adapt according to the current situation. There was an overnight shift of conventional classrooms into e-classrooms, that is, educators have shifted their entire pedagogical approach to tackle new market conditions and adapt to the changing situations. During COVID-19 tough time, the concern was not about whether online teaching–learning methods could provide quality education, it was rather how academic institutions would be able to adopt online learning in such a massive manner [11]. Examining students' perceptions would undoubtedly reveal the areas that need improvement in online teaching as well as would give insights to both teachers and educators about the opportunities that can be invested [29].

Investigating the data that was collected from students could provide in-depth understanding of the effectiveness of online learning [28]. It has been stated by Jackson and Helms [16] that, "the learner's or student's perception offers crucial information in assessing and defining quality" (p. 8). During the rapid transition to online teaching as a result of COVID-19, the need to address the factors that would improve the students' performance in online courses from their perspective has become an urgent need. This study intended to explore the factors that constitute students' perceptions about the decisive factors that would help in students' engagement and success in EFL online courses.

Several factors were considered in the present study after reviewing the past studies. These factors included students' pre-requisite skills, general beliefs about online learning, desire of interaction, and self -management, as confirmed by Bernard and others [7]. Similarly, Jiang and Ting [17] affirmed that the importance of instructional emphasis on learning through interaction significantly influenced students' perceptions of learning. Moreover, flexibility and availability of opportunities to communicate teachers in online environment were among the factors that affected students' positively [18]. Further, technology is a crucial factor that could play a vital role in the success of

online learning [13], [14]. Students' ability to overcome the technical problems and the way they deal with them have been valued from the students' perspectives' [27].

This study was carried out to present the factors that would help the students engage and succeed in online learning from their perspective in a not the Technical University College in Jordan during the COVID-19 pandemic. Further, it intended to examine the relationship between these factors and self-management. By the end of March 2020, Luminus Technical University College (LTUC) has transmitted to online teaching as a result of COVID-19. LTUC has distinguished itself from all other Jordanian institutions in its preparedness to meet the pandemic. Thus, its transition was very smooth due to the LMS it has and the quality of the training its staff has received. This study focuses on the following research questions:

1. What are the most predictable factors that help students engage in online learning in EFL classroom?
2. What is the level of self-management for students engagement in online learning in EFL classroom?
3. Is there any significant statistical relationship between the students' responses on predictable factors that help students engage in online learning and their responses on self-management?

The results of this study would definitely provide implications for the improvement of teaching online English courses. In particular, it is hoped that this study would provide a better understanding of the issues related to teaching and learning in online in the EFL context. Additionally, it would provide the teachers with some of the practices that help students to be more self-disciplined.

2 Literature review

Online learning literature has expanded considerably after the appearance of COVID-19 in 2020. Online learning emphasizes Internet-based courses offered synchronously and asynchronously. Synchronous learning is a form of learning with direct interactions between students and teachers while simultaneously using online forms such as conferences and online chat. Meanwhile, asynchronous learning is a form of learning indirectly (not at the same time) using an independent learning approach. Some subject matter is designed and displayed on LMS on Moodle, or email systems, blogs, online discussions, Wikipedia, videos, articles, and other platforms [26], [23]. During the shift to online learning, public and private institutions have faced many obstacles. These obstacles represented firstly in the poverty of the infrastructure. Secondly, the shift from teaching traditionally through face-to-face to more online methods. Thirdly, the lack of training the teachers have received in changing the instructional materials to online and the methods to interact with students and reach each other easily. Fourthly, teachers have not been informed even theoretically about the difference between teaching face-to face and online. Fifthly, the difficulties in dealing with technology.

Reviewing the factors that help in students' engagement in online learning in the past studies while considering the challenges that face students, is a very important issue needs to be addressed. Thus, this study presents the issue from the students' perceptions. Several factors have been considered while investigating this issue. Students' digital skills,

beliefs toward online learning, self-management, and interaction [7]. Further, in Parkes & Reading [22], students were also found to be poorly prepared for several e-learning competencies and academic-type competencies. Additionally, there is a low-level preparedness among the students concerning the usage of Learning Management Systems.

The unexpected change to online learning has become a measure of organizational agility for several academic institutions which have primarily focused on the transfer of the educational content to the digital world and not specifically on online teaching and delivery methods [1]. Nonetheless, it was a reminder of the lack of resources in academic institutions and the social marginalization of students, where insufficient access and availability of the internet and the lack of latest technology have affected organizational responsiveness and students' capacity to participate in digital learning. Lack of proper interaction with instructors is another major concern associated with online learning [31]. Additionally, virtual classes cannot be of interest to students who are tactile learners. Conventional classroom socialization is another major missing in online learning. Students only communicate with their fellows digitally and never see fellow students in person, and thus the real-time sharing of ideas, knowledge and information is partially missing from the digital learning world.

Twigg [25] linked the problems of online education to: (a) the requirement of separate quality assurance standards, (b) programs having low (or no) quality standards, and (c) the lack of consensus on what constitutes learning quality. Federal regulators, accreditors, state regulators, administrators, faculty, and students need to have a better understanding of what contributes to quality in online learning [21].

Eaton [12] argued that online education has "the potential to disrupt basic quality expectations within the academic community throwing higher education and accreditation into disarray" (p. 10). Recognizing Eaton's and others concerns, Yang and Durrington [30] stated that "To prevent disruption and chaos in the education arena, accrediting organizations need to assess distance learning over the Internet to verify that it meets their standards thereby establishing the credibility of the medium to other stakeholders" (p. 2). One step in this direction is to more specifically identify problems and issues related to online education [30].

From a macro viewpoint, very little is established regarding the decisive predictors that affect online education [20]. Furthermore, the capacity to successfully teach digitally is likely to differ based on the wide range of learning goals that guide the instructional and the educational priorities [19]. Consequently, educators and policymakers alike recognize the importance of understanding their students' perceptions in online learning environments as they play a vital role in uncovering the factors that affect the learning process. Consumer demands, organizational excellence and efficiency, and accountability to stakeholders should be the driving forces that ensure the quality of online courses.

3 Past studies

Past studies [5, 6, 15, 24, 4, 8] have reported different favourable and unfavourable perceptions by students on online learning. Various studies have reported that having digital literacy skills in online environment, the general beliefs toward online learning,

self-management, and interaction are among the most important factors that affect online learning from students' perspectives.

Research has affirmed that students have had some technical difficulties in online learning. In a Jordanian study, Almahasees et al., [5] confirmed that although the merits of online learning which have been represented in self-learning or directing, flexibility, and reducing the costs, teachers and students have uncovered some problems related to technical and internet issues, lack of interaction and motivation, data privacy and security.

In another two recent studies conducted by Al-Nofaie [6] & Al-Qahtani [15] within the Saudi context, students showed positive attitudes toward online learning. In her study, Al-Nofae [6] identified the challenges of online learning from students' perspectives on their learning experiences during the sudden shift to online learning and suggested practical solutions. 25 university students majoring in the English language and enrolled in Morphology class were included in the study. Based on an analysis of the students' learning logs, the results showed students' preference to asynchronous environment rather than synchronous due to its flexibility. Further, the study revealed that virtual education was not always preferred to students. Similarly, Al-Qahtani [15] investigated teachers' and students' perceptions of English as a foreign language (EFL) in virtual classes. The study aimed to highlight the effect of this kind of virtual class on enhancing communication skills. This study was conducted in the English Department, King Khalid University. 30 teachers and students who were divided into two equal groups were included in the study. Data were collected via a questionnaire. The results showed positive attitudes toward teaching and learning through EFL virtual classes from the students and the teachers' perspectives. The results affirmed the significant role of virtual courses in enhancing communication skills.

Further, Ta'amneh [24] examined students' attitudes towards virtual classes in learning English courses. He aimed to identify the obstacles that face students in online learning. The sample of the study consisted of 336 students at Taibah University in Saudi Arabia. A questionnaire was administered to collect data. The results asserted that students' attitudes towards the use of the online learning were positive. To elaborate more, students considered virtual learning as a tool that helped them in organizing their homework, assignments, and time. They agreed that the use of virtual learning saved their times and efforts. Furthermore, students confirmed the existence of some pedagogical, technical and personnel problems while attending virtual classes.

In Alshumaimeri & Alhumud [4] study, students affirmed the effectiveness of virtual classrooms in enhancing their communication skills. The sample consisted of 43 female students from the English Department at a Saudi university. A mixed method design was implemented to collect data. Two data collection instruments were used: a questionnaire and observations. The findings showed students' lack of confidence, anxiety when making mistakes, and lack of vocabulary as their greatest challenges when communicating in English. The qualitative data revealed that virtual classrooms could play a significant role in enhancing students' communication skills. However, despite the positive attitudes toward online classes, students agreed that the lack of face-to-face communication was a major obstacle in online learning.

In another EFL context, Cakrawati [8] investigated students' perceptions on the use of online learning platform in English as a Foreign Language (EFL) classroom. 40 participants were involved in the study. Quantitative and qualitative data were collected via

a questionnaire and interviews. Most of the participants affirmed the efficacy of using Edmodo or Quipper in English teaching and learning in terms of time, online platforms could be a good choice to encourage practicing language skills, acquiring new vocabulary, and helping students in understanding the content. However, the results showed that slow-speed internet was one of the main difficulties in using online.

Some of the studies have focused on the instructional practices in online environment between the students and their teachers, the students and the content, and among the students themselves. For example, Cheung, A. [9] has investigated the interaction patterns that occur in online environment and its effectiveness on the students. In his study, Cheung examined multi-modal exchanges between the teacher and the students. Data were obtained via 80 recordings from whole-class and small-group sessions over in four months. Various modes of synchronous computer-mediated communication that the teacher utilized were analysed. The findings showed that skilful students could demonstrate remarkable interactional skills during small-group sessions. One concern emerged through interaction was students' reticence, though it was alleviated by extending the wait-time. The study confirmed the importance for re-conceptualizing the constituents of classroom interactional practices. Similarly, Jiang and Ting [17] found that the degree of instructional emphasis on learning through interaction significantly influenced students' perceptions of online learning. Results indicated that percent of grade weight on discussion and instructor's specification of requirements of students' contributions in discussion were significantly and positively correlated to students' perceived amount of learning.

Reviewing the past studies, it was found that very few studies have considered all the elements that might affect the students' engagement in online education in the Arab context. The researchers in the presents study tried to highlight the most important factors that might contribute to a better online education in the Jordanian context in particular and the Arab world in general. Because of the dearth of studies in online education in Jordan, the present study would contribute to the literature of online education not only in Jordan but also in the Arab context.

4 Methodology

4.1 Participants and context

The present analytical correlational study attempts to explore the predictable factors that help students' engage in online English courses and their relationship to self-management for students at Luminus Technical University College (LTUC), in Jordan. Researchers who choose this design are interested in research that aims to detect the relationships between some variables [10]. The target population in this study is represented by all students who registered for the English Language Skills course at the Foundation Department, LTUC, Jordan. The sample included 59 students who were randomly selected. The included students in the study have already passed some other online English courses. The English Language Skills course was delivered online through D2L platform integrated with Zoom. The students' ages ranged between 19–21 years old. They were also homogenous in terms of their mother tongue (which is

Arabic), cultural background and the years of studying EFL (12 years) in the Jordanian schools.

4.2 Data collection

Data were collected using a questionnaire for predicting online learning achievement which was adapted from Bernard et al., [7]. The questionnaire used in this study consisted of three parts. The first part was constructed to collect background information about the participants (age, gender, class level, and number of English online hours that have been taken).The second part of the questionnaire includes 18 items, which covered three domains (Confidence in prerequisite skills, (5) items, General beliefs about online learning, (7) items, and Desire for interaction, (6) items). The third part includes 4 items on self-management. Five-point Likert scale (1=never, 2=occasionally, 3=sometimes, 4=usually and 5=always) was used to obtain data on students' perceptions toward the factors that help them engage in online English courses and self-management. Validation of the instrument was conducted by asking a jury of university instructors to give their remarks on the validity of the questionnaire. Analysis of reliability of the questionnaire refers to how the items in the questionnaire are interrelated among themselves. For questionnaires, one of the most popular methods is the Alfa Cronbach method. Value of the Alfa Cronbach method results of 59 students were (0.82–0.89) for the domains and (0.90) for the whole questionnaire

4.3 Data analysis

The factors that help students engage in online learning in EFL classroom were addressed through analysing students' responses to 18 items. The researchers examined these factors in relation to students' self-management. Self-management consisted of 4 items. To specifically address this, SPSS software was considered to answer the research questions. The data were analyzed by using the descriptive statistics (frequencies, percentages, means, and standard deviation) and Pearson Correlation Coefficient.

5 Results

The results of the present study are presented by research question:

Question 1: What are the most predictable factors that help students engage in online learning in EFL classroom?

As presented in Table 1, students' responses on the most predictable factors that help them engage in online learning in EFL classroom were computed. Table 1 shows that "confidence in prerequisite skills" domain ranked first based on the mean value (4.13±0.74). Meanwhile, "desire for interaction" domain ranked second based on the mean value (3.95±0.76), "general beliefs about online learning" domain ranked the least based on the mean value (3.35±0.57), which is considered as neither high nor low. The results indicate that overall mean score of the students' responses on predictable factors that help them engage in online learning in EFL classroom was (3.77±0.49).

Table 1. Means and standard deviations of the students' responses on the most predictable factors that help them engage in online learning in EFL classroom

#	The Domains	# of Items	Mean	Std. Dev.	Degree
1	Confidence in prerequisite skills	5	4.13	0.74	*High*
3	Desire for interaction	7	3.95	0.76	*High*
2	General beliefs about online learning	6	3.35	0.57	*Mid*
The Whole Predictable Factors		18	3.77	0.49	*High*

Note: Out of (5).

As presented in Tables 2, 3, and 4, the items in each domain were arranged based on the mean value of each item.

Table 2 presents the first four top items which included, "I am able to easily access the online classes via Zoom" and it ranked the first based on the mean value (4.56±0.82), "I have been trained by my power users in the college to communicate electronically via LMS and Pulse application which has been downloaded on my mobile" and it ranked the second based on the mean value (4.39±1.00), "I am able to communicate with my classmates as well as my teachers electronically" and it ranked third based on the mean value (4.25±1.03), and "I can text my teachers and my classmates via LMS on my mobile" ranked the forth based on the mean value (4.27±1.08), where they all considered as high. However, item number 5, "I feel comfortable communicating online in English" ranked the least based on the mean value (3.29±1.44), which is considered as neither high nor low. Based on the overall mean score of the students' responses on confidence in prerequisite skills domain it was (4.13±0.74).

Table 2. Means and standard deviations of the students' responses on confidence in prerequisite skills items

#	The Items	Mean	Std. Dev.	Degree
1	I am able to easily access the online classes via Zoom.	4.56	0.82	*V. High*
2	I have been trained by my power users in the college to communicate electronically via LMS and Pulse application which has been downloaded on my mobile.	4.39	1.00	*V. High*
3	I am able to communicate with my classmates as well as my teachers electronically.	4.25	1.03	*V. High*
4	I can text my teachers and my classmates via LMS on my mobile.	4.27	1.08	*V. High*
5	I feel comfortable communicating online in English.	3.29	1.44	*Mid*
The Whole Domain		4.13	0.74	*High*

Note: Out of (5).

Table 3 shows that item 9, "I can practice English grammar via the online activities outside the class" ranked first based on the mean value (4.34±0.86), which is considered as very high. However, item number 8, "Learning in class or online at home is the same" ranked the least based on the mean value, which is considered as low (2.00±1.25). Based on the analysis of the results, items 7 and 11 where considered as neither high nor low based on the mean value (3.10±1.31) and (2.66±1.65) respectively. The total mean score of the students' responses on general beliefs about online learning domain was (3.35±0.57).

Table 3. Means and standard deviations of the students' responses on general beliefs about online learning items

#	The Items	Mean	Std. Dev.	Degree
9	I can practice English grammar via the online activities outside the class.	4.34	0.86	*V. High*
10	I feel can improve my listening skills using the online activities and links provided by the teacher.	4.32	0.80	*V. High*
6	I am motivated by the content on my LMS outside the class.	3.81	1.21	*High*
12	I believe I can complete online course without any difficulty.	3.47	1.32	*High*
7	Learning activities contain clear, detailed instructions for students better than a conventional class.	3.10	1.31	*Mid*
11	Online learning at home is more motivating to me than a face-to-face class.	2.66	1.65	*Mid*
8	Learning in class or online at home is the same.	2.00	1.25	*Low*
The Whole Domain		3.35	0.57	*Mid*

Note: Out of (5).

Table 4 shows that item 18, "I can interact with the teacher via the posts he shares with us via the LMS outside the class" ranked first based on the mean value (4.46±0.84), which is considered as very high when compared to the other items. With reference to the remaining items 17, 14, 16, 15, and 13, all were considered as high. However, item number 13, "As a student, I enjoy working with other students via Breakout rooms" ranked the least based on the mean value (3.49±1.43) although it was considered as high. The results indicate that the overall mean score of the students' responses on desire for interaction domain was (3.95±0.76) and considered as high.

Table 4. Means and standard deviations of the students' responses on desire for interaction items

#	The Items	Mean	Std. Dev.	Degree
18	I can interact with the teacher via the posts he shares with us via the LMS outside the class.	4.46	0.84	*V. High*
17	I can collaborate with other students outside the class to finish the tasks and the assignments.	3.98	1.15	*High*
14	I feel that face-to-face contact with my teacher is necessary for learning to occur.	3.97	1.25	*High*
16	Online learning activities encourages me to interact with the content outside the class.	3.92	1.06	*High*
15	Online learning activities encourage me to interact with students outside the class.	3.73	1.14	*High*
13	As a student, I enjoy working with other students via Breakout rooms.	3.49	1.43	*High*
The Whole Domain		3.95	0.76	*High*

Note: Out of (5).

Question 2: What is the level of self-direction or management for students engagement in online learning in EFL classroom?

To answer the second research question, the researcher used the descriptive statistics (means and standard deviations) of the students' responses on the self-direction or management in the EFL online class. As shown in Table 5, meanwhile item (19) "When it comes to learning and studying, I am a self-directed person" ranked first based on the mean value (4.37±0.81), item (22), "In my studies, I set goals and have a high degree of initiative" ranked second based on the mean value (4.20±0.92), and both are considered as very high. However, item (21), "I am able to manage my study time effectively and easily complete assignments on time" ranked the least based on the mean value (3.69±0.97). The overall mean score of the students' responses on self-direction items was (4.02±0.73).

Table 5. Means and standard deviations of the students' responses on self-direction or management items that help them engage in online learning in EFL classroom

#	The Items	Mean	Std. Dev.	Degree
19	When it comes to learning and studying, I am a self-directed person.	4.37	0.81	*V. High*
22	In my studies, I set goals and have a high degree of initiative.	4.20	0.92	*V. High*
20	In my studies, I am self-disciplined and find it easy to put time for reading and doing all my homework.	3.81	1.06	*High*
21	I am able to manage my study time effectively and easily complete assignments on time.	3.69	0.97	*High*
The Whole Self-Direction or Management Items		4.02	0.73	*High*

Note: Out of (5).

Question 3: Is there any significant statistical relationship between the students' responses on predictable factors that help students engage in online learning and their responses on self-management?

The third research question intended to identify the relationship between the predictable factors that help students engage in online learning and their responses on self-management. To achieve this, the researcher used Pearson correlation coefficient. The results are presented in Table 6.

Table 6. Pearson correlation coefficients of the study subjects' responses on the self-management and desire for interaction

Predictable Factors that Help Students Engage in Online Learning	Pearson Correlation	P-Value
Confidence in prerequisite skills	0.525	0.009*
General beliefs about online learning	0.618	0.003*
Desire for interaction	0.659	0.002*
The whole predictable factors	0.692	0.001*

Note: *Significant at ($\alpha \leq 0.01$).

Table 6 shows that there is a strong positive correlation coefficient between the study subjects' responses on the predictable factors that help students engage in online learning and their responses on self-management.

6 Discussion

In this study, we have examined the predictable factors that affect the online learning in the Jordanian EFL context. These factors included the general beliefs about online learning, confidence in the prerequisite skills, interaction and self-management. A quantitative research design was used to address the three research questions of the study. Data were analyzed using SPSS tests which included descriptive statistics (means, standard deviation, frequencies, and percentages) and Pearson Correlation Coefficient. This study has revealed that the students' responses on the most predictable factors that affect Jordanian EFL students engage in online learning in the English Language Skills course are arranged as follows: (1) confidence in prerequisite skills domain ranked first, (2) desire for interaction ranked second, (3) and the general beliefs about online learning domain ranked third. While the study revealed a strong positive correlation coefficient between the students' responses on the predictable factors that affect the students' engagement in online learning and their responses on self-management. These findings can be attributed to the awareness of the students' ability to use technology at LTUC. LTUC has adopted the blended methods of teaching very early before COVID-19 and it was in a continuous work to invest appropriately in the educational technology. Thus, the shift to online learning took place smoothly, fast, and professionally.

Talking about LTUC context, its students are familiar with the use of technology in learning. Even though, technical problems would appear from time to time. The results of the present study showed the students' positivity toward online learning as well as comfort with some of the basic skills and components of online learning which could help in determining their self-confidence as users of technology and online learners. Examples on these skills included the ease in accessing online classes via Pulse application which is integrated with Zoom, the ability to communicate electronically with their teachers as well as their classmates via the LMS, and the comfort in communicating in English. With reference to the findings of our study, Al-Qahtani [15] asserted similar results with regard to the improvement in communication skills in the virtual classes. However, the results of the study were opposite to some of the results reported in Alshumaimeri & Alhumud [4], where students showed lack of self-confidence and anxiety when making mistakes.

In addition, interaction has been looked at as one of the key factors that leads to the success of online learning. The results showed that instructor's interaction with their students had a positive impact on the students' perceptions toward online learning. Further, students' satisfaction in online learning was high because students received training to use LMS and Pulse application. Even though, lack of internet connection could affect the levels interaction. Opposite to what has been reported in Al-mahasees et al., [5] study, where they affirmed that one of the obstacles in the online learning was the lack of interaction among the students themselves, the teachers and the students, or the students and the content. Similarly, this was asserted by Alshumaimeri &

Alhumud [4]. Thus, all the previous types of interaction should be encouraged in online classes.

Furthermore, the results revealed that students were aware to the difference between online learning and conventional learning. The results also affirmed that online learning was neither better nor worse than face-to-face learning. These results were consistent with An-Nofae [6] study where the results showed that online education was not always preferred to students. Additionally, students showed that asynchronous environment was more preferred and motivating than synchronous. This might be attributed to the flexibility in choosing the suitable time to do their assignments.

Self-management is one of the most important factors that help the success of online learning from the students' perspective. Stating course goals and objectives at the beginning of any course should be communicated clearly with the students in first orientation classes. Getting know what is expected from the students would help students overcome their fears from the course and would reduce the levels of anxiety. Monitoring students' progress would be helpful to keep them motivated. As a result, students' opportunities to become self-directed learners would improve. In the current study, the students showed high level of self-management. Further, the strong relationship that was revealed between the prerequisite skills, general beliefs toward online learning, and desire for interaction and self-management could draw the teachers' attention to the factors that could enhance the online learning process. Self-management would definitely leads to creating an independent learner. Online learning needs students to be more independent learners. The results of the study are supported by Ta'amneh [24] and Cakrawati [8], where they affirmed the goodness of virtual learning as a tool to improve students' ability in organizing their homework, assignments, and time during the EFL online classes.

Establishing a healthy online environment is the teachers, course designers, and policy makers' responsibility. Studies have been done to uncover the gaps in online learning. Thus, generalizations cannot be made based on the present study. More studies should be conducted to examine different factors as well as various contexts need to be considered to make online learning easy, and accessible to a greater audience of students.

7 Conclusion

This analytical correlational study aimed at identifying the most predictable factors that help EFL Jordanian students engage in English online classes in an English Language Skills course. This study also sought to identify the relationship between the confidence in prerequisite skills of online learning, desire for interaction, and the general beliefs about online learning and self-management. This study showed students positive perceptions toward the most predictable factors that help Jordanian EFL students engage in online learning in an English Language Skills course. The findings affirmed that confidence in prerequisite skills domain ranked first, desire for interaction ranked second, and the general beliefs about online learning domain ranked third. Further, the study confirmed a strong positive relationship between the students'

responses on the predictable factors that affect students' engagement in online learning and their responses on self-management. The findings of the study could contribute to the knowledge in the field of online learning in the EFL Jordanian context, and other EFL contexts. Online learning is a complex process which necessitates various factors to be considered to guarantee a successful and a sustainable online learning. Uncovering the relationship between different factors would help in the improvement of online learning in various contexts.

Future studies may focus on other contexts. Different factors may be examined. Further, employing different methods of qualitative and quantitative research methods could contribute in the field as well. Meanwhile the present study has been limited to studying confidence in the prerequisite skills, desire for interaction, the general beliefs toward online learning, and self-management, other studies could consider the different levels of interaction in online environment, the online preference learning style (e.g., synchronous or asynchronous) and social presence in online learning.

8 References

[1] Adnan, M., & Anwar, K. (2020). Online Learning amid the COVID-19 Pandemic: Students' Perspectives. Online Submission, 2(1), 45–51. https://doi.org/10.33902/JPSP.2020261309

[2] Albashtawi, A., & Al Bataineh, K. (2020). The effectiveness of google classroom among EFL students in Jordan: An innovative teaching and learning online platform. International Journal of Emerging Technologies in Learning (iJET), 15(11), 78–88. https://www.learntechlib.org/p/217100/; https://doi.org/10.3991/ijet.v15i11.12865

[3] Aliyyah, R. R., Rachmadtullah, R., Samsudin, A., Syaodih, E., Nurtanto, M., & Tambunan, A. R. S. (2020). The perceptions of primary school teachers of online learning during the COVID-19 pandemic period: A case study in Indonesia. Journal of Ethnic and Cultural Studies, 7(2), 90–109. https://doi.org/10.29333/ejecs/388

[4] Alshumaimeri, Y. A., & Alhumud, A. M. (2021). EFL students' perceptions of the effectiveness of virtual classrooms in enhancing communication skills. English Language Teaching, 14(11). https://doi.org/10.5539/elt.v14n11p80

[5] Almahasees, Z., Mohsen, K., & Amin, M. O. (2021). Faculty's and students' perceptions of online learning during COVID-19. Front. Educ., 6. https://doi.org/10.3389/feduc.2021.638470

[6] Al-Nofaie, H. (2020). Saudi university students' perceptions towards virtual education during Covid-19 pandemic: A case study of language learning via blackboard. Arab World English Journal (AWEJ), 11. https://ssrn.com/abstract=3705062; https://doi.org/10.24093/awej/vol11no3.1

[7] Bernard, R. M., Brauer, A., Abrami, P. C., & Surkes, M. (2004). The development of a questionnaire for predicting online learning achievement. Distance Education, 25(1), 31–47. https://doi.org/10.1080/0158791042000212440

[8] Cakrawati, L. M. (2017). Students' perceptions on the use of online learning platforms in EFL classroom. Elt Tech: Journal of English Language Teaching and Technology, 1(1), 22–30. https://doi.org/10.17509/elt%20tech.v1i1.9428

[9] Cheung, A. (2021). Synchronous online teaching, a blessing or a curse? Insights from EFL primary students' interaction during online English lessons. System, 100, 102566. https://doi.org/10.1016/j.system.2021.102566

[10] Curtis, E. A., Comiskey, C., & Dempsey, O. (2016). Importance and use of correlational research. Nurse Researcher, 23(6). https://doi.org/10.7748/nr.2016.e1382

[11] Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. Journal of Educational Technology Systems, 49(1), 5–22. https://doi.org/10.1177/0047239520934018
[12] Eaton, J. S. (2000). Core academic values, quality, and regional accreditation: The challenge of distance learning.
[13] Essex, C., & Cagiltay, K. (2001). Evaluating an online course: Feedback from "distressed" students. Quarterly Review of Distance Education, 2(3), 233–239.
[14] Hara, N., & Kling, R. (2001). Student distress in web-based distance education. Educause Quarterly, 24(3), 68–69.
[15] Hussain Al-Qahtani, M. (2019). Teachers' and students' perceptions of virtual classes and the effectiveness of virtual classes in enhancing communication skills. Arab World English Journal (AWEJ) Special Issue: The Dynamics of EFL in Saudi Arabia. https://doi.org/10.2139/ssrn.3512530
[16] Jackson, M. J., & Helms, M. M. (2008). Student perceptions of hybrid courses: Measuring and interpreting quality. Journal of Education for Business, 84(1), 7–12. https://doi.org/10.3200/JOEB.84.1.7-12
[17] Jiang, M., & Ting, E. (1998, April). Course design, instruction, and students' online behaviors: A study of instructional variables and students' perceptions of online learning. In American Educational Research Association Annual Meeting.
[18] Klingner, B. G. (2003). The relationship between learning styles of adult learners enrolled in online courses at Pace University and success and satisfaction with online learning (Doctoral dissertation, Walden University).
[19] Liguori, E., & Winkler, C. (2020). From offline to online: Challenges and opportunities for entrepreneurship education following the COVID-19 pandemic. Entrepreneurship Education and Pedagogy, 3(4), 346–351. https://doi.org/10.1177/2515127420916738
[20] McPherson, M. S., & Bacow, L. S. (2015). Online higher education: Beyond the hype cycle. Journal of Economic Perspectives, 29(4), 135–54. https://doi.org/10.1257/jep.29.4.135
[21] Meyer, K. A. (2002). Quality in Distance Education: Focus on On-Line Learning. ASHE-ERIC Higher Education Report. Jossey-Bass Higher and Adult Education Series. Jossey-Bass, 989 Market Street, San Francisco, CA 94103-1741.
[22] Parkes, M., Stein, S., & Reading, C. (2015). Student preparedness for university e-learning environments. The Internet and Higher Education, 25, 1–10. https://doi.org/10.1016/j.iheduc.2014.10.002
[23] Tarman, B. (2020). Reflecting in the shade of pandemic. Research in Social Sciences and Technology, 5(2), i–iv. https://doi.org/10.46303/ressat.05.02.ed
[24] Ta'amneh, M. A. A. A. (2021). Attitudes and challenges towards virtual classes in learning english language courses from students' perspectives at Taibah university during COVID-19 pandemic. Journal of Language Teaching and Research, 12(3), 419–428. https://doi.org/10.17507/jltr.1203.12
[25] Twigg, C. A. (2001). Innovations in online learning. In moving beyond no significant difference. The PEW Learning and Technology Program. (symposium monograph). Troy, NY: Center for Academic Transformation. Rensselaer Polytechnic Institute.
[26] Sturm, E., & Quaynor, L. (2020). A window, mirror, and wall: How educators use Twitter for professional learning. Research in Social Sciences and Technology, 5(1), 22–44. https://doi.org/10.46303/ressat.05.01.2
[27] Song, L., Singleton, E. S., Hill, J. R., & Koh, M. H. (2004). Improving online learning: Student perceptions of useful and challenging characteristics. The Internet and Higher Education, 7(1), 59–70. https://doi.org/10.1016/j.iheduc.2003.11.003
[28] Vonderwell, S. (2003). An examination of asynchronous communication experiences and perspectives of students in an online course: A case study. The Internet and Higher Education, 6(1), 77–90. https://doi.org/10.1016/S1096-7516(02)00164-1

[29] Vrasidas, C., & McIsaac, M. S. (1999). Factors influencing interaction in an online course. International Journal of Phytoremediation, 21(1), 22–36. https://doi.org/10.1080/08923649909527033

[30] Yang, Y., & Durrington, V. (2010). Investigation of students' perceptions of online course quality. International Journal on E-Learning, 9(3), 341–361. https://www.learntechlib.org/primary/p/29460/

[31] Zhong, B. L., Luo, W., Li, H. M., Zhang, Q. Q., Liu, X. G., Li, W. T., & Li, Y. (2020). Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: A quick online cross-sectional survey. International Journal of Biological Sciences, 16(10), 1745. https://doi.org/10.7150/ijbs.45221

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The Importance of Using the Internet of Things in Education

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Abstract—The subject of the Internet of Things is very important, especially at present, which is why it has attracted the attention of researchers and scientists due to its importance in human life. Through it, a person can do several things easily, accurately, and in an organized manner. The research addressed important topics, the most important of which are the concept of the Internet of Things, the history of its emergence and development, the reasons for its interest and importance, and its most prominent advantages and characteristics. The research sheds light on the structure of the Internet of Things, its structural components, and its most important components. The research dealt with the most important search engines in the Internet of Things, the steps of designing Internet of things systems. Among the important topics included in the research are the use of Internet of things technology in the educational field, the role of the Internet of things in solving education problems, and the most important applications of the Internet of things in education and its importance for students and teachers. Also indicated the contribution of the Internet of Things to ensuring sustainable development, environmental protection and the most important areas of application of the Internet of Things. The research sample amounted to (152 teaching staff) from Iraqi Universities and their academic achievement (84 Ph.D., 68 Master's, 42 Bachelor's) from (17) different scientific specializations; and (42 students). The number of respondents who use the Internet in education is 191 and the number of those who do not use the Internet and teach in person is (3) from (194) person. Students and professors use smartphones in study and teaching at a rate of (97.42%) and computers and their necessities at a rate of (92.27%) are higher than electronic devices and equipment including the smart board (11,86%). Use of IoT technology is of great and medium importance in providing electronic lectures effectively, with a percentage of 96.91%, the use of it has a large and medium role in solving education problems in giving lectures in light of health crises, especially in light of the Coronavirus crisis. Availability at the local and global levels, whether with the appropriate content or the selection of professors anywhere in the world, at a rate of 98.45%.

Keywords—notifications, data, homes, cars, networks, platforms, systems, technology

1 Introduction

Internet of things technology has gained the attention of a large number of researchers in computer science and other disciplines, both scientific and human, due to its importance in various fields of life, especially educational ones, due to the important services it provides to most educational institutions [1, 2]. Given the importance of the subject, the researchers chose to study the Internet of Things, clarify its applications, indicate its importance in education, and identify students and professors as the focus of the educational process. The Research problem lies in the following two questions: What are the applications of the Internet of Things in education; and What is the importance of IoT technology for students and teachers? A statement of the concept of the Internet of Things, its origins, and its importance. A statement of the applications of the Internet of Things in education. Explanation of the role of the Internet of Things in solving education problems. Explain the importance of the Internet of Things for students and teachers. The questionnaire was distributed to a random sample of Iraqi universities students and professors through social media groups (WhatsApp, Telegram, and Viber).

In [3], the research paper seeks to clarify what is meant by the Internet of things and to indicate its characteristics and areas of application. And clarifying the justifications that call for the need to benefit from the technology of the Internet of Things in the educational field and the areas in which the Internet of things can be used to develop the services and activities of educational institutions and clarifying the challenges facing the use of the Internet of things in the field of education. The research came out of the recommendations, including increasing awareness of the importance of the role of the Internet of Things in developing the services of educational institutions, and allocating many discussion panels and seminars on the subject of the Internet of things and its services and benefiting from its advantages to solve educational problems. B. Walid Youssef Mohamed Ibrahim and Rania Atef Shorb, Internet of Things Technology IoT: Concept and Educational Applications (2). The research paper deals with the Internet of things in terms of the concept and statement of the main components and requirements of the technology of the Internet of things from devices, protocols, middleware, applications, presentation, and distinctive characteristics of Internet of things technology and its advantages and a statement of educational services within universities, including smart education and smart classes. C. Jamal bin Matar Al Salmi, Khaled Ateeq Saeed Abdullah and Abdullah bin Salem Al Hinai, The Role of the Internet of Things in Knowledge Management in Information Institutions (3). This research paper seeks to highlight the role of Internet of Things applications in supporting knowledge management activities in information organizations and thus improving their services. The research relied on the descriptive approach, and through the investigation and analysis of the intellectual output published in the Arab world and abroad, to extrapolate the areas of the relationship between the Internet of Things and knowledge management activities in information institutions. One of the recommendations of the research is the need to take advantage of the Internet of things in information institutions to keep pace with the technological changes that are taking place and to invest in the Internet of things applications for better service and to benefit from the huge data available to them in making appropriate decisions. The advantage and benefits of the current research paper compared to previous studies: The research paper was distinguished

from previous studies by showing the importance of using IoT technology in education by taking the opinions of a sample of students and professors in Iraqi universities, as well as stating the role of IoT in solving problems facing education. The benefit of previous studies was to write the theoretical framework for the research

2 The theoretical framework of the research

2.1 The concept of the Internet of Things

The Internet of Things means that all the devices and gadgets that we use in our daily lives can connect to the Internet and are managed through the mobile application of smartphones, through a computer, or through control devices that are also connected to the World Wide Web. This means that these devices collect data, learn about user decisions, are remotely managed, get updates, and rely on the Internet to communicate and function [4, 5]. In other words, Internet connectivity is no longer limited to smartphones and computers in its narrow and traditional sense, but rather includes televisions, surveillance cameras, house and room keys, home entertainment devices, sports equipment, electronic panels, cars, etc. An IoT "thing" can be any object that has the required computing power, Internet connectivity, and the ability to collect and transmit data over a network without assistance or manual intervention. The technology embedded in the organisms helps to interact with the internal states or the external environment, which in turn affects the decisions taken as in Figure 1. [6, 7]. The Internet of Things "is a modern technology that aims to connect all electronic devices via the Internet so that they can communicate with each other through special protocols, and also communicate with humans by sending text messages. In this technology, communication is a device with a device or a device with a human or A human with a device, and often the human is the endpoint [8]. It is an emerging global Internet-based information architecture whose purpose is to provide an information technology infrastructure to facilitate the safe and reliable exchange of goods and services. That is, its function is to overcome the gap between things in the physical world and to represent it in information systems [2, 9].

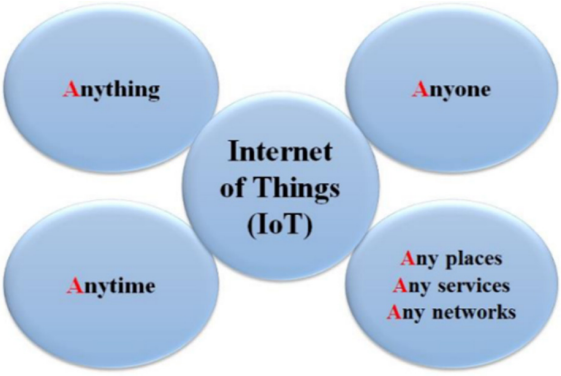

Fig. 1. Internet of Things concept

It is a modern terminology that focuses on the future of the Internet, its uses, and advanced applications based on the Internet. Kevin Ashton is the first to use the term "internet of things" in 1999, and he is one of the pioneers in the field of technology. He is the founder of the first research center at the Massachusetts Institute of Technology. This term means that things will be able to be more useful with less effort by enabling them to communicate with each other through the Internet [10–12]. Ashton expressed IoT in his quote from the RFID Magazine article "If we had computers that knew everything using the data collected without human intervention we would be able to track and account for everything and greatly reduce loss and cost" [13, 14]. The researchers define the Internet of Things procedurally; it is a modern technology that connects various devices and equipment to the Internet and facilitates the process of interaction and communication between teachers and students to transmit data and information electronically over the network without manual intervention.

2.2 The emergence of the Internet of Things

The idea of the Internet of Things emerged as an initiative in 2000 by Kevin Ashton to improve supply management by connecting RFID tracking data to the Internet, at his workplace at Proctor & Gamble. While working there, Ashton had the idea of putting a PFIC tag on lipstick and connecting it to a wireless receiver so he could monitor sales and inventory and signal when additional storage was needed. He assumed that such collected data would help solve many problems in the real world. The term was then used in theses by Neil Gere Shenfield, who was talking about similar ideas from the Massachusetts Institute of Technology's Media Lab in his book When Things Begin to Think [15, 16]. In January of the same year, the Korean electronics company LG announced the first refrigerator with the Internet of Things technology. In 2005, the International Telecommunication Union approved the research and development of the Internet of Things and published this in the annual report for the year 2005. In 2008, the International Internet of Things Union, called IPSO, was formed to promote the use of the Internet of Things protocol on network-connected devices in energy consumption. By 2009, the concepts and applications of the Internet of Things dominated a large part of the research and academic studies and the applications that tried to benefit from it. There are more things connected to the Internet than the number of people connected to the same network. In 2012, the sixth version of the Internet protocol was released, which made it possible to assign a private address to everything on this earth without restrictions or obstacles. Thus, we guarantee the possibility of connecting millions of devices [17]. The Internet of Things can operate through the use of smartphones, other handheld devices, generations of mobile data transmission services, as well as the use of software that relies on satellite systems or GPS remote sensors. Researchers in the field of the Internet of things have been able to develop tools, software, and the language of communication via the Internet among themselves, which has led to today's access to what is known as the Internet of Things. Internet things are all tangible physical things (smart things) that are linked together over a network and can be identified on the Internet by sticking a clear and static IP address on the car, TV, Google goggles, and various household items such as refrigerators, washing machines, alarms, home entrances, and home appliances. Air conditioning, the goods, and products available on the shelves of

shops and on the animals on the farms, and everything we want to control, monitor, or deal with through their electronic understanding through software and sensors that can connect to the network. So these things can collect and share data. And the human being in this case is the beneficiary of all these understandings and communications between things that are communicated to each other over the Internet. It can even be monitored and controlled online by a mobile smartphone app. All these things in airports, roads, shops, hospitals, schools, universities, at home, and at work are under control and can be managed and controlled via the Internet of Things by a mobile phone or any other means connected to the Internet [18, 19].

2.3 The importance of the Internet of Things

Interest in the Internet of Things, in general, is due to several reasons, including The Internet of Things works by linking things together through a private identity. The applications of the Internet of Things are not very different for workers in information institutions who have previously dealt with RFID object tracking technology, as they are similar in tracking things through remotely connected sensors. However, the difference here is that the communication between things and devices is via the Internet of Things through the Internet. The Internet of Things is an effective way to overcome some of the problems facing the learner and helps him to overcome the barriers of time and space and enables remote control of learning management successfully. The Internet of Things can help strengthen the relationship between the student and the teacher so that each of them can reach each other through IoT applications without the need for an actual interview. The teacher will be able to give an order to the textbook or the teaching aid to move towards the side where the student or students are in the classroom if the specialized robots that carry out the request are available. Every human being today expects to have a smartphone on which he uses applications for multiple services. The school can, through its application, provide the opportunity for learners and parents to communicate with the school via the Internet and use its electronic resources, attend classes, participate, express an opinion, and give commands to the devices available in the school to turn on or stop, or the like. It can also be tracked and its data collected through the sensors installed on those objects. Enterprises can use this technology to reduce production costs by increasing cooperation and automation between machines instead of workers. Organizations can provide more efficient, diverse, and real-time offerings based on real-time data collection from users. Institutions must change their policy in advertising their goods to potential customers and deliver those offers to the user at his doorstep through his smart mobile device at a record and convenient time. The Internet of Things offers an effective means of effective marketing its services through communication between its holdings. Rapid, sensitive, and secure response to achieve the information needs of the beneficiaries within the Internet of Things network. Raising the productivity of devices and systems by increasing the accuracy of data handling, remote implementation of operations, and less reliance on the human factor. Increasing the level of availability within information systems by improving their ability to perform their work and the speed of access and obtaining information through those things. Enabling the delivery of things anytime and anywhere for someone who uses IoT network services perfectly. Develop reference services and allow users to conduct reference questions and get answers from within the Internet of Things.

Ensuring the users' access within the Internet of Things network to view the resources and information sources through their authenticated and defined identity, and sometimes also through additional codes that are defined. Facilitate the process of saving and storing resources through cloud computing and fog computing systems, through which information resources and sources are controlled, monitored, monitored, and controlled, and their data is accurately and permanently received. The ability to sense things and give appropriate alerts, warnings, and reports about them through its ability to process and analyze data, and continuously monitor, track and make smart decisions [20–24].

2.4 Advantages of the Internet of Things

1. Data: The Internet of Things provides a lot of information that helps us to make the right decisions at the right time.
2. Time: IoT technology saves a lot of time by providing accurate information at the right time and in the fastest time.
3. Economic: IoT technology is very economical depending on the application scenarios.
4. Tracking: IoT helps in tracking or monitoring various physical objects which in turn saves time and money.
5. It contributes strongly to saving time, effort, and money by enabling the individual and the organization to remotely control things to implement what is required of them accurately, in addition to the possibility of understanding things among themselves through sensors that communicate with each other via the Internet. This achieved many results that contributed to saving time, effort, and money.
6. The human being is liberated from the constraints of time and place, where he can manage and control things through the Internet protocol without the need for him to be in the same place; and without his direct intervention in many cases, if he gives instructions in advance. [24–26]

These are some of the services that can be provided by the IoT and are considered among its advantages:

1. Monitoring Manufacturing Equipment: Optimize processes with Industrial Internet of Things (IoT) technologies. Use advanced sensors and analytics to predict needed maintenance and reduce unplanned downtime that cuts into production time.
2. Monitor customer equipment: New business models are designed that provide predictive maintenance and performance monitoring for the equipment they produce; which provides a better customer experience.
3. Field Service Improvement: Access sensor data to improve field service scheduling ensuring that the right technicians and tools are deployed before potential problems become a major problem.
4. Optimizing the use of natural resources: IoT application of scenarios ranging from energy to agriculture to deliver environmentally friendly energy transmission and efficiencies at lower prices to customers.
5. Create safer cities: Connect better traffic management infrastructure, make emergency systems more efficient, and reduce police and emergency medical response times.

6. Creating Smart Buildings: Linking building devices and systems together to provide more efficient operations and control capabilities for building owners, managers, and occupants.
7. Improving field service: Improve service efficiency, from repairing broken streetlights to maintaining traffic lights to improving garbage truck lanes. [27]

2.5 Characteristics of the Internet of Things

This system is characterized by a set of characteristics, the most important of which are:

1. Interaction: About the Internet of Things, it can be anything that is interconnected with the global information and communication network infrastructure.
2. Heterogeneity: It is one of the main characteristics of the Internet of Things (IoT) network based on its connection to different device systems and networks, where they can interact with other devices or service platforms across different networks; this supports the basic design requirements of the Internet of Things and its environments, in scalability and interoperability.
3. Dynamic Changes: The state of the connected devices within the Internet of Things network changes from the state of connected or disconnected. Also, in the context of devices including location and speed, addition, the number of devices can change dynamically, the people connected to them, and the weight of the connection.
4. Things-Related Services: Able to provide things-related services within the constraints of things such as privacy protection and semantic consistency between physical things and the virtual things associated with them.
5. Intelligence: The Internet of Things comes through a set of algorithms, software, and hardware that are linked to form an intelligent network whose capabilities are enhanced by surrounding intelligence. Which facilitates things through intelligent response to a specific situation and supports it in carrying out specific tasks, including achieving interaction between the user and the device through standard saving methods and a graphical user interface.
6. Sensing: The Internet of Things relies in its infrastructure on digital sensors and sensor applications that detect or measure any changes in the environment and give alerts and reports on their status, or even interact with the environment. Remote sensing techniques provide a means to create capabilities that reflect true awareness of the physical world and the people in it.
7. Connectivity: The Internet of Things (IoT) enables interconnection through network accessibility and compatibility, the shared ability to consume and enhance data production through collective intelligence, and provides intelligent communication between smart applications and humans.
8. Enormous Scale: The Internet of Things is characterized by massive capacity or scale. As the number of devices within the IoT network that need to be managed and that communicate with each other at least is greater than the devices connected to the current Internet. In addition, the management of the data generated and interpreted for application purposes is related to the semantics of the data, as well as the efficient processing of the data.

9. Safety: The Internet of Things (IoT) network is designed for the security of personal data and associated objects and to secure data transmission points within networks from attacks and pollutants through an expansive security model.
10. Energy: It relies on energy efficiency and its devices do not require much energy, to enable the Internet of Things network to operate with the least energy possible to ensure its continuity in work and remote places.
11. Connectivity: The devices and sensor systems are connected through the Internet or any other network.
12. Communication: Connect devices so you can communicate and analyze data.
13. Intelligence: It is the perception aspect provided by the Internet of Things devices, through remote sensing and data collection that is analyzed.
14. Action: It is considered the most important step as it monitors and discusses the phenomenon based on previously collected data, as happens, for example, in temperature change decisions.
15. Ecosystem: Providing the appropriate environment for the presence of this technology, by providing the Internet for everything and choosing the appropriate platform.
16. User Interfaces: Smart objects can communicate with people appropriately, either directly or indirectly.
17. Localization: Intelligent objects are aware of their physical location or can be located, and mobile phone networks are suitable technologies to achieve them.
18. Embedded Information Processing: Smart objects have a processor or controller, and in addition to storage capacity, these resources can be used to process and interpret sensor information.
19. Identification: Objects are identifiable by a reader medium such as RFID or a mobile device [28].

2.6 Using Internet of Things technology in the educational field

The Internet of Things improves education itself and contributes to the improvement of the physical and structural environment. A smart school has facilities that operate smoothly to provide a higher level of personalized learning. And smart devices that are used in the educational institution use a Wi-Fi network to send data and receive instructions, which helps to create smarter lesson plans. Keeping important resources on track and improving access to information, contribute to rapid communication between students and teachers in and out of the classroom anytime and anywhere. Therefore, many educational institutions have begun to realize the importance of introducing technology and integrating it, especially the Internet of Things, in their daily educational methods. There are some reasons and justifications for taking this step. The most important justifications for calling the use of the Internet of Things in education are as follows:

1. The education sector is always at the forefront of sectors that employ modern technologies at its service, as this sector represents the main pillar upon which the trends of the knowledge economy are built, which is the most prominent front for major economies in the coming years.

2. The technology of the Internet of Things and its applications in education has given and will give many advantages and benefits to each teacher, student, and school, and contribute to the tangible practical clarification of the educational process in a way that raises and raises the quality of education, and its outputs are what the country needs in terms of qualified human resources.
3. The applications of the Internet of Things in the field of education make the practical reality of educational institutions at all levels in line with everything new and modern in the areas of technology applied in practice in education in many countries of the world.
4. Experts expect the Internet of Things to change how schools, universities, and teaching and learning institutions work, and bring about an anticipated revolution in all stages of work, from teaching, guiding, learning, managing, following up, and communicating among all members of the educational process to self-managed customer services. Rather, it will be able to connect all parties to the digital network, which means that it can be monitored remotely even after completion of studies and graduation.
5. The Internet of Things is the future technology that all fields await, including educational institutions, and major institutions are racing to explore its depths and reap its fruits. Several institutions and technology companies are racing to spread and popularize the Internet of Things in all areas of our lives. So we can say that the Internet of Things will become a global force, and this technology has achieved an unprecedented connection to the digital network that included people, machines, tools, and "things" in general. These communications allow companies to monitor most of the operations that take place around us.
6. They contribute to ridding us of simple, repetitive tasks daily, focusing on important matters, and leaving machines to do repetitive tasks.
7. IoT technology enables us to automate and comply with ever more stringent international industrial regulations, codes, and standards, by improving movement within a facility, and tracking hazardous materials, components, and other products. As well as the management of vital contact points, especially in the field of food processing. However, the current price of this technology does not help much to improve the cost.
8. This technology provides a rich and flexible platform for students, teachers, administrators, and others to explore, learn and interact with the educational system in a super-intelligent environment.
9. Advanced technology helps students learn new things by supporting educational goals. It allows students and teachers to share documents online and make changes in real-time on the screen, helps teachers organize all student resources, and helps record lessons directly on the computer. It also helps students to access any information they need through a single search of one of the search engines.
10. Technology helps students communicate with teachers using different methods, it helps teachers to keep track of all students, assign them homework through various online tools and track their performance. Teachers stay in touch with students all the time and eliminate any communication gap between them. Technological use of technologies helps students take on multiple roles and take responsibility for

learning and gives them freedom of expression and work in a modern and safe environment.

11. Contribute to education anytime and anywhere, as things play a vital role in building society using different platforms on the internet, advanced technology helps teachers monitor students' progress, making it possible for learners to gain knowledge from anywhere and at any time. It allows students and teachers to keep in touch via various means, check out upcoming media and events away from the classroom, and even respond to jobs. It is one of the applications that provide a secure network and complete privacy as it allows to store unique ideas and ensure complete confidentiality [29–30].

2.7 The role of the Internet of Things in solving education problems

a. Availability in Wide Geographical Coverage: Wired and wireless networks now cover most of the population, creating unlimited platforms that increase availability. Here, the Internet of Things helps learners globally to make available locally and globally, whether with the appropriate content or by choosing teachers anywhere. The solutions offered by the Internet of Things allow a large number of learners in China, for example, to learn English through text messages and audio lessons, despite the scarcity of specialized and qualified local teachers.
b. Timely Availability, Autonomy: The Internet of Things offers educational alternatives anytime and anywhere, unlike traditional classrooms. For example, in some isolated villages, some university professors deliver lessons through podcasts that allow learners to access them anytime and anywhere and learners interact with them through text messages in an independent way for each learner in the learning process.
c. Adaptation: Educators can use IoT technology to adapt education to each learner individually, unlike the one-to-many method that provides the average needs of the group and, accordingly, reduces the importance of adapting education to the group of learners, the Internet of things helps to change that by:
    1. Customization: Each student has his learning style and a different learning speed. Therefore, teachers are often unable to follow up and respond to these differences in the learning style and speed of learners' achievement. Here, we find that the Internet of Things (IoT) technology can provide real data directly at the same time as learning through simple formative assessments via wireless technology, which helps teachers to adapt and customize education for each student individually. For example, interactive learning methods allow different ways of adjusting the difficulty levels, number, type of hints, etc, for students based on observing their different reactions to many problems.
    2. Collaboration: Students often understand and apply concepts best through discussion and collaboration with their peers. However, traditional learning environments do not allow this, especially with large class sizes. So IoT helps learners get their content, share it with peers, and share different learning paths through collaboration [31–32].

2.8 Applications of the Internet of Things in education

IoT has contributed to the development of many services that contribute to the development of the educational process, including the following:

1. Smart education: Smart education is a special teaching method that is completely different from the traditional method, where the teacher can add a lot to the educational process through various means with the help of electronic tools and helps the learner choose from a wide range of educational aids, and provides quality content on 24 x 7 range.
2. Smart Classroom: The smart classroom is the place for comprehensive educational activities and where there is learning, teaching, and assessment all happen differently and effectively. The Internet of Things also provides the ability to control smart classroom components of electronic gadgets, such as a digital screen, projector, and Internet-enabled devices that enable smart learning to be managed successfully.
3. A better educational experience, as the main function of the Internet of Things, is to enable understanding between things, such as understanding one device with another, and it saves the time and effort of the teacher in connecting, managing, and controlling devices, and helping him to provide a distinctive learning experience that can be transferred to learners.
4. Proof of attendance: Each student is verified on a dedicated cloud application using data collected from each student's RFID reader or scanner.
5. SMS Alerts: Automated receipt and access alerts are sent to parents via mobile phone.
6. Smart School Bus Management School vehicles can be effectively tracked and managed, and the bus's compliance with the road is monitored. A student's parent or principal can get alerts when a bus driver is off the road to refuel, time, and other transportation safety with the help of smart IoT technologies. And the ability to track live by displaying the bus journey live on the map, allowing more visibility for safety.
7. Emergency management: In the event of an emergency, safe paths can be identified inside the school for students to cross safely, and school buses can be routed on the road at the time of accidents or disasters. In addition to detailed information about students, such as blood type, home address, parent's phone, sensing fires inside laboratories, halls, classrooms, room temperature sensors, the nearest ambulance point, and so on. With many students in educational institutions, monitoring them is a difficult task, moreover, students in educational institutions are more vulnerable so smart security should be used compared to employees in their workplaces. The Internet of Things can greatly enhance the security of schools, colleges, and any other learning centers. With the help of technologies such as 3D positioning, students can be monitored 24/7 and their presence reported at any time in addition to providing the option of distress buttons, with these technologies the alarm can be sounded when needed. And wireless door locks that can control the doors of educational institutions remotely.

8. Improving operational efficiency in educational institutions that have many common stakeholders and the Internet of Things, thus helping to manage those relationships efficiently in terms of tracking students, staff, resources, equipment, and devices. The operation of these things can be effectively managed by implementing effective operational management process techniques that lead to overall success across IoT applications.
9. Reducing the cost: The main expenditures in the educational process represent a large proportion of the budgets of countries that consider education one of the basics of nation-building. The obsession with controlling these expenses and reducing them in a way that does not affect the quality of education remains a real concern, and when the Internet of Things is applied in the educational process, it leads to enabling automatic communication between the educational sectors and the different systems and things in them. It will automatically enhance the ability to closely monitor, thus reducing overall expenses.
10. RELIABILITY IoT applications enhance the reliability of the system and its components and the ability to manage them efficiently.
11. Educational applications: educational applications that benefit from the Internet of Things can be considered powerful creative tools that are transforming the normal way of teaching and learning. It also enables teachers and students to create 3D graphic books that feature videos and the ability to take notes. In addition to the large number of educational games it provides. Where these games provide many features that offer interesting possibilities in teaching and learning and this is what can develop the desire to learn more than ever. The educational applications that can be provided through the Internet of Things are many and varied, and the most prominent of these applications are poster boards that have been developed using the Internet of Things, where they are using multimedia stickers, as it is possible to easily create virtual posters that combine images, audio, video, text, and hyperlinks. Smartboard applications can help teachers to explain lessons more easily with the help of online presentations and videos, students are encouraged to treat interactive games as a powerful platform. Web-based tools and software help students learn more effectively [33–35].
12. Increasing Efficiency In many schools and colleges students spend a lot of time on activities that do not add any value to the primary purpose of their actual existence. For example, attendance of students should be taken several times a day and additionally, this data should be sent to the central office for various purposes. But the Internet of Things can put an end to this inefficient system. With the help of IoT circulating devices, this data can be collected and sent to the central telephone server automatically eliminating the need for any human intervention. Due to this revolutionary shift towards the Internet of Things, the tedious tasks of teachers and students can be reduced allowing them to focus more on teaching and learning [36–42].
13. Smart Classroom: Internet of Things technology can control smart classroom components from electronic tools such as digital screens, smart board control, tablets, printers, e-books, student ID cards, projectors, and Internet-enabled devices, which successfully achieves smart learning [34–36].

3 A practical framework

This framework deals with two axes. The first axis analyzes the characteristics of the research sample in terms of achievement, type of work, and general and precise specialization. The second axis provides an analysis of the data of the answers of the research sample to the questions of the questionnaire, which included (6) questions and was distributed to a random sample of professors and students of Iraqi universities and amounted to (194) individuals; after it was presented to a group of experts to prove its sincerity. It was prepared electronically according to Google Forms, the form https://forms.gle/4rjN2f7Zs68jGQbZ9 and sent via social media groups (WhatsApp, Viber, Telegram) to university students and professors.

3.1 The first axis: analysis of the characteristics of the research sample

A-The academic achievement of the respondents: Table 1 shows the academic achievement of the respondents, where the category of Ph.D. holders represented the highest and most prominent category of those who answered the questionnaire. Their number was (84) or 43.30% of the total. The second place was for those who obtained a master's degree, as their number was (68) with a rate of 35.05%, and the third for a bachelor's degree was (42) with a rate of 21.65%.

Table 1. Academic qualification of the respondents

No.	Academic Achievement	Number	Percentage
1	Doctorate	84	43,30
2	Master	68	35,05
3	Bachelor	42	21,65
Total		194	100%

B-Type of employment: Table 2 shows the type of work of the respondents. Where it represented the highest number and percentage of the category of teachers, as their number reached (152) and a rate of 78.35%. The student category ranked second, with several (42) and a rate of 21.65%.

Table 2. Type of work for respondents

No.	Type of Work	Number	Percentage
1	152	152	152
2	42	42	42
Total		194	100%

C-General and specific jurisdiction: Table 3 shows the type of general and exact terms of reference for the respondents. Where it represented the number of specializations (17) specialization. The highest number and percentage of history specialization was (34), with a rate of 17.53%. Then the specialization of educational and

psychological sciences, as number reached (31) with a rate of 15.98%. Then the Arabic language specialization, as their number reached (24) with a rate of 12.37%. The lowest percentage was represented by the specialization of physical education and specialization of education (kindergartens), as their number reached (1), at a rate of 0.55%.

Table 3. The general and specific specialization of the respondents

No.	Specialization	Number	Percentage
1	History (ancient, Islamic, modern, contemporary)	34	17.53%
2	Educational and psychological sciences (educational administration, educational psychology, measurement and evaluation, curricula and teaching methods, developmental psychology)	31	15.98%
3	Arabic language (linguistic studies, literature, language, rhetoric, and stylistics)	24	12.37%
4	Islamic sciences (Quranic studies, Tafseer, Islamic jurisprudence, hadith, theology, Islamic faith)	22	11.34%
5	Geography (natural, human, methods of teaching geography)	21	10.83%
6	Science (physics, chemistry, biology, botany, science teaching methods)	17	8.76%
7	Information and libraries (information services, information technologies, libraries)	14	7.22%
8	English (literature, linguistics)	11	5.67%
9	Kurdish Language (Methods of Teaching of the Kurdish Language)	4	2.06%
10	Medicine (surgery, dentistry, veterinary)	3	1.55%
11	Media (digital media, press, radio, and television)	3	1.55%
12	Common Law (criminal procedure, civil law)	2	1.03%
13	Agricultural engineering (horticulture and landscaping, animal production)	2	1.03%
14	Management and Economics (Management, International Economy)	2	1.03%
15	Arts (Design, Architecture)	2	1.03%
16	Physical education (physical movement)	1	0.51%
17	Education (Kindergarten)	1	0.51%
Total		194	100%

3.2 The second axis: data analysis of the answers of the research sample to the questionnaire questions

1. Do you use the internet in education? Table 3 shows the number and percentage of respondents who use the Internet in education. The number of those who use the Internet (191) represented 98.45%, which is the highest percentage. The number of those who do not use the Internet and teach in person is (3), at a rate of 1.55%.

Table 4. Number and percentage of respondents who use the Internet in education

No.	Answer	Number	Percentage
1	I use the internet in education	191	98.45%
2	I do not use the internet in education	3	1.55%
Total		194	100%

2. Identify the electronic devices and equipment you use for education: Table 5 shows the electronic devices and equipment used by students and professors in teaching. The highest number and percentage of those who use the smartphone was (184) individuals, at a rate of 97.42%, and the lowest number of those who use smart panels was (2) individuals, at a rate of 1.03%.

Table 5. Electronic devices and equipment used by the respondents for education

No.	Equipment	Number	Percentage
1	Mobile phone	184	97.42%
2	Computer	179	92.27%
3	Electronic and interactive information sources	35	18.04%
4	Digital display	26	13.40%
5	AI	24	13.37%
6	Smart Board	23	11.86%
7	Digital Pen	18	9.28%
8	HD TV	5	2.58%
9	Other equipment	3	1.55%
10	Tablets	2	1.03%

Notes: The answer to other devices and equipment, please mention them: the respondents mentioned (advanced presentations (data show), electronic classes, and specialized electronic programs).

3.3. Determine the importance of using Internet of Things technologies in education: Table 6 shows the respondents' answers about the importance of using Internet of Things technologies in education. Where it represented the highest importance (providing students with academic courses and their sources) with a number (147) and a rate of 75.77%. Of great importance, is number (35) with a rate of 18.04%. The least important (guaranteeing students' participation in various electronic and interactive educational activities) was represented by the number (81), with a rate of 41.75%. Of great importance, with a number (of 22) and a rate of 11.34%, it is not important.

Table 6. Respondents' answers about the importance of using Internet of Things technologies in education

No.	The Importance of Using IoT	Very Important		Medium Importance		Not Important	
		No.	%	No.	%	No.	%
1	Providing students with courses and their resources	147	75.77	35	18.04	12	6.19
2	Giving electronic lectures at the appropriate times	141	72.68	38	19.59	15	7.73
3	Effective presentation of educational content using modern presentation technologies	135	69.59	44	22.68	15	7.73
4	Ensuring speedy performance of assessment tests and obtaining immediate results	135	69.59	38	19.59	21	10.82
5	Effectively presenting electronic lectures	134	69.07	54	27.84	6	3.09
6	Recording electronic lectures and making them available to students	122	62.89	63	32.47	9	4.64
7	Digital simulation for all students regardless of where they are	112	57.73	63	32.47	19	9.79
8	Ensuring the participation of all students in the lectures and preparing lists for that	106	54.64	69	35.57	19	9.79
9	Ensuring the participation of students in groups and making the educational material available to them	106	54.64	72	37.11	16	8.25
10	Ensuring students' participation in various electronic and interactive educational activities	81	41.75	91	46.91	22	11.34

3.4. Determine the role of using Internet of Things technology in solving education problems: Table 7 shows the respondents' answers about the role of using Internet of Things technology in solving education problems, as the highest paragraph (giving lectures in light of crises, especially the spread of infectious diseases in light of the Coronavirus crisis) represented a significant role with several (156) and a percentage of 80.41% and represented the highest paragraph (the ability of the professors to adapt to the students and identify their levels and assign each student a special learning style). Of the paragraphs that have no role in solving problems, a number (28) and a percentage of 14.43%.

Table 7. Respondents' answers about the role of using Internet of Things technology in solving education problems

No.	The Role of Using IoT Technology in Solving Education Problems	Major Role		Medium Role		Has No Role	
		No.	%	No.	%	No.	%
1	Giving lectures in light of crises, especially the spread of infectious diseases in light of the Coronavirus crisis	156	80.41	35	18.04	3	1.55
2	Availability at the local and global level, whether with the appropriate content or choosing professors anywhere in the world	119	61.34	72	37.11	3	1.55
3	The lectures are presented interactively, recorded, and made available to students at any time, unlike traditional education which is limited to a specific time	116	59.79	63	31.96	16	8.25
4	The Internet of Things helps students access and share their content with peers and facilitate collaboration	100	51.55	78	40.21	16	8.25
5	The ability of teachers to adapt to students, recognize their levels, and assign each student a special learning style	63	32.47	103	53.09	28	14.43

4 Conclusion

The IoT means all the devices and tools that we use in our daily lives that can connect to the Internet and are managed through the application of smartphones or computers and others. It is a modern, global technology based on the Internet whose purpose is to provide an information technology infrastructure. Among the most prominent benefits of the Internet of Things and its importance, organizations can use this technology to reduce costs, and introduce products through advertising and promotion with ease. It is an effective way to overcome some problems and strengthen the relationship between the student and the teacher. Also, it saves a lot of time and data, in addition to being low in cost, and frees people from the restrictions of time and place. Among the most important characteristics of the Internet of Things: Interaction, heterogeneity, dynamic changes, intelligence, sensing, massive capacity, communication, and others. The IoT architecture consists of the device layer, the gateway and network layer, and the management service layer. Among the most important structural components of the Internet of Things architecture are identity verification, sensors, and a central server. Among the most important components of the Internet of Things: are solid materials, Internet of things software, technology, and Internet of Things protocols. Among the most prominent Internet of Things search engines are Shodar, Thingful, and Wais. Among the most important applications of the Internet of Things in education: are smart education, proof of attendance, emergency management, improving operational efficiency, increasing efficiency for students, and the Edmodo educational network. One of the

most important contributions of the Internet of Things to sustainable development is building smart cities and protecting the environment. IoT technology appeared in the year 2000 AD to improve sales management and monitoring. As a result of the rapid developments, this technology has been used in all areas of life, including education by relying on electronic devices, equipment, and software, including smartphones, handheld devices, smart boards, electronic classes, and high-definition television, etc. Internet of things technology has several characteristics, the most important of which are (environmental interaction, dynamic changes, intelligence, sensing, interconnection, huge capacity, safety, etc.). One of the advantages of using the Internet of Things technology in education is that it is an effective way to overcome some of the problems facing the learner and helps him to overcome the barriers of time and space and enables him to successfully control the learning management from a distance. The use of IoT technology in education helps students learn new things by supporting educational goals and helps them communicate with teachers using different methods. Among the applications of the Internet of Things in education (smart education, smart classes, proof of attendance, text message alerts, emergency management in educational institutions, improving operational efficiency in educational institutions, educational applications, etc.).

5 References

[1] N. A. Jasim and M. S. Farhan, "Internet of Things (IoT) application in the assessment of learning process," in *IOP Conference Series: Materials Science and Engineering*, 2021, vol. 1184, no. 1: IOP Publishing, p. 012002. https://doi.org/10.1088/1757-899X/1184/1/012002

[2] N. Jassim, A. Zkear, and B. Majeed, "Smart learning based on moodle e-learning platform and development of digital skills for university students," *International Journal of Recent Contributions from Engineering, Science IT*, vol. 10, no. 1, pp. 109–120, 2022. https://doi.org/10.3991/ijes.v10i01.28995

[3] G. El-Dahshan, "Employing internet of things in education," *International Journal of Research in Educational Sciences*, vol. 2, no. 3, pp. 49–92, 2019. https://doi.org/10.29009/ijres.2.3.1

[4] A. H. M. Alaidi and O. H. Yahya, "Using modern education technique in Wasit university," *International Journal of Interactive Mobile Technologies*, vol. 14, no. 6, pp. 82–94, 2020. https://doi.org/10.3991/ijim.v14i06.11539

[5] H. T. Salim and H. T. Hazim, "Secure Chaos of 5G wireless communication system based on IOT applications," *International Journal of Online and Biomedical Engineering(iJOE)*, vol. 18, no. 12, pp. 89–102, 2022. https://doi.org/10.3991/ijoe.v18i12.33817

[6] A. U. Echedom and I. F. Kakiri, "Prospects and challenges of internet of things application in library services," *Prospects*, 2021.

[7] K. A. M. Zeinab and S. A. A. Elmustafa, "Internet of things applications, challenges and related future technologies," *World Scientific News*, vol. 67, no. 2, pp. 126–148, 2017.

[8] D. A.-R. Al-Malah, S. I. Hamed, and H. Salim, "The interactive role using the Mozabook digital education application and its effect on enhancing the performance of e-learning," *International Journal of Emerging Technologies in Learning*, vol. 15, no. 20, pp. 21–41, 2020. https://doi.org/10.3991/ijet.v15i20.17101

[9] K. Mahidi and F. Fernan, "Internet of things: between the requirements of sustainable development and legal challenges," *Journal of Legal and Economic Studies*, vol. 4, no. 1, pp. 275–281, 2021.
[10] A. Bin Theeb, "The return of IoT applications to the educational process," *International Journal of Research in Educational Sciences*, vol. 2, no. 3, pp. 102–114, 2019.
[11] M. Siham and D. Heiba, "The contribution of the Internet of things to value creation–an analytical study," *Strategy and Development Journal*, vol. 10, no. 5, pp. 526–529, 2020.
[12] H. Abdel-Aty and A. Talaat, "The interaction between the support pattern (fixed/flexible) and the control center (internal/external) in a personal e-learning environment based on internet of things applications and its impact on developing website design and creation skills and cognitive motivation among middle school students," *Journal of the Egyptian Association for Educational Computers*, vol. 8, no. 1, pp. 187–192, 2020.
[13] I. Al-Muhammadi, A. Muhammad, and M. Abdul Razzaq, "The skills of designing learning environments based on the Internet of things for students of educational technology using the Arduino system," *Journal of the Faculty of Education, Damietta University*, no. 77, pp. 15–27, 2021.
[14] B. H. Majeed and L. F. Jawad, "Computational Thinking (CT) among university students," *International Journal of Interactive Mobile Technologies*, vol. 16, no. 10, pp. 244–252, 2022. https://doi.org/10.3991/ijim.v16i10.30043
[15] F. Zakaria, "A future vision for the role of Egyptian universities in benefiting from the recent developments of the Internet, the Internet of Things as a model," *Journal of the Future of Arab Education*, vol. 26, no. 117, pp. 54–57, 2019.
[16] B. Hasan, L. Fouad, and H. AlRikabi, "Tactical thinking and its relationship with solving mathematical problems among mathematics department students," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 9, pp. 247–262, 2021. https://doi.org/10.3991/ijet.v16i09.22203
[17] A. Faraj, "Investing in internet of things technologies to enhance information awareness mechanisms in information institutions: A planning study, the 27th conference of the Arab federation for libraries and information (Knowledge)," *Information Culture in the Arab Knowledge Society: Reality Challenges and Future Bets*, pp. 8–11, 2016.
[18] W. Youssef and R. Atef, "IoT technology IoT technology concept and educational applications," *Egyptian Association for Educational Technology*, vol. 30, no. 10, pp. 3–13, 2020.
[19] D. K. A.-R. Al-Malah and H. H. K. Jinah, "Enhancement of educational services by using the internet of things applications for talent and intelligent schools," *Periodicals of Engineering Natural Sciences*, vol. 8, no. 4, pp. 2358–2366, 2020.
[20] J. Al-Salmi, K. Ateeq, and A. Al-Hinai, "The role of the internet of things in knowledge management in information organizations," *Journal of Information and Technology Studies*, vol. 3, no. 1, pp. 1–9, 2020.
[21] D. Khalid, I. A. Aljazaery, and H. A. Mutar, "Cloud computing and its impact on online education," in *IOP Conference Series: Materials Science and Engineering*, 2021, vol. 1094, no. 1: IOP Publishing, p. 012024. https://doi.org/10.1088/1757-899X/1094/1/012024
[22] L. Fouad and B. Majeed, "The impact of teaching by using STEM approach in the development of creative thinking and mathematical achievement among the students of the fourth scientific class," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 13, 2021. https://doi.org/10.3991/ijim.v15i13.24185
[23] N. A. Hussien, S. A. A. A. Alsaidi, I. K. Ajlan, and M. F. M. Firdhous, "Smart shopping system with RFID technology based on internet of things," *International Journal of Interactive Mobile Technologies*, vol. 14, no. 4, pp. 17–29, 2020. https://doi.org/10.3991/ijim.v14i04.13511

[24] L. F. Jawad, B. H. Majeed, and H. T. ALRikabi, "The impact of CATs on mathematical thinking and logical thinking among fourth-class scientific students," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 10, pp. 194–211, 2021. https://doi.org/10.3991/ijet.v16i10.22515

[25] R. Arroyo González, E. Fernández-Lancho, and J. Montejo-Gámez, "Bringing education closer to the advantages of the internet of things: An e-learning-based course to scientific multilingual writing instruction," in *The Internet of Things for Education*: Springer, 2021, pp. 165–182. https://doi.org/10.1007/978-3-030-85720-2_10

[26] B. Majeed, "The skill of decision-making and its relationship to academic achievement among students," *International Journal of Recent Contributions from Engineering, Science IT (iJES)*, vol. 9, no. 4, pp. 77–89, 2021. https://doi.org/10.3991/ijes.v9i4.26363

[27] R. a. M. Al_airaji, I. A. Aljazaery, and A. H. M. Alaidi, "Automated cheating detection based on video surveillance in the examination classes," *International Journal of Interactive Mobile Technologies*, vol. 16, no. 8, pp. 124–137, 2022. https://doi.org/10.3991/ijim.v16i08.30157

[28] N. A. Jasim and H. T. S. ALRikabi, "Design and implementation of smart city applications based on the internet of things," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 13, pp. 4–15, 2021. https://doi.org/10.3991/ijim.v15i13.22331

[29] X. Li, C. Pak, and K. Bi, "Analysis of the development trends and innovation characteristics of internet of things technology–based on patentometrics and bibliometrics," *Technology Analysis Strategic Management*, vol. 32, no. 1, pp. 104–118, 2020. https://doi.org/10.1080/09537325.2019.1636960

[30] D. K. A.-R. Al-Malah, H. H. K. Jinah, and H. T. S. J. P. o. E. ALRikabi, "Enhancement of educational services by using the internet of things applications for talent and intelligent schools," *Periodicals of Engineering and Natural Sciences (PEN)*, vol. 8, no. 4, pp. 2358–2366, 2020.

[31] L. F. Jawad and M. K. Raheem, "The effectiveness of educational pillars based on Vygotsky's theory in achievement and information processing among first intermediate class students," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 12, pp. 246–262, 2021. https://doi.org/10.3991/ijet.v16i12.23181

[32] M. Al-Sarry and I. Faris, "A future vision of mathematics teacher preparation program at the universities," *International Education Culture Studies*, vol. 2, no. 1, pp. 1–12, 2022.

[33] H. Salim, B. Hassan, and A. Z. Abass, "The influence e-learning platforms of undergraduate education in Iraq," *International Journal of Recent Contributions from Engineering, Science & IT (iJES)*, vol. 9, no. 4, 2021. https://doi.org/10.3991/ijes.v9i4.26995

[34] M. Kassab, J. DeFranco, and P. Laplante, "A systematic literature review on internet of things in education: Benefits and challenges," *Journal of Computer Assisted Learning*, vol. 36, no. 2, pp. 115–127, 2020. https://doi.org/10.1111/jcal.12383

[35] B. Majeed, "The Conceptual Mathematical Knowledge and Analytical Thinking for the First Stage Students at Math Sciences Department, Faculty of Education for Pure Sciences, IBN Alhaithem, University of Baghdad," *International Journal of Science and Research (IJSR)*, vol. 6, no. 12, pp. 1379–1392, 2017. https://doi.org/10.21275/ART20178962

[36] Hasan B., "Procedural knowledge for the , Mathematics Departments Students, College of Education for Pure Sciences/Ibn al-Haytham, University of Baghdad," *ASEP*, vol. 85, no. 2, pp. 393–402, 2017.

[37] Y. Bao, "Analysis of the learning evaluation of distance education based on the internet of things," *World Transactions on Engineering Technology Education*, vol. 14, no. 1, pp. 168–172, 2016.

[38] M. Hasam, "Logical mathematical intelligence and its relationship to the skill of decision-making among students of colleges of education in Baghdad governorate," *Research and Islamic Studies Journal*, no. 54, pp. 75–124, 2018.

[39] B. Hasan, "The impact of reflexive learning strategy on mathematics achievement by first intermediate class students and their attitudes towards e-learning," *Turkish Journal of Computer Mathematics Education*, vol. 12, no. 7, pp. 3271–3277, 2021.
[40] H. Majeed, "The Relationship Between Conceptual Knowledge and Procedural Knowledge among Students of the Mathematics Department at the Faculty of Education for Pure Science/Ibn Al-Haitham," *International Journal of Innovation, Creativity Change (IJICC)*, vol. 12, no. 4, pp. 333–346, 2020.
[41] M. J. S. Al-Sarry, B. H. Majeed, and S. K. Kareem, "Cognitive load of university students and its relationship to their academic achievement," *Periodica Journal of Modern Philosophy, Social Sciences and Humanities*, vol. 3, pp. 65–77, 2022.
[42] M. K. R. Al-Haydary and B. H. Majeed, "Impact of ASSURE model on mathematical correlation and achievement in mathematics," *European Journal of Humanities Educational Advancements*, vol. 2, no. 11, pp. 62–68, 2021.

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A New Resource Recommendation Method for Experiential Leaching Based on the Completion Degree of Online Learning Tasks

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Abstract—Experiential Learning (ExL) is an effective way to consolidate theoretical knowledge and deepen understandings, and the recommendation of ExL resources needs to also take the effect of students' theoretical learning into consideration. However, existing studies generally ignore the stage-by-stage assessment of students' completion of online learning tasks, and the recommendation performance of existing resource recommendation models for ExL is not satisfactory enough. Therefore, the recommendation method needs to be innovated, and the interpretability of recommendation results is facing challenges. To respond to these issues, this paper studied a new resource recommendation method for ExL based on the completion degree of online learning tasks. At first, the paper gave the principle of recommending ExL resources based on the completion degree of online learning tasks, and built an online learning task completion degree prediction model. Then, this paper adopted a bi-directional GRU network model based on attention mechanism to analyze the recent online learning behavior sequence of students and attain the completion degree of students' short term learning tasks. After that, a knowledge map representing ExL resources and the correlation of knowledge attributes was drawn; by combining the completion degree of both the short-term and long-term learning tasks, the ExL resources suitable for students were recommended to them. At last, experimental results verified the effectiveness of the constructed model.

Keywords—online learning, task completion degree, Experiential Learning (ExL), learning resource recommendation

1 Introduction

With the advent of Internet and big data, the sharp increase in data volume and the continuous optimization of information collection and sharing methods have resulted in the problem of information overload, and online learning platforms have to develop learning resource recommendation systems to deal with this problem [1–6]. The learning resource recommendation systems can analyze students' learning behavior, mine the personalized learning requirements of students based on their completion degree of online learning tasks, and help them find learning resources that are suitable for their learning level and might attract their interests [7–11].

Experiential Learning (ExL) is an effective way to consolidate theoretical knowledge and deepen understandings. To assist students to enhance their hands-on ability and get good learning effect, the recommendation of ExL resources should be able to connect theory with practice and it must take the effect of students' theoretical learning into consideration [12–21]. Therefore, the recommendation method needs to be innovated, and the interpretability of recommendation results is facing challenges.

Zhang et al. [23] pointed out that as smart education is being extensively applied in higher education, now the recommendation of personalized learning resources has become an important research field of smart learning. The authors proposed a Q-LRDP-D (Learning Resource Difficulty Prediction and Dijkstra based on Q matrix) algorithm. At first, the learning resources were modeled based on the Q matrix theory, and the students' learning difficulty was predicted by the long short-term memory (LSTM) algorithm of the learning resource difficulty prediction module; then, according to the requirements of the teaching units, the knowledge points to be learnt were combined for cyclic prediction so as to form a directed path map of learning resources; at last, the shortest path algorithm was used to recommend the minimum learning resources suitable for students' learning level to complete the learning tasks. Dien et al. [24] constructed a deep matrix decomposition model which is an extension from standard matrix decomposition, and used it to recommend learning resources based on the capabilities and requirements of learners. The authors tested the model on two sets of experimental data, one dataset was a college student's learning results of recommended courses, another dataset was the learning resource data of five users; at last, the authors gave a few useful suggestions for the learners. In terms of ExL, Zhang and Guan [25] researched the assessment background, characteristics, contents, and methods of ExL and gave a few application examples. Cardona Zapata and López Ríos [26] introduced the potential of a heuristic V diagram designed as a theoretical-methodological tool that can increase the potential of data acquisition system in ExL, aiming to solve the shortage in teaching resources for experimental scenarios.

After reviewing relevant literatures, we found that field scholars in the world have conducted a lot of research on the influence of students' online learning preferences on their learning effect, but there're differences in the determination of factors affecting students' completion of online learning tasks, and few of them have given stage-by-stage assessments on students' completion degree of online learning tasks, or built resource recommendation model for ExL. To fill in this research blank, this paper aims to develop a new resource recommendation method for ExL based on the completion degree of online learning tasks. In the second chapter, this paper gave the principle of recommending ExL resources based on the completion degree of online learning tasks, and built an online learning task completion degree prediction model. In the third chapter, this paper adopted a bi-directional GRU network model based on attention mechanism to analyze the recent online learning behavior sequence of students and attain the completion degree of students' short term learning tasks, and a knowledge map representing ExL resources and the correlation of knowledge attributes was drawn. In the fourth chapter, the paper combined the completion degree of both the short-term and long-term learning tasks, and generated suitable ExL resources for students and made recommendations. At last, experimental results verified the effectiveness of the constructed model.

2 Prediction model based on completion degree of online learning tasks

Figure 1 shows the principle of recommending learning resources for ExL based on online learning. At first, the learning resource recommendation algorithm analyzes the target student's online learning behavior based on texts; then, it calculates the potential correlation between the target student and the ExL resources, searches for ExL resources that fit the student's completion degree of online learning tasks, and screens them; at last, recommendations are made for the target student.

In order to assess students' completion of online learning tasks stage by stage, this paper collected the data of students' online learning task scores, the number of teaching videos watched, the watching frequency of teaching videos, and the average watching time of each teaching video. These data can reflect the differences in the knowledge structure of students formed by their learning styles and theoretical knowledge review states before the learning of ExL resources in the online learning environment.

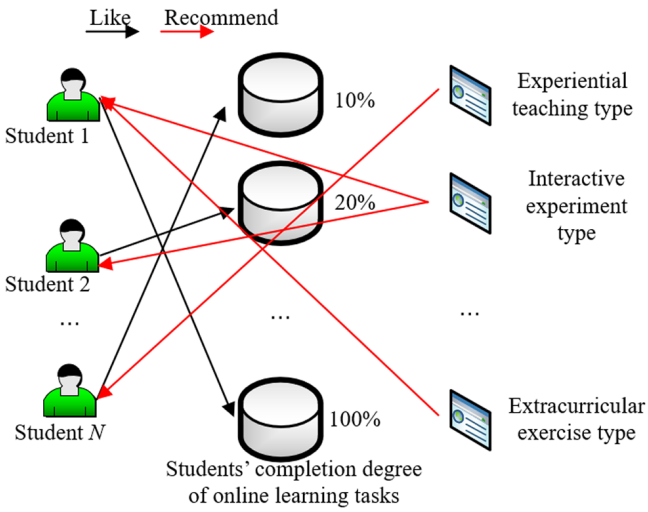

Fig. 1. Principle of recommending ExL resources based on completion degree of online learning tasks

When building the prediction model, at first, this paper assumed that the final scores of the online learning tasks reflect the comprehensive completion degree of students for the learning tasks of each theoretical learning topic, it can be considered that for students with different completion degrees of online learning tasks, their final scores might be the same. The formula below gives the full probability formula of the online learning task completion degree prediction model, which describes the probability of the completion degree of primary task constituted by the completion degrees of sub-tasks.

$$GU'_p = \sum_{i=1}^{n} GU(r_i) \cdot GU(p|r_i) \tag{1}$$

Assuming: GU represents the probability that a student has completed a certain learning task; p represents an online learning unit task; GU_p represents the probability that the student has fully grasped the learning topic corresponding to task p; r_i represents the quiz sub-task corresponding to task p; n represents the number of quizzes. When p represents the task in the class, then it can be considered that GU_p is the probability of the student getting full score in the online learning task.

At this time, the prediction model hadn't involved the collected data of the online learning behavior of students. In this paper, a 5-dimensional vector q was set, and the function g about the online learning behavior of students was equivalent to $GU(p|r_i)$, which satisfies $GU(p|r_i)=g(U)$ and its value range is [0,1]; let $U=<U_s,U_m,U_g,U_p,K_o>$, then the expression of function g is:

$$g(U) = sigmoid(U \cdot q') \tag{2}$$

Combining the above two formulas, we can get the formula for calculating the expected completion degree of learning tasks:

$$GU'_p = \sum_{i=1}^{n} GU(r_i) \cdot sig(U \cdot q'_i) \tag{3}$$

Assuming: q'_i represents the weight coefficient of learning task topic i; $Q = \left[q'_1, q'_2, ...q'_n\right]$ represents the weight coefficients of all learning task topics. Then, Q was trained with the minimization of the variance of the difference between GU_p and $P'_e GU'_p$ as the objective, and the formula below gives the expression of the optimization training process:

$$\min \left\| GU_p - GU'_p \right\|^2 \tag{4}$$

By combining Formula 1, Formula 2, and the above Formula, we have:

$$\min \left\| GU_p - GU \cdot G \right\|^2 \tag{5}$$

Assuming: $GU=[GU(r_1), GU(r_2),...GU(r_n)]$, $G = \left[sig(U \cdot q'_1), sig(U \cdot q'_2)...sig(U \cdot q'_n)\right]^{-1}$, the constraint of the optimization training process is:

$$\sum_{i=1}^{n} sig(U \cdot q'_i) = 1 \tag{6}$$

As important independent variables for predicting the completion degree of learning tasks, the tags of the data collected from four aspects are multidimensional. To increase the accuracy of prediction results, after the collected data were pre-processed, this paper adopted the multivariate linear regression to fit the prediction model. Assuming: S represents the total number of visits of the videos of all sub-tasks under a certain learning

task topic; M represents the total number of visits of the videos of all sub-tasks under the learning task topic within a fixed time period; U represents the average watching time of the videos of all sub-tasks under the learning task topic within the fixed time period; E represents the average score of all sub-tasks under the learning task topic, then the expression of the regression model is:

$$GU_p = 59.447 - 0.521 * S + 0.635 * M + 3.215 * U - 6.074 * P \tag{7}$$

3 Knowledge map of ExL resources

To capture students' completion degree of recent online learning tasks, this paper built a bi-directional GRU network model based on attention mechanism to analyze the recent online learning behavior sequence of students and attain the completion degree of students' short term learning tasks. The completion degrees of both the short-term and long-term learning tasks were combined to recommend suitable ExL resources to students. To enrich the correlation between the ExL resources, this paper plotted a knowledge map to show the ExL resources and the correlation between the attributes of the knowledge in the ExL resources, and attained the knowledge vector of ExL resources that contain the information of the knowledge attributes of ExL resources, at last, based on the attained vector, the recommendations were made.

Assuming: $V=\{v_1,v_2,...\}$ represents the set of students; $U=\{u_1,u_2,...\}$ represents the set of ExL resources, the formula below gives the definition of $B=\{b_{vu}|v\in V,u\in U\}$, the interaction matrix of ExL resources based on students' implicit feedback:

$$b_{vu} = \begin{cases} 1, if \ \text{int} ER \ (v,u) \ is \ OB \\ 0, otherwise \end{cases} \tag{8}$$

If the value of b_{vu} is 1, then it indicates that there is a possibility of clicking, browsing, watching, or other types of interactions between student v and ExL resource u. Assuming: triplet (f,t,r) represents the entity-relation tuple in knowledge map H; σ and T are the set of entities and the set of relations in H. In this paper, the purpose of establishing the ExL resource recommendation model is to predict the possibility of potential interactions between student v and the unknown ExL resource u. Assuming: b'_{vu} represents the probability that student v would visit ExL resource u, Ψ represents the relevant function parameter, then the prediction function can be represented by $b'_{vu} = G(v,u;\Psi)$.

The completion degree of online learning tasks is often affected by short-term factors. To improve the recommendation performance, the ExL resource recommendation model constructed in this paper not only can fully consider the completion degree of short-term online learning tasks, but also can extract the correlations between students, ExL resources, and knowledge attributes in the knowledge map through the *RippleNet* algorithm, then it could apply the constructed knowledge map and the extracted correlations to the ExL resource recommendation tasks.

Assuming: B represents the interaction matrix; the formula below defines the set of first l ExL resources recommended by the *RippleNet* algorithm to student v:

$$\sigma_v^l = \left\{ r \mid (f,t,r) \in H \ and \ f \in \sigma_v^{l-1} \right\}, l = 1,2,...,F \tag{9}$$

Student v's *TupleSet* is defined as:

$$\xi_v^l = \left\{ (f,t,r) \mid (f,t,r) \in H \ and \ f \in \sigma_v^{l-1} \right\}, l = 1,2,...,F \tag{10}$$

Student v's *RippleSet* is defined as:

$$O_v = \left\{ (v,l,p) \mid (f,t,r) \in \xi_v^l \ and \ p \in \{f,r\} \right\}, l = 1,2,...,F \tag{11}$$

Assuming: c represents the dimension of eigenvectors u and f corresponding to the ExL resources and the knowledge attributes; for resource u and the knowledge attribute f corresponding to u in the knowledge map, at first, a cross matrix $D \in R^{c \times c}$ was built as:

$$D = uf^T = \begin{bmatrix} u^{(1)} f^{(1)} & \cdots & u^{(1)} f^{(c)} \\ \cdots & & \cdots \\ u^{(c)} f^{(1)} & \cdots & u^{(c)} f^{(c)} \end{bmatrix} \tag{12}$$

Figure 2 gives a diagram showing the cross-compressed units. Assuming: $q \in R^c$ represents the weight of the cross-compressed unit; $\tau \in R^c$ represents the bias parameter, then the formula below gives the expression of the output of the cross-compressed unit:

$$\begin{aligned} u_{out} &= Dq^{UU} + D^T q^{FU} + \tau^U = uf^T q^{UU} + fu^T q^{FU} + \tau^U \\ f_{out} &= Dq^{UF} + D^T q^{FF} + \tau^F = uf^T q^{UF} + fu^T q^{FF} + \tau^F \end{aligned} \tag{13}$$

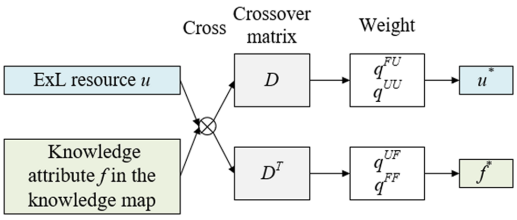

Fig. 2. Diagram of cross-compressed unit

By adjusting parameters q and τ, the two steps of the semantic matching of knowledge attributes in the knowledge map and the recommending of ExL resources could be completed at the same time. At first, this paper processed (f), (t), and (r) via the deep semantic matching mechanism, then f and t were spliced, and the dimension was reduced to c to attain the predicted r, denoted as $\dot{r}$; assuming DD_u represents

the cross-compressed unit, *DGJ* represents the multilayer perceptron and it satisfies $DGJ(a)=\varepsilon(Qa+\tau)$, then there are:

$$f = DD_u(u, f)[f] \tag{14}$$

$$r = DGJ(r) \tag{15}$$

$$\dot{r} = DGJ\left(DGJ\left(\begin{bmatrix} f \\ t \end{bmatrix}\right)\right) \tag{16}$$

Assuming: ε represents the nonlinear activation function the *sigmoid* function; at last, the similarity function g_{lh} was used to evaluate the prediction results:

$$SIM(r, \dot{r}) = g_{lh}(r, \dot{r}) = -\varepsilon(r^T \dot{r}) \tag{17}$$

4 ExL resource recommendation model

In the ExL resource recommendation module, the students' completion degree of short-term learning tasks in the recent online learning behavior sequence was learnt based on the cyclic neural network, the attention mechanism was introduced into the bi-directional cyclic neural network to optimize the ability of the network model to learn the completion degree of short-term learning tasks, and the structure of the model is shown in Figure 3.

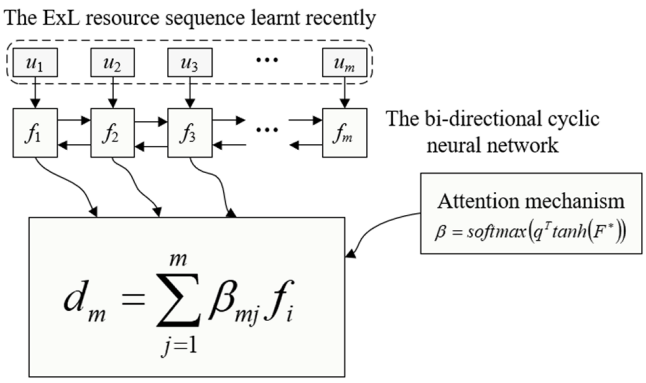

Fig. 3. Bi-directional cyclic neural network with attention mechanism introduced

Inputs of the ExL resource recommendation model were the first *m* learnt ExL resource sequences in the recent online learning behavior sequences, denoted as u^m_{LR}; assuming: a_r represents the input vector of the *r*-th time step; f_{r-1} represents the information of the previous time step *r*–1; *Z* and *V* represent parameter matrixes; then when the time step is *r*, the calculation formulas of the update door and reset door are:

$$c_r = \varepsilon(Q^c a_r + V^c f_{r-1}) \tag{18}$$

$$s_r = \varepsilon(Q^s a_r + V^s f_{r-1}) \tag{19}$$

Assuming: ⊗ represents the Hadamard product; f_{r-1} represents the hidden layer of the previous moment; then the calculation formulas of $\dot{f}_r$ (the hidden layout output of the cyclic neural network at the current moment) and f_r (the final output of the hidden layer) are:

$$\dot{f}_r = tanh(Q^f a_r + V^f (f_{r-1} \otimes a_r)) \tag{20}$$

$$f_r = (1 - c_r) \otimes f_{r-1} + c_r \otimes \dot{f}_r \tag{21}$$

For the final output f_r, the amount of information that needs to be forgotten by f_{r-1}, and the amount of $\dot{f}_r$ that needs to be added were both controlled by c_r. Assuming: F^* represents the hidden layer output of the cyclic neural network; q^T represents the parameter matrix; s represents the cyclic neural network with weight taken into consideration; then the formula below gives the expression of the introduced attention mechanism:

$$\beta = softmax(q^T tanh(F^*)) \tag{22}$$

$$s = F^* \beta^T \tag{23}$$

After that, through the multilayer perceptron, the completion degree of short-term learning tasks with weight taken into consideration was attained, and the process of attaining the completion degree could be written in a simple form as:

$$FR = DGJ(u_{LR}^m) \tag{24}$$

Because the inputs of the ExL resource recommendation model constructed in this paper were eigenvectors v and u that describe the student and the ExL resource and the sequence u^m_{LR} of ExL resources that recently learnt by the student, if the eigenvector of student v is known, then the eigenvector of student v^* after subjected to cross-compression and processed by the multilayer perceptron is:

$$v_{dd} = DD_v(v, f)[v] \tag{25}$$

$$v^* = DGJ(DGJ(\ldots DGJ(v_{dd}))) \tag{26}$$

Similarly, the processed u^* could be attained through the following steps:

$$u_{dd} = DD_u(u, f)[u] \tag{27}$$

$$u^* = DGJ(DGJ(\ldots DGJ(u_{dd}))) \tag{28}$$

Assuming: μ_1 represents the weight of the completion degree of short-term learning tasks; $FR(u^m{}_{LR})$ represents the student's completion degree of short-term learning tasks, then the following formula gives the comprehensive recommendation of ExL resources:

$$\dot{b}_{vu} = (1-\mu_1)\cdot v^* u^{*T} + \mu_1 \cdot FR(u_{LR}{}^m)u^{*T} \tag{29}$$

Assuming: ψ represents the cross-entropy loss function; WQ_{TO} represents the loss value of the ExL resource recommendation model; WQ_{LHv} and WQ_{LHu} represent the loss values of the fitting degree of the "student – relation – ExL resource knowledge attribute" triple and the "ExL resource – relation – ExL resource knowledge attribute" triple; $\|Q\|_2{}^2$ represents the regularization term; μ_2 represents the coefficient of the regularization term, then the loss function of the constructed recommended model is:

$$\begin{aligned} WQ &= WQ_{TO} + WQ_{TO_v} + WQ_{LH_u} \\ &= \sum_{v\in V, u\in U} \psi(\hat{b}_{vu}, b_{vu}) + \sum_{(f,t,r)\in H} SI_v(r,\hat{r}) + \sum_{(f,t,r)\in H} SI_u(r,\hat{r}) + \mu_2 \|Q\|_2^2 \end{aligned} \tag{30}$$

5 Experimental results and analysis

Figure 4 shows the fitting results of four types of data: the score of online learning tasks, the number of watched teaching videos, the watching frequency of teaching videos, and the average watching time of teaching videos. The results showed that the effect of the model designed in this paper is significant. Next, comparative experiment was designed to compare the performance of the logistic regression model and the model proposed in this paper in predicting the completion degree of online learning tasks. Table 1 lists the prediction accuracy of different models. The fitting degree and prediction accuracy of the proposed model are both higher, indicating that it is feasible to predict the students' completion of online learning tasks based on the four types of data mentioned above. This is because after a student has finished all online learning tasks, the prediction of his/her completion degree of online learning tasks depends on the differentiated online learning behavior of the student. That is to say, the summative assessment and prediction of the completion degree of online learning tasks wouldn't affect the learning process of this student.

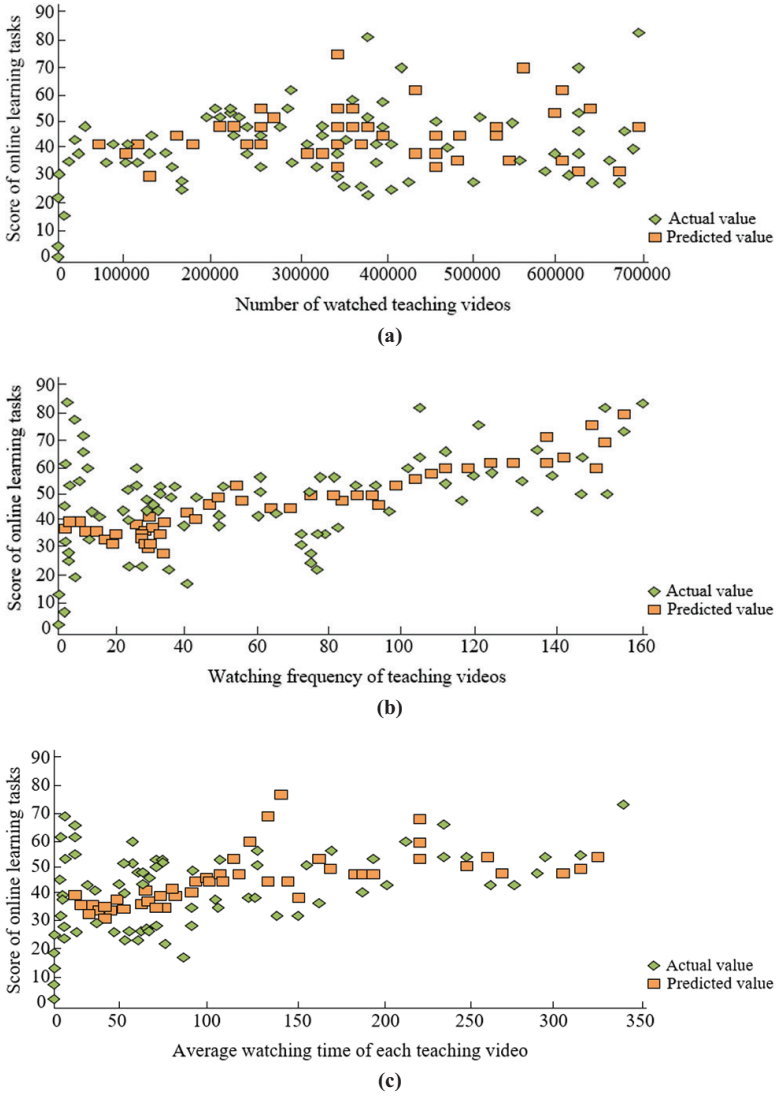

Fig. 4. Fitting effect of each type of collected data

Table 1. Prediction accuracy of different models

	Training Accuracy		**Prediction Accuracy**	
	Avg	***s.d.***	***Avg***	***s.d.***
The proposed model	0.528	0.069	0.536	0.058
Logistic regression model	0.41	0.47	0.43	0.041

Table 2. Model prediction accuracy for different learning topics

Learning Topic	Model Accuracy	
	Logistic Regression Model	The Proposed Model
*Topic*1	0.48	0.56
*Topic*2	0.49	0.59
*Topic*3	0.43	0.57
*Topic*4	0.47	0.59
*Topic*5	0.41	0.57
*Topic*6	0.49	0.63

Table 3. Experimental results of different models in recommending ExL resources

Model	Dataset 1		Dataset 2	
	AUC	*ACC*	*AUC*	*ACC*
SVD++	0.8152	0.8032	0.625	0.7152
CNN+K-Means	0.8695	0.8159	0.6392	0.7485
CNN+FP Tree	0.8325	0.8362	0.6147	0.7362
GBDT	0.8471	0.8171	0.6853	0.7481
LDA	0.8269	0.8629	0.6295	0.7596
The proposed model	0.8326	0.8361	0.6847	0.7158

Table 2 shows the model prediction accuracy for different learning topics. Based on the 4 types of data collected after the student finished the learning tasks of Topic 3, the proposed model attained a prediction rate close to 60%, while the prediction rate of the logistic regression model was lower than 50%; when the student began the learning tasks of Topic 4, the prediction rate of the completion degree of the proposed model far exceeded that of the logistic regression model, in other words, regardless of the collected data is all or part of the learning behavior data, the proposed model can attain better prediction effect of the completion degree of online learning tasks, and this makes it possible for the ExL resource recommendation system to predict students' basic level of theoretical learning in advance and provide corresponding intervention measures.

Table 3 gives the experimental results of different models in recommending ExL resources. Specifically, the results include the recommendation AUC and accuracy of different models attained in the same experimental environment on the training set. These models are: *SVD++* (reference algorithm 1), *CNN+K-Means* (reference algorithm 2), *CNN+FP Tree* (reference algorithm 3), *GBDT* (reference algorithm 4), *LDA* (reference algorithm 5), and the proposed algorithm. According to the table, compared with other recommendation algorithms, the proposed model attained the best results in terms of both performance indicators. On dataset 1 (for science and engineering students), compared with other models, the proposed model showed a 1.75% improvement in terms of AUC, and a 1.18% improvement in terms of accuracy. On dataset 2 (for liberal arts students), compared with other models, the proposed model obtained a 1.92% improvement in AUC and a 1.31% improvement in accuracy, indicating that the introduction

of knowledge map can improve the recommendation performance of the ExL resource recommendation model, and this has proved the superiority of the proposed model.

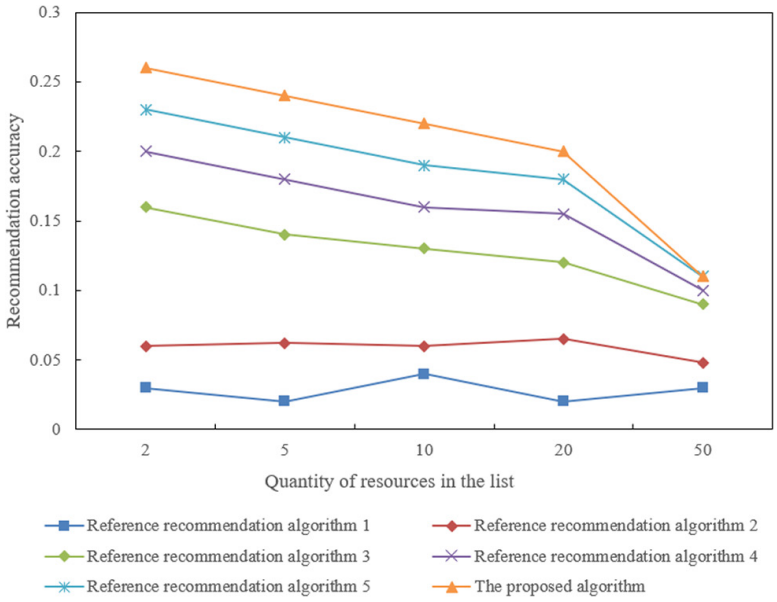

Fig. 5. Accuracy of different models in recommending ExL resources

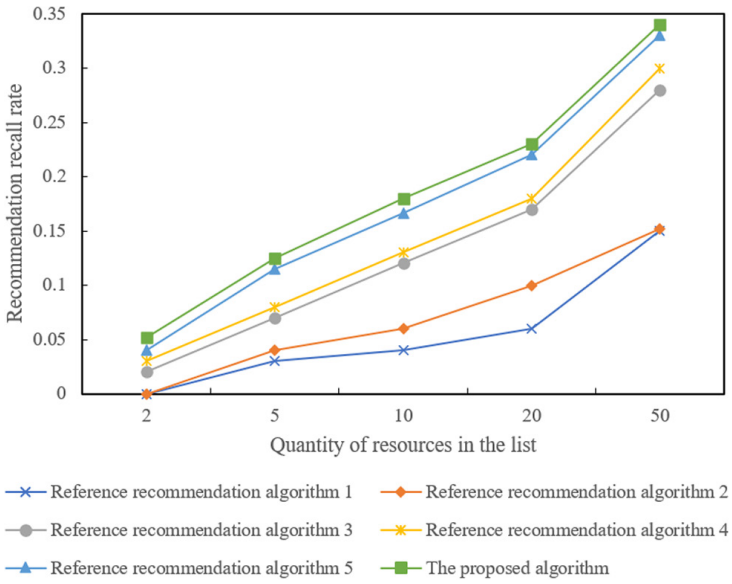

Fig. 6. Recall rate of different models in recommending ExL resources

After experiment, the accuracy and recall rate of different models in recommending ExL resources are shown in Figure 6. As can be seen from the figure, compared with other recommendation models, the proposed model showed great improvements in both indicators, wherein when the list resource quantity is 10, the improvement in accuracy of the proposed model is 10.5% compared with other models, and the improvement in recall rate is 7.8%, which has further proved the superiority of proposed model in recommending ExL resources.

6 Conclusion

This paper studied a ExL resource recommendation method based on the completion degree of online learning tasks. In the beginning, this paper gave the principle of recommending ExL resources based on the completion degree of online learning tasks, and built an online learning task completion degree prediction model. Then, the paper adopted a bi-directional GRU network model based on attention mechanism to analyze the recent online learning behavior sequence of students and attained the completion degree of students' short term learning tasks, and a knowledge map representing ExL resources and the correlation of knowledge attributes was drawn. After that, this paper combined the completion degrees of both the short-term and long-term learning tasks, and generated suitable ExL resources for students and made recommendations. In the experimental part, the fitting results of four types of data (including the score of online learning tasks, the number of watched teaching videos, the watching frequency of teaching videos, and the average watching time of teaching videos) were given, which verified that the effect of the model designed in this paper is significant. Then, the results of the accuracy of different models verified that the fitting degree and prediction accuracy of the proposed model are both higher; and the results of the model prediction accuracy for different learning topics verified that regardless of the collected data is all or part of the learning behavior data, the proposed model can attain better prediction effect of the completion degree of online learning tasks. Next, the experimental results, accuracy, and recall rate of different models in recommending ExL resources were given, which verified that the introduction of knowledge map can improve the recommendation performance of the ExL resource recommendation model, and this had also proved the superiority of the proposed model.

7 References

[1] Liu, Z.Y., Dong, L.Y., Wu, C.L. (2020). Research on personalized recommendations for students' learning paths based on big data. International Journal of Emerging Technologies in Learning, 15(8): 40–56. https://doi.org/10.3991/ijet.v15i08.12245

[2] Benjelloun, T.Y., Abdelladim, H., Nour-Eddine. E.F., Samir, B. (2020). Intelligent chatbot-LDA recommender system. International Journal of Emerging Technologies in Learning, 15(20): 4–20. https://doi.org/10.3991/ijet.v15i20.15657

[3] Mikić, V., Ilić, M., Kopanja, L., Vesin, B. (2022). Personalisation methods in e-learning-A literature review. Computer Applications in Engineering Education, 30(6): 1931–1958. https://doi.org/10.1002/cae.22566

[4] Rahmania, A., Jesslyn, K., Gui, A., Sari, S.A. (2022). Understanding higher education students continuance intention towards e-learning. In 2022 2nd International Conference on Information Technology and Education (ICIT&E), pp. 196–200. https://doi.org/10.1109/ICITE54466.2022.9759858

[5] Sergeyeva, T., Festeu, D., Bronin, S., Turlakova, N. (2021). Student-training environment interaction: Soft skills development within e-learning. In IT & I, 290–298.

[6] Alamsyah, D.P., Hikmawati, N.K. (2022). Model of expected benefit, e-learning curriculum, and education partners on e-learning. In 2022 International Conference on Information Management and Technology (ICIMTech), pp. 318–322. https://doi.org/10.1109/ICIMTech55957.2022.9915129

[7] Hao, C., Yang, T. (2022). Deep collaborative online learning resource recommendation based on attention mechanism. Scientific Programming, 2022: Article ID: 3199134. https://doi.org/10.1155/2022/3199134

[8] Ming, L. (2022). A deep learning-based framework for human resource recommendation. Wireless Communications and Mobile Computing, 2022: Article ID: 2377143. https://doi.org/10.1155/2022/2377143

[9] Liu, X. (2022). Personalised resource recommendation method for collaborative tagging system based on machine learning. International Journal of Industrial and Systems Engineering, 42(1): 1–19. https://doi.org/10.1504/IJISE.2022.126023

[10] Ahmed, S.T., Kumar, V.V., Singh, K.K., Singh, A., Muthukumaran, V., Gupta, D. (2022). 6G enabled federated learning for secure IoMT resource recommendation and propagation analysis. Computers and Electrical Engineering, 102: 108210. https://doi.org/10.1016/j.compeleceng.2022.108210

[11] Zhou, F. (2022). Research on teaching resource recommendation algorithm based on deep learning and cognitive diagnosis. Journal of Healthcare Engineering, 2022: Article ID: 5776341. https://doi.org/10.1155/2022/5776341

[12] El-Mahdy, D., Alaa, A. (2022). An experimental study of a curved brick wall using robot assembly as a teaching tool in architectural curriculum. In 2022 International Conference on Electrical, Computer and Energy Technologies (ICECET), pp. 1–6. https://doi.org/10.1109/ICECET55527.2022.9872791

[13] Huang, Z.B. (2021). Research on experimental teaching information collection method of visual communication specialty in hybrid universities under intelligent terminal. In International Conference on Advanced Hybrid Information Processing, pp. 601–614. https://doi.org/10.1007/978-3-030-94551-0_47

[14] Wei, X., Zhang, M. (2022). Experimental research and analysis of immersive virtual reality technology on children's language teaching. In 2022 International Symposium on Educational Technology (ISET), pp. 186–188. https://doi.org/10.1109/ISET55194.2022.00047

[15] Wei, S., Liu, Y., Wang, J. (2022). Experimental teaching reform of angle measuring method in digital signal processing course. In 2022 Asia Conference on Algorithms, Computing and Machine Learning (CACML), pp. 379–384. https://doi.org/10.1109/CACML55074.2022.00070

[16] Tao, J., Xia, Q., Liu, Q., She, X. (2022). Design and research of a virtual computer network experimental teaching system. In 2022 11th International Conference on Educational and Information Technology (ICEIT), pp. 16–20. https://doi.org/10.1109/ICEIT54416.2022.9690752

[17] Zhang, X., Zhou, F., Yan, Y. (2022). Multi-collaborative C++ language experimental teaching reformation based on PTA. In Proceedings of the 2022 6th International Conference on E-Education, E-Business and E-Technology, pp. 15–21. https://doi.org/10.1145/3549843.3549846

[18] O'Connell, B. (2022). Work in progress: Teaching MATLAB through authentic data collection and analysis experiences using self-contained, guided experimental setups with a range of disciplinary themes. In 2022 ASEE Annual Conference & Exposition.
[19] Xu, W., Wu, C., Lu, J. (2021). Exploration of experimental teaching reforms on c programming design course. In 2021 International symposium on advances in informatics, Electronics and Education (ISAIEE), pp. 330–333. https://doi.org/10.1109/ISAIEE55071.2021.00086
[20] Deng, X., Lei, J., Chen, M. (2021). Application of VR in the Experimental Teaching of Animation Art. Mobile Information Systems, 2021: Article ID: 4642850. https://doi.org/10.1155/2021/4642850
[21] Song, B., Sun, Y., Guo, J., Zhao, D., Tan, J. (2021). Application of case teaching method and Microteaching Method in experimental teaching based on wechat platform. In Proceedings of the 2021 International Conference on Bioinformatics and Intelligent Computing, pp. 407–411. https://doi.org/10.1145/3448748.3448988
[22] Wang, X. (2021). Construction of intelligent experimental teaching platform based on intelligent control algorithm. In 2021 International Symposium on Advances in Informatics, Electronics and Education (ISAIEE), pp. 228–231. https://doi.org/10.1109/ISAIEE55071.2021.00063
[23] Zhang, L., Zeng, X., Lv, P. (2022). Higher education-oriented recommendation algorithm for personalized learning resource. International Journal of Emerging Technologies in Learning, 17(16): 4–20. https://doi.org/10.3991/ijet.v17i16.33179
[24] Dien, T.T., Thanh-Hai, N., Thai-Nghe, N. (2022). An approach for learning resource recommendation using deep matrix factorization. Journal of Information and Telecommunication, 6(4): 381–398. https://doi.org/10.1080/24751839.2022.2058250
[25] Zhang, F., Guan, S. (2022). Evaluating the effectiveness of teaching experimental design in universities in the context of information technology. Scientific Programming, 2022: Article ID: 9087653. https://doi.org/10.1155/2022/9087653
[26] Cardona Zapata, M.E., López Ríos, S. (2022). Methodological elements for the implementation of data acquisition systems as support for experimental activity in the physics teaching. Technology, Knowledge and Learning, 27(3): 879–890. https://doi.org/10.1007/s10758-021-09517-2

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The Effect of a Proposed Strategy according to the Design Thinking Model in Mathematics Achievement and Personal Intelligence among Students of Sixth-Class Scientific

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Abstract—Researcher adopted the experimental research method with two groups (experimental; control) with a posttest; to know the impact of a proposed strategy according to the design thinking model on the achievement of mathematics and personal intelligence among students sixth-class scientific. The null hypotheses were made "there is no statistically significant difference at the significance level (0.05) between the mean scores of students sixth-class scientific (biology) who learned the mathematics subject assigned to them according to proposed strategy (the experimental group) with students who learned the same material by usual way (control group) in test of achievement". Community of research represent students sixth-class scientific (biology) from the General Directorate of Education of Karkh First. Research sample was selected (60) students, and the sample was divided into two groups (experimental) and (control). The equivalence of both groups was made in (previous achievement in "Mathematics", "level of intelligence", "chronological age"). For collecting data to the experiment, an achievement test was built in of (10) test paragraphs of essay type, plus a scale to measure personal intelligence with five test paragraphs. Analyzes were conducted the appropriate statistic, and the psychometric properties of the test were confirmed. Results indicated that students of the experimental group who studied according to the proposed strategy were superior to the students of control group who studied by usual method.

Keywords—proposed strategy, design thinking model, mathematics, personal intelligence, students sixth-class scientific

1 Introduction

Despite the continuous calls for the adoption of modern strategies in teaching to make new generations able to keep pace with the rapid developments of the era and face new challenges, we still notice a decrease in the level of achievement among students and to some extent students still have aversion to mathematics as it is dry, difficult, and incomprehensible, and despite Continuous emphasis on making the student's

role active and active, and avoiding memorization and indoctrination, but in fact, the student was not focused on the personal aspect [1]. What are his capabilities? and his feelings about the study? What do you accept to study mathematics? Is he clear and frank with himself to identify his weaknesses and strengths? Rather, these matters were implicitly addressed with the modern trends calling for renewal and attention to teaching thinking without focusing on the internal and external personality of the student. Design thinking is one of the modern models that have proven its efficiency in the field of business and engineering [2]. Therefore the problem of the current research can be summarized by answering the following question: Does the proposed strategy according to the design thinking model affect the achievement of mathematics and personal intelligence among students sixth – class sciences biological? The importance of the research, the theoretical aspect is determined by the fact that design thinking model is one of the most recent models that have been used recently in education. This model develops students' creative and imaginative abilities without restrictions or limits. Develops design capabilities to create new products. Employing scientific knowledge with practical practices helps to find practical and creative solutions to solve problems. The Design Thinking model helps students think outside the box. Interpersonal intelligence is one of the important intelligences that students should be trained on. Students' possession of personal intelligence increases the motivation to stand out and excel. Personal intelligence helps to increase self-confidence and thus confidence in personal abilities to face all challenges.

As for the practical side, to know if there is an effect of the proposed strategy according to the design thinking model and the achievement of students. Providing a measure of personal intelligence for students of the sixth scientific class that can be used in the educational field or by other researchers. Directing the attention of mathematics teachers to adopting new and modern models in teaching that focus on thinking and analysis in order to design solutions. Draw attention to the importance of students' personal intelligence and its role in increasing self-confidence. The research is limited on students sixth class science (biological) in General Directorate of Education/Karkh First in Baghdad Governorate. Chapter one (complex numbers) from the content of the mathematics book scheduled for them; edition 1 for the year 2021 and composed by a committee in the Ministry of Education. The 1st semester/year (2021–2022). Finally, the problem of current research can be summarized by answering the following question:

Does the proposed strategy according to the design thinking model affect in the achievement of mathematics and the personal intelligence of students sixth-class science?

2 Theoretical background

2.1 Design thinking

Educators and teachers have been so involved in design thinking that it has been used in more than sixty USA Universities and Colleges, in the form of lessons, courses,

workshops, as well as within degree programs, and to promote the development of 21st century skills for the K+16 class, with support from "IDEO" and "Hasso Blattner" Institute for Design [3]. So concept of design thinking within academic design dialogue has been under discussion for more than thirty years, and it's recent adoption as a method of innovation and creativity have led to its popularity across disciplines [4, 5]. Is a way of thinking that uses the designer's methods and feelings to analyze problems and find appropriate solutions to them, by finding tangible creative products [4, 6]. Also it is an action plan for sixth-class students (the experimental group) to study based on five stages (identifying the problem, then collecting information, proposing a method for solving, implementing the chosen solution, and then providing feedback) [7]. As mentioned, design thinking means different things to different societies and has two sides; descriptive models of the design process, based on observational research of real-life or laboratory design activities by individuals or teams. It is a method to be practiced in industries that strive to provide innovation products or services [8, 9]. According to [10, 11], the term Design Thinking has roots across disciplines, and is not exclusively associated with engineering, architecture, and related design disciplines in the early literature that focused on Design, and thus Promoting civic literacy, tenderness, adventure, and cultural awareness. It has been noted by [12, 13] change from discussing, studying "design thinking" as cognitive processes which designers use, to a specific way in which non-designers use design methods—a shift "from design as a science to design as a mindset". Thinking, because its core lies in placing participants in contexts that make them think, act like an expert designer. Design thinking mindset in education; people who want to innovate and create better experiences, products and services for their users or customers may benefit from applying certain situations that can enhance their thinking and creativity, so the design thinking mindset can focus on modifying, changing, or enhancing the mindsets of students, or even teachers in building the concept of complex thinking in In the classroom, in the context of teaching and learning. The design thinking mindset (DT Mindset) based on cognitive psychology that provides guidance for achieving learning goals through teaching activities and encourages a culture of thinking in education. The teaching process requires students to develop creativity and innovation through computing skills and build a set of Skills that balance the expert workers of the future [14–16]. Goal of Design Thinking goes beyond immediate boundaries of a problem to ensure that the right questions are addressed. Process predicts steps allow participants to analyze, synthesise, divergent, and generate insights from different domains by prototyping and telling stories. In the process of "Design Thinking" teachers encourage learners seeing limitations as inspiration [17–20]. The researcher believes that the goal of introducing design thinking to education is to make students think with the mentality of a designer in order to solve complex problems that they encounter in the classroom or in daily life, which we aspire to be creative solutions, as well as early detection of talented designers to prepare them for the labor market, and this is what all major countries seek to continue the wheel of progress Keeping abreast of developments in all fields [21, 22]. Design thinking models; there are a number of models put forward by thinkers and educators, including the model which consists of three linear sequential stages (understanding, exploration, and application). A model

it consists of six stages between which there is interaction, namely (understanding, observation, viewpoints, visualization, model building, and testing); it can be applied as a teaching method [23, 24]. A model which consists of seven stages (brief definition, research background, ideas solutions, first model solution, determine the rationale, implement delivery, learning feedback) which is a linear model. The model consists of five stages (discovery, interpretation, visualization, experimentation, and observation). Finally, a model was presented at Stanford University in 2016 and it consisted of five interactive stages (empathy, identification, perception, model building, and testing) [25–29]. Researcher thinks that these models, no matter how many and varied their stages, whether they are linear or circular, the main goal of them is to train students on the process of identifying the problem, how to collect information, and how to build a model for the solution in which we are marked by a creative solution. Based on these models, the researcher suggested an educational strategy that consists of five stages they are (Defining the problem: at this stage, the problem and the goal to be reached are identified). (Information collection: Information is collected about the problem in all its details and searches for similar problems that were previously solved). (Presenting ideas and discussing proposed solutions: The process of developing ideas and putting forward solutions that the designer deems appropriate to solve the problem begins). (Implementation: At this stage, the implementation process for the chosen solution begins). (Feedback: At this stage, implementation is followed up to ensure the correctness of the solution steps, with the possibility of modification or development in a way that enables us to reach creative ways in the solution) [30, 31].

2.2 Intelligence

Intelligence is a hypothetical concept, and that is why scholars differed about defining specific definitions of it, and because of this difference and controversy, it has received extensive and extensive study. Rather, it is considered one of the abilities that was most focused on in the last century because it examines the individual differences between individuals, and despite the discussion of this concept by psychologists, education, sociology, and heredity, they did not reach a clear and agreed upon definition, and this difference It led to a difference in the way it was studied and measured. There are many trends that have been adopted in the study of intelligence, including the philosophical concept, the biological and physiological concept, and the social concept. This difference may be due to the fact that the nature of intelligence is not materially sensible [32]. Howard Gardner sees according to his theory of multiple intelligences that every human possesses all kinds of intelligences, but the difference between humans by the percentage or level of each intelligence depending on the environmental and living conditions and the genetic genes of individuals. According to the intelligence they possess, Gardner considers that all traditional theories of intelligence do not adequately estimate human intelligence due to the weakness of their tests that require the individual to solve the problems presented in verbal or verbal formulas only, and they are suitable for school performance. He also sees that relying on paper

and pen in measuring performance Intelligent for life tasks, and considers success in life requires various intelligences, and believes that our best contributions are to know the intelligences and talents that children possess in order to focus on them [33, 34]. Personal intelligence; Gardner was not the first to talk about interpersonal intelligence. But rather; Hunt preceded him in (1928) and followed him by Walker & Foley [31], then Gardner addressed it in (1983). The follower of educational and psychological literature finds that personal intelligence has roots in educational psychology theories such as the theory of ability on Thorndike's Social Adaptation and Guilford's Mental Formation Theory [35]. Interpersonal intelligence is a central institution for other's intelligences because it depends on internal pivotal processes that enable individuals to distinguish between their feelings and thus can build a mental model for themselves. Introspection of his thoughts and emotions, and the individual becomes aware of his inner mood and self-esteem, and this helps him in arranging his lifestyle and planning his future. Those with this intelligence tend to reflect on their problems and capabilities. This intelligence is considered a certain good for those who possess it to persevere and face obstacles and frustrations because they are able to determine what they can do and what they cannot do [36]. Characteristics of personal intelligence: It focuses on the emotional aspect of the response, as it is a basis for understanding the emotional life of the human being. It is a mental process that appears through the individual's understanding of himself and the formation of an effective model for it and relying on this model in organizing his life and behavior. The lowest level is the individual's ability to distinguish his inner feelings in terms of pain and pleasure, those in the light of which the individual's personal characteristics such as introversion or extroversion are determined, while the highest level is the individual's ability to discover and organize his feelings. Individuals who possess this intelligence are able to understand their emotions and direct their behaviors, and tend to be contemplative and private. Personal intelligence is linked to self-reflection through contemplation and awareness of metacognition and is linked to focus and individual evaluation of his ideas [23, 37]. Researcher believes that personal intelligence shows the individual's ability to understand himself, determine his goals, this helps him in meeting his needs and helps him adapt to the reality in which he lives. Training students on this type of intelligence helps them understand themselves and determine their capabilities and helps them identify their weaknesses and thus work to strengthen them. It also generates incentives for them to improve their academic performance and excel in order to satisfy themselves [38, 39].

2.3 Previous studies

Researcher obtained a few of previous studies that are compatible with nature of the variables to benefit from them as shown in Table 1.

Table 1. Studies dealing with research variables

No.	Name; Year; Country	Educational Level	Sample	Subject	Curriculum Type	Independent Variable	Dependent Var.	Results
1	Hunter, 2006, Australia	College	11 male & female students	Mathematics	experimental	Learn & teach successful mathematics	Multiple Intelligences; Achievement	no effect of teaching & learning mathematics on multiple intelligences and achievement
2	Tabuk & Ozdemir, 2009, Turky	Primary	144 Male students	Mathe.	Exp.	Multiple intelligences	Project based learning; Achievement	there were no statistically significant differences in the dependent variables
3	Painter, 2018, USA	teachers	20	Math.	Case study			Employing design thinking strategies for middle school students led to mastery of mathematical concepts

3 Research methodology and procedures

Researcher choose the "Experimental Research Method", including experimental design of two groups (experimental plus control) with a post-test, which is one of real designs, as it represents proposed strategy (independent vari.) and personal intelligence with achievement (dependent variables) as shown in Table 2. The research community consisted of all students sixth class (biological sciences) in the General Directorate of Education of the First Karkh in the province of Baghdad. The researcher chose the distinguished high school – Al-Khadra for boys from the first Karkh Education Directorate to conduct the experiment on three study divisions, and (B) section was randomly selected as the experimental group and (C) section as the control group. The experimental group consisted of (30) students, the control group consisted of (30) students [40]. As for the control procedures (internal safety), groups of research were equalized in (age of chronological, intelligence, previous achievement in mathematics). The external integrity of the design, as the researcher trained the subject teacher to teach the proposed strategy and for the experimental and control groups. The class was taught to both groups; where the time period was equal for both of them which is (45) days within the 1st semester/academic year (2021–2022). The number of lessons scheduled for students is (5 lessons) per week in attendance, and it is equal for the experimental and control groups. The research tools, both measure of personal intelligence, achievement, were applied to the two groups. The classrooms of the two research groups in the same place on the first floor were close and similar in terms of physical characteristics such as lighting, ventilation and seating. As for experimental extinction; it is the impact that results from leaving a few of students within the research sample or interruption through work, so "no student" left the study or interrupted work except for the absences that two research groups were exposed to in approximately equal proportions.

Table 2. Equivalence of the two research groups in chronological age, intelligence, and previous achievement

Variable	Group	Students	SMA	Standard Deviation	T Value		Indication Level
					Cal.	Tab.	
age	1	30	213.22	6.57	1.15	1.97	Not statistically significant
	2	30	214.18	5.83			
intelligence	Exp.	30	48.4	4.35	0.17	1.97	
	Con.	30	47.3	4.29			
previous achiev.	1	30	70.4	10.43	0.769	1.97	
	2	30	69.3	9.89			

Notes: Exp. = 1; Con. = 2; significance level (0.05).

3.1 The achievement test

After determining the educational content, which is the third chapter of the mathematics book (combined numbers), the behavioral objectives were formulated and their number was (23) behavioral objectives according to Bloom's six levels of behavioral

objectives. A test map was developed to determine the questions for each of the six levels of Bloom, based on the opinion of the arbitrators, the total number of questions (10) paragraphs of the essay type were determined, they were (4) for the level of remembering, (3) for the level of comprehension, (3) the level of application. Test was given to a group of academic in a area of mathematics and its teaching methods in order to take their opinions and observations, after taking their opinions, it was ready to be applied to the exploratory sample. Table 3 shows the test map with the preparation of behavioral objectives for each chapter. For clarity, understanding of paragraphs, instructions of answer, calculating the time taken to answer, test was applied to a sample of (100) students from the research community and from outside the experiment sample (Al-Mutamayizeen High School – Al-Harithiya for Boys). To calculate the weighted mean among first and last three students who took test, (90) minutes was enough [41–44]. In order to obtain statistical indicators for examining the achievement test. First of all; calculating the coefficient discrimination for each items by adopting its own equation, and it was found that its value ranges between (0.32–0.69), which they are a good indicator of the acceptance of the items. Difficulty coefficient for the item; the results ranged between (0.27–0.64) and are acceptable, as the sources indicate that any paragraph within the distribution of the difficulty coefficients ranges between (0.20–0.80). Extracting the psychometric properties of the achievement test; validity coefficient, two types of honesty were extracted Face Validity which the test was presented to a number of arbitrators in mathematics disciplines and it's teaching methods. The opinions of the arbitrators were taken into account in reformulating and amending some paragraphs, and none of them were deleted. The paragraphs in their final form reached agreement (80%), and thus all returned. The test items are valid to measure the students' achievement from the sample. Content validity: a test map was drawn up in which the objectives were explained at their levels with the number of lessons needed to study each topic, and it was presented to a number of arbitrators and was approved by (80%). One of the content validity indicators in addition to what was indicated in the test map.

The Reliability; extracted the stability using the Kuder Richardson Equation – 21, the value of it was (0.82) considered an acceptable stability.

Thus, the achievement test has acceptable sincerity and stability.

Table 3. (Table of specifications) for the achievement test

Behavioral Goals		Remember	Comprehension	Application	Analysis	Sum
First semester	Relative weight / Number of lessons	32%	21%	36%	11%	100%
	20	3	2	4	1	10

3.2 Personal intelligence scale

Researcher reviewed a number of studies that dealt with multiple intelligences, including interpersonal intelligence to build a scale of personal intelligence consisting of (17) items with five options (strongly agree, agree, neutral, reject, strongly reject)

according to Likert scale, instructions were put in place to answer, they were taken into account to be clear; to indicate that the results obtained are for scientific research purposes only not used for other purposes. The sample members were asked not to leave any paragraph unanswered, in case; they are treated as error and write the solution on a piece of paper. Scale was introduced to arbitrators in methods of teaching math., with psychology, in light of their observations, the modifications were made and they were approved by 80%. Finding out clarity of scale paragraphs and their understanding by the sample of the exploratory application. Test was applied to (100) students who are not from the research sample (Al-Mutamayizin High School – Al-Harithiya for boys) from the research community. It turned out that all instructions were clear; (45) minutes was ok to finish test. Statistical analysis for scale items; the discrimination coefficient was extracted, so the t-test was applied for two independent samples, because it is an indicator that achieves distinction between paragraphs by comparing the calculated value with the tabular value (2) with a degree of freedom (58), and a level of significance (0.05) and it was accepted. Confirming the psychometric properties; the scale presented to a number of experts in math. & Its teaching methods, who agreed that scale's paragraphs are appropriate for which they were done for it. So, scale was apparently valid. The Reliability; He proceeded to extract the stability using the Alpha Cronbach Equation, its value was (0.79) and considered an acceptable.

4 Results and their interpretation

4.1 Achievement test results

The validity of the first null hypothesis "there is no statistically significant difference at the significance level (0.05) between the mean scores of the sixth-class biological science students who learned the mathematics subject according to proposed strategy and students who learned by traditional way in test of achievement test" was tested. The results were shown in Table 4.

Table 4. "Achievement test"

Groups	No.	Mean	Variance	Std. Dev.	t-Test		Indication Level
					Cal.	Tab.	
Exp.	30	70.8	202.49	14.23	2.186	1.97	Statistically significant at the (0.05) level
Con.	30	62.8	186.32	13.65			

From the above table, it's very clear that (2.186) higher than the tabular one at the significance level with degree of freedom (58), which indicates a statistically significant difference in achievement; thus the null hypothesis is rejected and the alternative hypothesis is accepted. The researcher believes that the reason may be the adoption of a proposed strategy according to design thinking model, which stimulated the minds of students to think with the mindset of the designer and search for creative solutions outside the box, with an emphasis on making the problems presented from the reality of the students' lives, which led to their retention of information for long periods.

4.2 Results related to personal intelligence test

The null hypothesis "there is no statistically significant difference at the significance level (0.05) between both mean scores of the sixth-class biological science students who learned the mathematics subject assigned to them according to the proposed strategy and between the students who learned by usual way at Personal Intelligence scale" and it was verified as Table 5.

Table 5. "Personal intelligence scale"

Groups	No.	Average	Var.	Standard Deviation	t-Test		Indication Level
					Calculated Value	Tabular Value	
Exp.	30	3.97	0.048	0.22	5.21	1.97	significant
Con.	30	3.71	0.017	0.13			

Noted that the (5.21) is greater than tabular, which indicates existence of statistically difference in personal intelligence. Therefore, the null hypothesis is rejected; the hypothesis accepted alternative. The reason may be the adoption of the proposed strategy according to the design thinking model has affected on personality of the students because it allowed them to start thinking freely and this made them realize their weaknesses and strengths and work on them and thus increase their self-confidence, also break the barrier of boredom, dryness of mathematics as a subject for them to be more fun with increased confidence their abilities and personalities.

5 Conclusions

Teaching, according to the proposed strategy, contributed to improving the achievement of students. The use of the proposed strategy contributed to generating positive impressions in mathematics among students as a new method of teaching. Students were able to reveal their strengths and weaknesses and face difficulties, thus increasing their self-confidence. The use of modern teaching strategies has an impact on raising students' achievement and improving their personal intelligence.

6 Recommendations

Recommending teachers to adopt the design thinking model in education because of its role in developing students' abilities; also paying attention to the personal intelligence (internal and external) of students and paying attention to the importance of making students confident in themselves and their abilities. Orientation Curriculum Designers in Ministry of Education to reconsider "Mathematics" curricula for the secondary stage and its content, presenting them in fun and an interesting manner, presenting them in the form of leading students think, research, not to be bound by known methods only, move away from memorization. Conduct training courses for teachers on the design thinking model and the possibility of suggesting multiple strategies to be applied in the classroom.

7 References

[1] A. Al-Darabse, "Teaching and Assessment Strategies," in *Студент и наука (гуманитарный цикл)-2017*, 2017, pp. 535–538.

[2] A. H. M. Alaidi and O. H. Yahya, "Using Modern Education Technique in Wasit University," *International Journal of Interactive Mobile Technologies*, vol. 14, no. 6, pp. 82–94, 2020. https://doi.org/10.3991/ijim.v14i06.11539

[3] A. Zkear and B. Majeed, "Smart Learning based on Moodle E-learning Platform and Development of Digital Skills for University Students," *International Journal of Recent Contributions from Engineering, Science IT (iJES)*, vol. 10, no. 1, 2022. https://doi.org/10.3991/ijes.v10i01.28995

[4] B. H. Majeed and L. F. Jawad, "Tactical Thinking and its Relationship with Solving Mathematical Problems Among Mathematics Department Students," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 9, pp. 247–262, 2021. https://doi.org/10.3991/ijet.v16i09.22203

[5] R. M. ALairaji and I. A. Aljazaery, "Abnormal Behavior Detection of Students in the Examination Hall From Surveillance Videos," in *Advanced Computational Paradigms and Hybrid Intelligent Computing*, vol. 1373: Springer Singapore, 2022, pp. 113–125. https://doi.org/10.1007/978-981-16-4369-9_12

[6] J. S. Qateef, A. H. M. Alaidi, and R. M. Al_airaji, "Face Patterns Analysis and Recognition System Based on Quantum Neural Network QNN," *International Journal of Interactive Mobile Technologies*, vol. 16, no. 8, 2022. https://doi.org/10.3991/ijim.v16i08.30107

[7] A. Hassan, "Mathematical Power and its Relationship to Mathematical Culture among High School Mathematics Teachers," *International Journal of Psychosocial Rehabilitation*, vol. 24, no. 03, 2020.

[8] J. Liedtka, "Innovative Ways Companies are Using Design Thinking," *Strategy Leadership*, 2014. https://doi.org/10.1108/SL-01-2014-0004

[9] B. H. Majeed, L. F. Jawad, and H. T. ALRikabi, "Computational Thinking (CT) Among University Students," *International Journal of Interactive Mobile Technologies*, vol. 16, no. 10, 2022. https://doi.org/10.3991/ijim.v16i10.30043

[10] R. Oxman, "Thinking Difference: Theories and Models of Parametric Design Thinking," *Design Studies*, vol. 52, pp. 4–39, 2017. https://doi.org/10.1016/j.destud.2017.06.001

[11] L. F. Jawad, B. H. Majeed, and H. T. ALRikabi, "The Impact of CATs on Mathematical Thinking and Logical Thinking Among Fourth-Class Scientific Students," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 10, pp. 194–211, 2021. https://doi.org/10.3991/ijet.v16i10.22515

[12] Y. Li et al., "Design and Design Thinking in STEM Education," vol. 2, ed. Journal for STEM Education Research: Springer, 2019, pp. 93–104. https://doi.org/10.1007/s41979-019-00020-z

[13] L. F. Jawad, B. H. Majeed, and H. T. ALRikabi, "The Impact of Teaching by Using STEM Approach in The Development of Creative Thinking and Mathematical Achievement Among the Students of The Fourth Scientific Class," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 13, pp. 172–188, 2021. https://doi.org/10.3991/ijim.v15i13.24185

[14] R. Lor, "Design Thinking in Education: A Critical Review of Literature," 2017.

[15] M. R. Hajji and A. K. Hassan, "The Effect of a Training Program based on High Impact Teaching Strategies (HITS) in the Teaching Practices of Mathematics Teachers," *Journal of Language Linguistic Studies*, vol. 18, no. 1, pp. 1204–1223, 2022.

[16] B. H. Majeed, "The Impact of Reflexive Learning Strategy on Mathematics Achievement by First Intermediate Class Students and their Attitudes Towards E-Learning," *Turkish Journal of Computer Mathematics Education*, vol. 12, no. 7, pp. 3271–3277, 2021.

[17] J. Boaler, *Mathematical Mindsets: Unleashing Students' Potential through Creative Mathematics, Inspiring Messages and Innovative Teaching,* John Wiley & Sons, 2022.
[18] L. F. Jawad, M. K. Raheem, and B. H. Majeed, "The Effectiveness of Educational Pillars Based on Vygotsky's Theory in Achievement and Information Processing Among First Intermediate Class Students," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 12, pp. 246–262, 2021. https://doi.org/10.3991/ijet.v16i12.23181
[19] H. TH. and H. Hazim, "Secure Chaos of 5G Wireless Communication System Based on IOT Applications," *International Journal of Online and Biomedical Engineering (iJOE)*, vol. 18, no. 12, pp. 89–102, 2022. https://doi.org/10.3991/ijoe.v18i12.33817
[20] A. H. M. Alaidi, R. a. M. Al_airaji, and S. H. Abbood, "Dark Web Illegal Activities Crawling and Classifying Using Data Mining Techniques," *International Journal of Interactive Mobile Technologies*, vol. 16, no. 10, 2022. https://doi.org/10.3991/ijim.v16i10.30209
[21] L.-A. Noel and T. L. Liub, "Using Design Thinking to Create a New Education Paradigm for Elementary Level Children for Higher Student Engagement and Success," *Design Technology Education*, vol. 22, no. 1, p. n1, 2017. https://doi.org/10.21606/drs.2016.200
[22] M. Al-Sarry, I. Faris, and B. Majeed, "A Future Vision of Mathematics Teacher Preparation Program at the Universities," *International Education Culture Studies*, vol. 2, no. 1, pp. 1–12, 2022.
[23] B. Majeed, "The Relationship Between Conceptual Knowledge and Procedural Knowledge among Students of the Mathematics Department at the Faculty of Education for Pure Sciences/Ibn Al-Haitham, University of Baghdad," *International Journal of Innovation, Creativity and Change (IJICC)*, vol. 12, no. 4, pp. 333–346, 2020.
[24] H. T. S. Alrikabi, N. A. Jasim, B. H. Majeed, A. Z. Abass, and I. R. N. ALRubee, "Smart Learning based on Moodle E-learning Platform and Digital Skills for University Students," *Int. J. Recent Contributions Eng. Sci. IT*, vol. 10, no. 1, 2022. https://doi.org/10.3991/ijes.v10i01.28995
[25] A. Roberts and J. Nash, "Enabling Students to Participate in School Improvement through a Students as Researchers Programme," *Improving Schools*, vol. 12, no. 2, pp. 174–187, 2009. https://doi.org/10.1177/1365480209106590
[26] G. Ambrose and P. Harris, *The Visual Dictionary of Pre-Press and Production*. Bloomsbury Publishing, 2010.
[27] B. Banerjee and T. Gibbs, "Teaching the Innovation Methodology at the Stanford d.school," in *Creating Innovation Leaders*: Springer, 2016, pp. 163–174. https://doi.org/10.1007/978-3-319-20520-5_9
[28] A. K. Hassan and H. Jabr, "The Logical and Inferential Thinking Skills of Secondary School Mathematics Teachers and their Relationship to their Mathematical Beliefs," *Turkish Online Journal of Qualitative Inquiry*, vol. 14, no. 4, p. 1154, 2021.
[29] B. H. Majeed, A. Z. Abass, and D. Al-Malah, "The Influence E-Learning Platforms of Undergraduate Education in Iraq," *International Journal of Recent Contributions from Engineering, Science IT*, vol. 9, no. 4, pp. 90–99, 2021. https://doi.org/10.3991/ijes.v9i4.26995
[30] A. K. Hassan and I. A. Al-Dahhan, "The Effect of Total Quality Strategy on Correcting the Misconception of Mathematical Concepts among College of Education Students in Baghdad Governorate. Xi'an Jianzhu Keji Daxue Xuebao," *Journal of Xi'an University of Architecture Technology*, vol. 12, pp. 3271–3277, 2020.
[31] D. Al-Malah, H. A. i Mutar, "Cloud Computing and its Impact on Online Education," *IOP Conference Series: Materials Science and Engineering*, vol. 1094, p. 012024, 2021. https://doi.org/10.1088/1757-899X/1094/1/012024
[32] B. H. Majeed, "Mathematical Logical Intelligence and its Relationship with Achievement among College of Education Students in Baghdad Governorate," *Nasaq*, vol. 1, no. 2, pp. 307–354, 2014.

[33] H. Gardner, "Multiple Intelligences," *New York*, 2010.
[34] H. T. Salim and H. Tauma, "Enhanced Data Security of Communication System Using Combined Encryption and Steganography," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 16, pp. 144–157, 2021. https://doi.org/10.3991/ijim.v15i16.24557
[35] R. R. Valencia and L. A. Suzuki, *Intelligence Testing and Minority Students: Foundations, Performance Factors, and Assessment Issues*. Sage, 2000. https://doi.org/10.4135/9781452231860
[36] M. Zeidner, G. Matthews, and R. D. Roberts, *What We Know about Emotional Intelligence: How it Affects Learning, Work, Relationships, and our Mental Health*. MIT press, 2012.
[37] J. D. Mayer, D. R. Caruso, and P. Salovey, "The Ability Model of Emotional Intelligence: Principles and Updates," *Emotion Review*, vol. 8, no. 4, pp. 290–300, 2016. https://doi.org/10.1177/1754073916639667
[38] M. J. S. Al-Sarry, B. H. Majeed, and S. K. Kareem, "Cognitive Load of University Students and its Relationship to their Academic Achievement," *Periodica Journal of Modern Philosophy, Social Sciences and Humanities*, vol. 3, pp. 65–77, 2022.
[39] N. M. Jasim and A. P. D. A. K. Hassan, "The Effectiveness of Educational-Learning Design According to the Progressive Inquiry Model in Mathematical Excellence Skills of Second-Grade Intermediate Students," *Journal of Language and Linguistic Studies*, vol. 18, no. 2, 2022.
[40] M. K. R. Al-Haydary and B. H. Majeed, "Impact of ASSURE Model on Mathematical Correlation and Achievement in Mathematics," *European Journal of Humanities Educational Advancements*, vol. 2, no. 11, pp. 62–68, 2021.
[41] B. Hasan, "The Skill of Decision-Making and its Relationship to Academic Achievement among Students," *International Journal of Recent Contributions from Engineering, Science IT (iJES)*, vol. 9, no. 4, pp. 77–89, 2021. https://doi.org/10.3991/ijes.v9i4.26363
[42] B. H. Majid, "Mathematical-Procedural Knowledge ant its Relation to Logical-Mathematical Intelligence among Students at the Third Stage in Mathematics Department," *Journal of Educational Psychological Researches*, vol. 15, no. 58, pp. 478–498, 2018.
[43] B. H. BH., "The Conceptual Mathematical Knowledge and Analytical Thinking for the First Stage Students at Math Sciences Department, Faculty of Education for Pure Sciences, IBN Alhaithem, University of Baghdad," *International Journal of Science and Research (IJSR)*, vol. 6, no. 12, pp. 1379–1392, 2017. https://doi.org/10.21275/ART20178962
[44] B. H. Majeed, "Impact of a Proposed Strategy according to Luria's Model in Realistic Thinking and Achievement in Mathematics," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 17, no. 24, pp. 208–218, 2022. https://doi.org/10.3991/ijet.v17i24.35979

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The Implementation of Online Learning in Conventional Higher Education Institutions During the Spread of COVID-19: A Comparative Study

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Abstract—The purpose of this study is to investigate and explore the degree of success of the implementation of online learning in conventional higher education institutions instead of face-to-face learning during the spread of the Covid-19 Pandemic during the 2019/2020 academic year, via exploring the undergraduate students' perceptions of the application of the online learning system at Ajman University in UAE, and Griffith University in Australia. In the study, the descriptive approach was used. A questionnaire consisting of 40 items was designed and distributed to 630 students from Ajman University and 675 students from Griffith University, who were randomly selected from different faculties of the two universities during the 2019/2020 academic year during the COVID-19 pandemic. The results of the study revealed that students' a moderate satisfaction with the University's readiness, training, and technical support for online learning and the university's teaching and learning process during the COVID-19 pandemic, with female students finding them more satisfaction than male students. Disciplines and computer skills also showed an impact on such satisfaction, with Pharmacy & Health Science College students at Ajman University and Architecture, Art, and Design discipline students at Griffith University, and those with excellent computer skills in both Universities. In addition, the results showed positive attitudes of students towards the use of online learning at the two universities during the COVID-19 pandemic.

Keywords—online learning, conventional higher education, COVID-19 pandemic, a comparative study

1 Introduction

A novel corona virus, known as Covid-19 pandemic, which discovered in the last month of the year 2019, in a seafood market in Wuhan is not only a serious public health emergency but an emergency on all societal levels, political, economic, social, and even on education level too [1]. World Health Organization (WHO) announced social distancing as a means of curbing the spread of this severity pandemic [2]. As a result of this announcement, schools, colleges, and universities around the world have closed down their campuses so that students are taking and follow social distancing measures [3]. According to the United Nations (UN) report, the pandemic of COVID-19 caused the greatest disruption of education systems in history, affecting approximately 1.6 billion students in more than 190 countries and all oceans. As a consequence of this severe pandemic, the educational system through their educational institutions has been motivated to create and develop modern learning strategies to support the continuity of education and training that are appropriate to the environment of this pandemic [4]. Online learning or distance learning has been adopted in most educational institutions like universities, schools in the world as one of the educational solutions during the covid-19 pandemic [5, 6]. On another side, although distance learning or online learning was a widespread matter of concern for political authorities, education, businesses, teachers, parents, and students alike, there was no other alternative. Most academic heads are now promoting online education as a solution to this crisis [4]. [7] indicated that online learning has become extremely prevalent in a number of higher education institutions around the world. The biggest international universities over the past decade are gradually moving their programs online and doing away with traditional learning delivery [8, 9]. Top universities in the world such as Peking University, Harvard, MIT, Yale, Oxford, Cambridge, among others are moving in this direction [10]. However, moving smoothly from an environment of conventional education to distance and virtual learning could not happen overnight. This rapid transformation is linked to various obstacles and challenges at this point [11]. For students Lack of proper interaction with instructors is a major concern associated with online learning [12]. It is important that online learners are familiar with the use of technology to make full use of the e-learning system because they will get frustrated when they are not familiar with the technology and lower their level of satisfaction [13, 14]. In the United Arab Emirates (UAE), 91% of residents use mobile Internet and more than 98% of households have Internet access [15]. In addition, mobile devices, such as smartphones, are used to access the Internet primarily at home or at work (Federal Competitiveness and Statistics Authority). The UAE government through cooperation with both of ministry of education and Etisalat Company implemented online learning during of COVID-19 pandemic from March 2020, and still applied it up to date in all UAE education sectors like public and private schools and higher education institutions. The main objective of this measure is to take precautions to protect students from the COVID-19 pandemic and to ensure students continue to learn in an appropriate manner and with high-quality teaching methodologies. In order to ensure a successful online learning process during of COVID-19 pandemic, the Ministry of education in UAE implemented professional

training for school teachers and allowed private schools to access their own online learning system. Moreover, It launched smart learning platforms and guidelines and instructions manual to manage students' behavior on online learning. In addition, the UAE government offered free satellite broadband services for learners in areas with no connectivity and free home internet for families with no home internet connection. Ajman University started implementing the online learning system, after joining the UAE's efforts to take the necessary precautionary measures to limit the spread of the new Coronavirus known as (COVID-19) in light of the directives of the Ministry of Education in the UAE. Moreover, the university organized training courses for more than 300 faculty members, which included methods and mechanisms for online learning to ensure full readiness for this experiment, and the absence of any challenges that could hinder the communication process. Furthermore, an interactive environment has been provided between students and the instructors that enable them to exchange views and ideas during the process of explaining educational materials pointing out that the online learning process is compatible with the skills of the current generation of students in their active dealing. Prior to COVID Griffith university, online learning and blended modes of learning (through the institutional learning management system) were already present but for the majority of faculty and students, fully online learning was new. Griffith focused on providing support to both students and staff in online learning. Numerous online training opportunities were provided to help upskill teaching staff in the use of digital tools.

2 Literature review

2.1 Coronavirus disease (COVID-19) pandemic

A novel strain of respiratory tract infection associated with the COVID-19 emerged in December 2019 in Wuhan at China which is the sprawling capital of Central China's Hubei province. This virus has spread rapidly worldwide in all countries of the world, regardless of whether they are rich or poor countries [1]. WHO On 12 January 2020 isolated this pathogenic virus and named it as the 2019 novel coronavirus [2]. According to [16], Coronavirus (COVID-19) is an enveloped, positive-sense, single-stranded, RNA virus genome in the size ranging from 26 to 32 kilobases, causes mild to severe symptoms of acute respiratory syndrome infections and even mortal. Similarly, the Ministry of health and prevention of the UAE defined it as a new strain of coronavirus that may cause illness in animals or humans. In humans, several coronaviruses are known to cause respiratory infections ranging from the common cold to more severe diseases.

2.2 Online learning

Online learning as a model of education emerged in 1982 in California in the united states [17]. This model of education as its first application has had great potential for effect on the planning, development, and construction of the education system at

all educational institutions and its educational levels [18–21]. Allen & Seaman [22] referred that online learning uses computers, laptops, other devices, and the Internet as the delivery mechanism with at least 80% of the course content delivered online. Where it is clear that long text-based lectures were not appropriate for the online environment, and learners were not easily and quickly engaged in discussion activities [23]. According to [24], as online learning started to expand, the governments of nations also began funding educational institutions that provided online programs in an improvement in the quality of online learning. Garrison [25], referred that online learning derives from constructivist theory learning, it poses a major change in contrast to conventional distance education, which is focused on the concept of autonomy and the industrial development of prepackaged study materials. Moreover, according to [26], online learning shifted learning from teacher-centered learning that presented in a classroom environment during traditional learning to learner-centered learning, where learners have much more responsibility and ownership. Where those learners in the online learning environment are able to choose what to learn when to learn, and who to learn with [27–29]. Thus, a certain degree of Self-guiding is required to pass an online class. Online learning, according to [14, 30–32], is a form of distance education in which technology mediates the learning process, teaching is provided entirely via the internet, and learners and teachers are not required to be present at the same time and location. Luyt [33] pointed out that features of online learning like access to the internet and the flexibility of online classes have made online learning an essential component of the learning system in higher education institutions. Limperos et al. [34] pointed out that the existence of financial problems in some institutions of higher education and many students' demands have directed the focus and shift of these institutions towards using online learning as one of the propitiate solutions that can be implemented. Furthermore, Al-Qatawneh et al. [35] pointed out that learning nowadays has become reliant on several advanced instructional methods, systems, and multimedia technology, which have led to the looks of the e-learning platform. Moreover, Online learning has progressively are becoming prevalent, providing learners flexibility in regard to the time and location they study, and enabling them to get knowledge rapidly by using numerous sources of education [36]. Moreover, Chaney [37] referred that nowadays, the expansion of the use of the Internet and technology have produced a surge in the demand for internet-based learning. Online learning is attractive to a variety of students and has become more familiar throughout educational environments including primary schools to secondary school and into higher education institutions like universities [23]. Moreover, Waldeck [38] pointed out that online learning comprises a wide variety of programs that use the Internet within and beyond school walls to provide access to instructional materials as well as facilitate interaction among teachers and students. Furthermore, according to Garrison [25], in the mid-1990s, advancements in educational technology and increased interest in asynchronous discussion groups gave rise to the term e-learning, which sought to describe learning delivered entirely online as well as learning that combines online and face-to-face elements referred to as blended or hybrid learning. Online learning environments can be classified into three core categories: Asynchronous Online Courses, Synchronous Online Courses, and Hybrid Courses as seen in Figure 1.

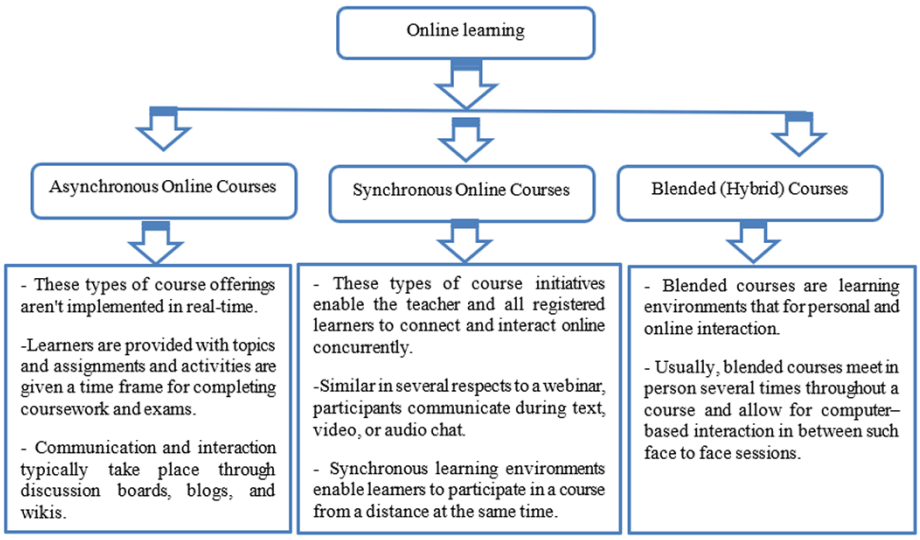

Fig. 1. Categories of online learning environments

The spread of the COVID-19 pandemic, like so many other aspects of daily life, has had a major influence on students, teachers, and educational organizations all over the world [39]. This forced most countries of the world to close their educational institutions [40]. According to [3], this procedure was done so that students could follow social distancing measures and thus protect them from the risk of contracting a Coronavirus disease (COVID-19). There is uncertainty as to when the pandemic will disappear completely in our lives and the lives of our students. Hence, in effort to maintain continuity of learning, most educational institutions around the world decided to take advantage of the available technologies, existing resources, and modern means of communication to create online educational programs [41]. Crawford et al confirms that the process of shifting smoothly from an environment of traditional learning to online learning could not happen directly overnight and hence a rapid shift in learning systems will surely be connected to diverse obstacles, problems, and challenges [11]. In reality, Covid-19 compelled experts and decision-makers in educational institutions to adopt online learning as a logical choice to address the risk of students ceasing to learn and study while the Covid-19 Pandemic spread [41]. The rapid shift in learning system is a test of how well educational institution like universities and schools are prepared to deal with the crisis of pandemic, and how effectively they are able to harness advanced technology, including hardware and software, to enable effective online learning [42–45]. Oncu and [46] identify the four goals for research to support the success of online learning environments classes (Figure 2).

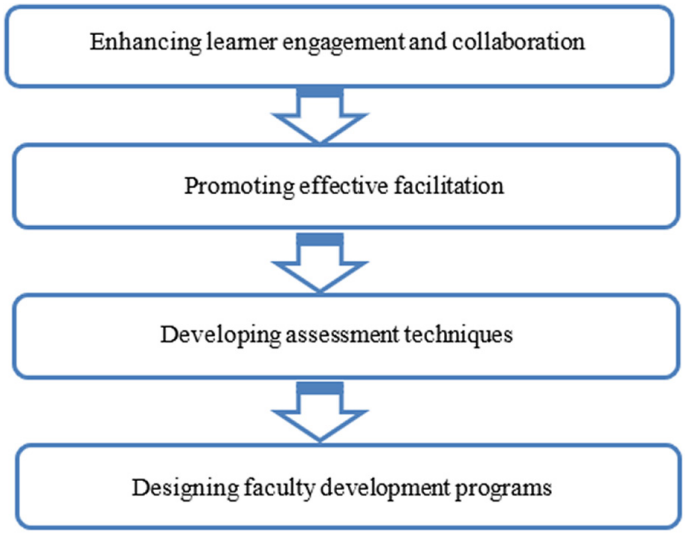

Fig. 2. The most important factors in the success of online learning classes

Online learning is considered to hold potential benefits and positive features given below as seen in Figure 3 [30, 47–49].

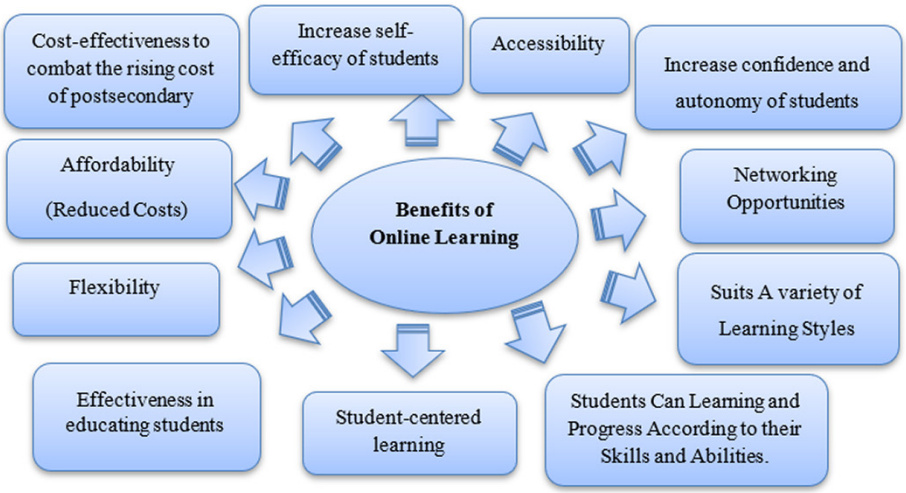

Fig. 3. Benefits of online learning [30, 47–50]

However, there are also potential disadvantages refers to the disadvantages of online learning such as: poor accessibility in Remote Areas, online learning more effective in digitally advanced countries; lack of access to fast, affordable, and reliable internet connections, online learning can cause social Isolation, online teachers tend to focus on theory rather than practice, and online learning is inaccessible to the computer illiterate population [30, 51].

2.3 Previous studies

Online learning has been present in higher education for many years. Most institutions of higher education have been steadily transitioning to online learning, either fully or as blended models. But, with the advent of the COVID pandemic, the steady transition turned into a literal dive into online learning. In lockdown online learning changed from choice to mandate. Almost overnight, instructors and students around the world were plunged into a fully online environment, many with little or no preparation or experience. Different educational institutions, in different countries and cultural contexts all across the globe found themselves to be on the common ground of the challenges of a sudden, forced shift to online learning. The situation, though unfortunate, provided a unique opportunity to gain cross-country insights into the experience of online learning, precipitating a large volume of literature and stimulating international collaboration among academics. To gain insight into the breadth of literature around online learning during the pandemic, the authors turned to Scopus. Scopus (https://www.elsevier.com/en-au/solutions/scopus), lays claim to being the largest database of peer reviewed literature, and therefore provides adequate insight into the breadth of literature around scientific topics of interest, including online learning and teaching during the COVID 2019 pandemic. A brief single 'surface' search, in September 2021 of Scopus articles, abstracts and keywords in articles (using keywords COVID AND learning AND (higher education), limited to conference papers and journal articles from 2020–2021 yielded 1863 relevant documents and the statistics available on Scopus showed that over three quarters of documents were journal articles with almost one-third of articles in the social sciences with computer science and medicine being disciplines of particular focus. The top 'producers' of literature were United States, Indonesia and the UK, in that order. A theme overview of the first 50 relevant papers, by abstract, provides an indication of the focus of the literature. Predictably, there is an emphasis in literature on the challenges of the Pandemic for higher education institutions and concern for how the pandemic is reshaping the future of higher education (twenty-eight of the fifty papers). Investigations of the impact of the pandemic on the student learning/experiences and faculty experience were also a focal point (nineteen of the 50 papers). Given the current state of higher education where institutions are already being challenged to survive in a global economy and now, even more uncertain economic times, the emphasis in literature on the institutional challenges and response as well as on the student experience is not surprising. It was observed that exploration of experiences of learning and teaching is occurring mostly within the confines of a particular institution or within a particular country. Comparative studies across countries were not common with only two of the 50 most relevant paper. Adding 'comparative' to the search terms yielded an additional five cross-country comparison research but these studies are seemingly scarce despite the potential richness of knowledge to be gained from what is a 'global laboratory [52]. Some studies representative of comparative studies of learning and teaching during COVID 19 are discussed below. Hall et al. [53] write about the impact of COVID on an international mobile learning project (European DEIMP Project) occurring across six countries including UK, Australia, Belgium, Cyprus, Ireland and The Netherlands. They explore the strategies used by each country to provide continuity of education across educational systems. One of the key issues arising is that of the digital divide and its impact particularly on schools and their students. Focusing narrowly

on higher education, Oleksiyenko, et al. [54] examine the impact of COVID from the frame of comparative education and international higher education from a global perspective. Tejedor et al. [55] take up the theme of digital literacy and the necessity of guaranteeing digital literacy for students and teachers to enable higher education to meet its objectives. The study also considered student perceptions of the competency of their teachers to teach successfully online, and empowerment of students in the online classes. Their quantitative study via questionnaire of 376 students across universities in Spain, Italy and Ecuador showed the necessity of adapting teaching methodologies in the presence of online learning pointing out that technology is merely a tool and its use alone does not create effective learning experiences. Tejedor et al. [55] demonstrate the necessity of training in "competencies within the scope of digital literacy in higher education students" (p. 2) – something that is often taken for granted. The study assessed from student perspectives the skill of the teacher to create engaging classes and the usability of teacher's engaging methodologies (which 56.8% of students found to be engaging and useful. Across Spain, Italy and Ecuador, students in Spain 72.3% perceived the classes during lockdown to be positive, while 36.95% Ecuador students and 52.8% of students in Italy perceived classes to be positive [55]. Interestingly, around three-quarters of students from Italy and Ecuador students felt teachers had skills appropriate to teaching online while approximately three-quarters of students from Spain felt that their teachers did not have appropriate skills [55]. The almost global 'unpreparedness' of institutions to pivot into online learning during the pandemic is a re-occurring theme in the surrounding literature. Kummitha, Kolloju, Chittoor and Madepalli [56], add the digital divide as a major concern for institutions. In a cross-sectional study of 281 academics across India and Ethiopia, the authors' found that lack of institutional preparedness and especially the digital divide severely limited the effective implementation of online learning. The situation was compounded by a lack of training programs to help academic staff utilize web resources. However, it is the issue of equitable access to technologies which is stressed as the most urgent challenge for higher education if online learning is to be effective and equitable. Furthermore, Zalite and Zvirbule's [57] study of digital readiness across the European Union pointed to a general lack of digital literacy adequate to support effective online learning and teaching. They also noticed the digital gap existing between more developed Nordic European countries and the less developed Southern and Eastern European countries. Insights into the student experience in the studies revealed that students perceived technological problems as less of an issue than the increased need to take personal responsibility for time management and learning process. Students' digital literacy and/or digital readiness as a factor impacting on learning and the learning experience is taken up by [58]. An k-means cluster analysis of results of 1826 university students revealed significant variation in their digital learning readiness (technology availability, prior experiences and skills). They also found that socio-emotional perceptions also play an major role in student learning and the student experience during online learning. One interesting backdrop to the findings of studies across international borders is the higher education student experience data obtained from the Student Experience Survey (SES) undertaken by QILT (Quality Indicators for Learning and Teaching) funded by the Australian Government Department of Education, Skills and Employment. The SES was developed in 2011 as the University Experience Survey but has since been renamed and expanded to include student from non-university higher education. The SES 'paints a picture' of the student experience

across the higher education sector in Australia. The 2020 SES included all 41 Australian Universities and 92 non university higher education institutions. 295, 473 valid surveys were received, a response rate of 44.1 per cent. In undergraduate students, the quality rating of their experience fell from 78% in 2019 to 69% in 2020. The greatest decline in the experience was in relation to learner engagement down 16% to 44% in 2020. It is interesting that while engagement decreased, participation in discussions either online or face to face increased marginally from 59% in 2019 to 60% in 2020. Teaching quality rating was seen to decline to a record low at 78%. The unpreparedness of teachers, students and institutions to pivot to online learning is apparently well documented in literature. In the few cross country studies of learning and teaching online as a result of COVID clearly show predominantly commonalities the experience and response of students, teachers and institutions to online learning during the pandemic. The dominating themes are around student, teacher and institutional readiness, the socio-emotional toll of rapid shift to online learning, and the exacerbation of the impact of the digital divide.

2.4 Research *problem*

Nowadays, the COVID 19 pandemic has had a major impact on many aspects of daily life. The education sector is considered to be one of the main aspects affected by this pandemic, which has forced all the world's educational institutions into a paradigm shift in the education system from face-to-face to online learning in the context of the pandemic. Implementing online learning effectively can be considered one of the 'wicked problems' in education. Institutions of higher educations have been delving into online learning since the advent of the internet in the late 1990's. The promise that online learning and new technologies would transform education remains, with a few exceptions, largely unrealized. The forced and rapid shift to online learning as a consequence of COVID-19 is likely to amplify the challenges and opportunities of online learning and perhaps crystalize new awareness. Hence, it is important to explore the success of the implementation of online learning in conventional higher education institutions during COVID-19. As the end-users of online education, insight into the experiences and perceptions of students are important to gaining greater insights into how online learning may be improved. Thus, the current study came to verify of degree of success of the implementation of online learning during a pandemic COVID-19 in higher education institutions in two higher education university, the first is Ajman University at the United Arab Emirates and the second is the Griffith University at Australia during the academic year 2019/2020, via exploring the undergraduate students' perceptions of the application of online learning system at Ajman University and Griffith University as two examples of higher education institutions in the world.

2.5 Research purpose

With the intent of contributing to an understanding of how quality online learning can be implemented, the purpose of this study is to explore undergraduate students' perceptions of the application of the online learning systems at Ajman University in UAE, and Griffith University in Australia during the spread of the Covid-19 Pandemic during the 2019/2020 academic year.

2.6 Research questions

To explore the degree of success of the implementation of online learning during COVID-19 in two higher education universities, Ajman University at the United Arab Emirates and Griffith University at Australia, the researchers raise the following questions for study:

RQ1: What is the level of student satisfaction with the University's readiness, training, and technical support for online learning during the COVID-19 pandemic at Ajman University and Griffith University?
RQ2: What is the level of student satisfaction with the University's teaching and learning process at Ajman University and Griffith University during the COVID-19 pandemic?
RQ3: What are students' attitudes toward the use of online learning at university during the COVID-19 pandemic at Ajman University and Griffith University?
RQ4: What are students' perceptions about development and improvement of Online Learning at Ajman University and Griffith University?
RQ5: Are there any differences in satisfaction with the use of online learning during the spread of the COVID-19 pandemic from the perspectives of students at Ajman University and Griffith University based on gender, disciplines, and computer skills?

2.7 The significance of the research

The significance of the study is rationalized as follows:
This Investigation

- will highlight of students' perception of the implementation of online learning in conventional higher education institutions during the spread of COVID-19 to solutions that higher education institutions have implemented in the countries of the world during spread of COVID-19 pandemic.
- may contribute to providing a clearer picture of the difficulties and challenges that students face during implemented of the online learning approach.
- may contribute further insights to the long-standing problem of implementing quality online learning

3 Method

3.1 Approach of the study

This study conducted by using the descriptive research approach via a quantitative (questionnaire) research method. According to Nassaji [59], the prime purpose of descriptive research is to examine phenomena and their specific features. Thus, a questionnaire and Interview instruments will be used to gather data from a sample of the population.

3.2 Study participants

The current study included 630 students from Ajman University and 675 students from Griffith University, who were randomly selected from different faculties of the two universities during the 2019/2020 academic year. during the COVID-19 pandemic. Tables 1 and 2 shown the Demographic information of Participants and Figures 4 and 5 show the frequency and percentage of participants.

Table 1. Demographic information of participants (Ajman University, UAE)

Study Variables	Variables Levels	Frequency (f)	Percentage (%)
Gender	Female	319	50.63
	Male	311	49.37
	Total	**630**	**100.00**
College	Dentistry	77	12.22
	Pharmacy & Health Sciences	63	10.00
	Engineering and information Technology	88	13.97
	Architecture, Art and design	78	12.38
	Business Administration	84	13.33
	Law	84	13.33
	Mass Communication	54	8.57
	Humanities and Sciences	71	11.27
	Medicine	31	4.92
	Total	**630**	**100.00**
Student academic evaluation (GPA)	2 – less than 2.5	188	29.84
	2.5 – less than 3	244	38.73
	3 – less than 3.5	133	21.11
	3.5–4	65	10.32
	Total	**630**	**100.00**
Computer Skills	Poor	77	12.22
	Moderate	122	19.37
	Good	256	40.63
	Excellent	175	27.78
	Total	**630**	**100.00**

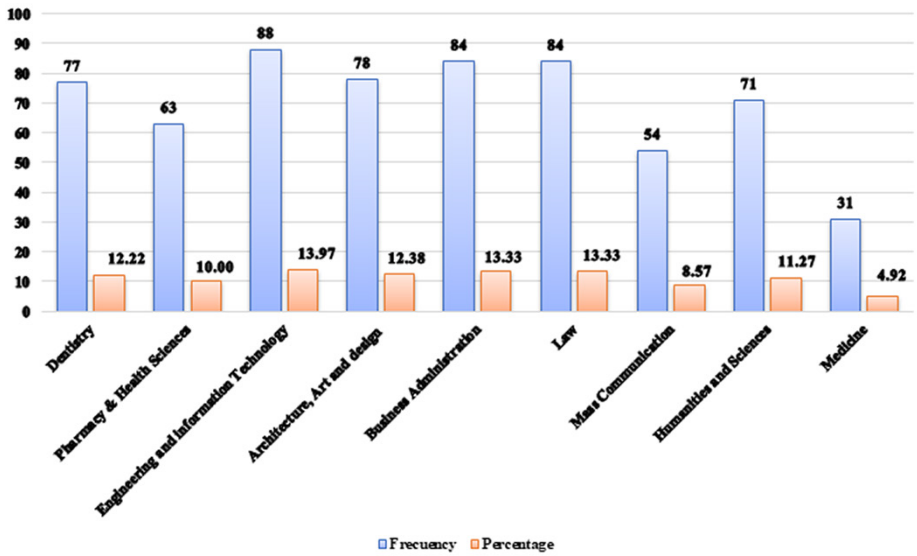

Fig. 4. Participants frequency and percentage (Ajman University, UAE)

Table 2. Demographic information of participants (Griffith University, Australia)

Study Variables	Variables Levels	Frequency (f)	Percentage (%)
Gender	Female	331	49.04
	Male	344	50.96
	Total	**675**	**100.00**
College	School of Medicine	91	13.481
	School of Humanities, Languages, and Social Science	92	13.630
	School of Pharmacy and pharmacology	83	12.296
	School of Information and Communication Technology	97	14.370
	Griffith Law School	82	12.148
	Griffith Business School	81	12.000
	School of Education and Professional Studies	76	11.259
	School of Dentistry and Oral Health	51	7.556
	Architecture, Art, and Design	22	3.259
	Total	**675**	**100.00**

(Continued)

Table 2. Demographic information of participants (Griffith University, Australia) *(Continued)*

Study Variables	Variables Levels	Frequency (f)	Percentage (%)
Student academic evaluation (GPA)	2 – less than 2.5	179	26.52
	2.5 – less than 3	276	40.89
	3 – less than 3.5	148	21.93
	3.5–4	72	10.67
	Total	**675**	**100.00**
Computer Skills	Poor	84	12.44
	Moderate	143	21.19
	Good	267	39.56
	Excellent	181	26.81
	Total	**675**	**100.00**

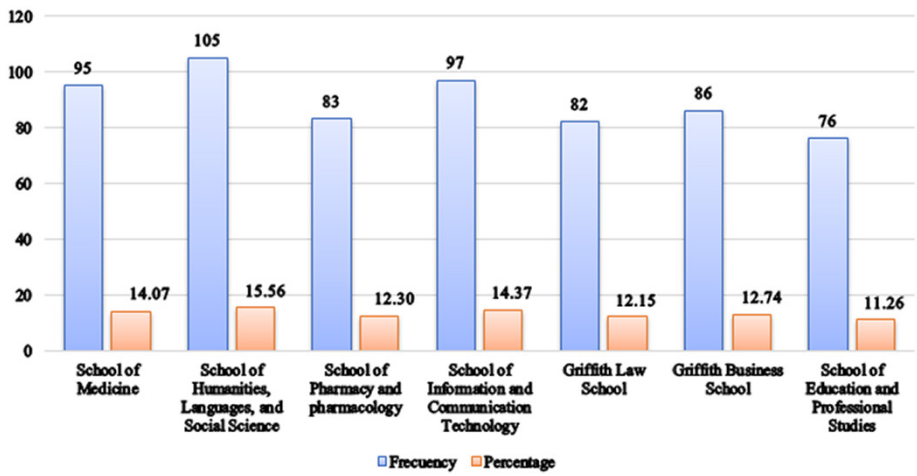

Fig. 5. Participants frequency and percentage (Griffith University, Australia)

3.3 Study instrument

The questionnaire was used to gather data from the participants students. It was sent to them during the second semester of the academic year 2019/2020, during the occurrence of the COVID-19 pandemic. The questionnaire comprised of two sections, the first section concerned students' basic information, and the second part represented the questionnaire elements (n=40) based on the study's objectives.

The validity of the instrument. A group of arbitrators (10 faculty members of UAE universities) with extensive experience in the field of education were asked to express their views on the items of the questionnaire, in terms of the relevance of items for achieving the research aims and the number and comprehensiveness of the

questionnaire items. The educational specialists' comments and suggested modifications were taken into account, and relevant deletions, amendments, and additions were made. As a result, the questionnaire after modification consisted of 27 elements, to achieve the objective of the research.

Reliability of the instrument. To verify the internal consistency of the study tool, Cronbach's α method was used. It was applied to a pilot study involving 35 students from outside the study sample, for which the calculated Cronbach alpha coefficient was 0.776. see Table 3.

Table 3. Cronbach's alpha coefficients for the reliability of questionnaire domains

Domain	No. of Items	Reliability Coefficient of Alpha Cronbach
University Readiness/Training and Technical Support for Online Learning	7	0.857
Students Attitudes Towards the Use of Online Learning	20	0.812
Challenges Facing Students in Online Learning	8	0.729
Development and Improvement of Online Learning	5	0.773
All questionnaire	**45**	**0.776**

3.4 Data analysis measures

In this analysis, a five-dimensional Likert scale is implemented, as shown in Table 4 below.

Table 4. Evaluation of scale data based on the options of scale and score intervals

Description	Scores	Intervals
Very high	5	4.21–5.00
High	4	3.41–4.20
Moderate	3	2.61–3.40
Low	2	1.81–2.60
Very low	1	1.00–1.80

3.5 Statistical analysis of the data

For data analysis, the researchers used the Statistical Package for the Social Sciences (SPSS) to compute the percentage, mean, standard deviation (SD), independent t-test tests, one-way ANOVA, and the Scheffe test.

3.6 Ethical considerations

This study was approved by the Research Ethics Committee/Deanship of Graduate Studies and Research of Ajman University (Reference number: H-F-H-2020-Oct-21) on September 26, 2020.

4 Results

First question: What is the level of student satisfaction with the University's readiness, training, and technical support for online learning during the COVID-19 pandemic at Ajman University and Griffith University?

To answer the first question of this study, mean scores and standard deviations for the students' responses to each of the questionnaire items 1−7 were calculated, as shown in Table 5.

Table 5. Descriptive statistics for the students' responses to the items about the degree of satisfaction with the University's readiness, training, and technical support for online learning during the COVID-19 pandemic at Ajman University and Griffith University

No	Items	Ajman University			Griffith University		
		Mean	SD	Description	Mean	SD	Description
Q1	The university provided me enough information about the online learning policy	2.76	0.95	Moderate	2.73	0.94	Moderate
Q2	The University has provided me with information on how to access and use the online learning system, (e.g. manuals, videos, email, website)	2.76	1.01	Moderate	2.74	1.02	Moderate
Q3	The information on how to access and use the online learning system provided by the university on online learning are simple, clear and sufficient	3.12	0.84	Moderate	3.01	0.90	Moderate
Q4	My university provides the online learning technical support services that I require	3.07	0.86	Moderate	3.07	0.88	Moderate
Q5	My university provides different ways to contact the technical support service	2.77	1.02	Moderate	2.72	1.04	Moderate
Q6	The University provides a speedy response to requests for technical support services	2.71	0.99	Moderate	2.68	1.01	Moderate
Q7	The online learning systems used by our university are clear and easy to use	2.91	0.89	High	2.87	0.91	Moderate
Total mean for the dimension		**2.87**		**Moderate**	**2.83**		**Moderate**
Standard deviation		**0.94**			**0.96**		

The results presented in Table 5 revealed that the arithmetic mean of all questionnaire items (1–7) for the AU was (2.87), with a standard deviation of (0.94), while for the GU it was (2.83), with a standard deviation of (0.96). This finding means that student satisfaction regarding readiness, training, and technical support for online learning during the COVID-19 pandemic at Ajman University and Griffith University came at a Moderate level. Table 5 also shows that the responses of AU students to item 3

"The information on how to access and use the online learning system provided by the university on online learning are simple, clear and sufficient" had the highest average (3.12), while for GU, item 4 "My university provides the online learning technical support services that I require" was the highest average (3.07), and the two items came in at the Moderate average level. Similarly, a 'Moderate' level was also found for Items 4, 7, 5, 2, and 1, of AU with the respective average values of 3.07, 2.91, 2.77, 2.76, and 2.76. while for GU, the Item 3, 7, 2, 1, and 5, with the respective average values of 3.01, 2.87, 2.74, 2.73, and 2.72. Furthermore, it is clear from the students' responses of the two universities (AU and GU) in Table 5, that the lowest average (2.71) for AU, and (2.68) for GU was obtained for Item 6 "The University provides a speedy response to requests for technical support services" with also moderate level.

Second question: What is the level of student satisfaction with the University's teaching and learning process at Ajman University and Griffith University during the COVID-19 pandemic?

To answer the second question of this study, mean scores and standard deviations for the students' responses to each of the questionnaire items 8−27 were calculated, as shown in Table 6.

Table 6. Descriptive statistics for the students' responses to the items about the degree of students' satisfaction with the University's teaching and learning process at Ajman University and Griffith University during the COVID-19 pandemic

No	Items	Ajman University			Griffith University		
		Mean	SD	Description	Mean	SD	Description
Q8	I am confident I can succeed academically when learning online	3.23	1.51	Moderate	3.17	1.54	Moderate
Q9	I have the time management/ organizational skills needed to succeed with online learning	3.23	1.45	Moderate	3.13	1.48	Moderate
Q10	I have the technical skills needed to learn online	3.02	1.45	Moderate	3.02	1.36	Moderate
Q11	I can get help easily, when I need it, from my instructors/tutors when I learn online	3.19	1.40	Moderate	3.11	1.43	Moderate
Q12	Using online tools, I can easily connect with other students, when learning online	3.58	1.41	High	3.55	1.43	High
Q13	I like the flexibility offered by online learning	3.20	1.38	Moderate	3.17	1.39	Moderate
Q14	I prefer to learn online	3.12	1.37	Moderate	3.08	1.37	Moderate
Q15	I prefer to learn on-campus in face-to-face mode.	3.33	1.37	Moderate	3.29	1.38	Moderate
Q16	Learning online is more difficult than learning in face-to-face mode	3.64	1.32	High	3.60	1.34	High

(Continued)

Table 6. Descriptive statistics for the students' responses to the items about the degree of students' satisfaction with the University's teaching and learning process at Ajman University and Griffith University during the COVID-19 pandemic *(Continued)*

No	Items	Ajman University			Griffith University		
		Mean	SD	Description	Mean	SD	Description
Q17	I find getting motivated is more difficult in online learning than in face-to-face modes	3.07	1.35	Moderate	2.94	1.45	Moderate
Q18	I find teamwork more difficult online than in face to face modes	3.55	1.36	High	3.50	1.36	High
Q19	Online education organizes my time in a productive way.	3.53	1.38	High	3.51	1.40	High
Q20	Online learning develops my skills in the use of IT.	3.48	1.31	High	3.42	1.32	High
Q21	I think that online learning takes into consideration individual differences between students	3.77	1.27	High	3.61	2.34	High
Q22	Academic achievement has improved for me by online learning.	3.43	1.34	High	3.41	1.34	High
Q23	Online learning gives me the opportunity to get back to the recorded lecture at any time.	3.47	1.34	High	3.42	1.36	High
Q24	Online learning promotes students' self-confidence	3.42	1.33	High	3.43	1.35	High
Q25	Online learning does not provide me the interaction and discussion I need with the instructor	3.67	1.35	High	3.66	1.37	High
Q26	I feeling that Using online learning is comfortable for me.	3.05	1.37	Moderate	3.26	1.45	Moderate
Q27	Online learning increases my social isolation	3.39	1.23	Moderate	3.74	1.29	High
Total mean for the dimension		**3.37**			**3.35**		**Moderate**
Standard deviation		**1.36**			**1.44**		

The results presented in Table 6 revealed that the arithmetic mean of all questionnaire items (8–27) for the AU was (3.37), with a standard deviation of (1.36), while for the GU it was (3.35), with a standard deviation of (1.44). This finding means that student satisfaction with the university's teaching and learning process at Ajman University and Griffith University during the COVID-19 pandemic is at a Moderate level.

Third question: What are students' attitudes toward the use of online learning at university during the COVID-19 pandemic at Ajman University and Griffith University?

To answer the third question of this study, mean scores and standard deviations for the students' responses to each of the questionnaire items 28−35 were calculated, as shown in Table 7.

Table 7. Descriptive statistics for the students' attitudes toward the use of online learning at university during the COVID-19 pandemic at Ajman University and Griffith University

No	Items	Ajman University			Griffith University		
		Mean	SD	Description	Mean	SD	Description
Q28	I experience Technical problems happening during the online classes (network failure or slowness – audio outage)	3.39	1.30	Moderate	3.40	1.31	Moderate
Q29	Faculty members have weak skills to teach online learning	3.45	1.36	High	3.46	1.37	High
Q30	The weakness of student's skills in using online learning.	4.21	1.01	V. High	4.24	1.00	V. High
Q31	Failure and delay of the services of technical support.	3.05	1.37	Moderate	3.06	1.40	Moderate
Q32	Students find difficulty in dealing with online learning assessments.	3.42	1.33	High	3.72	1.15	High
Q33	Online examination systems are difficult to use	3.67	1.35	High	3.66	1.37	High
Q34	The unsuitability of students' home environment for participation in online learning (limited area /presence of children / ....) is problematic	3.05	1.37	Moderate	3.06	1.40	Moderate
Q35	Online learning reduces the level of direct communication between students and faculty members.	3.33	1.37	Moderate	3.61	1.16	High
Total mean for the dimension		**3.45**			**3.53**		
Standard deviation		**1.31**			**1.27**		

The results presented in Table 7 revealed that the arithmetic mean of all questionnaire items (28–35) for the AU was (3.45), with a standard deviation of (1.31), while for the GU it was (3.53), with a standard deviation of (1.27). This finding means that the students' attitudes toward the use of online learning at university during the COVID-19 pandemic at Ajman University and Griffith University came at a High level. Table 7 also shows that the responses of AU and GU students to item 30 "The weakness of student's skills in using online learning." had the highest average with the respective average values of (4.21), and (4.24) and it came in at the High level. Similarly, a 'High' level was also found for Items 33, 29, and 32, of AU with the respective average values of 3.67, 3.45, and 3.42. while for GU, the Item 32, 33, 35, and 29, with the respective average values of 3.72, 3.66, 3.61, and 3.46. Furthermore, it is clear from the students' responses of the two universities (AU and GU) in Table 7, that the lowest average (3.05) for AU belong to Item 34, and also Item 34 (3.06) and Item 31 (3.06) for GU was obtained with also moderate level.

Fourth question: What are students' perceptions about development and improvement of Online Learning at Ajman University and Griffith University?

To answer the fourth question of this study, mean scores and standard deviations for the students' responses to each of the questionnaire items 36−40 were calculated, as shown in Table 8.

Table 8. Descriptive statistics for the students' responses to the items about the development and improvement of Online Learning at Ajman University and Griffith University

No	Items	Ajman University			Griffith University		
		Mean	SD	Description	Mean	SD	Description
Q36	There needs to be provision for continuous training for different and updated applications for online learning.	3.64	1.32	High	4.16	1.19	High
Q37	The necessity to design Courses Empowered with Videos	3.07	1.35	Moderate	3.02	1.36	Moderate
Q38	There needs to be improvement in providing technical support in quickly and continuously	4.17	1.18	High	3.60	1.34	High
Q39	There needs to be re-organization and adjustment the assignments, quizzes, and exams.	3.53	1.38	High	3.51	1.40	High
Q40	The necessity of Creating interactive content.	3.48	1.31	High	3.42	1.32	High
Total mean for the dimension		**3.58**			**3.54**		
Standard deviation		**1.31**			**1.32**		

The results presented in Table 8 revealed that the arithmetic mean of all questionnaire items (36–40) for the AU was (3.58), with a standard deviation of (1.31), while for the GU it was (3.54), with a standard deviation of (1.32). This finding means that the students' attitudes toward the use of online learning at university during the COVID-19 pandemic at Ajman University and Griffith University came at a High level. Table 8 also shows that the responses of AU students to item 38 "There needs to be improvement in providing technical support in quickly and continuously" was the highest mean (4.17), while for GU, item 36 "There needs to be provision for continuous training for different and updated applications for online learning." The highest average (4.16), the two items came in at the high level. Similarly, a 'High' level was also found for Items 36, 39, and 40, of AU with the respective average values of 3.64, 3.53, and 3.48. while for GU, the Item 38, 39, and 40, with the respective average values of 3.60, 3.51, and 3.42. From the students' responses of the two universities (AU and GU) in Table 8, it is clear that the lowest average (3.07) for AU belongs to Item 37, as well as Item 37 (3.02) for GU with a moderate level.

Fifth question: Are there any differences in satisfaction with the use of online learning during the spread of the COVID-19 pandemic from the perspectives of students at Ajman University and Griffith University based on gender, disciplines, and computer skills? The independent t-test and variance test were conducted to investigate the significance of differences between averages. Scheffe's test for post-hoc comparisons

were also conducted to find the significance of differences between means. The results related to the responses of the study subjects are detailed below according to the study variables.

Table 9. The means and standard deviations of the students' responses according to gender

University	Gender	N	Mean	Std. Deviation	T. Value	Sig (tailed)
AU	Female	311	3.37	1.904	1.904	0.029*
	Male	319	3.28	0.6504		
GU	Female	331	3.37	0.657	1.919	0.028
	Male	344	3.27	0.646		

Note: *Statistically significant at $\alpha \leq 0.05$.

In Table 9, for AU, the calculated t-value of 1.904 was greater than that of the t-table, indicating significant differences in males and females at the 0.029 significance level, which is lower than the required level (0.05) which was in favor of female students. Also, for GU the computed t-value of 1.919 was greater than the t-table, which indicates significant differences in males and females at the significance level of 0.028, which is less than the required level (0.05), and came also in favor of female students.

Table 10. Analysis of variance according to the disciplines variable by One-Way ANOVA test

			Sum of Squares	df	Mean Square	F	Sig (tailed)
AU	disciplines	Between Groups	14.291	8	1.786	4.391	0.001
		Within Groups	252.634	621	0.407		
		Total	266.926	629			
GU	disciplines	Between Groups	16.293	8	2.037	5.007	0.000
		Within Groups	270.917	666	0.407		
		Total	287.210	674			

Note: *Statistically significant at $\alpha \leq 0.05$.

The findings of the one-way ANOVA test of this variable are shown in Table 10. As displayed in Table 10, the results clearly illustrated that there are statistically significant differences in students' perspectives according to the variable of disciplines. For the AU the p-value is 0.001, which is less than the required statistical significance level (0.05). Also, for the GU the p-value is 0.000, which is also less than the required statistical significance level (0.05). In order to determine the reason for the differences between the comparisons presented in Table 10, the LSD test was applied. Results from the LSD test were showed in the Table 11.

Table 11. Results from the Scheffe test were used to determine the causes of differences among students' responses in relation to the disciplines variable of AU and GU

Ajman University				Griffith University			
(I) College	**(J) College**	**Mean Difference (I–J)**	**Sig.**	**(I) College**	**(J) College**	**Mean Difference (I–J)**	**Sig.**
Medicine	Dentistry	0.22674	0.095	School of Medicine	School of Humanities, Languages, and Social Science	0.06841	0.468
	Business Administration	.39952*	0.003		School of Pharmacy and pharmacology	.20515*	0.034
	Engineering & IT	.42459*	0.002		School of Information and Communication Technology	.27124*	0.004
	Mass Communication	0.07578	0.598		Griffith Law School	.27694*	0.004
	Pharmacy & Health Sciences	–0.01893	0.892		Griffith Business School	–0.18252	0.061
	Humanities & Sciences	0.24916	0.070		School of Education and Professional Studies	0.13518	0.173
	Law	.27988*	0.037		School of Dentistry and Oral Health	0.08164	0.465
	Architecture, Art, and Design	.38995*	0.004		Architecture, Art, and Design	–0.22932	0.131
Dentistry	Medicine	–0.22674	0.095	School of Humanities, Languages, and Social Science	School of Medicine	–0.06841	0.468
	Business Administration	0.17278	0.086		School of Pharmacy and pharmacology	0.13675	0.157
	Engineering & IT	.19785*	0.047		School of Information and Communication Technology	.20284*	0.029
	Mass Communication	–0.15096	0.183		Griffith Law School	.20854*	0.032
	Pharmacy & Health Sciences	–.24567*	0.024		Griffith Business School	–.25093*	0.010
	Humanities & Sciences	0.02242	0.831		School of Education and Professional Studies	0.06678	0.500
	Law	0.05314	0.598		School of Dentistry and Oral Health	0.01324	0.905
	Architecture, Art, and Design	0.16321	0.112		Architecture, Art, and Design	–.29773*	0.050

(Continued)

Table 11. Results from the Scheffe test were used to determine the causes of differences among students' responses in relation to the disciplines variable of AU and GU *(Continued)*

Ajman University				Griffith University			
(I) College	**(J) College**	**Mean Difference (I–J)**	**Sig.**	**(I) College**	**(J) College**	**Mean Difference (I–J)**	**Sig.**
Business Administration	Medicine	–.39952*	0.003	School of Pharmacy and pharmacology	School of Medicine	–.20515*	0.034
	Dentistry	–0.17278	0.086		School of Humanities, Languages, and Social Science	–0.13675	0.157
	Engineering & IT	0.02507	0.797		School of Information and Communication Technology	0.06609	0.489
	Mass Communication	–.32374*	0.004		Griffith Law School	0.07179	0.470
	Pharmacy & Health Sciences	–.41845*	0.000		Griffith Business School	–.38767*	0.000
	Humanities & Sciences	–0.15036	0.144		School of Education and Professional Studies	–0.06997	0.490
	Law	–0.11964	0.225		School of Dentistry and Oral Health	–0.12351	0.277
	Architecture, Art, and Design	–0.00957	0.924		Architecture, Art, and Design	–.43447*	0.005
Engineering & IT	Medicine	–.42459*	0.002	School of Information and Communication Technology	School of Medicine	–.27124*	0.004
	Dentistry	–.19785*	0.047		School of Humanities, Languages, and Social Science	–.20284*	0.029
	Business Administration	–0.02507	0.797		School of Pharmacy and pharmacology	–0.06609	0.489
	Mass Communication	–.34881*	0.002		Griffith Law School	0.00570	0.952
	Pharmacy & Health Sciences	–.44352*	0.000		Griffith Business School	–.45376*	0.000
	Humanities & Sciences	–0.17543	0.085		School of Education and Professional Studies	–0.13606	0.164
	Law	–0.14471	0.137		School of Dentistry and Oral Health	–0.18960	0.086
	Architecture, Art, and Design	–0.03464	0.727		Architecture, Art, and Design	–.50056*	0.001

Mass Communication	Medicine	–0.07578	0.598	Griffith Law School	School of Medicine	–.27694*	0.004
	Dentistry	0.15096	0.183		School of Humanities, Languages, and Social Science	–.20854*	0.032
	Business Administration	.32374*	0.004		School of Pharmacy and pharmacology	–0.07179	0.470
	Engineering & IT	.34881*	0.002		School of Information and Communication Technology	–0.00570	0.952
	Pharmacy & Health Sciences	–0.09471	0.424		Griffith Business School	–.45946*	0.000
	Humanities & Sciences	0.17338	0.133		School of education and Professional Studies	–0.14176	0.163
	Law	0.20410	0.067		School of Dentistry and Oral Health	–0.19530	0.086
	Architecture, Art, and Design	.31417*	0.006		Architecture, Art, and Design	–.50626*	0.001
Pharmacy & Health Sciences	Medicine	0.01893	0.892	Griffith Business School	School of Medicine	0.18252	0.061
	Dentistry	.24567*	0.024		School of Humanities, Languages, and Social Science	.25093*	0.010
	Business Administration	.41845*	0.000		School of Pharmacy and pharmacology	.38767*	0.000
	Engineering & IT	.44352*	0.000		School of Information and Communication Technology	.45376*	0.000
	Mass Communication	0.09471	0.424		Griffith Law School	.45946*	0.000
	Humanities & Sciences	.26809*	0.015		School of Education and Professional Studies	.31770*	0.002
	Law	.29881*	0.005		School of Dentistry and Oral Health	.26416*	0.021
	Architecture, Art, and Design	.40888*	0.000		Architecture, Art, and Design	–0.04680	0.760

(Continued)

Table 11. Results from the Scheffe test were used to determine the causes of differences among students' responses in relation to the disciplines variable of AU and GU *(Continued)*

Ajman University				Griffith University			
(I) College	**(J) College**	**Mean Difference (I–J)**	**Sig.**	**(I) College**	**(J) College**	**Mean Difference (I–J)**	**Sig.**
Humanities & Sciences	Medicine	–0.24916	0.070	School of Education and Professional Studies	School of Medicine	–0.13518	0.173
	Dentistry	–0.02242	0.831		School of Humanities, Languages, and Social Science	–0.06678	0.500
	Business Administration	0.15036	0.144		School of Pharmacy and pharmacology	0.06997	0.490
	Engineering & IT	0.17543	0.085		School of Information and Communication Technology	0.13606	0.164
	Mass Communication	–0.17338	0.133		Griffith Law School	0.14176	0.163
	Pharmacy & Health Sciences	–.26809*	0.015		Griffith Business School	–.31770*	0.002
	Law	0.03072	0.765		School of Dentistry and Oral Health	–0.05354	0.643
	Architecture, Art, and Design	0.14079	0.179		Architecture, Art, and Design	–.36450*	0.019
Law	Medicine	–.27988*	0.037	School of Dentistry and Oral Health	School of Medicine	–0.08164	0.465
	Dentistry	–0.05314	0.598		School of Humanities, Languages, and Social Science	–0.01324	0.905
	Business Administration	0.11964	0.225		School of Pharmacy and pharmacology	0.12351	0.277
	Engineering & IT	0.14471	0.137		School of Information and Communication Technology	0.18960	0.086
	Mass Communication	–0.20410	0.067		Griffith Law School	0.19530	0.086
	Pharmacy & Health Sciences	–.29881*	0.005		Griffith Business School	–.26416*	0.021
	Humanities & Sciences	–0.03072	0.765		School of Education and Professional Studies	0.05354	0.643
	Architecture, Art, and Design	0.11007	0.273		Architecture, Art, and Design	–0.31096	0.056

The results shown in Table 11 indicate that the source of the differences in the students' the perspective of students of Ajman University, the differences were related to the disciplines variable in favor of the Pharmacy & Health Sciences discipline. While from the perspective of students of Griffith University, the differences were related to the disciplines variable in favor of the Architecture, Art, and Design discipline.

Student academic evaluation (GPA). The One-Way ANOVA test results for students' responses related to the Student academic evaluation (GPA) variable are shown in Table 12.

Table 12. Analysis of variance according to the Student academic evaluation (GPA) variable by One-Way ANOVA test

			Sum of Squares	df	Mean Square	F	Sig (tailed)
AU	Computer skills	Between Groups	2.328	3	0.776	1.836	0.139
		Within Groups	264.598	626	0.423		
		Total	266.926	629			
GU	Computer skills	Between Groups	2.904	3	0.968	2.285	0.078
		Within Groups	284.305	671	0.424		
		Total	287.210	674			

Note: *Statistically significant at $\alpha \leq 0.05$.

The results reported in Table 12 indicate that there are not statistically significant differences in students' perspectives according to the variable GPA, for both Universities AU and GU.

5 Discussion

The primary purpose of the present study was to gain insights into the level of success of the implementations of online learning during the COVID-19 pandemic in two institutions, Ajman University in the United Arab Emirates, and Griffith University in Australia. The surveyed students' at Ajman University and Griffith University acknowledged positive aspects of online learning amid the disruption of COVID-19. The challenges of online learning are also apparent from student responses to the survey items. Interestingly, means of the students' responses to most survey items were comparable across AU and GU, pointing to similarities in students' perceptions and experiences of online learning across both universities – likely a reflection of the similar manner in which both Universities were forced to plunge, with little time for preparation, into online learning. When other studies of the online learning experiences of university students during the pandemic are examined, it becomes apparent that despite institutional and cultural differences across international borders, there are commonalities in student perceptions and experiences of online learning during COVID-19. The results of the present study show that students hold an overall positive view of online learning. The positive student response of university students to online learning during the pandemic

is documented in other studies such as [60], Responses to the survey in the present study indicate student awareness and experiences of some shortcomings in technical preparedness of institutions, preparedness of students themselves and the capabilities of staff to teach online. The lowest means in the descriptive statistics related to university readiness, training and technical support are indicative of students' moderate disagreement that the university provided needed technical information and instructions on how to use and access online learning, timely technical support, and adequate mechanisms for contacting support services. Technical preparedness of institution, faculty and students is identified in literature as an important factor to the success of online learning [60]. In the descriptive statistics of the survey items relating to student attitudes towards online learning there is further evidence of the manifestation of technical challenges of online learning – students agreed that they experienced technical problems alongside failure and delay of technical support services. It is clear that technical preparedness (technical support, information, quality of service, training) is an important element of the online learning experience given that students highly agreed that the provision of continuous training and updated applications for online learning are necessary improvements. More so, students highly agreed on the necessity of providing continuous and timely technical support to support their online learning. For most universities, prior to the Pandemic, the trajectory to online learning was characterized by incremental change, and sometimes fragmented adoption as they sought to shift technology rich education for social, economic and pedagogical reasons. In the context of having to unexpectedly respond the circumstance of the Pandemic, the technical preparedness of universities for supporting online learning on mass was put to the test. The need for better technical infrastructures and timely technical support is brought to the fore in other studies of student experiences of online learning during COVI-19 [60, 61]. The preparedness of institutions aside, it is also apparent from the study results that students may have felt themselves to not be as well prepared for online learning as they needed to be/ or could have been for online learning. They very highly agreed on the importance of the weakness of students' skills in using online learning. This finding reinforces that online learning differs substantially from face to face learning and students require additional skillsets and capabilities to engage successfully in online learning. The students surveyed in both universities only moderately agreed that they had the necessary time management, technical and organizational skills and confidence to succeed – a finding supported by other studies of student perceptions of online learning during COVID-19 [62]–[67]. Flexibility is an oftentimes stated advantage of online learning. Surveyed students responded positively to the flexibility and more 'individualized' and self-directed capability of online learning, they also acknowledged the challenges, highly agreeing that motivation, teamwork, connection with others and especially assessment are difficult in the online environment.

6 Conclusion

The COVID-19 was unexpected and disrupted higher education globally. It provided a unique opportunity to study online learning across international borders as universities around the world found themselves in very much 'the same situation'. There's little

doubt that the pandemic has not only accelerated the move online learning but amplified the under-developed state of technology rich education and online learning. If we are to truly realize the 'transformation of education' that some authors [68–70] claim as the result of the impact of COVID-19 on education, then we are called to investigate, analyze and learn from the experiences of online learning of institutions on an international stage [70–78]. With this in mind, the current study was undertaken and the survey was constructed to covering a comprehensive range of aspects of the student experience of online learning during the pandemic across two higher education institutions Ajman University in the UAE and Griffith University in Australia, the study enriches our understanding of what is important to students in online learning and the results provide some foundation for formulating some recommendations for practice and future research. The study has highlighted the comparable experiences of students in universities across two countries and serves to highlight the broader issues and challenges that universities, regardless of location, are likely to face on the stage of online learning. To help progress quality online education, some recommendations and considerations arising from the present study are given below in the hope that they will trigger further discussion and analysis towards advancing high quality online learning.

7 References

[1] C. Huang et al., "Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China," *The Lancet,* vol. 395, no. 10223, pp. 497–506, 2020. https://doi.org/10.1016/S0140-6736(20)30183-5

[2] WHO, "Coronavirus disease (COVID-19) pandemic," *World Health Organization,* 2020. [Online]. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019

[3] C. M. Toquero, "Challenges and opportunities for higher education amid the COVID-19 pandemic: The Philippine context," *Pedagogical Research,* vol. 5, no. 4, 2020. https://doi.org/10.29333/pr/7947

[4] UNESCO, "Global Education Coalition. UNESCO," https://en.unesco.org/covid19/educationresponse/globalcoalition, 2020.

[5] B. Williamson, R. Eynon, and J. Potter, "Pandemic politics, pedagogies and practices: digital technologies and distance education during the coronavirus emergency," ed: Taylor & Francis, 2020, pp. 107–114. https://doi.org/10.1080/17439884.2020.1761641

[6] D. Al-Malah and H. ALRikabi, "Enhancement of educational services by using the internet of things applications for talent and intelligent schools," *Periodicals of Engineering and Natural Sciences (PEN),* vol. 8, no. 4, pp. 2358–2366, 2020.

[7] I. E. Allen and J. Seaman, "Digital compass learning: Distance education enrollment report 2017," *Babson Survey Research Group,* 2017.

[8] W. Bao, "COVID-19 and online teaching in higher education: A case study of Peking University," *Human Behavior Emerging Technologies,* vol. 2, no. 2, pp. 113–115, 2020. https://doi.org/10.1002/hbe2.191

[9] D. Al-Malah and H. Salim, "The interactive role using the Mozabook digital education application and its effect on enhancing the performance of eLearning," *International Journal of Emerging Technologies in Learning (iJET),* vol. 15, no. 20, pp. 21–41, 2020. https://doi.org/10.3991/ijet.v15i20.17101

[10] A. G. Picciano, "Theories and frameworks for online education: Seeking an integrated model," *Online Learning,* vol. 21, no. 3, pp. 166–190, 2017. https://doi.org/10.24059/olj.v21i3.1225
[11] J. Crawford et al., "COVID-19: 20 countries' higher education intra-period digital pedagogy responses," *Journal of Applied Learning Teaching,* vol. 3, no. 1, pp. 1–20, 2020. https://doi.org/10.37074/jalt.2020.3.1.7
[12] M. Adnan and K. Anwar, "Online learning amid the COVID-19 pandemic: Students' perspectives," *Online Submission,* vol. 2, no. 1, pp. 45–51, 2020. https://doi.org/10.33902/JPSP.2020261309
[13] M. Nakamura, "The state of distance education in Japan," *Quarterly Review of Distance Education,* vol. 18, no. 3, pp. 75–87, 2017.
[14] H. T. S. ALRikabi, D. K. Abdul-Rahman Al-Malah, B. Hassan Majeed, and A. Z. Abass, "The influence E-Learning platforms of undergraduate education in Iraq," *International Journal of Recent Contributions from Engineering, Science & IT (iJES),* vol. 9, no. 4, 2021. https://doi.org/10.3991/ijes.v9i4.26995
[15] Knoema, "No Emirados Árabes – Share of households with Internet" 2018. [Online]. Available: https://pt.knoema.com/atlas/Emirados-Árabes/topics/Telecomunicação/Usuários-de-internet/Share-of-households-with-Internet
[16] S.-Q. Li et al., "Clinical application of an intelligent oropharyngeal swab robot: Implication for the COVID-19 pandemic," vol. 56, no. 2, 2020. https://doi.org/10.1183/13993003.01912-2020
[17] R. Rowan, "Executive Education at Computer U. Fortune" 1983.
[18] L. Harasim, "Shift happens: Online education as a new paradigm in learning," *The Internet Higher Education,* vol. 3, no. 1–2, pp. 41–61, 2000. https://doi.org/10.1016/S1096-7516(00)00032-4
[19] D. Al-Malah, H. TH., and H. A. Ali Mutar, "Cloud computing and its impact on online education," *IOP Conference Series: Materials Science and Engineering,* vol. 1094, p. 012024, 2021. https://doi.org/10.1088/1757-899X/1094/1/012024
[20] L. Fouad and B. H. Majeed, "The impact of teaching by using STEM approach in the development of creative thinking and mathematical achievement among the students of the fourth scientific class," *International Journal of Interactive Mobile Technologies (iJIM),* vol. 15, no. 13, pp. 172–188, 2021. https://doi.org/10.3991/ijim.v15i13.24185
[21] H. T. Salim, I. A. Aljazaery, J. S. Qateef, A. H. M. Alaidi, and R. a. M. Al_airaji, "Face patterns analysis and recognition system based on Quantum Neural Network QNN," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 8, 2022. https://doi.org/10.3991/ijim.v16i08.30107
[22] I. E. Allen and J. Seaman, "Sizing the opportunity: The quality and extent of online education in the United States, 2002 and 2003," *Sloan Consortium,* 2003.
[23] M. Kebritchi, A. Lipschuetz, and L. Santiague, "Issues and challenges for teaching successful online courses in higher education: A literature review," *Journal of Educational Technology Systems,* vol. 46, no. 1, pp. 4–29, 2017. https://doi.org/10.1177/0047239516661713
[24] H. E. Kentnor, "Distance education and the evolution of online learning in the United States," *Curriculum Teaching Dialogue,* vol. 17, no. 1, pp. 21–34, 2015.
[25] D. R. Garrison, *E-Learning in the 21st Century: A Framework for Research and Practice*. Routledge, 2011. https://doi.org/10.4324/9780203838761
[26] L. F. Koch, "The nursing educator's role in e-learning: A literature review," *Nurse Education Today,* vol. 34, no. 11, pp. 1382–1387, 2014. https://doi.org/10.1016/j.nedt.2014.04.002
[27] A. Sun and X. Chen, "Online education and its effective practice: A research review," *Journal of Information Technology Education: Research,* vol. 15, 2016. https://doi.org/10.28945/3502

[28] B. H. Majeed and L. F. Jawad, "Computational Thinking (CT) among University students," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 10, 2022. https://doi.org/10.3991/ijim.v16i10.30043

[29] L. Fouad Jawad, B. Hassan Majeed, and H. T. S. ALRikabi, "The impact of CATs on mathematical thinking and logical thinking among fourth-class scientific students," *International Journal of Emerging Technologies in Learning (iJET),* vol. 16, no. 10, pp. 194–211, 2021. https://doi.org/10.3991/ijet.v16i10.22515

[30] D. Indira and A. Sakshi, "Online learning," *International Education Research Journal,* vol. 3, no. 8, pp. 32–34, 2017.

[31] B. Hasan, "Tactical thinking and its relationship with solving mathematical problems among mathematics department students," *International Journal of Emerging Technologies in Learning (iJET),* vol. 16, no. 9, 2021. https://doi.org/10.3991/ijet.v16i09.22203

[32] A. Alaidi and O. Yahya, "Using modern education technique in Wasit University," *International Journal of Interactive Mobile Technologies,* vol. 14, no. 6, pp. 82–94, 2020. https://doi.org/10.3991/ijim.v14i06.11539

[33] I. Luyt, "Bridging spaces: Cross-cultural perspectives on promoting positive online learning experiences," *Journal of Educational Technology Systems,* vol. 42, no. 1, pp. 3–20, 2013. https://doi.org/10.2190/ET.42.1.b

[34] A. M. Limperos, M. M. Buckner, R. Kaufmann, and B. N. Frisby, "Online teaching and technological affordances: An experimental investigation into the impact of modality and clarity on perceived and actual learning," *Computers Education,* vol. 83, pp. 1–9, 2015. https://doi.org/10.1016/j.compedu.2014.12.015

[35] S. Al-Qatawneh, N. Alsalhi, A. Al Rawashdeh, T. Ismail, and K. Aljarrah, "To E-textbook or not to E-textbook? A quantitative analysis of the extent of the use of E-textbooks at Ajman University from students' perspectives," *Education Information Technologies,* vol. 24, no. 5, pp. 2997–3019, 2019. https://doi.org/10.1007/s10639-019-09912-4

[36] B. Plangsorn and S. Poopan, "Development of producing and using E-books competencies of Teachers in Chachengsao, Thailand," *World Journal on Educational Technology: Current Issues,* vol. 9, no. 2, pp. 112–117, 2017. https://doi.org/10.18844/wjet.v9i2.690

[37] E. G. Chaney, "Web-based instruction in a rural high school: A collaborative inquiry into its effectiveness and desirability," *NASSP Bulletin,* vol. 85, no. 628, pp. 20–35, 2001. https://doi.org/10.1177/019263650108562803

[38] J. H. Waldeck, "The development of an industry-specific online learning center: Consulting lessons learned," *Communication Education,* vol. 57, no. 4, pp. 452–463, 2008. https://doi.org/10.1080/03634520801894747

[39] M. Mailizar, A. Almanthari, S. Maulina, and S. Bruce, "Secondary school mathematics teachers' views on e-learning implementation barriers during the COVID-19 pandemic: The case of Indonesia," *Eurasia Journal of Mathematics, Science Technology Education,* vol. 16, no. 7, 2020. https://doi.org/10.29333/ejmste/8240

[40] D. Cucinotta and M. Vanelli, "WHO declares COVID-19 a pandemic," *Acta Bio Medica: Atenei Parmensis,* vol. 91, no. 1, p. 157, 2020.

[41] G. Kaur, "Digital life: Boon or bane in teaching sector on COVID-19," *CLIO an Annual Interdisciplinary Journal of History,* vol. 6, no. 6, pp. 416–427, 2020.

[42] K. Mukhtar, K. Javed, M. Arooj, and A. Sethi, "Advantages, limitations and recommendations for online learning during COVID-19 pandemic era," *Pakistan Journal of Medical Sciences,* vol. 36, no. COVID19-S4, p. S27, 2020. https://doi.org/10.12669/pjms.36.COVID19-S4.2785

[43] H. T. Salim and H. T. Hazim, "Secure chaos of 5G wireless communication system based on IOT applications," *International Journal of Online and Biomedical Engineering (iJOE),* vol. 18, no. 12, pp. 89–102, 2022. https://doi.org/10.3991/ijoe.v18i12.33817

[44] S. H. Abbood and S. M. Rahim, "DR-LL Gan: Diabetic retinopathy lesions synthesis using generative adversarial network," *International Journal of Online and Biomedical Engineering,* vol. 18, no. 3, pp. 151–163, 2022. https://doi.org/10.3991/ijoe.v18i03.28005

[45] H. T. S. Alrikabi, N. A. Jasim, B. H. Majeed, A. Z. Abass, and I. R. N. ALRubee, "Smart learning based on Moodle E-learning platform and digital skills for University students," *Int. J. Recent Contributions Eng. Sci. IT,* vol. 10, no. 1, 2022. https://doi.org/10.3991/ijes.v10i01.28995

[46] S. Oncu and H. Cakir, "Research in online learning environments: Priorities and methodologies," *Computers Education,* vol. 57, no. 1, pp. 1098–1108, 2011. https://doi.org/10.1016/j.compedu.2010.12.009

[47] C. de la Varre, J. Keane, and M. J. Irvin, "Enhancing online distance education in small rural US schools: A hybrid, learner-centred model," *Journal of Asynchronous Learning Networks,* vol. 15, no. 4, pp. 35–46, 2011. https://doi.org/10.24059/olj.v15i4.205

[48] J. Lorenzetti, "Academic administration-running a MOOC: Secrets of the world's largest distance education classes," *Magna Publication, Wisconsin,* 2013.

[49] G. Mahajan, "Attitude of teachers towards the use of Technology in Teaching," *Educational Quest-An International Journal of Education Applied Social Sciences,* vol. 7, no. 2, pp. 141–146, 2016. https://doi.org/10.5958/2230-7311.2016.00031.3

[50] D. D. Prior, J. Mazanov, D. Meacheam, G. Heaslip, and J. Hanson, "Attitude, digital literacy and self efficacy: Flow-on effects for online learning behavior," *The Internet Higher Education,* vol. 29, pp. 91–97, 2016. https://doi.org/10.1016/j.iheduc.2016.01.001

[51] M. Sadeghi, "A shift from classroom to distance learning: Advantages and limitations," *International Journal of Research in English Education,* vol. 4, no. 1, pp. 80–88, 2019. https://doi.org/10.29252/ijree.4.1.80

[52] Á. Benito et al., "Changes that should remain in higher education post COVID-19: A mixed-methods analysis of the experiences at three universities," *Higher Learning Research Communications,* vol. 11, p. 4, 2021. https://doi.org/10.18870/hlrc.v11i0.1195

[53] T. Hall et al., "Education in precarious times: A comparative study across six countries to identify design priorities for mobile learning in a pandemic," *Information and Learning Sciences,* 2020. https://doi.org/10.1108/ILS-04-2020-0089

[54] A. Oleksiyenko et al., "Comparative and international higher education in a new key? Thoughts on the post-pandemic prospects of scholarship," *Compare: A Journal of Comparative and International Education,* vol. 51, no. 4, pp. 612–628, 2021. https://doi.org/10.1080/03057925.2020.1838121

[55] S. Tejedor, L. Cervi, A. Pérez-Escoda, and F. T. Jumbo, "Digital literacy and higher education during COVID-19 lockdown: Spain, Italy, and Ecuador," *Publications,* vol. 8, no. 4, p. 48, 2020. https://doi.org/10.3390/publications8040048

[56] H. R. Kummitha, N. Kolloju, P. Chittoor, and V. Madepalli, "Coronavirus disease 2019 and its effect on teaching and learning process in the higher educational institutions," *Higher Education for the Future,* vol. 8, no. 1, pp. 90–107, 2021. https://doi.org/10.1177/2347631120983650

[57] G. G. Zalite and A. Zvirbule, "Digital readiness and competitiveness of the EU higher education institutions: The COVID-19 pandemic impact," *Emerging Science Journal,* vol. 4, no. 4, pp. 297–304, 2020. https://doi.org/10.28991/esj-2020-01232

[58] M. Händel, M. Stephan, M. Gläser-Zikuda, B. Kopp, S. Bedenlier, and A. Ziegler, "Digital readiness and its effects on higher education students' socio-emotional perceptions in the context of the COVID-19 pandemic," *Journal of Research on Technology in Education,* pp. 1–13, 2020. https://doi.org/10.31234/osf.io/b9pg7

[59] H. Nassaji, "Qualitative and descriptive research: Data type versus data analysis," ed: Sage Publications Sage UK: London, England, 2015. https://doi.org/10.1177/1362168815572747

[60] T. Muthuprasad, S. Aiswarya, K. Aditya, and G. K. Jha, "Students' perception and preference for online education in India during COVID-19 pandemic," *Social Sciences & Humanities Open,* vol. 3, no. 1, p. 100101, 2021. https://doi.org/10.1016/j.ssaho.2020.100101
[61] Z. Almahasees, K. Mohsen, and M. O. Amin, "Faculty's and students' perceptions of online learning during COVID-19," in *Frontiers in Education*, 2021, vol. 6: Frontiers Media SA. https://doi.org/10.3389/feduc.2021.638470
[62] M. Bączek, M. Zagańczyk-Bączek, M. Szpringer, A. Jaroszyński, and B. Wożakowska-Kapłon, "Students' perception of online learning during the COVID-19 pandemic: A survey study of polish medical students," *Medicine,* vol. 100, no. 7, 2021. https://doi.org/10.1097/MD.0000000000024821
[63] T. K. Chiu and T. K. Hew, "Factors influencing peer learning and performance in MOOC asynchronous online discussion forum," *Australasian Journal of Educational Technology,* vol. 34, no. 4, 2018. https://doi.org/10.14742/ajet.3240
[64] R. M. Cutri, J. Mena, and E. F. Whiting, "Faculty readiness for online crisis teaching: Transitioning to online teaching during the COVID-19 pandemic," *European Journal of Teacher Education,* vol. 43, no. 4, pp. 523–541, 2020. https://doi.org/10.1080/02619768.2020.1815702
[65] O. B. Adedoyin and E. Soykan, "Covid-19 pandemic and online learning: The challenges and opportunities," *Interactive Learning Environments,* pp. 1–13, 2020. https://doi.org/10.1080/10494820.2020.1813180
[66] D. Curtin, C. Wright, M. Beare, and F. McCallum, "Hot water-extractable nitrogen as an indicator of soil nitrogen availability," *Soil Science Society of America Journal,* vol. 70, no. 5, pp. 1512–1521, 2006. https://doi.org/10.2136/sssaj2005.0338
[67] I. Seetal, S. Gunness, and V. Teeroovengadum, "Educational disruptions during the COVID-19 crisis in Small Island Developing States: Preparedness and efficacy of academics for online teaching," *International Review of Education,* vol. 67, no. 1, pp. 185–217, 2021. https://doi.org/10.1007/s11159-021-09902-0
[68] V. J. García-Morales, A. Garrido-Moreno, and R. Martín-Rojas, "The transformation of higher education after the COVID disruption: Emerging challenges in an online learning scenario," *Frontiers in Psychology,* vol. 12, p. 616059, 2021. https://doi.org/10.3389/fpsyg.2021.616059
[69] C. Li and F. Lalani, "The COVID-19 pandemic has changed education forever," in *World Economic Forum,* 2020, vol. 29: The rise of online learning during the COVID-19 pandemic| World Economic ….
[70] N. A. Jasim, H. T. S. AlRikabi, and M. S. Farhan, "Internet of Things (IoT) application in the assessment of learning process," in *IOP Conference Series: Materials Science and Engineering,* 2021, vol. 1184, no. 1: IOP Publishing, p. 012002. https://doi.org/10.1088/1757-899X/1184/1/012002
[71] S. Dhawan, "Online learning: A panacea in the time of COVID-19 crisis," *Journal of Educational Technology Systems,* vol. 49, no. 1, pp. 5–22, 2020. https://doi.org/10.1177/0047239520934018
[72] N. F. A.-B. Azhar Al-zubidi, Rajaa K. Hasoun, Soukaena Hassan Hashim, Haider Th.Salim Alrikabi, "Mobile application to detect Covid-19 pandemic by using classification techniques: Proposed system," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 16, pp. 34–51, 2021. https://doi.org/10.3991/ijim.v15i16.24195
[73] D. Conrad, "University instructors' reflections on their first online teaching experiences," *Journal of Asynchronous Learning Networks,* vol. 8, no. 2, pp. 31–44, 2004. https://doi.org/10.24059/olj.v8i2.1826
[74] N. Diekelmann, R. Schuster, and C. Nosek, "Creating new pedagogies at the millennium: The common experiences of University of Wisconsin-Madison teachers using distance education technologies," *Distance Education Systemwide Interactive Electronic Newsletter,* vol. 5, no. 7, 1998.

[75] C. A. McQuiggan, "Teaching with new eyes: Transformative faculty professional development for online teaching," 2012.
[76] H. T. H. H. Alrikabi, "Enhanced data security of communication system using combined encryption and steganography," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 16, pp. 144–157, 2021. https://doi.org/10.3991/ijim.v15i16.24557
[77] D. Song and D. Kim, "Effects of self-regulation scaffolding on online participation and learning outcomes," *Journal of Research on Technology in Education,* vol. 53, no. 3, pp. 249–263, 2021.
[78] I. A. Aljazaery, H. T. S. ALRikabi, and A. H. M. Alaidi, "Encryption of color image based on DNA strand and exponential factor," *iJOE,* vol. 18, no. 03, p. 101, 2022. https://doi.org/10.3991/ijoe.v18i03.28021

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An Analysis of Emotional Responses of Students in Bilingual Classes and Adjustment Strategies

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Abstract—Students' willingness to participate in bilingual communication is greatly influenced by their positive emotions in the bilingual class. The automatic recognition of students' emotional state in bilingual class can assist teachers to correctly master the laws of students' emotional changes during the bilingual learning process as fast as possible. However, the speech emotion features extracted by existing speech emotion recognition models are not universal and not suitable for bilingual speech emotion recognition, and the accuracy needs to be improved. To cope with these issues, this paper aims to study the emotional responses of students in bilingual class based on emotional analysis and provide adjustment strategies for it. At first, the signals of students' speech records in bilingual class were pre-processed, the one-dimensional features of the signals were converted into 2-dimensional speech spectrum features so as to attain more useful information to facilitate the emotional recognition of students' speech records in the bilingual class. Then this paper combined the bi-linear Convolution Neural Network (CNN) with capsule network to construct a bilingual class student emotion recognition model, and experimental results verified the effectiveness of the constructed model.

Keywords—emotional analysis, bilingual class, emotion recognition, bi-linear convolution neural network (CNN), capsule network

1 Introduction

As positive psychology has been applied in the field of education, now teachers have paid more attention to students' positive emotions in the class, especially the bilingual teachers who need to interact with students more often [1–6]. Studies have shown that students' willingness to engage in bilingual communication is significantly influenced by their positive emotions in the bilingual class [7–16]. For this reason, world field scholars have conducted research on students' emotional responses in bilingual class, and found that the automatic recognition of students' emotional state in bilingual class can assist teachers to correctly master the laws of students' emotional changes during the bilingual learning process as fast as possible, thereby formulating targeted teaching intervention measures according to the actual emotional state of students [17–19].

Liang et al. [20] pointed out that speech emotion recognition is one of the research hotspots in artificial intelligence. In the paper, the authors attempted to introduce speech emotion into classroom teaching and extract the emotional features of speech, they proposed a multi-channel convolution combining with SEnet network as an emotion recognition model, which performed well in terms accuracy, F1 value, and recall rate on a self-built emotion dataset. Li et al. [21] proposed a DNN-based multi-modal learning emotion analysis method, which integrated video and voice to detect the real-time learning emotions of students, the authors applied this method to the automatic recognition of the learning emotions of students in primary school English class, and used a PAD emotion scale to correspond learning emotions to learning states, then teachers could judge students' learning state according to the changes in their learning emotions and adjust the teaching methods and strategies in time. He et al. [22] used deep learning and attention mechanism methods to automatically modelling the temporal process, and built a DMTN-BTA model based on multitask learning for recognizing students' emotions through classroom videos. The proposed method contained a CNN used for spatio-temporal feature extraction, and a BLSTM-RNN used for emotion recognition which had introduced a novel bridge-temporal-attention. Lei et al. [23] proposed a deep convolution classroom facial analysis method based on channel interaction for the purpose of solving problems in camera shooting distance, indoor illumination, and other classroom scene factors, and the unbalanced expression image and poor recognition effect caused by fuzzy facial spectra of students. Their experimental results showed that data enhancement and model improvement have good effects on facial expression analysis. Liang et al. [24] studied the teacher speech signals and designed a set of emotion detection audio processing system to judge their emotions based on the speech. The authors used the recurrent neural network algorithm to build a speech emotion recognition classification model, pre-processed the data based on pre-weighting, frame-adding window, and endpoint detection, re-classified the emotions, and established a speech emotion corpus of teacher evaluation system. Their experimental results showed that, the improved eigenvalues of Mel frequency cepstral coefficients and neural networks can improve the recognition rate of speech emotions more effectively than conventional speech emotion recognition methods, and can be applied to speech emotion recognition in classroom teaching.

For bilingual speech emotion recognition, the existing corpus is not individualized enough, the speech emotion features extracted by existing speech emotion recognition models are not universal and not suitable for bilingual speech emotion recognition, and the accuracy needs to be improved. Speech emotion recognition models with excellent performance are generally improved or build based on fine-tuned conventional models, so choosing the right combination model is an important condition for effective emotion recognition of bilingual speech. This paper studied the emotional responses of students in bilingual class and the adjustment strategies. In the second chapter, this paper preprocessed the signals of students' voice records in bilingual class to make the signals smoother so that the features of the signals could be extracted easier. In the third chapter, this paper converted the one-dimensional features of recording signals into 2-dimensional speech spectrum features so as to attain more useful information and to facilitate the recognition of students' speech emotions in bilingual class. In the fourth

chapter, this paper combined the bi-linear CNN with capsule network to construct a combination model for recognizing emotions of students in bilingual class. At last, experimental results verified the effectiveness of the constructed model.

2 Preprocessing of recording signals of bilingual class

During the recording process, there might be various interference factors such as environmental noise, equipment noise, speaking interval, low clarity, and irregular duration in the record database of bilingual class. To make the signals of students' voice records in bilingual class smoother to facilitate feature extraction, the original signals of bilingual speech records need to be pre-processed.

In the bilingual speech records of students, the energy of high-frequency areas was less than the energy of the low-frequency areas. This paper used the digital high-pass filter to pre-accentuate the recording signals to increase the signal-to-noise ratio of the bilingual speech records and enhance the energy of the high-frequency areas. Assuming: $Y[L]$ represents the input signal sequence of the bilingual speech records; $X[L]$ represents the output signal sequence, then the formula below gives the formula of filtering processing:

$$X[L] = Y[L]*0.97Y[L-1] \tag{1}$$

The long-time recording signals need to be truncated, that is, the overlapping area between a frame and the next frame needs to be separated based on its macro stability, and here the length of the overlapping area is defined as the frame shift. In this paper, the frame length and frame shift were respectively set as 25 and 10 ms so as to maximize the retained information of student emotions in the bilingual speech records.

The preprocessed recording signals must be continuous, so they need to be superimposed with the window function, namely to be subjected to the windowing operation. The window function can be considered as a data of equal length, and its expression is given by the following formula:

$$Q(m) = \begin{cases} 0.54 - 0.46\cos\left(\dfrac{2\pi m}{M-1}\right), 0 \le m \le M-1 \\ 0, Others \end{cases} \tag{2}$$

To get the frequency spectrum of the signals of the bilingual speech records, the fast Fourier transform was applied to the recording signals after windowing. Assuming: $B(k)$ represents the frequency domain sample of the recording signals, $b(n)$ represents the time domain sample, N represents the size of the fast Fourier transform, expression of the fast Fourier transform is given by the following formula:

$$B(k) = \sum_{n=0}^{N-1} b(n) p^{-i\left(\frac{2\pi}{N}\right)nk} (k = 0, 1, L\ N-1) \tag{3}$$

3 Feature extraction of speech spectrum of bilingual record signals

In this paper, the one-dimensional features of the recoding signals were converted into two-dimensional speech spectrum features to attain more useful information for the recognition of student emotions in the bilingual class. Compared with conventional CNN, the bi-linear CNN with two parallel convolution layers can perform deep extraction on the texture features of the spectra corresponding to the recording signals through the outer product operation of different recording signal features, thereby realizing more satisfactory emotion recognition accuracy. There're certain similarities in the features of different recoding signals, to solve the unsatisfactory emotion recognition accuracy caused by such similarities, this paper introduced the capsule network based on bi-linear CNN.

Generally, the speech spectra are of large size, so this paper converted the large-size speech spectrum into the Mel spectrogram based on the Meyer filter group to ensure that the bi-linear CNN could attain speech spectrum input with reasonable size.

Features of the Mel spectrogram could be attained by the following steps:

Step 1: Perform a series of preprocessing operations such as filtering, framing, windowing, and Fourier transform on the original signals of bilingual speech records of students;

Step 2: Calculate the Mel frequency;

Step 3: Perform multiplying and adding operations on the corresponding energy spectrum to obtain the spectrogram. Some research results have verified that the Mel frequency is more consistent with the auditory characteristics of human, namely the two have a basically linear relationship, its expression is given by Formula 4:

$$g_{MF} = 2595 \cdot \lg\left(1 + \frac{g}{700Hz}\right) \tag{4}$$

Formula 5 gives the expression for converting into actual frequency:

$$NS^{-1}(n) = 700\left(p^{\frac{n}{1125}} - 1\right) \tag{5}$$

Assuming: L represents the length of FFT, Gr represents the sampling rate, $\Gamma()$ represents the integer function, the formula below calculates the Mel frequency resolution:

$$g(i) = \Gamma\left(\frac{(L+1) * f(i)}{Gr}\right) \tag{6}$$

Assuming: n represents the n-th Mel filter; $g(n-1)$ and $g(n+1)$ represent the upper frequency and lower frequency of the filter; $g(n)$ represents the center frequency of the Mel filter; l represents the serial number of dots; multiple filters are defined and denoted as $F_n(l)$, the formula for calculating the output of the filter is:

$$F_n(l) = \begin{cases} \dfrac{l - g(n-1)}{g(n) - g(n-1)}, g(n-1) \le l \le g(n) \\ \dfrac{l - g(n-1)}{g(n) - g(n-1)}, g(n) \le l \le g(n+1) \\ \\ 0, \textit{Others} \end{cases} \tag{7}$$

Assuming: $|a(l)|^2$ represents the size of the energy of the l-th dot in the energy spectrum, the Mel spectrogram was attained by multiplying and adding the energy spectrum with the filter output corresponding to each dot, the calculation formula of the Mel spectrogram is given by the following formula:

$$MclSpec(n) = \sum_{l=g(n-1)}^{g(n+1)} F_n(l) * \left|A(l)\right|^2 \tag{8}$$

4 Construction of the bilingual class student emotion recognition model

In this paper, bi-linear CNN was adopted to extract the fine-grained features of the spectra corresponding to the recording signals of student speech in the bilingual class, the effect of spectrum texture recognition was good, which can be used for the emotion classification and recognition of different language speech signals. Figure 1 gives the structure of bi-linear CNN. Assuming: g_x and g_y represent the feature functions extracted by different convolution kernels; E represents the pooling operation; D represents the speech signal emotion classification function, then the bi-linear CNN model can be written as $G=(g_x, g_y, E, D)$.

Feature function $g(h)$ can map spectrum F corresponding to the input recording signals and its position K to into a feature with a size of $d \times C$, which satisfies the function mapping relationship of $g{:}K \times F \rightarrow R^{d \times C}$. In order to attain the effective bi-linear convolution features, the different features of spectra corresponding to the input recording signals at a same position were combined through the outer product operation of the matrix. Assuming: Y represents the bi-linear operation, then there is:

$$Y(k, I, g_x, g_y) = g_x(k, I)^T g_y(k, I) \tag{9}$$

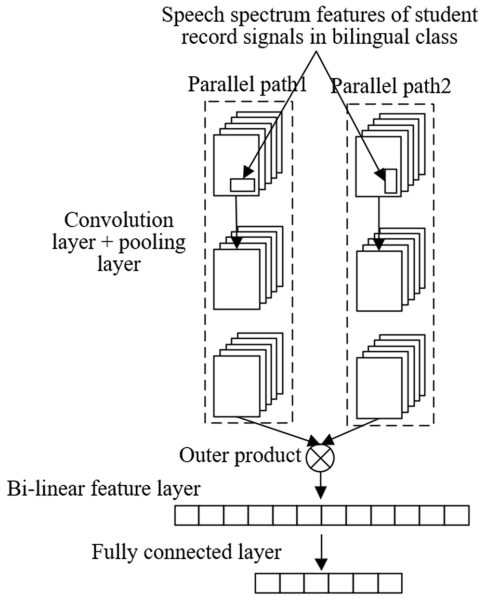


Fig. 1. Structure of bi-linear CNN

Because for different types of languages, there will be large differences in the expression of a same emotion, so when recognizing the emotions in the speech signals containing two kinds of languages, there might be differences in the extracted features in terms of size, direction, and state. Although the convolution operation of CNN can extract more subtle matrix features based on the attained emotion features of recording signals, it cannot deal with the changes in above features, and the emotion recognition effect will be greatly affected, so in order to make up for the defect of CNN, this paper introduced the capsule network.

Capsules in the capsule network transmit in the form of vectors, the probability and attribute of the emotion features of recording signals are respectively characterized by the length and dimension values of the vectors. For the recording signals being detected, if the corresponding spectrum and its position or state undergoes changes, then it can be considered that only the vector direction has changed, and the vector length hasn't changed.

Assuming: q_i represents the transition matrix, then the vector of the extracted fine-grained features of the spectrum corresponding to the recoding signals was multiplied by q_i to get the vector that can be recognized by the capsules in the capsule network, the formula is:

$$v_i = q_i x_i \tag{10}$$

Different capsule vectors need to be assigned with different weights, the expression of weight d_i is given by the following formula:

$$d_i = softmax\,(y_i) \tag{11}$$

The weighted vector r can be expressed as:

$$r = \sum_i d_i v_i \tag{12}$$

Because the value range of the probability of emotion features of recording signals is [0,1], this paper introduced a squashing function to compress the capsule vector length that represents this parameter, and the formula is:

$$u_i = \frac{\|r\|^2}{1+\|r\|^2}\frac{r}{\|r\|} \tag{13}$$

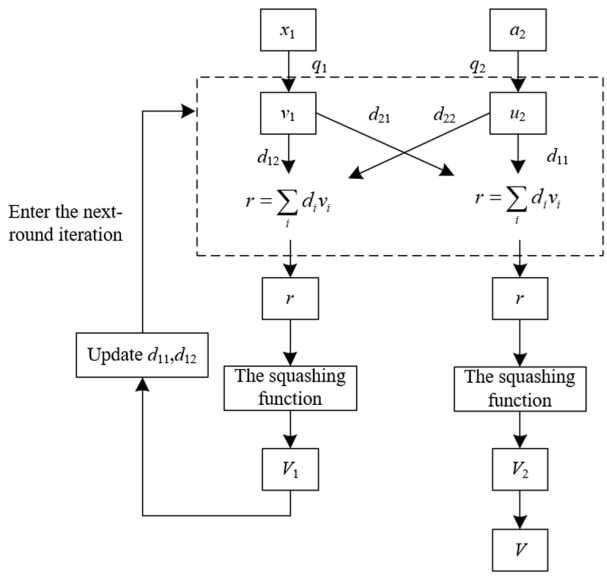


Fig. 2. Flow of the dynamic routing algorithm

The calculation results of the above formula were updated based on the dynamic routing algorithm. Figure 2 shows the flow of the dynamic routing algorithm. If the algorithm terminates, then the final result u_i is output; if the algorithm does not terminate, then y_i is updated, and the algorithm enters the next-round iteration, the following formula gives the calculation formula of y_i:

$$y_i^* = y_i + v_i u_i \tag{14}$$

When a certain emotion feature appears in the feature spectrum corresponding to the recording signals, then the final output of the capsule network is an instantiated vector that represents the probability of the occurrence of the emotion feature, and the length of the vector should be relatively long. The following formula gives the expression of edge loss function K_l used for student emotion recognition:

$$K_l = O_l max\left(0, n^+ - \|u\|^2\right) + \mu(1 - O_l) max\left(0, \|u\| - n^-\right)^2 \tag{15}$$

If a student emotion is recognized as the l-th type, then O_l=1; otherwise, O_l=0. n^+ and n^- were used to limit the length of the vector, and their values were 0.9 and 0.1. In order to reduce the loss of recognition when the student emotion type does not exist, μ was set to 0.5.

After the speech spectrum features corresponding to the recoding signals of students in bilingual class were constructed, this paper combined the bi-linear CNN with capsule network to construct a combination model, the bilingual class student emotion recognition model, as shown in Figure 3, the bi-linear CNN can further attain the features of the speech spectrum textures corresponding to the recoding signals to improve the accuracy of emotion recognition, and the capsule network had made up for the defect that the CNN cannot deal with the changes of features in size, direction, and state.

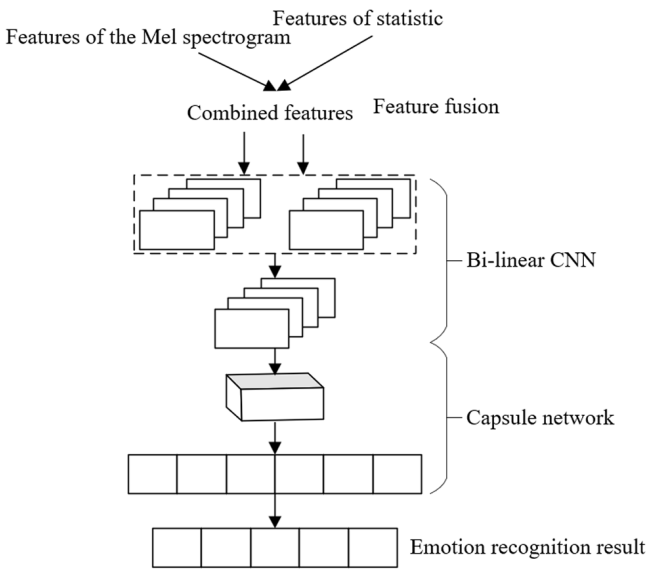


Fig. 3. Structure of the combination model of bilingual class student emotion recognition

The features of the Mel spectrogram corresponding to the recording signals of student speech in bilingual class and the features of statistic were fused to generate the combined features with time series attribute. The two parallel paths in the bi-linear CNN then performed convolution and pooling operations on the combined features for multiple times, and the deep-level features of the recording signals were attained. Next, after the outer product processing, the deep-level features were input into the capsule network, and eigenvectors representing the probability and attribute of the emotion features of the recording signals were judged to attain the ultimate correct recognition results of the emotions of students in the bilingual class.

The fusion of the features of the Mel spectrogram corresponding to the recording signals of student speech in bilingual class and the features of statistic has a large impact on the quality of the extracted features. The specific steps of feature fusion are:

Step 1: The recording signals were converted into a Mel spectrogram feature matrix with a size of $m*n$, wherein m and n are respectively the frequency length and time length of the matrix.

Step 2: The features of the frame-statistic of the recoding signals were extracted to attain a m_1*n feature matrix, wherein m_1 and n respectively correspond to the feature number and time length.

The feature matrix of the Mel spectrogram and the feature matrix of the statistic were fused according to time series to generate a combined feature matrix with a dimension of $(m+m_1)*n$. Assuming: r_{ij} and K_{ij} respectively represent the vector of the j-th segment of the i-th Mel spectrogram and the i-th frame-statistic feature, then there is:

$$w_{ij} = [r_{ij}, K_{ij}] \tag{16}$$

5 Experimental results and analysis

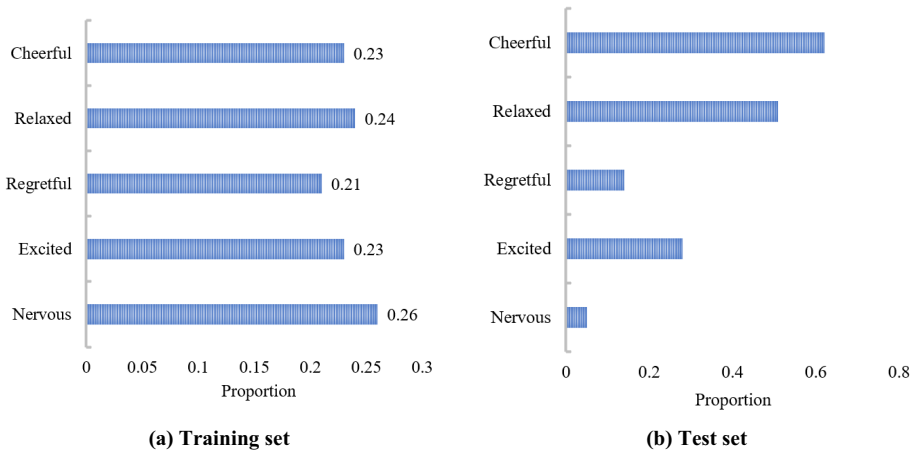


Fig. 4. Distribution of emotion type samples of the training set and test set

Proportions of the emotions in the training sample set and test sample set of the recording signals of students in the bilingual class are given in Figure 4a and b, the emotions contain five types: cheerful, relaxed, regretful, excited, and nervous.

Table 1. Student emotion recognition results of different networks

Emotion Recognition Model	*IPL* Features	Mel Spectrogram Features	Statistic Features	Combined Features
VGG16	75.62%	71.92%	71.6%	75.4%
Resnet34	70.9%	71.4%	77.9%	80.9%
SVM	74.6%	77.3%	70.7%	76.2%
LSTM	79.3%	76.9%	73.4%	73.4%
Residual network	85.7%	83.1%	88.7%	85.9%
The proposed model	80.4%	87.4%	89.4%	92.7%

Table 2. Confusion matrix of student emotion recognition numbers corresponding to Mel spectrogram features

	Cheerful	Relaxed	Regretful	Excited	Nervous
Cheerful	36	2	1	4	7
Relaxed	2	25	8	3	5
Regretful	4	1	17	2	4
Excited	7	2	6	28	6
Nervous	2	9	1	6	29

Table 3. Confusion matrix of student emotion recognition numbers corresponding to combined features

	Cheerful	Relaxed	Regretful	Excited	Nervous
Cheerful	36	2	7	4	5
Relaxed	6	22	9	5	1
Regretful	8	5	28	3	7
Excited	3	8	6	29	4
Nervous	8	4	2	1	26

The final student remotion recognition results are shown in Table 1. According to the table, compared with other five types of emotion recognition models, the proposed model that fused the features of the Mel spectrogram and the frame-statistic exhibited better recognition effect, and it can further improve the accuracy of emotion recognition of different students in the bilingual classroom environment.

To further verify the effectiveness of the feature fusion processing of the Mel spectrogram and the frame-statistic, this paper designed comparative experiments, and Tables 2 and 3 respectively give the confusion matrix of student emotion recognition numbers corresponding to Mel spectrogram features, and the confusion matrix of student emotion recognition numbers corresponding to combined features. By comparing the two tables, it's known that the combined features can effectively and correctly classify the five types of student emotions in the bilingual class. More intuitively, according to the comparison of student emotion recognition rate for different features shown in Figure 5, the combined features had improved the recognition rate of the five types of student emotions to a certain extent.

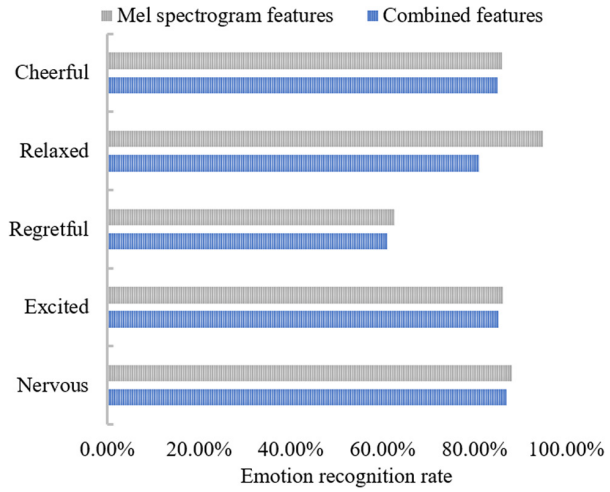
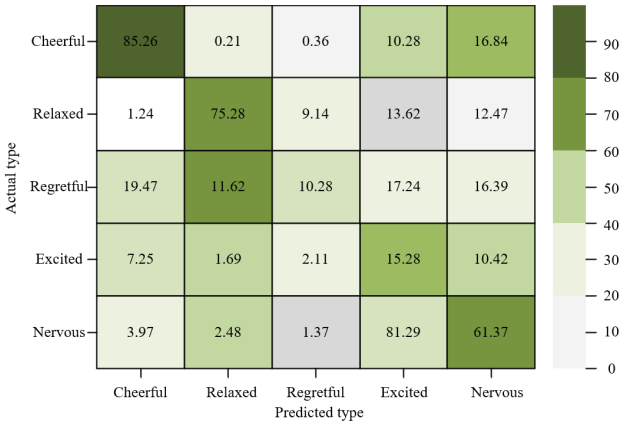
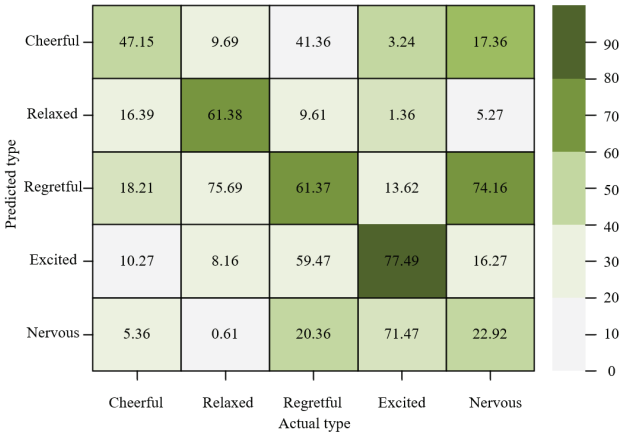


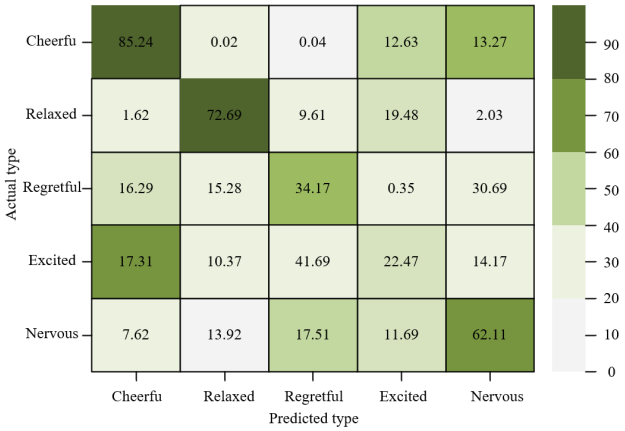
Fig. 5. Comparison of student emotion recognition rate for different features



(a) English



(b) English+Chinese



(c) German+Chinese

Fig. 6. Confusion matrixes of speech emotion recognition model under monolingual and bilingual conditions

To verify the applicability of the bilingual class student emotion recognition model constructed in this paper to different language samples, this paper took the English, English+Chinese, and German+Chinese classes as examples to carry out related experiments, and Figure 6 gives the experimental results. By observing the three confusion matrixes corresponding to English, English+Chinese, and German+Chinese classes, we can know that, based on the extracted features of bilingual speech signal spectra, the proposed model achieved ideal recognition rate of student emotions, that is, the model can well capture the features of emotion factors that are not significant enough, which had further verified the effectiveness of the proposed model. Based on the output of this model, teachers can adjust their teaching strategies in time to promote the interaction between teachers and students in bilingual class.

6 Conclusion

This paper studied emotional responses of students in bilingual class based on emotional analysis and the adjustment strategies. At first, this paper preprocessed the recording signals of bilingual class and converted the one-dimensional features of the recording signals into 2-dimensional speech spectrum features to attain more useful information and to facilitate the recognition of student emotions in the bilingual class. Then, this paper combined the bi-linear CNN with capsule network to construct a combination model for recognizing emotions of students in the bilingual class. After that, the experimental results of student emotion recognition of different networks proved that the proposed model outperformed other five emotion recognition models in terms of recognition effect. The confusion matrix of student emotion recognition numbers corresponding to Mel spectrogram features, and the confusion matrix of student emotion recognition numbers corresponding to combined features were given, which had further verified the effectiveness of the feature fusion processing of the Mel spectrogram and the frame-statistic. At last, the confusion matrixes of speech emotion recognition model under monolingual and bilingual conditions were given, which had verified the applicability of the bilingual class student emotion recognition model constructed in this paper to different language samples.

7 References

[1] Walifa, R.K. (2020). The effect of stressful factors, locus of control and age on emotional labour and burnout among further and adult education teachers in the U.K. International Journal of Emerging Technologies in Learning, 15(24): 26–37. https://doi.org/10.3991/ijet.v15i24.19305

[2] Walifa, R.K. (2020). The influence of policy on emotional labour and burnout among further and adult education teachers in the U.K. International Journal of Emerging Technologies in Learning, 15(24): 232–241. https://doi.org/10.3991/ijet.v15i24.19307

[3] Wang, S.Y. (2021). Online learning behavior analysis based on image emotion recognition. Traitement du Signal, 38(3): 865–873. https://doi.org/10.1134/S105466182103024X

[4] Cui, L.L., Kong, W.G., Sun, Y.M., Shao, L. (2022). Expression identification and emotional classification of students in job interviews based on image processing. Traitement du Signal, 39(2): 651–658. https://doi.org/10.18280/ts.390228

[5] Zhang, Z., Li, Y., Sun, S., Tang, Z. (2022). Intervention effect of group counseling based on positive psychology on psychological crisis of college student. Computational Intelligence and Neuroscience, 2022: 3132016. https://doi.org/10.1155/2022/3132016

[6] Jiang, L., Zhang, Y. (2022). Prediction and influencing factors of big data on college students' positive psychological quality under mobile wireless network. Mobile Information Systems, 2022: 4344747. https://doi.org/10.1155/2022/4344747

[7] Yao, R. (2021). Construction of bilingual teaching hierarchy model based on flipping classroom concept. In International Conference on Data and Information in Online, Hangzhou, China, pp. 421–425. https://doi.org/10.1007/978-3-030-77417-2_34

[8] Guo, J., Cong, X., Miao, Z., Feng, Z., Yang, E. (2021). Research and practice on bilingual teaching method of applied talents training based on flipped classroom teaching mode. In 2021 2nd International Conference on Big Data and Informatization Education (ICBDIE), Hangzhou, China, pp. 591–594. https://doi.org/10.1109/ICBDIE52740.2021.00140

[9] Palacios-Hidalgo, F.J. (2020). Video-based analysis of pre-service primary bilingual teachers' perceptions about the inclusion of gender and LGBT+ issues in the EFL classroom. In 2020 Sixth International Conference on E-Learning (Econf), Sakheer, Bahrain, pp. 110–114. https://doi.org/10.1109/econf51404.2020.9385471

[10] Xia, W., Zhang, Z., Guo, C. (2019). Novel education technology may derive from personal genome data: A language gene polymorphism site potentially associated with translation-writing errors in a bilingual classroom of Chinese students. In Proceedings of the 2019 International Conference on Modern Educational Technology, New York, United States, pp. 45–48. https://doi.org/10.1145/3341042.3341067

[11] Suárez, E., Otero, V. (2014). Leveraging the cultural practices of science for making classroom discourse accessible to emerging bilingual students. Boulder, CO: International Society of the Learning Sciences, 2: 800–807. https://doi.dx.org/10.22318/icls2014.800

[12] Ren, X., Han, J., Hu, D. (2011, August). Reform and Practice on Bilingual Classroom Instruction Patterns in Professional Courses Based on Web Resources. In International Conference on Computer Science, Environment, Ecoinformatics, and Education, Wuhan, China, pp. 122–126. https://doi.org/10.1007/978-3-642-23339-5_22

[13] Zhang, L. (2010). Classroom bilingual teaching quality standards system based on Delphi method and AHP. In 2010 International Conference on E-Health Networking Digital Ecosystems and Technologies (EDT), Shenzhen, China, pp. 152–155. https://doi.org/10.1109/EDT.2010.5496488

[14] Van Laere, E., Agirdag, O., van Braak, J. (2016). Supporting science learning in linguistically diverse classrooms: Factors related to the use of bilingual content in a computer-based learning environment. Computers in Human Behavior, 57: 428–441. https://doi.org/10.1016/j.chb.2015.12.056

[15] Bovo, R., Callegari, E. (2009). Effects of classroom noise on the speech perception of bilingual children learning in their second language: Preliminary results. Audiological Medicine, 7(4): 226–232. https://doi.org/10.3109/16513860903189499

[16] Bourguet, M.L. (2006). Introducing strong forms of bilingual education in the mainstream classroom: A case for technology. In Sixth IEEE International Conference on Advanced Learning Technologies (ICALT'06), Kerkrade, Netherlands, pp. 642–646. https://doi.org/10.1109/ICALT.2006.1652523

[17] Su, C., Wang, G. (2020). Design and application of learner emotion recognition for classroom. In Journal of Physics: Conference Series, 1651(1): 012158. https://doi.org/10.1088/1742-6596/1651/1/012158

[18] Liang, Y. (2019). Intelligent emotion evaluation method of classroom teaching based on expression recognition. International Journal of Emerging Technologies in Learning, 14(4): 127–141. https://doi.org/10.3991/ijet.v14i04.10130
[19] Putra, W.B., Arifin, F. (2019). Real-time emotion recognition system to monitor student's mood in a classroom. In Journal of Physics: Conference Series, 1413(1): 012021. https://doi.org/10.1088/1742-6596/1413/1/012021
[20] Liang, K.J., Zhang, H.J., Liu, Y.Q., Zhang, Y., Wang, Y.Y. (2022). Classroom speech emotion recognition based on multi-channel convolution and SEnet network. In Artificial Intelligence in China, pp. 242–248. https://doi.org/10.1007/978-981-16-9423-3_30
[21] Li, M., Liu, M., Jiang, Z., et al. (2022). Multimodal emotion recognition and state analysis of classroom video and audio based on deep neural network. Journal of Interconnection Networks, 22(S4): 2146011. https://doi.org/10.1142/S0219265921460117
[22] He, J., Peng, L., Sun, B., Yu, L., Guo, M. (2021). Dual multi-task network with bridge-temporal-attention for student emotion recognition via classroom video. In 2021 International Joint Conference on Neural Networks (IJCNN), Shenzhen, China, pp. 1–8. https://doi.org/10.1109/IJCNN52387.2021.9533471
[23] Lei, L., He, Y., Li, X., Yu, S., Yin, Y., Qin, L., Liang, M. (2021). Classroom facial emotion recognition based on channel attent. In 2021 IEEE International Conference on Emergency Science and Information Technology (ICESIT), Chongqing, China, pp. 419–423. https://doi.org/10.1109/ICESIT53460.2021.9697038
[24] Liang, J., Zhao, X., Zhang, Z. (2020). Speech emotion recognition of teachers in classroom teaching. In 2020 Chinese Control and Decision Conference (CCDC), Hefei, China, pp. 5045–5050. https://doi.org/10.1109/CCDC49329.2020.9164823

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Development of the Hands-free AI Speaker System Supporting Hands-on Science Laboratory Class: A Rapid Prototyping

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Abstract—The recent progress of natural language processing (NLP), speech recognition, and speech generation envision using hands-free artificial intelligence (AI) speakers in classrooms to support student learning. In science education, conventional hands-on laboratory education has been considered crucial in fostering students' manipulative experimentation skills. However, touching things with gloved hands other than experimental equipment and apparatuses is strictly restricted because of the safety issue, which calls for another channel to get timely support. Therefore, we ideated that adopting hands-free AI speakers in the hands-on science laboratory classroom would support student learning. Using the rapid prototyping method, we designed and developed an AI speaker-based system that answers student queries concerning solution-making, experimental processes, and waste liquid disposal, corresponding to the initial, middle, and final phases of a laboratory class. The system was internally validated by usability tests of 9 expert panels and 18 university students and then revised. The revised system was externally validated in an analytical chemistry experiment class for 3 sessions with 13 university students. We present the result of the prototype development and internal and external validations with quantitative and qualitative data. The AI speaker system enabled students to use the auditory learning mode in the laboratory while concentrating on the experimentation with their hands in the external validation. Future research topics were suggested.

Keywords—AI in education (AIEd), hands-free AI speaker, hands-on science laboratory class, rapid prototyping, natural language processing (NLP)

1 Introduction & background

The innovative educational research and practices to follow up the rapidly changing contemporary world are now supported by Artificial Intelligence (AI) technologies [1]. The Natural Language Processing (NLP) technology has explosively grown due to the deep learning algorithms [2], which are relevant to converting human speech to text (STT; or speech recognition, SR) and text to human-like speech (text to speech, TTS; or speech generation). This technological development yielded products, services, and

platforms of AI-based smart speakers, such as Microsoft Cortana, Apple Siri, Amazon Alexa and Google Home [3]; and they are more and more integrated into our daily lives.

For decades, scholars have insisted that the AI in Education (AIEd) will bring innovations in teaching and learning and suggested their framework for its roles [4–6]. Although there can be many frameworks of visions for AIEd, its epitome seems clear: the AI comes into the classroom where there are instructors and students, changes the processes of learning, reducing instructors' burdens for repetitive work and allowing them to engage with more valuable teaching behavior, and supporting student learning in cognitive, affective, or any other learning modes (based on [6–8]).

However, there seems that there has not been much empirical research on the possibilities of AI Speakers in Education (AISEd), and there is still a need for explorative studies on its utility in being an intelligent agent to answer students' questions based on natural languages. (cf. [9]) Some innovative research on AISEd has focused on the possibility of native language or English education [6, 10–11]. Nevertheless, it seems that there has been little research that incorporated AI speakers into the science classroom.

Science education has emphasized the 'hands-on' laboratories science 1980s [12]. In the usual hands-on science laboratory class, students gather weekly in the lab and conduct an experiment to get data, which is interpreted in light of scientific theories. And the important learning mode in the so-called hands-on laboratory class is kinesthetic [13] as they are expected to foster experimentation skills [14–15]. Students manipulate apparatuses and equipment such as beakers and other glassware, pipettes, pH meter, UV-VIS spectrometers, and treat reagents that need caution to avoid accidents [16]. Therefore, strict safety rules compel students to wear latex gloves, goggle, and lab coats and not allow them to touch non-experimental items with gloved hands, such as door handles, elevator buttons, smartphones, laptops and even lab notes (see [17]).

Consequently, in principle, students cannot freely access the information they need during the experiment and cannot help but ask TA frequently. Here, the 'hands-free' characteristic of the AI speaker stands out – as a user need not use their hands to operate it but verbally calls a system to get the information they require, students in a science laboratory class will also benefit from it, without mitigating the safety rules. Therefore, the need for empirical research that implements AI speakers in an authentic laboratory teaching and learning site arise.

In this study, the researchers took the design and development (D&D) research approach for the hands-free AI speaker system supporting a hands-on science laboratory class. As the product of this research is a novel instructional tool, the rapid prototyping (RP) method that acquires user feedback for revision before the final field test would be helpful. Throughout the development and evaluation of the AI speaker system, the researchers would investigate its merits based on the responses of experts in AI, educational technology, and science education, and university students. And further, the current status, limitations, and future directions for the AI speaker system in the science laboratory class will be discussed.

2 Research questions

1. How the prototype of the hands-free AI speaker system supporting a hands-on science laboratory class is developed using the RP approach?
2. How was the result of the internal validation of the prototype of the hands-free AI speaker system supporting a hands-on science laboratory class?
   2.1. What were the responses from experts?
   2.2. What were the responses from university students?
3. How was the result of the external validation of the prototype of the hands-free AI speaker system supporting a hands-on science laboratory class? (what were the responses from university students who experienced the system in the authentic science laboratory classroom?)

3 Method

3.1 Design and development research

D&D research is "the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for the creation of instructional … tools" [18]. D&D research is categorized as follows – Type I: Product & tool research and Type II: Model research [18]. As the former is relevant to this study, we focused on the specific product and yields context-specific lessons learned from developing it and analyzing the conditions for its optimal use [19].

3.2 Rapid prototyping approach

This study took an RP approach [20–21]) to develop a hands-free AI speaker system supporting hands-on laboratory classes. As the RP involves the typical stages of analysis, design, development, implementation, and evaluation (ADDIE) while emphasizing the formative evaluation and iterative process [22], we followed the generic steps.

3.3 Research field

The research field of this study was Hankuk University (pseudonym), located in Seoul, Republic of Korea. Two considerations arose from the characteristics of the research field: (1) As the STT technology of the Korean language is behind that of the English language, the performance of the AI speaker also reflects its current level. (2) Most student participants in this study were enrolled in the Department of Chemistry Education – i.e., most of them were pre-service chemistry teachers.

3.4 The ADDIE process

Need analysis and design of the AI speaker system. The researchers of this study consisted of one expert, one doctoral candidate, and three master's students of chemistry

education. They all had a teacher's license for secondary chemistry. They had years of university laboratory teaching experience.

As a need analysis, the researchers reviewed literature related to the characteristics of hands-on science laboratory education (e.g. [12, 14–15]) to analyze the need for the AI speaker system for hands-on laboratory classes (cf. [23]). And they preliminarily asked several pre-service chemistry teachers what functions of the AI speaker system would help them take laboratory classes. As a result, the researchers concluded that a supporting tool for hands-on science laboratory class should reduce the instructors' repeated work and promote student learning, particularly for necessary but repetitive work in the laboratory class – i.e., solution-making, checking experimental procedures and disposing of liquid waste according to safety rules. The three functions of the AI speaker system derived from those needs are presented in Table 1. And the overall conceptual flow chart for the system is illustrated in Figure 1.

Table 1. Summary of three functions of hands-free AI speaker system supporting hands-on science laboratory class

Function	Target Phase of the Laboratory Class	Need	References
(1) Solution-making helper	The beginning	– Students must calculate the amount of reagent needed to make various kinds of solutions using complex formulas.	[24–27]
(2) Experimental process helper	The middle	– Students repeatedly check that they are proceeding well according to the experimental procedure. – Students frequently question the reason and issues of a certain procedure.	[28–30]
(3) Liquid waste disposal helper	The end	– Students must dispose of liquid wastes into each safety container according to their property.	[31–33]

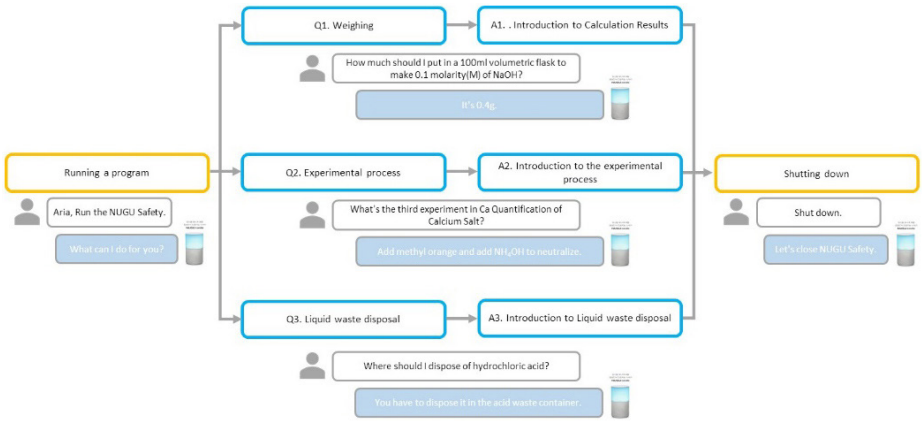

Fig. 1. Conceptual flow chart (scenario) of the AI speaker system supporting hands-on laboratory

The NUGU platform required the AI speaker to be connected online to receive a signal from the servers. Therefore, it was considered that the AI speaker should be connected to the Wi-Fi as a network environment. If the Wi-Fi speed increases, the time required to SR, NLP, and respond to user articulation would decrease. Therefore, the network environment had to be accessible to high-speed Wi-Fi.

Meanwhile, the user-AI speaker interface was designed. As most AI speaker platform provides a Q&A system with alternate articulation between the user and the speaker, this study followed the structure. The three functions were initially designed to have a single-turn conversation – i.e., the user asks a speaker a question in a sentence and the speaker answers for that. While designing and testing function 1, the need for error handling arose while the function needed to recognize three parameters from the user's speech. Therefore, the researchers took a multi-turn approach to recognize a parameter from the user's single articulation.

Development of the prototype. We developed the prototype of the AI speaker system upon the NUGU AI speaker platform serviced by SK Telecom Co., Ltd. In the platform, entity means a developer-defined category of word tokens; intent implies the user's intention while speaking to the AI speaker, inferred by a combination of entities; and action means the AI speaker's response matched with each intention. We defined the required entities, intents, and actions in the NUGU Player Builder (Figure 2). The examples of entity, intent, and action for each function are presented in Figure 3. And we trained the natural language understanding (NLU) model in the NUGU platform by inputting several word tokens for an entity and dozens of sentences that include a combination of entities for an intent. The actions of *function 2* and *function 3* were directly saved in the Play. Meanwhile, the external proxy server was connected to *function 1* in the JSON format using Python Flask to calculate the amount of reagent.

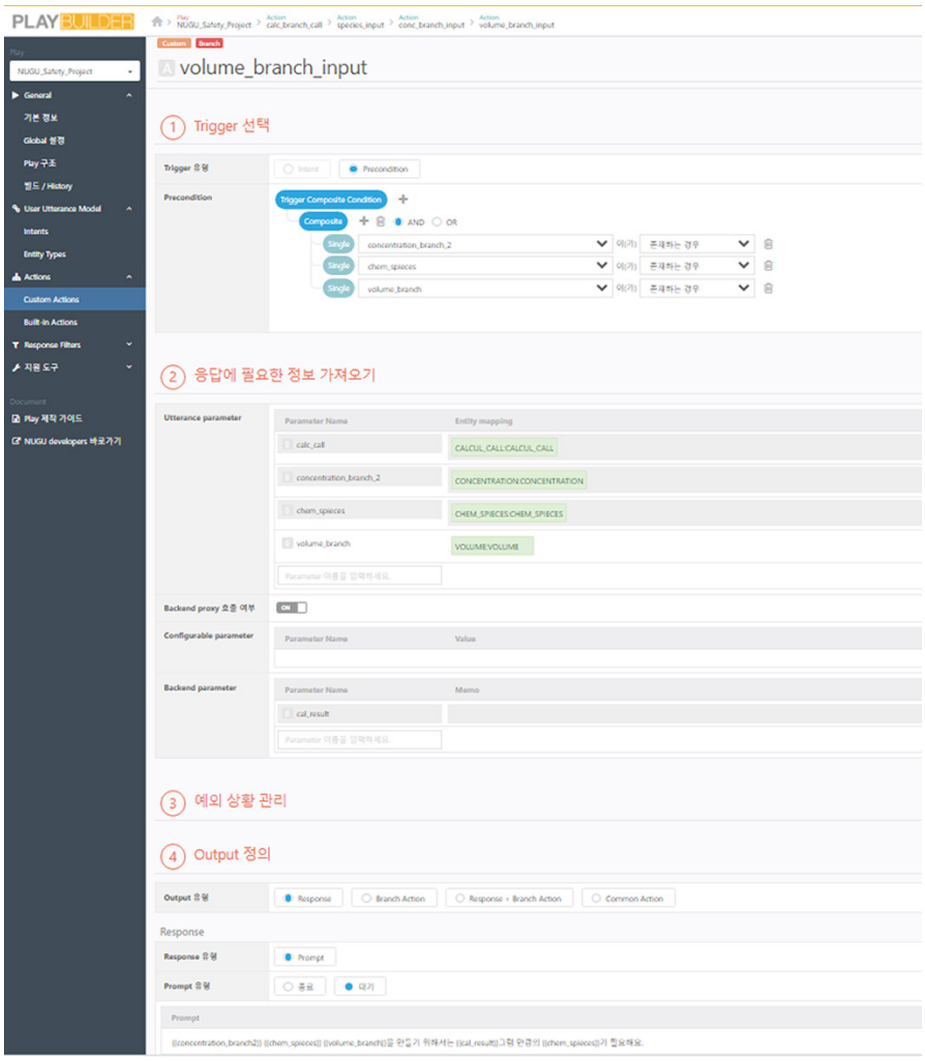

Fig. 2. Example of the development on the NUGU play builder

Function	Intent (user speech)	Entity (word token)	Action (AI speaker speech)
(1) Solution-making helper	- CALCULATION_BRANCH_CALL: "I want to **make** a solution." (multi-turn conversation starts) (1) SPECIES_INPUT: "**sodium hydroxide**" (2) CONCENTRAION_BRANCH_INPUT: **0.1M**" (3) VOLUME_BRANCH_INPUT: **100 milliliters**"	- MAKE: make, produce - CHEM_SPIECES: NaOH, Sodium hydroxide - CONCENTRATION: 0.1M, 0.1mol, 0.1 molarity - VOLUME: 100mL, 100 milliliters, one hundred milliliters - HOW_MUCH: how much, how many, how, to what amount - GRAM: gram, grams	- CALCULATION_BRANCH_CALL: "What reagent are you going to use?" (multi-turn conversation starts) (1) SPECIES_INPUT: "How much molarity will you make?" (2) CONCENTRATION_BRANCH_INPUT: "How many milliliters of volumetric flask are you going to use?" (3) VOLUME_BRANCH_INPUT: "To make **100 milliliters** of **0.1M** of **sodium hydroxide** solution, you need **{{CALCULATION_RESULT}}*** of NaOH."
(2) Experimental process helper	- PROCEDURE_ASK: "What is **the second process** of **$HClO_4$ solution standardization** experiment?"	- HCLO_TITRATION: $HClO_4$ solution standardization, perchloric acid solution standardization - PROCEDURE_TWO: second process, second step, the second process, second	- PROCEDUER_RESPONSE: "**The second process** of **$HClO_4$ solution standardization** is to dissolve KHP solution with acetic acid in a 100-milliliter volumetric flask."
	- ENDPOINT_CALL**: "How does the color change at the **endpoint** ~~in the titration~~ experiment?" - CAUTION_CALL**: "What should I **be careful** about in today's experiment?"	- ENDPOINT: endpoint, end point, equivalence point - TITRATION: titration - CAUTION: caution, points to note, be careful	- ENDPOINT_RESPONSE: "The indicator will turn purple to blue when titration is done." - CAUTION_RESPONSE: "The experiment manual has changed, so we have to put 15 milliliters of KHP solution in the process of number 2 of HClO4 solution standardization today. And be careful with acidic solutions because today's experiment is non-aqueous titration."
(3) Liquid waste disposal helper	- ACID_DISPOSAL: "Where do you throw **nitric acid**?" - BASE_DISPOSAL: "What kind of waste liquid is **sodium hydroxide**?" - ORGANIC_DISPOSAL: "Where do you throw **methyl orange**?" - INORGANIC_DISPOSAL: "What kind of waste liquid is **arsenic trioxide**?" - NEUTRAL_DISPOSAL: "Where do you throw **sodium bicarbonate**?"	- ACID: vitamin C, nitric acid, perchloric acid, chloric acid - BASE: sodium hydroxide, ammonium hydroxide, methyl violet - ORGANIC: ammonium oxalate, methyl orange, sodium acetate - INORGANIC: arsenic trioxide, potassium iodide, potassium permanganate, iodine - NEUTRAL: starch, sodium bicarbonate	- ACID_DISPOSAL: "Throw **nitric acid** in acid liquid waste container." - BASE_DISPOSAL: "**Sodium hydroxide** is alkali." - ORGANIC_DISPOSAL: "Throw **methyl orange** in organic liquid waste container." - INORGANIC_DISPOSAL: "**Arsenic trioxide** is inorganic substance." - NEUTRAL_DISPOSAL: "You can throw **sodium bicarbonate** away in the sink."

{{}}: Denotes parameter

*: The value of {{CALCULATION_RESULT}} is returned from the external server connected to the Play ; **: Added after the formative assessment of the prototype (internal validation)

Dotted arrows (-->): Signifies the flow of conversation in the multi-turn conversation. ; Arrows (→): Signifies that the recognized work token from the user's articulation is transferred to the AI speaker's articulation.

Fig. 3. The corresponding structure of user intents, entities, and actions in the AI speaker system

Internal validation as a formative evaluation. The researchers shot a video that shows a person using the AI speaker prototype with three functions in sequence. In the video, a person awakes the system and asks the speaker how to make a specific solution (*function 1*), what is the first or second step of the experimental procedure (*function 2*), and where to dispose of a couple of kinds of waste liquids (*function 3*), and finally ends the session. The video was about 2 minutes long.

The participants of the internal validation consisted of two groups: the expert review panel and the student group. The expert review panel consisted of nine experts from three fields – three from AI technology, three from educational technology, and three from science education. They were asked to read the documents related to the background and process of this study, watch the video, and respond to an individual interview, explicating their thoughts on the system. The student group consisted of 16 pre-service chemistry teachers, 1 in-service chemistry teacher, and 1 chemistry graduate student. Ten of the pre-service teachers were taking an Analytical Chemistry Experiment (ACE) class for the secondary pre-service chemistry teachers.

The items for the usability test were adopted from the PACMAD (People At the Centre of Mobile Application Development) usability model [34]. Further, we asked them about the pros and cons of the system and suggestions for the system revision.

External validation as a summative evaluation. We implemented the hands-free AI speaker system supporting a hands-on science laboratory class. The research field was the ACE class at Hankuk University mentioned above. Thirteen university students (pre-service chemistry teachers) who took the course participated in the study.

While revising the AI speaker system based on the results of the internal validation, the researchers implemented and observed students using each function of the system in a laboratory session (Table 2). The scene of students using the AI speaker-based laboratory class supporting system was videotaped.

Table 2. Functions of the hands-free AI speaker system supporting hands-on science laboratory class

Session	Content of Experiment	Tested Function
1	Production and standardization of $KMnO_4$ solution	Solution-making helper
2	Titration in the non-aqueous solvent	Experimental process helper
3	Iodiometric titration of Vitamin C	Liquid waste disposal helper

After the three sessions with the AI speaker system, students were asked to respond to the survey. The survey consisted of three parts: (1) The system usability scale (SUS) consisted of 10 items on a 5-point Likert scale [35]. (2) The researchers newly developed a survey to investigate students' Perceptions of an AI Speaker System in a Science Laboratory Classroom (PASS-SLC) that consisted of 18 items on a 5-point Likert scale. It was developed with reference to the previous literature on the technology acceptance model or usability of AI speakers or chatbots [36–39], and the learning outcomes of the science laboratory class [14–15]. (3) The survey included open-ended questions at the end of SUS and PASS-SLC, asking, "why did you think like that for these items?" And the survey asked students about the pros and cons of the AI speaker system and suggestions for future revision.

4 Results

4.1 The prototype of the AI speaker system supporting hands-on science laboratory class

Figure 4 represents the one-shot demonstration video of the prototype of the AI speaker system developed in this study, which is about 2 minutes long. At first, a researcher awakened the system by calling 'Aria' (the designated name of the agent in the NUGU platform) (Figure 4a and b). After the Play was loaded, a researcher requested *function 1* to *function 3* in sequence, which the speaker successfully performed (Figure 4c–v). Note that, during the multi-turn conversation in *function 1*, the speaker handled an error recognizing the VOLUME entity (Figure 3), asking the user again (Figure 4h–k). After the user finished testing all the functions, he commanded to shut down, which was realized (Figure 4w–x). The response time of the AI speaker for each articulation of the user took a couple of seconds.

4.2 Internal validation

The survey scores from the expert review panel and university students are presented in Table 3.

Table 3. The PACMAD quantitative survey result of internal validation (1–4 scale)

Category	Item	Expert (N = 9)	Student (N = 18)
User	Effectiveness	3.55 (.53)	3.29 (.69)
	Efficiency	3.44 (.73)	2.88 (.86)
	Average	3.5 (.56)	3.09 (.59)
Task	Satisfaction	3.22 (.67)	3.18 (.57)
	Learnability	3.67 (.71)	3.65 (.61)
	Average	3.44 (.58)	3.41 (.57)
Content	Memorability	3.89 (.33)	3.59 (.62)
	Error	3 (.5)	2.76 (.75)
	Cognitive load	3.78 (.5)	3.44 (.63)
	Average	3.56 (.29)	3.26 (.44)
Overall		3.51 (.3)	3.25 (.43)

Expert review panel. Experts evaluated the effectiveness of the prototype at 3.55 and efficiency 3.44, which were averaged to 3.5 in the user category. They scored the satisfaction of it at 3.22 and learnability 3.67, which were averaged to 3.44 in the task category. Finally, they scored the memorability of it at 3.89, error 3, and cognitive load 3.78, which were averaged to 3.56. The overall score of the quantitative survey from expert review panel was 3.51, which is quite positive (> 2.5) on the 4-point Likert scale.

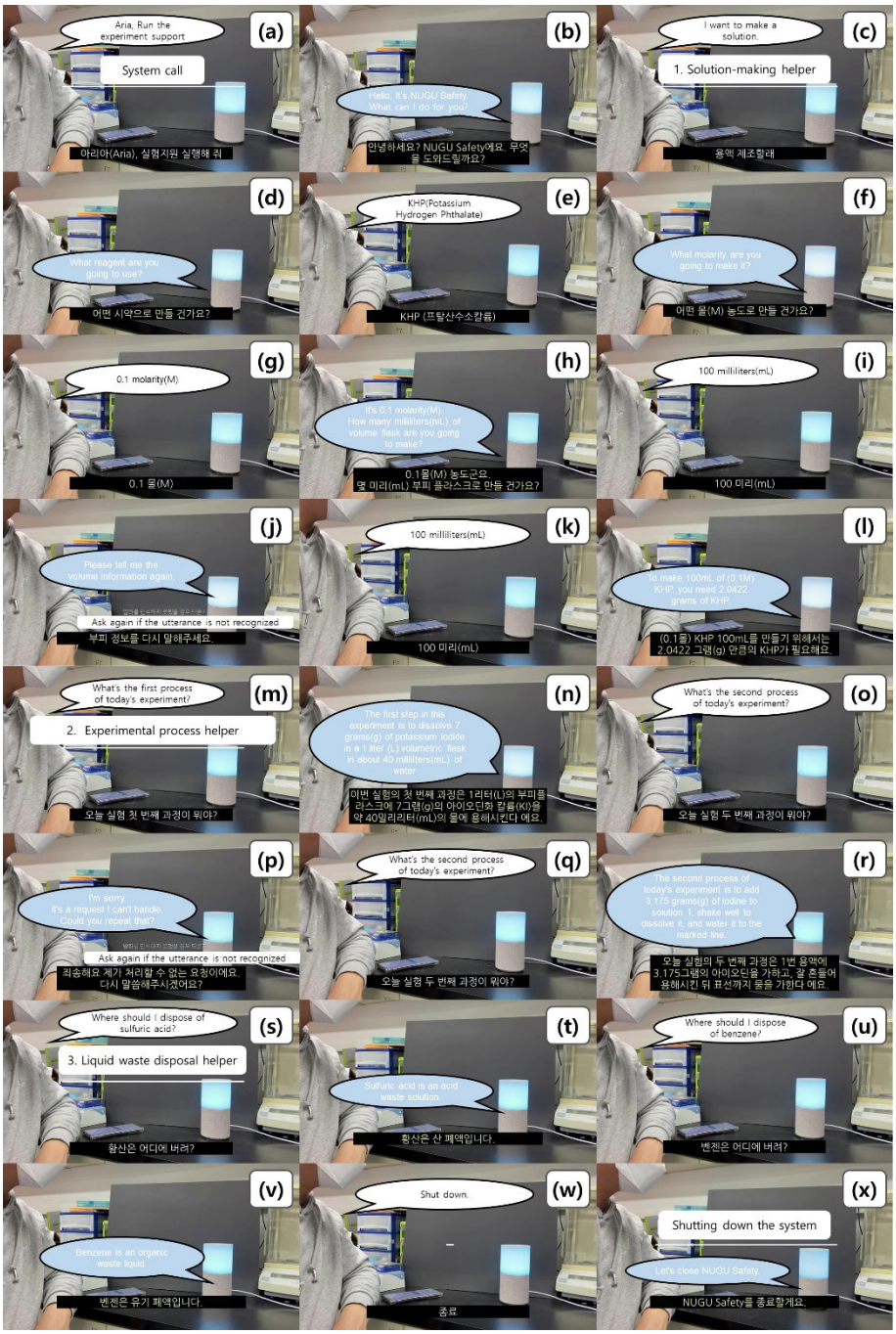

Fig. 4. Demonstration video of the prototype of a hands-free AI speaker system supporting hands-on science laboratory class

University students. University students evaluated the effectiveness of the prototype at 3.29 and efficiency 2.88, which were averaged to 3.09 in the user category. They scored the satisfaction of it at 3.18 and learnability 3.65, which were averaged to 3.41 in the task category. Finally, they scored the memorability of it at 3.59, error 2.76 and cognitive load 3.44, which were averaged to 3.26. The overall score of the quantitative survey from university students was 3.25, which is positive (> 2.5) on the 4-point Likert scale.

Suggestions for the prototype revision. In the interview, experts pointed out that the SR performance should be improved. Also, they suggested that more student questions should be recognizable to the speaker and further proposed that the scenario should be more elaborated for each function. Practically, they ideated that a brief introduction to what the speaker can provide to students is needed. Students similarly proposed processing more questions in the system, and the scenario should be more elaborated.

Consequently, the researchers were able to revise the AI speaker system before the external validation process, as follows: (1) The system awakening was simplified; (2) The number of error handling was increased for *function 1*; (2) Another entity-intent-action was added to *function 2* – providing additional tips not presented in the experiment manual (Figure 3); (3) Another entity was added to *function 3* to handle questions such as "where should I dispose of a solution after titrating I2?"; (4) More sentences were put to train the NLU model more precisely; and (5) The manual for using the AI speaker system was prepared.

4.3 External validation

Figure 5 shows the implemented AI speakers in the ACE course and the manuals provided to students.

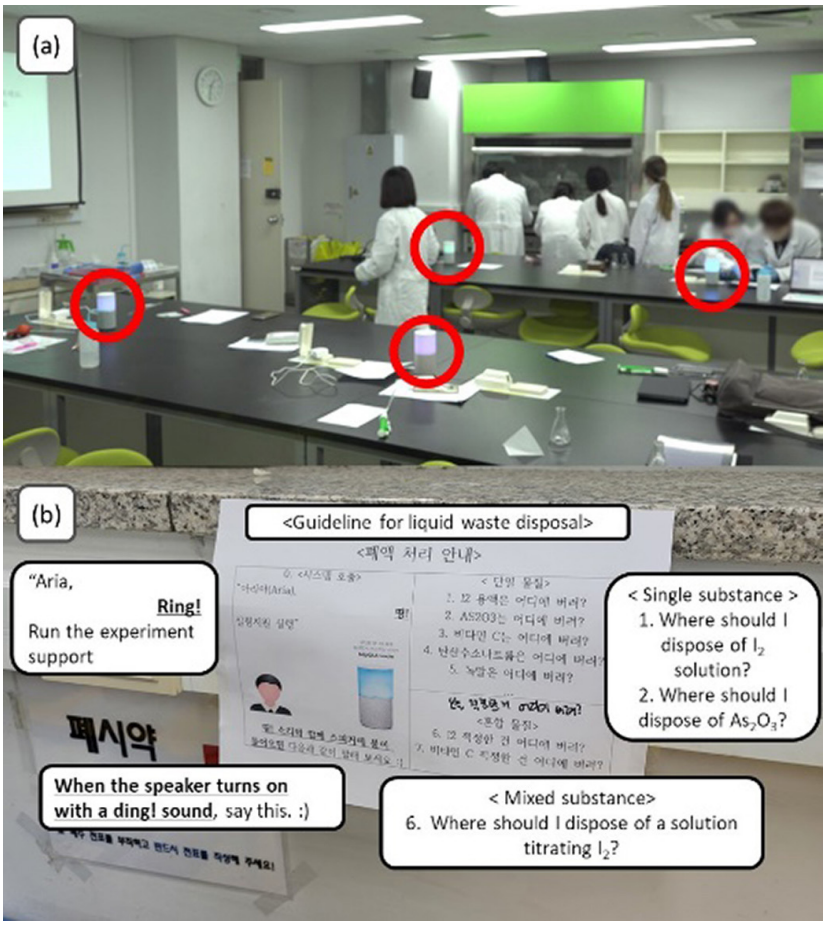

Fig. 5. AI speaker system installed in the science laboratory classroom (red circle) (a) and an example of the manual provided beside the speaker (b)

***Function 1* – solution-making helper.** At the beginning phase of the experiment, students asked the AI speaker system the amount of reagent needed to make a solution (Figure 6). First, a student called the system (Figure 6a) and requested a solution-making helper (Figure 6b). As the speaker did not catch what he had said, he bent toward the speaker to let it hear his voice clearer, which succeeded in calling *function 1* (Figure 6c). Then, the student and AI speaker made a conversation about the reagent, concentration, and volume of the solution to make a potassium permanganate solution, and consequently, the AI speaker gave the student answer to the question (Figure 6d–f). As the AI speaker was installed at the fume hood where the reagent needed to make a solution was kept, the student could make a solution according to the direction of the AI speaker.

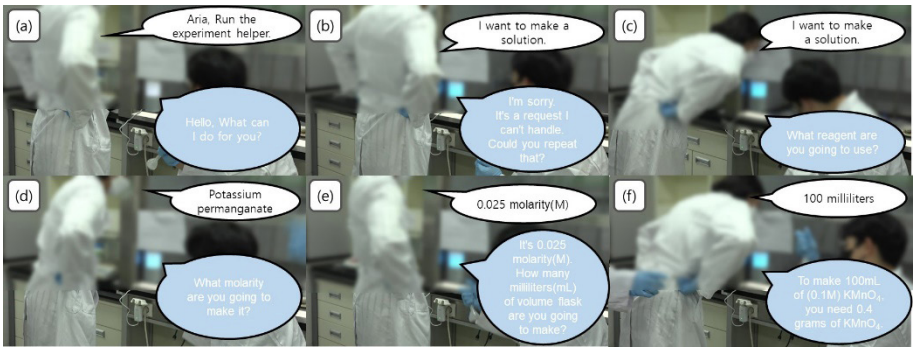

Fig. 6. The use of AI speaker *function 1* – solution-making helper

***Function 2* – experimental process helper.** At the middle phase of the experiment, students asked the AI speaker system what they should notice in the procedure. At the 'titration in the non-aqueous solvent' experiment session (Table 2), a student called the system (Figure 7a) before asking the speaker about the indicator's color change at the titration endpoint. However, at first, the AI speaker system did not detect student's saying (Figure 7b). Although the student tried again, the speaker malfunctioned and played pop music, which made the other students laugh (Figure 7c and d). It was the last time she succeeded in calling the system and got the information – the indicator changes its color from purple to blue (Figure 7e and f).

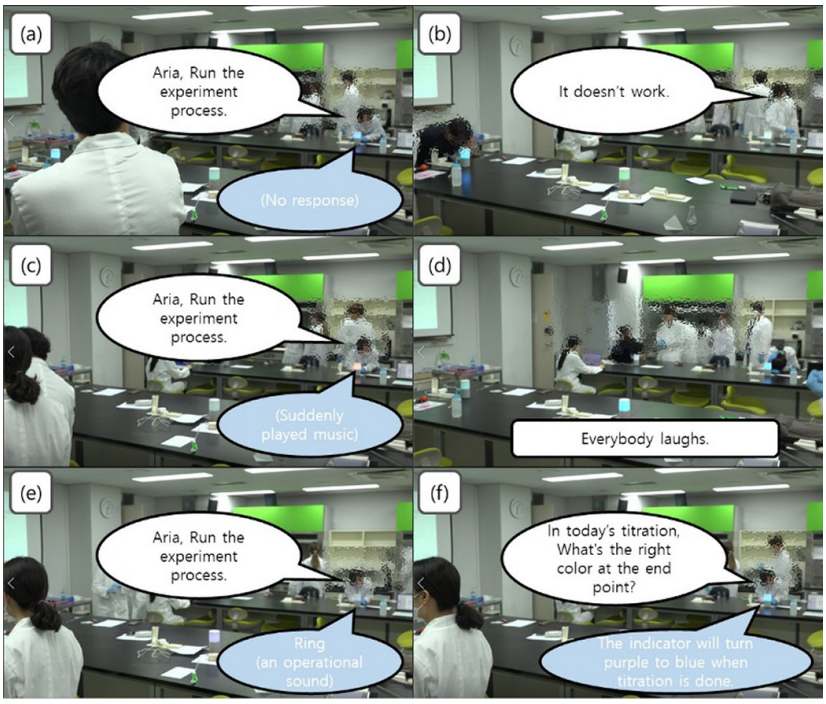

Fig. 7. The use of AI speaker *function 2* – experimental process helper

***Function 3* – liquid waste disposal helper.** At the end phase of the experiment, students asked the AI speaker system in which container (acid, base, organic, or inorganic) to dispose of certain liquid waste. In Figure 8a, a student asked a colleague where to dispose of Arsenic trioxide (As_2O_3), and in response, she suggested that they would ask it to the AI speaker system (Figure 8a). She called the system, and it responded by asking her what waste liquid she wanted to dispose of (Figure 8b). When she answered the AI speaker concerning Arsenic trioxide, the speaker gave her appropriate information – i.e., it is an inorganic waste liquid. Then she wondered, making an exclamation ("Oh~") (Figure 8d).

Fig. 8. The use of *function 3* – liquid waste disposal helper

System Usability Scale (SUS). The overall SUS score scaled to 0–100 was 63.85 (Table 4). Bangor et al. [35] reported that the mean SUS score from about 3,500 surveys from 273 studies was 69.5. Therefore, the SUS score in this study is lower than the average. Consequently, this score lies in the range of "good" SUS score with "marginal" acceptability [35]. Also, items 1 and 10 satisfied benchmark scores for average SUS studies (≥ 3.39, ≤ 2.09, respectively), and item 7 satisfied that for industrial sense (≥ 4.19) [40]. These items show the strengths of the system developed in this study.

Table 4. The SUS quantitative survey result of external validation (N = 13) (1–5 scale)

Item No.	Question	Mean [SD]
1	I think that I would like to use this product frequently.[p]	3.69 (.85)*
2	I found the product unnecessarily complex.[n]	2.54 (1.05)
3	I thought the product was easy to use.[p]	3.62 (.77)
4	I think that I would need the support of a technical person to be able to use this product.[n]	2.77 (1.17)
5	I found the various functions in the product were well integrated.[p]	3.46 (.78)

(Continued)

Table 4. The SUS quantitative survey result of external validation (N = 13) (1–5 scale) *(Continued)*

Item No.	Question	Mean [SD]
6	I thought there was too much inconsistency in this product.[n]	2.62 (1.04)
7	I imagine that most people would learn to use this product very quickly.[p]	4.31 (.75)**
8	I found the product very awkward to use.[n]	2.54 (1.05)
9	I felt very confident using the product.[p]	3 (.82)
10	I needed to learn a lot of things before I could get going with this product.[n]	2.08 (1.12)*
Overall SUS score		63.85

Notes: p: positive statements, n: negative statements; *: satisfies an average item benchmark; **: satisfies a common industrial item benchmark

In an open-ended question aligned with the SUS, students responded that the AI speaker system was "easy to use," "easy to learn," "convenient," "simple," "intuitive," or "not complex nor difficult," which elaborates their response to the item no. 3, 7, and particularly 10. Therefore, it seems that the perceived ease of usage led to students' willingness to use the AI speaker system (item 1).

Meanwhile, students responded that there are some weaknesses in the system, which are related. (1) The inflexible structure (plot) of the "command" or conversation "as written in the manual" and the number of questions they should articulate was inconvenient (seven students). (2) The SR accuracy of the AI speaker was problematic, which led to the incorrect reaction of the system (e.g., not responding, playing pop music).

Perceptions of an AI Speaker System in a Science Laboratory Classroom (PASS-SLC). The overall average score of PASS-SLC items was 3.35 (Table 5). Students responded that they could ask the speaker how they usually speak (M = 3.46) – however, the speaker did not understand their intentions well (M = 2.46). Notably, the answers from the AI speaker was easy to understand (M = 4.31), with correct information (M = 3.85), consistently (M = 4.15), and reliably M = (4.08). However, the system was not convenient compared to calculators or smartphones (M = 2.69). Although they responded that the laboratory class became safer due to the AI speaker system (M = 3.62), it was not comfortable to use the system compared to asking friends or TA (M = 2.62). They perceived that using the system did not help them gain more scientific knowledge (M = 2.23). However, the same question for the scientific skills scored higher (M = 2.85), and the question for the attitudes toward science class got a positive response (M = 3.46). It seems that it was not due to the change in the laboratory class process (M = 2.77), the roles of instructors' (M = 2.92) or students' (M = 3), nor the reduced performance time (M = 2.77). Rather, their fun (M = 4.46) and enjoyable (M = 4.54) user experience with the AI speaker system probably led to their increased perception of attitude toward science class.

Table 5. The PASS-SLC quantitative survey result of external validation (N = 13) (1–5 scale)

Item No.	Question	Mean [SD]
1	I was able to ask the speaker in the way I usually speak.	3.46 (0.88)
2	The speaker understood the intention of my question well.	2.46 (0.66)
3	The answer of the speaker was easy to understand.	4.31 (0.63)
4	The speaker told the correct information needed for the laboratory class.	3.85 (0.99)
5	The information the speaker told was consistent.	4.15 (0.99)
6	The information the speaker told was reliable.	4.08 (0.95)
7	The system was more convenient for getting the information I wanted than using calculators or smartphones.	2.69 (1.03)
8	The laboratory class became safer than before through this system.	3.62 (0.87)
9	Using the system was more comfortable than asking friends or TA.	2.62 (1.26)
10	As a result of using the system, I could gain more scientific knowledge.	2.23 (0.73)
11	As a result of using the system, I could gain more scientific skills.	2.85 (1.14)
12	As a result of using the system, I could gain more attitudes toward science class.	3.46 (1.2)
13	The process of laboratory classes using the system became different from before.	2.77 (1.24)
14	The role of the instructor has changed in the laboratory class using the system.	2.92 (1.04)
15	The role of the students has changed in the laboratory class using the system.	3 (0.91)
16	The laboratory performance time has been reduced when using the system.	2.77 (1.09)
17	The user experience of the system was fun.	4.46 (0.66)
18	The user experience of the system was enjoyable.	4.54 (0.52)
Overall average of PASS-SLC items		3.35 (1.17)

In an open-ended question aligned with the PASS-SLC, students responded that rather than asking the system, “asking TA” or “using a calculator” to get information would be more “convenient,” “fast,” and “correct” (items 7 and 9). Also, four students problematized the structured way of asking the speaker as “complex” and “took time” (item 16). The reason for this was the SR accuracy (four students). And three responded that the AI speaker system would be useful when the SR accuracy increases.

Pros, cons, and suggestions for revision. Students pointed out the pros of the AI speaker system implemented in the classroom as follows: First, five out of thirteen acknowledged the high “accessibility” of the system, which could be used “easily” “whenever” they wanted, and this feature drew students’ interest (two students) (items 1, 12, 17, and 18 in the PASS-SLC; Table 5). Second, three students appreciated that the system had freed their hands, lest they repeatedly put on and off the gloves to touch things other than experimental, which supports keeping safety (one student). Further, three students responded that the workload of the TA has been reduced due to the AI speaker system.

5 Discussion

5.1 Research question 1

The ADDIE process of developing and validating the hands-free AI speakers supporting hands-on science laboratory classes shown throughout this study answers research question 1.

It should be noted that the available technology largely shaped the characteristics of the prototype. First, the AI speaker system developed in this study is 'explainable.' As explainability is becoming increasingly important for ethics in AIEd [7–8], the characteristic of AISEd should be appreciated and further pursued. Meanwhile, one of the reasons for non-satisfying SR accuracy is attributed to the current state of the Korean NLP (cf. [41]), which is lower than that of the English. Thus, we can anticipate different responses if the equivalent research was conducted in English-speaking situations or any other context, which calls for further study [5].

5.2 Research question 2

The responses of experts and university students had commonalities and differences in the PACMAD items. The categories that scored highest and lowest were similar. For example, the learnability, memorability, and cognitive load categories took the first to third ranks in both groups (Table 4). The issue of explainability mentioned above can be connected to the learnability and memorability in the PACMAD. Also, reducing the cognitive load is the main contribution of AIEd [7–8]. These signify that the AI speaker system satisfied those criteria, possibly leading to students' concentration on hands-on experimentation. Further, the experts and students said the error is the most concern in the PACMAD in parallel, providing corresponding suggestions for revising the prototype. These showed the possibilities and current status of the AI speaker system in the science laboratory.

However, there were some differences between the perceptions of experts and students. The experts' PACMAD scores were higher in every category and thus overall items compared to those of students. Particularly, the efficiency showed the most gap between experts (3.44) and students (2.88) (Table 4), which was backed up by the open-ended questions. For example, experts said, "an AI speaker is efficient because it answers to the query immediately," "hands must be used in the laboratory environment in general, but one can get an answer for his/her question by just an articulation," "if it can be realized, it would be definitely helpful for the safe experimentation and would reduce time," and "it adds to efficiency because one can ask for information and get an answer." On the contrary, students said that "it takes a too long time to get an answer," "one may feel jammed up because it takes a long time asking and getting an answer," and "I think it is very good and positive, but it seems to have a long way to go."

Reflecting on the differences, it seems that the experts' background experiences made them evaluate the prototype positively. Meanwhile, students may have imagined the realistic situation the AI speaker is implementing in their laboratory classroom, making them not give high scores. Future research that scrutinizes why there

are disparities in the perceptions of introducing AI (speaker) into a classroom between educational experts and students would be meaningful.

5.3 Research question 3

First, the mobile characteristics of the AI speaker enabled its optimal use according to each function – from the fume hood, laboratory table, or near the liquid waste container. Second, it is manifest that the unsafe situations in that students touch non-experimental things with their gloved hands reduced significantly. It inherently leads to the third strength, the incorporation of another learning mode – i.e., auditory one – into the science laboratory class to support students' experimentation. Much literature has shown that visual (V), kinesthetic (K), and reading/writing (R) learning modes are important in science laboratories in the hands-on inquiry, minds-on inquiry, and lab report writing [12–15]. However, almost no research seems to have pointed out that the auditory (A) learning mode can be utilized in a science laboratory class, which complements the VARK multi-modal learning [42]. This implies that the implementation of the AI speaker in the lab raised a significant, noteworthy theoretical thesis for the science education field.

The interpretation of the SUS score needs caution. According to Bangor et al. [43], while the mean SUS score of interactive voice response (IVR) systems was 73.84 (N = 401), that of a combinatory Web/IVR system was 59.45 (N = 50). Further, recent studies on the usability of Amazon Alexa showed a score of 63.69 (N = 61) [39]. These indicate that the SUS score of this study (63.85) is intermediate as an AI speaker. Therefore, according to the SUS score, the product of this study shows promises and suggests future research implications of AI speakers supporting hands-on science laboratories, although the immediate industrial or practical implications might be few.

The result of the PASS-SLC survey shows that the most strength of the AI speaker supporting the science laboratory class can be its affordance to draw students' interest in a science laboratory class. In the PASS-SLC, students responded that they did not directly gain more knowledge or skills through the system – however, if we expect the affective domain to lead to active engagement in laboratory activities, the development of knowledge and skills might follow in a long-term sense.

Manifestly, the most urgent problem for the suggestions for future revision is improving the AI speaker's SR accuracy (in Korean) to catch students' natural language articulations. It would enable more functions and a flexible conversation structure of AISEd optimized in various situations, reducing resources spent on error handling.

However, the instructional designers shall not just rely on the advancement of technologies but contemplate the possible remedies for problems listening from the learners. University students, who were pre-service chemistry teachers, suggested both increasing SR accuracy and allowing flexible conversations. At first glance, it seems contradictory and has a trade-off relationship. However, students suggested the keyword-based conversation for the AI speaker system in the external validation. It seems possible to catch two birds with one stone, even with the current technologies. Research focusing on the type of conversation (natural language-based versus keyword-based) in AISEd should follow.

6 Conclusion

Using the RP method, we designed and developed a hands-free AI speaker-based system that answers student queries concerning solution-making, experimental processes, and waste liquid disposal, corresponding to the initial, middle, and final phases of a hands-on laboratory class. The system was internally validated by usability tests of 9 expert panels and 18 university students and then revised. The revised system was externally validated in an analytical chemistry experiment class for 3 sessions with 13 university students. We presented the result of the prototype development and internal and external validations with quantitative and qualitative data. The AI speaker system enabled students to use the auditory learning mode in the laboratory while concentrating on the experimentation with their hands in the external validation. It can be considered as opening a channel for the auditory learning mode in science laboratory class to the previous visual, reading/writing, and kinesthetic modes to complement the VARK multi-modal learning.

One of the novelties of this case study lies in its research field – a science laboratory classroom filled with Korean-speaking learners. Ironically this leads to the need for more generalizable instructional knowledge (see [18]). Although this study carefully designed, developed, and implemented an AI speaker system for the science laboratory class, it does not provide comprehensive principles, guidelines, or models for future designers of AI speakers used in a classroom. Therefore, research that presents design principles for or model of AISEd in authentic teaching and learning sites should follow.

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8 References

[1] J. Huang, G. Shen, and X. Ren, "Connotation analysis and paradigm shift of teaching design under artificial intelligence technology," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 5, pp. 73–86, 2021. https://doi.org/10.3991/ijet.v16i05.20287

[2] S. Russel and P. Norvig, Eds., *Artificial Intelligence: A Modern Approach*. London: Pearson, 2021.

[3] V. Kepuska and G. Bohouta, "Next-generation of virtual personal assistants (microsoft cortana, apple siri, amazon alexa and google home)," In proc. IEEE annual computing and communication workshop and conference '08, 2018, pp. 99–103. https://doi.org/10.1109/CCWC.2018.8301638

[4] B. K. Prahani, I. A. Rizki, B. Jatmiko, N. Suprapto, and T. Amelia. "Artificial intelligence in education research during the last ten years: A review and bibliometric study," *International Journal of Emerging Technologies in Learning*, vol. 17, no. 8, pp. 169–188, 2022. https://doi.org/10.3991/ijet.v17i08.29833

[5] N. Pinkwart, "Another 25 years of AIED? Challenges and opportunities for intelligent educational technologies of the future," *International Journal of Artificial Intelligence in Education*, vol. 26, no.1, pp. 771–783, 2016. https://doi.org/10.1007/s40593-016-0099-7

[6] X. Chen, D. Zou, H. Xie, and G. Cheng, "Twenty years of personalized language learning," *Educational Technology & Society*, vol. 24, no. 1, pp. 205–222, 2021.
[7] R. Luckin, W. Holmes, M. Griffiths, and L. B. Forcier, *Intelligence Unleashed: An Argument for AI in Education*. London: Pearson, 2016.
[8] V. Srinivasan, "AI & learning: A preferred future," *Computers and Education: Artificial Intelligence*, vol. 3, 100062, 2022. https://doi.org/10.1016/j.caeai.2022.100062
[9] S. B. Lovato, A. M. Piper, and E. A. Wartella, "Hey Google, do unicorns exist? Conversational agents as a path to answers to children's questions," In Proc. ACM International Conference on Interaction Design and Children '18, 2019, pp. 301–313. https://doi.org/10.1145/3311927.3323150
[10] S. Chung and B. K. Woo, "Using consumer perceptions of a voice-activated speaker device as an educational tool," *JMIR Medical Education*, vol. 6, no. 1, e17336, 2020. https://doi.org/10.2196/17336
[11] K. Pietroszek, "Providing language instructor with artificial intelligence assistant," *International Journal of Emerging Technologies in Learning*, vol. 2, no. 4, pp. 61–65, 2007.
[12] A. Hofstein and V. N. Lunetta, "The laboratory in science education: Foundations for the twenty-first century," *Science Education*, vol. 88, no. 1, pp. 28–54, 2004. https://doi.org/10.1002/sce.10106
[13] L. B. Flick, "The meanings of hands-on science," *Journal of Science Teacher Education*, vol. 4, no. 1, pp. 1–8, 1993. https://doi.org/10.1007/BF02628851
[14] D. S. Domin, "A review of laboratory instruction styles," *Journal of Chemical Education*, vol. 76, no. 4, pp. 543–547, 1999. https://doi.org/10.1021/ed076p543
[15] N. Reid and I. Shah, "The role of laboratory work in university chemistry," *Chemistry Education Research and Practice*, vol. 8, no. 2, pp. 172–185, 2007. https://doi.org/10.1039/B5RP90026C
[16] A. D. Ménard and J. F. Trant, "A review and critique of academic lab safety research," *Nature chemistry*, vol. 12, no. 1, pp. 17–25, 2020. https://doi.org/10.1038/s41557-019-0375-x
[17] D. L. Sewell, "Laboratory safety practices associated with potential agents of biocrime or bioterrorism," *Journal of Clinical Microbiology*, vol. 41, no. 7, pp. 2801–2809, 2003. https://doi.org/10.1128/JCM.41.7.2801-2809.2003
[18] R. C. Richey and J. D. Klein, *Design and Development Research: Methods, Strategies, and Issues*. Thames, Oxfordshire: Routledge, 2007.
[19] R.C. Richey, J. Klein, and W. Nelson, "Developmental research: Studies of instructional design and development," in *Handbook of Research for Educational Communications and Technology*, D. Jonassen, Eds. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 2004, pp. 1099–1130.
[20] S. D. Tripp and B. Bichelmeyer, "Rapid prototyping: An alternative instructional design strategy," *Educational Technology Research and Development*, vol. 38, no. 1, pp. 31–44, 1990. https://doi.org/10.1007/BF02298246
[21] C. Lim, Y. Song, S. Hong, and C. Park, "A study on the applications and improvement of the rapid prototyping to instructional systems design (RPIsd) model," *Journal of Educational Technology*, vol. 36, no. 3, pp. 589–617, 2020. [in Korean] https://doi.org/10.17232/KSET.36.3.589
[22] T. S. Jones and R. C. Richey, "Rapid prototyping methodology in action: A developmental study," *Educational Technology Research and Development*, vol. 48, no. 2, pp. 63–80, 2000. https://doi.org/10.1007/BF02313401
[23] Argonne National Lab (ANL), *AI for Science: Report on the Department of Energy (DOE) Town Halls on Artificial Intelligence (AI) for Science*. Argonne, IL: United States, 2020.
[24] F. M. Dunnivant, D. M., Simon, and S. Willson, "The making of a solution: A simple but poorly understood concept in general chemistry," *The Chemical Educator*, vol. 7, no. 4, pp. 207–210, 2002. https://doi.org/10.1007/s00897020581a

[25] V. R. Ralph and S. E. Lewis, "Chemistry topics posing incommensurate difficulty to students with low math aptitude scores," *Chemistry Education Research and Practice*, vol. 19, no. 3, pp. 867–884, 2018. https://doi.org/10.1039/C8RP00115D
[26] P. L. Gentili, "Small steps towards the development of chemical artificial intelligent systems," *RSC Advances*, vol. 3, no. 48, pp. 25523–25549, 2013. https://doi.org/10.1039/c3ra44657c
[27] L. B. Ayres, F. J. Gomez, J. R. Linton, M. F. Silva, and C. D. Garcia, "Taking the leap between analytical chemistry and artificial intelligence: A tutorial review," *Analytica Chimica Acta*, 1161, 338403, 2021. https://doi.org/10.1016/j.aca.2021.338403
[28] U. G. Jack, "Analysis of senior secondary school students' experienced difficulty in science process skills acquisition in chemistry," PhD. Thesis, Delta State University, Abraka, 2012.
[29] D. F. Treagust, K. C. D. Tan, N. K. Goh, and L. S. Chia, "Major sources of difficulty in students' understanding of basic inorganic qualitative analysis," *Journal of Chemical Education*, vol. 81, no. 5, p. 725, 2004. https://doi.org/10.1021/ed081p725
[30] M. Stieff, S. M. Werner, B. Fink, and D. Meador, "Online prelaboratory videos improve student performance in the general chemistry laboratory," *Journal of Chemical Education*, vol. 95, no. 8, pp. 1260–1266, 2018. https://doi.org/10.1021/acs.jchemed.8b00109
[31] N. Choudhary, R. Bharti, and R. Sharma, "Role of artificial intelligence in chemistry," *Materials Today: Proceedings*, vol. 48, no. 5, pp. 1527–1533, 2021. https://doi.org/10.1016/j.matpr.2021.09.428
[32] Z. J. Baum, X. Yu, P. Y. Ayala, Y. Zhao, S. P. Watkins, and Q. Zhou, "Artificial intelligence in chemistry: Current trends and future directions," *Journal of Chemical Information and Modeling*, vol. 61, no. 7, pp. 3197–3212, 2021. https://doi.org/10.1021/acs.jcim.1c00619
[33] L. He, L. Bai, D. D. Dionysiou, Z. Wei, R. Spinney, C. Chu, ... and R. Xiao, "Applications of computational chemistry, artificial intelligence, and machine learning in aquatic chemistry research," *Chemical Engineering Journal*, vol. 426, 131810, 2021. https://doi.org/10.1016/j.cej.2021.131810
[34] R. Harrison, D. Flood, and D. Duce, "Usability of mobile applications: Literature review and rationale for a new usability model," *Journal of Interaction Science*, vol. 1, no. 1, pp. 1–16, 2013. https://doi.org/10.1186/2194-0827-1-1
[35] A. Bangor, P. Kortum, and J. Miller, "Determining what individual SUS scores mean: Adding an adjective rating scale," *Journal of Usability Studies*, vol. 4, no. 3, pp. 114–123, 2009.
[36] K. Sohn and O. Kwon, "Technology acceptance theories and factors influencing artificial Intelligence-based intelligent products," *Telematics and Informatics*, 47, 101324, 2020. https://doi.org/10.1016/j.tele.2019.101324
[37] J.-m. Lee, M. Jung, J. Lee, Y.-e. Kim, and C. An, "Consumer perception and adiption intention of artificial intelligent speaker: Nun-users perspective," *Journal of Consumer Studies*, vol. 30, no. 2, pp. 193–213, 2019. [in Korean] https://doi.org/10.35736/JCS.30.2.9
[38] Y. Min, J. Ahn, and S. Kim, "Structural relationship analysis between the intention to use educational chatbots and influential factors based on technology acceptance model," *The Journal of the Education Information and Media*, vol. 26, no. 3, pp. 799–825, 2020. [in Korean] https://doi.org/10.15833/KAFEIAM.26.4.799
[39] D. S. Zwakman, D. Pal, and C. Arpnikanondt, "Usability evaluation of artificial intelligence-based voice assistants: The case of Amazon Alexa," *SN Computer Science*, vol. 2, no. 1, pp. 1–16, 2021. https://doi.org/10.1007/s42979-020-00424-4
[40] J. R. Lewis and J. Sauro, "Item benchmarks for the system usability scale," *Journal of Usability Studies*, vol. 13, no. 3, pp. 158–167, 2018.
[41] J. Kim, E. Shin, K. Han, S. Park, J. H. Youn, G. Jin, and J. Y. Lee, "Efficacy of smart speaker–based metamemory training in older adults: Case-control cohort study," *Journal of Medical Internet Research*, vol. 23, no. 2, e20177, 2021. https://doi.org/10.2196/20177

[42] N.D. Fleming, and C. Milss, "Not another inventory, rather a catalyst for reflection," *To Improve the Academy*, vol. 11, pp. 137–155. https://doi.org/10.1002/j.2334-4822.1992.tb00213.x
[43] A. Bangor, P. T. Kortum, and J. T. Miller, "An empirical evaluation of the system usability scale," *International Journal of Human–Computer Interaction*, vol. 24, no. 6, pp. 574–594, 2008. https://doi.org/10.1080/10447310802205776

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Enhancement the Educational Technology by Using 5G Networks

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Abstract—With the spread of global markets for modern technical education and the diversity of programs for the requirements of the local and global market for information and communication technology, the universities began to race among themselves to earn their academic reputation. In addition, they want to enhance their technological development by developing IMT systems with integrated technology as the security and fastest response with the speed of providing the required service and sure information and linking it The network and using social networking programs with wireless networks which in turn is a driver of the emerging economies of technical education. All of these facilities opened the way to expand the number of students and solve the problem of accumulation, collection and analysis of data by storing it with large, expanded and automatically interconnected databases between university places and departments to provide services adapted to the desire of demand. This research dealt with a sample from of the academic's opinions and students. The sample is 319 questionnaires. It concluded that each of the infrastructure, devices, Internet of things, smart classrooms, and administrative database, with the presence of the fifth-generation network and its equipment, have a statistically significant correlation with technical education technology.

Keywords—educational material, educational strategies, systems and applications, produce, educational devices

1 Introduction

AI and 5G networks have been identified as critical areas of innovation and creativity necessary to enable smarter and more proactive technology communities. The next generation is the fifth generation technology, the generation of virtual technology with mobile communication standards equipped with applications and services of the Internet at its new speed, which showed a significant improvement in the performance of technical education technology, which enhanced confidence between the user and the technological investor by sensing the magnitude of data, managing and coordinating

network resources, and providing connected and independent smart systems [1]. Therefore, higher and technical education institutions have embarked on the process of shifting to automated education, including an automated electronic teacher and virtual reality, including virtual classrooms, smart boards, 3D artificial intelligence laboratories, and high-resolution photographic sensor cameras. Coding and numbering university students and benefiting from the advantages of the Internet of Things and remote sensing by supporting them with the fifth generation networks FG-ML5G, modern computers and mobile devices, and a team specialized in studying cases, services, requirements, interfaces, protocols, algorithms, and network architecture for machine learning and data formats [2]. Education or teaching is the intentional organized design of the experience that helps the learner to achieve the desired change in performance, targeted learning outcomes. Learning is a subjective activity carried out by the learner, with or without the supervision of the faculty, with the aim of acquiring knowledge or skill or changing behavior. Learning is everything that a person acquires through practice and experience, and it is the other side of the education process and its product, and it is associated with it so that one cannot be separated from the other. When talking about education, it is necessary to shed light on learning to form a clear and complete picture on the subject. Teaching differs from learning in that teaching is an activity undertaken by a qualified person; To facilitate the learner's acquisition of the required knowledge and skills, while learning is the self-efforts made by the learner to acquire the knowledge and skills he seeks to acquire [3]. Teaching strategy is the strategies used by a faculty member to improve student learning. It can be defined as a set of general rules and outlines that concern the means to achieve the desired goals of teaching. It refers to the methods and plans followed by the faculty member to reach the learning objectives. It is the set of activities or mechanisms used (presentation – coordination – training – discussion) in order to achieve specific teaching objectives. Thus, it includes two components, namely, the method and the procedure, which together form a total plan for teaching a lesson, unit, course, or other. That is, a faculty member may go according to his own style of teaching, approaching any teaching method. He chooses it, but it does not deviate from a general framework that has its general teaching procedures. It includes teaching objectives and the movements that a faculty member makes and organizes; to walk according to her in his teaching. Organizing the classroom environment and managing the classroom. Learners' responses to stimuli presented, planned, and organized by the faculty member [4, 5]. Learning strategies are the behaviors and actions a learner engages in that aim to influence how you process information and learn different tasks. It is also defined as the behavioral patterns and thinking processes that learners use and affect what has been learned and the treatment of learning problems. Learning is strategic when learners are aware of the specific skills and strategies (specific procedures and methods) that they use in learning, and control their attempts to use them [6–8].The current era is characterized by expansion in all different fields and to ensure keeping pace with this expansion Knowledge, scientific development and technical employment, the role of education becomes the development of the learner in the aspect Cognitive and skillful, through multiple teaching methods and methods, instilling in the learner the direction of employment technology in everyday life. Accordingly, teaching aids represent a set of devices, tools, and materials that a faculty member uses to improve the teaching and learning process. Among the

devices that helped in this computer, which contributed in many ways to teach, including educational games, and a problem-solving environment [9, 10]. Instructional "educational" material can refer to the rate of development or progression of a student's cognitive development, abilities, interests, and other aspects. It allows the student to develop strategies for assessing, planning, and organizing his or her own learning. The characteristics of the educational material vary according to the objectives, characteristics of the students and conditions of study, as well as infrastructures and access to technologies. You can design educational material for different contexts in such a way that your design sparks interest and curiosity about the issue. So that it is a source of information and directed to motivate. It can be adapted for use with or without teacher assistance. It can be used individually or in combination. That is, it is multi-use [11, 12].

1.1 Educational devices, systems and applications

The use of smart devices and harnessing their capabilities in the service of teaching and learning is one of the necessities of this age, and diversity in teaching methods is one of the priorities of the teacher of this century. It is also necessary to address challenges and facilitate ways and means, so there must be material and human support, training and management to introduce this technology and work on it in the educational field [13, 14]. Due to the widespread use of smart technologies, most universities have been keen to invest in supporting the educational process from various aspects by using the options provided by these technologies such as SMS, mobile learning management systems and applications to attract learners to integrate into the electronic environment they provide. Most of today's learners who are involved in university education have become familiar with the use of mobile devices of all kinds, especially mobile phones and tablets. As most students are younger than the tablets or stationary computers they use in their daily lives, that is, they have grown up with computer technologies that have enhanced and enhanced many aspects of their lives, including: Education [15].

So Educational technology is based on a theoretical basis of principles, ideas and theories based on it, and it falls within an applied scientific field in which ideas and theories are put into practice and scientific practice. It is based on the entrance of systems, meaning that it is an integrated system that includes man, machine, ideas, practical methods, and management [16, 17].

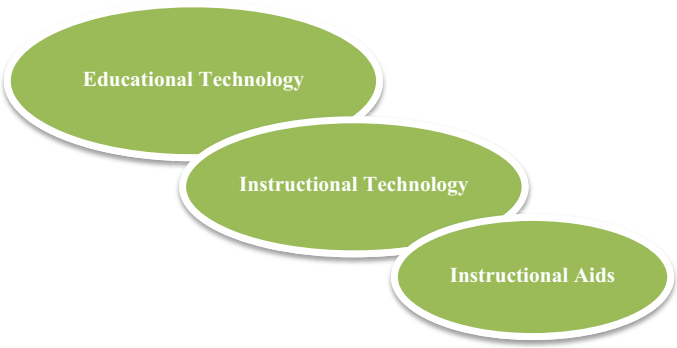

Fig. 1. The difference between educational technology and instructional technology

1.2 Educational technology

It is difficult to ignore the growing role of educational technologies in the integrated e-learning adopted by most universities, as these technologies have contributed to transferring teaching and learning to a new level in which learning resources are easily accessible when needed. It also provided an educational environment in which the teaching and learning processes are conducted by the teacher and the learner, through mobile devices and wireless networks wherever they are and at any time they want to. This environment is characterized by its wide spread as it is not restricted by place or time and gives a special character to teaching and learning activities and emphasizes self-directed learning in which educational applications play an important role in achieving it [18, 19]. Technological progress has led to the emergence of new methods and methods for indirect education, which depend on the employment of technological innovations to achieve the required learning, including the use of computers and its innovations, satellites and satellite channels, and the international information network, in order to provide learning throughout the day and night for whoever wants it and in the place that suits him [20], Through various methods and methods supported by multimedia technology with its various components, to provide educational content through a combination of written and spoken language, static and animated visual elements, and various audio-visual effects and backgrounds, which are presented to the learner through the computer, which makes learning interesting and enjoyable, and achieved with the highest efficiency, With the least effort, and in the least time, which leads to the quality of education [21, 22]. Educational technology has also witnessed wide changes due to the launch of social media, information storage and transmission, the use of visual and audio media, the production of its educational outcomes and it's sharing among students. The role of technology has expanded from being a mere tool for study and inquiry to an integrated approach and use in technical education. Technical education specialists are responsible for educating and guiding their students in the optimal and beneficial use of their studies [23, 24]. In the sixties of the last century, the exploration of the possibilities of self-service based on technology began to complement or replace the personal services provided to the student category and performed by the staff of the Student Affairs Division at a time when services were considered less important in creating economic value and financial returns from student registration, and with the growth of technology and consumer desire Because of the technology interfaces and their available capabilities to facilitate the student's task and complete his treatment as quickly as possible, educational institutions have tended to move forward with the advanced technological reality [25, 26]. Educational technology as any activity or benefit based on technologies provided by service providers so that customers can perform the service or parts of the service themselves, in the field of educational technology applications, the service provider is a machine that the customer uses to perform the service himself, which facilitates The process of replacing student affairs personnel who were necessary in the provision of the traditional service [27, 28]. Other similar authors have suggested terms such as self-service technologies, which are defined as technological interfaces that enable customers to produce a service independent of the

involvement of direct service personnel [29]. Research has recognized the benefits of education technology to clients including time and cost savings, greater control over service delivery, reduced waiting time, higher level of personalization, convenience of location, and enjoyment of using technology, efficiency, flexibility, greater satisfaction and mental innovation .There are quick ways to transfer information (Super High Way Information) from one place to another, and the emergence of the international information network (World Wide Web) known as the Internet, and its employment in all walks of life, shows the importance of information As a commodity that is bought and sold [30, 31].

1.3 ET tools

1. Educational material: the professor, the educational content, the student [32, 33].
2. Educational strategies: interactive education, educational content diversification, educational investment, simulation, cyber security, reality virtual, program integrated [34].
3. Systems and applications: artificial intelligence programs such as the automatic teacher system, the human senses simulation system and addressing its educational problems, intelligent platforms, smart network protocols and algorithms, data management base, fog computing, cloud computing, internet of things, machine learning [35].
4. Produce: economic investment, social investment, educational investment [36].
5. Ed. devices: laptop computer (tablets), course projector, digital camera, smart boards, digital interactive whiteboards, communication network, digital projectors, intelligent career path driver, high frequency equipment, sub band wireless coverage, fiber optic cables, millimeter wave radio links and relays, robotics, real time system, distributed real time system, network security [37, 38]; as noted in Figure 2.

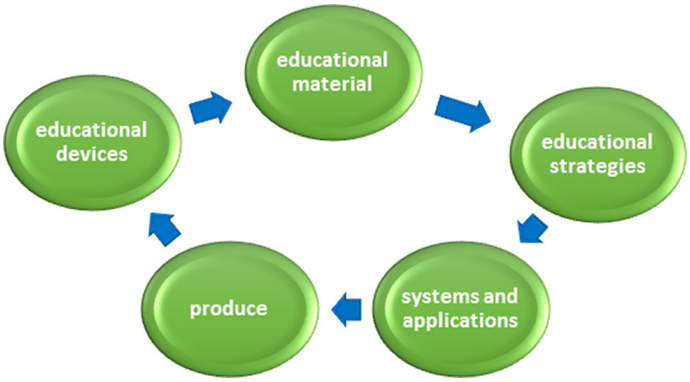

Fig. 2. Educational technology tools

2 Literature review

The research dealt with a group of previous research that dealt with educational technology and fifth generation networks. It was presented in table to show the similarities and the most important aspects that it touched upon.

Table 1. Presentation of the most important research papers that dealt with educational technology and fifth generation networks

Authors	Objectives	Conclusions
[39]	It focuses on interactive learning during lectures while discussing and evaluating various applications of educational technology in the field of medical education. Medical schools regularly use lectures and other group learning sessions. It is well recognized that encouraging interactive learning in big groups can be difficult. The development of technology to improve engagement and communication is a promising addition to interactive lectures.	Education in the medical field now includes a variety of educational technologies. To maximize learning results, technology use and integration should be guided by educational needs. Prerequisites for the best success include a specific job and objectives. Selected technology can promote interactive learning in educational activities. To increase students' involvement and participation in lectures and other group learning sessions, many technology applications have been deployed. To find or develop the proper technological tools for effective instruction based on educational theories, collaborative and ongoing efforts are needed.
[40]	This paper dealt with the possibilities offered by the fields of artificial intelligence and their use, and the process of evaluating exam results.	Many faculty members have struggled to use this technology because of their extensive knowledge and the students' limited understanding of it.

The current study aimed at the extent of the impact of the fifth generation networks with their mobile devices, and the 5G network as a technology that brings by its nature aspects such as high speed, extremely low latency, high bandwidth and wireless network communications that contributed to the establishment of the Internet of Things as an important part in technical education, facilitated a major paradigm shift The educational process, in which users interact with big data, and what huge data warehouses provide, has reinforced the goal of educational investment, entering the labor market, and offering educational products through social media and websites, as well as dealing with artificial intelligence applications to enter the technical field as robots and smart language programs.

3 Methodology

To describe the study sample, a random sample was selected and the opinions of the academic staff and students were taken. The site of the current study is the Northern Technical University. The electronic questionnaires were collected, which numbered 319 valid questionnaires for analysis. The confirmatory factor analysis was chosen that

deals with issues of validity and reliability in measurement by examining the validity and reliability of the scores. On the variables used within 9 criteria set to measure the extent to which the hypothetical model matches the analytical model. Given an acceptable level of validity and reliability of the result, scores are used in statistical analysis to model structural equations, correlated factors, and observed variables that measure each factor. To explore the number of factors, present, whether the factors are interrelated, and the observed variables that seem to measure each factor better. For the study variables and using the Amos v26 analysis system, the questionnaire contained 17 questions that were adopted as variables and divided into independent dimensions (x1, x2, x3, x4, x6, x7, x8, x9, x10, x11, x12) variables represented the educational technology variable and its axes of internet of things, database management, artificial intelligence, smart education system, while the variable is the fifth generation, the dimensions of the dependent were calculated (y1, y2, y3, y4, y5), as shown in Figures 3 and 4.

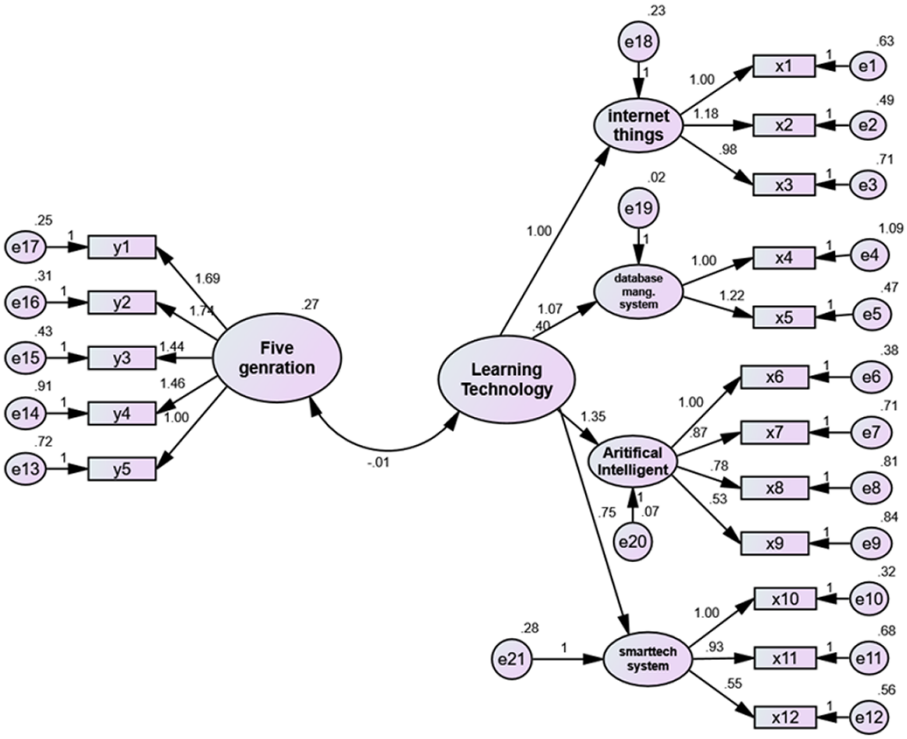

Fig. 3. Confirmatory factor analysis (untenderized system)

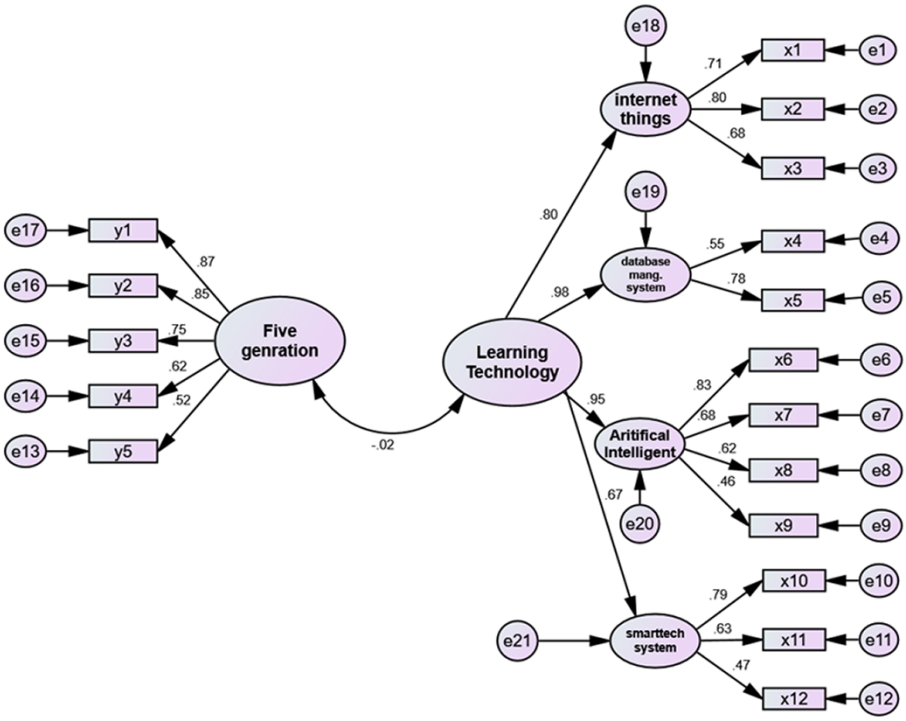

Fig. 4. Confirmatory factor analysis (standardized estimate)

Source: Prepared by researchers based on the results of the analysis (Amos V26).

4 Results and discussion

Table 2's computation of degrees of freedom demonstrates how Amos determines degrees of freedom as the difference between the number of distinct sample moments and the number of distinct parameters requiring estimation. Variances and covariances are always included in the count of distinct sample moments. When you estimate means and intercepts, it also includes sample means. Multiple parameters that are forced to be equal to one another count as a single parameter when calculating the total number of different parameters to be estimated. Fixed parameters with unchanging values have no effect.

Table 2. Degrees of freedom computation (default model)

Number of distinct sample moments:	153
Number of distinct parameters to be estimated:	39
Degrees of freedom (153–39): DF	114
minimum chi-square CMIN:	316

When calculating the probability ratio/(degrees of freedom) CMIN/DF, a value of 2.8 appeared, which is a value between 2 and 5, which means that the value of the

chi-square did not exceed the upper bound and as calculated by equation No. 1, the minimum chi-square is divided by the degrees of freedom.

$$CMIN/DF = 316/114 = 2.8... \quad (1)$$

Chi-square, which is the ratio between the value of the number of sample moments, which must be from 2 in the case of an exact match, and less than 5 in the case of acceptance of the model.

We note in Tables 3 and 4 the imposed model is identical to the data, which is compared with the saturated model at 0 degree of freedom, which has no value to be done through only theoretical calculations. In Table 3, we see the minimum variance to be chi-square estimation is a method of estimation of unobserved quantities based on observed data. In certain chi-square tests, one rejects about a population distribution because a specified test statistic is too large. One effect of its application is that the test statistic does indeed roughly follow a chi-square distribution. The number of degrees of freedom for each parameter evaluated using this method is typically reduced by 1.

Table 3. RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.066	.895	.859	.667
Saturated model	.000	1.000		
Independence model	.333	.414	.341	.368

Table 4 shows the root mean squared (RMR), is a statistical measure of the values of varying quantities. It is especially useful when the values vary into positive and negative, Goodness-of-fit (GFI) establishes the discrepancy between the observed values and those expected of the model in a normal distribution case, The adjusted goodness of fit index (AGFI) corrects the GFI, which is affected by the number of indicators of each latent variable, The modifications are made to penalize less parsimonious models and favor simpler theoretical processes over more intricate ones. The fit index decreases as model complexity increases. PGFI is a parsimonious fit index (based on the GFI).

Table 4. Baseline Comparisons

Model	NFI Delta1	RFI rho1	PCFI
Default model	.856		.756
Saturated model	1.000	.829	.000
Independence model	.000		.000

The normed fit index (NFI) examines the difference between the null model's chi-squared value and that of the hypothesized model. Relative Fit Indices, also called the incremental fit, includes a factor that represents deviations from a null model; so these are sometimes called comparative indices.

Table 5 showed that the data were collected in a random way, and that the sample size is large, reaching 319, and the presence of (connectivity) in the sense of the

dependent variable as a continuous variable, with moderation between the approved variables and random error, no abnormal values appeared in the statistical analysis, a problem appeared. There is a multiplicity of linear relationship between the independent variables, so we relied on the unweighted least squares method for the free scale.

Table 5. The most important indicators of good conformity and the limits of its acceptance

Acceptance Limits	Pointer
It was 2.8 which is less than (5) accepts the assumed model	**Likelihood ratio (degrees of freedom) CMIN/DF**
the value is 0.895, which is greater than or more (0.90), which means a good match	Goodness of Fit Index **GFI**
Its value is 0.859 which means production quality matching	Adjusted Goodness of Fit Index **AGFI**
Its value is 0.856, which indicates the good quality of the model	Normative Fit Index **NFI**
Its value is 0.756, which indicates the good quality of the model	Parsimony Goodness of fit index **PGFI**
Its value of 0.829 indicates the good quality of the model and its conformity with the data	Relative Fit Index **RFI**
Its value is 0.066 This indicator indicates a good fit of the model	Root Mean Square Residual **RMR**

Diagram (1) shows the linear regression equation for the independent study variable fifth generation networks and the study variable approved by the technical education technology and the matching ratio for the hypothetical model is $R^2 = 0.998$, and the linear equation No. (2) represents the effect between the variable X and the Y variable.

$$Y = 3.31E\text{-}4 + 0.4*x \ldots \quad (2)$$

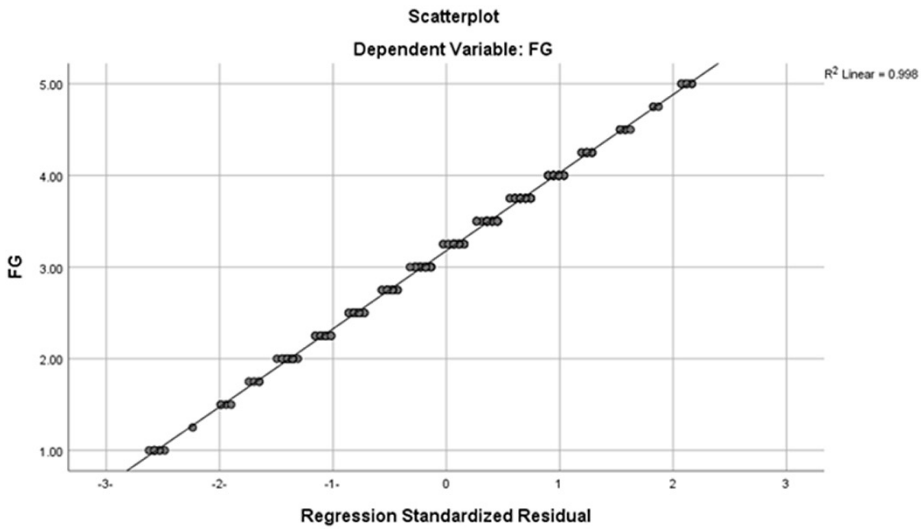

Fig. 5. It shows the regression equation between the variables

5 Conclusions

The conclusions represent an analytical outcome and are summarized as follows:

1. All opinions were directed by all academics to gain the experience and competence necessary to create interactive lectures that enhance participation between professor and student, which improved the outcomes of technical education.
2. The methodological content contributed to changing the strategies of teaching methods and the reliability of providing correct and accurate information to the student.
3. Adopting smart teaching systems that enhance the creativity and innovations of both the professor and the student.
4. The availability of high-frequency equipment accelerated the delivery of information and in a short period of time, reduced the wages of studies, and did not rely on private lessons for the spread of lessons and lectures through easy-to-use study channels and platforms.
5. The educational technology industry using wireless coverage with sub-bands with offers and incentives for commercial applications between public and private universities, encouraging scientific competition and increasing scientific research activity.
6. Opening new markets for technical education technology, which contributed to increasing the professor's degree and scientific activity, which reflected positively on raising his financial level.
7. Encouraging pilot projects for the purpose of testing them and then engaging them in the labor market.
8. The values of the correlation coefficient between each approved base variable of the fifth-generation networks and the approved variable of technical education technology at the level of the surveyed institution was identical with a ratio of $R^2 = 0.998$, which is an integrated and comprehensive percentage of the trend towards the use of technical education technology.
9. There are parameters whose results matched the results of the study, which made the default model identical to the standard model. The relative probability indicators, the matching quality index, the standard congruence index, the economic conformity quality index, the relative matching index, and the root mean index of the residual squares were all identical.

6 Recommendations

1. The necessity of empowering workers regarding modern technologies and evoking the technical culture in conjunction with the requirements of the technical transformation process without making huge mistakes that reflect a negative result that leads to the rejection of the digital transformation process and the preservation of the old traditional system.
2. Working to secure common opinions for the advancement of technical education to higher levels and to come up with solutions and results that contribute to the strengthening and continuation of the work of the technical education technology system.

3. Avoiding the idea of technical control in the field of work, but must secure ways to ensure the success of its use and find ways to support it.
4. The necessity of choosing reliable infrastructures and devices that can be relied upon to transition to technical education technology for administrative matters that would expedite the tasks of the professor, student and administration, and preserve data and information and not lose it.
5. Adopting modern thought and innovations and motivating innovators to reach the goals of technical education technology and sustain their achievement.

7 References

[1] P. L. R. Dangi, G. Choudhary, I. You, and G. Pau, "Study and Investigation on 5G Technology: A Systematic Review," *Sensors,* vol. 22, no. 1, p. 26, 2021. https://doi.org/10.3390/s22010026

[2] H. Salim, and A. Z. Abass, "The Influence E-Learning Platforms of Undergraduate Education in Iraq," *International Journal of Recent Contributions from Engineering, Science & IT (iJES),* vol. 9, no. 4, 2021. https://doi.org/10.3991/ijes.v9i4.26995

[3] B. H. Majeed, "The Conceptual Mathematical Knowledge and Analytical Thinking for the First Stage Students at Math Sciences Department, Faculty of Education for Pure Sciences, IBN Alhaithem, University of Baghdad," *International Journal of Science and Research (IJSR),* vol. 6, no. 12, pp. 1379–1392, 2017. https://doi.org/10.21275/ART20178962

[4] L. F. Jawad, and M. K. Raheem, "The Effectiveness of Educational Pillars Based on Vygotsky's Theory in Achievement and Information Processing Among First Intermediate Class Students," *International Journal of Emerging Technologies in Learning (iJET),* vol. 16, no. 12, pp. 246–262, 2021. https://doi.org/10.3991/ijet.v16i12.23181

[5] H. T. Alrikabi, and H. Tuama Hazim, "Secure Chaos of 5G Wireless Communication System Based on IOT Applications," *International Journal of Online and Biomedical Engineering (iJOE),* vol. 18, no. 12, pp. 89–102, 2022. https://doi.org/10.3991/ijoe.v18i12.33817

[6] L. F. Jawad, and H. Ban, "Computational Thinking (CT) Among University Students," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 10, 2022. https://doi.org/10.3991/ijim.v16i10.30043

[7] D. K. A.-R. Al-Malah, and H. H. K. Jinah, "Enhancement of Educational Services by Using the Internet of Things Applications for Talent and Intelligent Schools," *Periodicals of Engineering Natural Sciences,* vol. 8, no. 4, pp. 2358–2366, 2020.

[8] A. H. M. Alaidi, R. a. M. Al_airaji, I. A. Aljazaery, and S. H. Abbood, "Dark Web Illegal Activities Crawling and Classifying Using Data Mining Techniques," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 10, 2022. https://doi.org/10.3991/ijim.v16i10.30209

[9] B. H. Majeed, "Impact of a Proposed Strategy according to Luria's Model in Realistic Thinking and Achievement in Mathematics," *International Journal of Emerging Technologies in Learning (iJET),* vol. 18, 2023.

[10] I. Roll, R. S. d. Baker, V. Aleven, and K. R. Koedinger, "On the Benefits of Seeking (and Avoiding) Help in Online Problem-Solving Environments," *Journal of the Learning Sciences,* vol. 23, no. 4, pp. 537–560, 2014. https://doi.org/10.1080/10508406.2014.883977

[11] M. K. R. Al-Haydary, and B. H. Majeed, "Impact of ASSURE Model on Mathematical Correlation and Achievement in Mathematics," *European Journal of Humanities Educational Advancements,* vol. 2, no. 11, pp. 62–68, 2021.

[12] R. a. M. Al_airaji, I. A. Aljazaery, H. T. Salim ALRikabi, and A. H. M. Alaidi, "Automated Cheating Detection based on Video Surveillance in the Examination Classes," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 8, 2022. https://doi.org/10.3991/ijim.v16i08.30157

[13] N. A. Jasim, and M. S. Farhan, "Internet of Things (IoT) Application in the Assessment of Learning Process," in *IOP Conference Series: Materials Science and Engineering,* 2021, vol. 1184, no. 1: IOP Publishing, p. 012002. https://doi.org/10.1088/1757-899X/1184/1/012002

[14] A. Alaidi, O. Yahya, and H. Alrikabi, "Using Modern Education Technique in Wasit University," *International Journal of Interactive Mobile Technologies,* vol. 14, no. 6, pp. 82–94, 2020. https://doi.org/10.3991/ijim.v14i06.11539

[15] N. Jassim, A. Zkear, and B. Majeed, "Smart Learning based on Moodle E-learning Platform and Development of Digital Skills for University Students," *International Journal of Recent Contributions from Engineering, Science IT,* vol. 10, no. 1, pp. 109–120, 2022. https://doi.org/10.3991/ijes.v10i01.28995

[16] F. Luthans, B. C. Luthans, and K. W. Luthans, *Organizational Behavior: An Evidence-Based Approach Fourteenth Edition.* IAP, 2021.

[17] R. Khairy, "The Detection of Counterfeit Banknotes Using Ensemble Learning Techniques of AdaBoost and Voting," *International Journal of Intelligent Engineering and Systems,* vol. 14, no. 1, pp. 326–339, 2021. https://doi.org/10.22266/ijies2021.0228.31

[18] B. H. Majeed, and L. F. Jawad, "Tactical Thinking and its Relationship with Solving Mathematical Problems Among Mathematics Department Students," *International Journal of Emerging Technologies in Learning,* vol. 16, no. 9, pp. 247–262, 2021. https://doi.org/10.3991/ijet.v16i09.22203

[19] H. T. Salim, and H. Tauma, "Enhanced Data Security of Communication System using Combined Encryption and Steganography," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 16, pp. 144–157, 2021. https://doi.org/10.3991/ijim.v15i16.24557

[20] B. Majeed, "The Relationship Between Conceptual Knowledge and Procedural Knowledge among Students of the Mathematics Department at the Faculty of Education for Pure Science/Ibn Al-Haitham," *International Journal of Innovation, Creativity and Change (IJICC),* vol. 12, no. 4, pp. 333–346, 2020.

[21] L. L. Berry, *Discovering the soul of service: The nine drivers of sustainable business success.* Simon and Schuster, 1999.

[22] P. A. Dabholkar, "Consumer Evaluations of New Technology-Based Self-Service Options: An Investigation of Alternative Models of Service Quality," *International Journal of Research in Marketing,* vol. 13, no. 1, pp. 29–51, 1996. https://doi.org/10.1016/0167-8116(95)00027-5

[23] M. J. Bitner, S. W. Brown, and M. L. Meuter, "Technology Infusion in Service Encounters," *Journal of the Academy of Marketing Science,* vol. 28, no. 1, pp. 138–149, 2000. https://doi.org/10.1177/0092070300281013

[24] P. A. Dabholkar, "Incorporating Choice into an Attitudinal Framework: Analyzing Models of Mental Comparison Processes," *Journal of Consumer Research,* vol. 21, no. 1, pp. 100–118, 1994. https://doi.org/10.1086/209385

[25] S. Lazar, "The Importance of Educational Technology in Teaching," *International Journal of Cognitive Research in Science, Engineerin and Education,* vol. 3, no. 1, pp. 111–114, 2015. https://doi.org/10.23947/2334-8496-2015-3-1-111-114

[26] C. Folke, S. Carpenter, T. Elmqvist, L. Gunderson, C. S. Holling, and B. Walker, "Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations," *AMBIO: A Journal of the Human Environment,* vol. 31, no. 5, pp. 437–440, 2002. https://doi.org/10.1579/0044-7447-31.5.437

[27] B. Tunca, and J. Anselmsson, "Social Media Consumption among Grocery Customers in Sweden," pp. 1–13, 2021.
[28] M. L. Meuter, A. L. Ostrom, R. I. Roundtree, and M. J. Bitner, "Self-Service Technologies: Understanding Customer Satisfaction with Technology-Based Service Encounters," *Journal of Marketing,* vol. 64, no. 3, pp. 50–64, 2000. https://doi.org/10.1509/jmkg.64.3.50.18024
[29] E. Bigne, "A Model of Adoption of AR-Based Self-Service Technologies: A Two Country Comparison," *International Journal of Retail Distribution Management,* 2021.
[30] M. L. Meuter, and M. J. Bitner, "Self-Service Technologies: Extending Service Frameworks and Identifying Issues for Research," in *American Marketing Association. Conference Proceedings,* 1998, vol. 9: American Marketing Association, p. 12.
[31] R. J. Kauffman, and L. Lally, "A Value Platform Analysis Perspective on Customer Access Information Technology," *Decision Sciences,* vol. 25, no. 5–6, pp. 767–794, 1994. https://doi.org/10.1111/j.1540-5915.1994.tb01869.x
[32] B. H. Majeed, "Mathematical Logical Intelligence and its Relationship with Achievement among College of Education Students in Baghdad Governorate," *Nasaq,* vol. 1, no. 2, pp. 307–354, 2014.
[33] L. F. Jawad, and H. T. ALRikabi, "The Impact of CATs on Mathematical Thinking and Logical Thinking Among Fourth-Class Scientific Students," *International Journal of Emerging Technologies in Learning,* vol. 16, no. 10, pp. 194–211, 2021. https://doi.org/10.3991/ijet.v16i10.22515
[34] B. Hasan, "The Impact Of Reflexive Learning Strategy On Mathematics Achievement By First Intermediate Class Students And Their Attitudes Towards E-Learning," *Turkish Journal of Computer Mathematics Education,* vol. 12, no. 7, pp. 3271–3277, 2021.
[35] D. K. A.-R. Al-Malah, I. A. Aljazaery, and H. A. Mutar, "Cloud Computing and Its Impact on Online Education," in *IOP Conference Series: Materials Science and Engineering,* 2021, vol. 1094, no. 1: IOP Publishing, p. 012024. https://doi.org/10.1088/1757-899X/1094/1/012024
[36] N. Hussien, I. Ajlan, and M. M. Firdhous, "Smart Shopping System with RFID Technology Based on Internet of Things," pp. 17–29, 2020. https://doi.org/10.3991/ijim.v14i04.13511
[37] M. Al-Sarry, I. Faris, and B. Majeed, "A Future Vision of Mathematics Teacher Preparation Program at the Universities," *International Education Culture Studies,* vol. 2, no. 1, pp. 1–12, 2022.
[38] L. F. Jawad, and B. H. Majeed, "The Impact of Teaching by Using STEM Approach in The Development of Creative Thinking and Mathematical Achievement Among the Students of The Fourth Scientific Class," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 13, pp. 172–188, 2021. https://doi.org/10.3991/ijim.v15i13.24185
[39] F. Tuma, "The Use of Educational Technology for Interactive Teaching in Lectures," *Annals of Medicine Surgery,* vol. 62, pp. 231–235, 2021. https://doi.org/10.1016/j.amsu.2021.01.051
[40] P. Gao, J. Li, and S. Liu, "An Introduction to Key Technology in Artificial Intelligence and Big Data Driven E-Learning and E-Education," *Mobile Networks Applications,* vol. 26, no. 5, pp. 2123–2126, 2021. https://doi.org/10.1007/s11036-021-01777-7

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Influences of Problem-Based Online Learning on the Learning Outcomes of Learners

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Abstract—Influenced by the COVID-19 pandemic, online learning has become a major learning mode for most university students in China. For high-quality online teaching, teachers must optimize the teaching mode and strengthen the enthusiasm of students in classroom learning. In this study, a comparative experiment was carried out based on the course *Cross-border E-commerce Customer Services* for sophomore E-commerce majors at Huanghuai University in Zhumadian City, Henan Province, China. In the experiment, the teaching effect of the problem-based learning (PBL) mode in higher education was verified and gender differences in learning outcomes of learners who accepted PBL were analyzed. Results showed a significant difference at the 0.01 level between pre- and post-test results of the experimental group ($t = -11.367$, $p = 0.000$), proving the teaching effect of PBL. The academic performances of the experimental class are significantly better compared with those of the control class, indicating that PBL is more beneficial to improve learning outcomes of students than traditional teaching methods. Gender has significant influences on post-test results at the 0.01 level ($p = 0.002 < 0.01$). The median of final exam scores of male students is obviously higher than that of female students. Research conclusions can provide important references to test the effectiveness of PBL in learning outcomes of a specific subject, construct a PBL mode that can promote deep learning, and facilitate development of university teaching from knowledge teaching to core quality training of students.

Keywords—online teaching, teaching mode, learning outcome, paired sample T-test, independent sample T-test

1 Introduction

The updating and development speeds of knowledge are far higher than the acceptance speed of people. Internalizing and applying knowledge in a short period is often difficult for learners. Given that life is surrounded by various types of fragmented and entertainment information, gaining a deep understanding of knowledge is even more difficult for the student group. Most students only have a superficial understanding. To develop good self-study habits through independent learning, university students need to use diversified learning strategies positively under the effective guidance of teachers, develop complete critical thinking and problem solving ability, train the

consciousness of cooperation and exchange, and emphasize individual enthusiasm in reconstruction of new and old knowledge, thereby developing learning habits with high-order thinking ability and achieving deep understanding and effective migration. However, the traditional simple exam-oriented education mode can no longer meet students' needs for life and comprehensive quality improvement. The traditional teaching modes have long been centered on teachers, so that they have been put in a passive learning position. Teachers have single teaching methods instead of providing effective teaching according to the learning needs of learners, and they pour teaching contents into students repeatedly. How to make students develop and improve their independent learning ability truly is key to current teaching reform in disciplines in universities. One important university teaching goal and requirement is to further develop and improve the independent learning ability and learning outcomes of students.

PBL is a mode that is centered on learners and guided by problems. Introducing PBL into teaching activities in universities is critical for its many obvious advantages compared with traditional teaching methods. PBL advocates that students focus on problems during learning activities. Students can collect relevant information, review, screen, and discuss the collected information in a group, and finally develop solutions to their problem. PBL is more conducive to developing the independent learning enthusiasm of students fully. PBL is centered on problems and students are asked to think about the problem and discuss it with a group. Students may take the initiative to seek solutions in this process, thus strengthening their learning interests and increasing their learning initiation. Through the scenarios of well-designed practical life problems, PBL helps learners in ways and methods to find solutions during self-study from perspectives such as guess hypothesis, scheme design, experimental exploration, data analysis, summarization and exchange, and reflection. Moreover, the goal and philosophy of PBL are highly consistent with deep learning. Therefore, a series of targeted measures to improve teaching activities in universities and suggestions to improve independent learning ability of university students were proposed based on comparative analysis of the teaching effect of the PBL mode, enabling an increase in the overall teaching level of universities.

2 Theoretical basis and hypotheses development

2.1 Theoretical basis

PBL theory was proposed by Hmelo-Silver, C. E [1], who believed that PBL mainly includes teachers' careful selection and design of problems, learners solving the problem through critical thinking, and developing independent learning ability and team cooperation skills. PBL is viewed as a teaching method that can help learners to acquire methods, thinking, and ability to solve problems in the learning process. PBL combines the problem-based teaching of teachers and problem-based learning of students and views problems as the source of learning. Students cooperate, explore, and complete learning contents independently. A PBL mode that can improve students' ability is different from traditional teaching. PBL is a teaching mode based on problems, centered on students, and implemented by group cooperation. PBL highlights the dominant role

of students, while teachers are responsible for supervising and facilitating learning of students as guiders and organizers of students' learning activities, and they play an important role in stimulating the enthusiasm of students in learning. PBL also emphasizes putting learning in complicated and meaningful real problem scenarios, in which students find the learned contents and choose and use knowledge and methods of multiple aspects to solve the practical problem, thereby establishing the knowledge system successfully. In the teaching process, PBL advocates group cooperation positively and makes reasonable grouping according to students' requirements for individual development. Given the ability and interests of students, PBL assures consistent inter-group level and encourages team members to communicate and discuss mutually, exhibit and report on the lesson, and finally make summaries and evaluations. PBL stimulates students to explore and innovate around problems continuously by setting the problem scenarios, thereby causing obvious influences on deep learning of learners.

2.2 Hypotheses development

PBL plays a very important role in the international education and teaching field. The primary effect of PBL is that it helps students in strengthening their thinking about structural problems. Based on this thinking process, students solve existing problems using divergent thinking and previously learned knowledge. Studies on how PBL influences the learning outcomes, motivation, and learning strategies of learners are introduced as follows. Qomariyah, S. N [2] carried out a comparative study on 80 students from two classes by using a quasi-experiment. Results showed that PBL and traditional modes had some influences on learning outcomes, but the influences of the former were significant. Belland, B. R et al. [3] analyzed results of PBL in 33 empirical studies and found that whether PBL influenced learning outcomes was related with sample size and experimental method to a certain extent. Distlehorst, L. H et al. [4] carried out comparative experiments of students from nine graduating classes in the School of Medicine, Southern Illinois University, and found that PBL teaching helped students to obtain better clinical performances and caused significant differences in medical knowledge accumulation, clinical reasoning, and non-cognitive behaviors. Preeti, B et al. [5] believed that PBL is an effective, coherent, comprehensive, and concentrated education approach. He implemented a questionnaire survey to 72 medical students from Ludhianada Dayanand Medical College and hospital. Results showed that PBL could facilitate independent subject learning and guaranteed a better ability in practice learning and interest in innovation. Wong, D. K. P et al. [6] carried out a comparative experiment on 132 sophomores majoring in social work who attended social work theory and practice and skill laboratory core courses under PBL. Results demonstrated that PBL teaching could improve students' cognition of social work knowledge, skills, and values. Steele, D. J et al. [7] carried out a comparative analysis of influences of Web-based PBL teaching on learning outcomes of students. Results showed that using PBL technology had positive effects on academic performances of students. Mulyanto, H et al. [8] carried out an experimental study on 309 students and found significant differences in math learning outcomes among students using PBL and the traditional learning mode. Prosser, M [9] pointed out that differences among students in cognition

and understanding of PBL are vital to their learning methods and outcomes. Timor, A. R et al. [10] carried out a comparative experimental study on 29 medical students and found that PBL had very obvious influences on learning outcomes and learning motivation. Dupri, D et al. [11] found that PBL could increase cooperation among students obviously and also improved learning outcomes significantly. The comparative experimental results of Khusaini, K et al. [12] showed that learning outcomes of students using PBL had significant differences from those of students using traditional method. PBL increased learning motivation of students. Reinsini, C. E et al. [13] pointed out that using PBL could significantly improve learning outcomes of students in basic repairing ability of a braking system. Based on at least 20 studies since 1990, Albanese, M. A et al. [14] introduced how PBL influences learning outcomes of students majoring in a medical department. Stentoft, D [15] pointed out that PBL is a teaching method that fully supports interdisciplinary learning in higher education, and it is conducive to improve students' potentials in interdisciplinary learning. Khatiban, M et al. [16] compared effects of PBL and traditional clinical education. Results showed that comprehensive ability and unique ability of students using PBL were improved significantly more compared with students in the control group. PBL trained ability, attitude, and performances of nursing students. Goni, A. M et al. [17] analyzed influences of PBL on learning outcomes of Grade 4 students. Results showed that after PBL teaching, math learning outcomes of students were improved obviously. Miller, S. K [18] analyzed differences in performances and satisfaction of pharmacological students who adopted PBL compared with traditional teaching mode. Results showed that both modes might be course teaching methods with the same effectiveness. Aslam, L. K et al. [19] concluded that PBL could obviously facilitate improvement of skills of learners. Utami, I et al. [20] applied PBL to teaching basic skills of volleyball passing, finding that in the first cycle, PBL increased the number of students skilled in passing. Winning, T et al. [21] found that PBL can provide an incentive learning environment, promote comprehensive learning, encourage systematic patient management methods, and develop independent learning skills. AlHaqwi, A. I [22] conducted a questionnaire survey of 174 undergraduates in medical school and found that PBL had positive effects on the development of their cognitive, individual, and team cooperation abilities. Teachers were recommended to be equipped with professional knowledge about contents and process, so that learners can easily obtain the best outcomes from PBL. Dharma, I. M. A et al. [23] conducted a comparative analysis of 68 students from two schools by using one-way analysis of variance (ANOVA) and multivariate ANOVA analysis. Test results indicated that PBL improved students' ability in understanding the theme easily and quickly during the learning process and it had some influences on learning outcomes in social studies and critical thinking ability of students. Hmelo-Silver, C. E et al. [24] found that PBL could decrease cognitive loads of learners and allow students to improve their content knowledge, cognitive practices, cooperation, and independent learning ability in complicated fields. McPhee, A. D [25] introduced the development of PBL and some of its applications and introduced possible uses of PBL in this field.

Our literature review indicates that the procedure of PBL has been extensively approved and used in developed countries, such as those in Europe and America. A consensus shows that PBL not only achieves good teaching effect but also improves independent learning ability of students significantly and trains creativity, practice

ability, cooperative spirit, and communication ability of students, and finally improving their academic performances obviously. Additional studies have proved through comparative experiments that PBL is an excellent teaching method and has outstanding teaching effects. Given that PBL emphasizes the dominant role of students in learning activities compared with the traditional learning mode, the classroom is returned to students and it fully motivates the subjective initiative of students, so that students improve their comprehensive quality in analyzing and solving problems. Using PBL in specific subjects can facilitate learning of students effectively. However, comparative experiments about PBL and learning outcomes might arrive at different research conclusions in different subjects (e.g., physics, chemistry, geography, Chinese, history, and biology).

3 Methodology

3.1 Experimental objects

To test the effects of PBL on learning outcomes of learners, an experiment of *Cross-border E-commerce Customer Services* for sophomore E-commerce majors was carried out. Two groups were set: the experimental group that used PBL and the control group that used the traditional teaching method. Students of both groups were collected from Huanghuai University in Zhumadian City, Henan Province, with an average age of 20.3. There were 28 males and 12 females. To assure an average homogeneous level of students in these two groups, all students had a mid-term exam in *Cross-border E-commerce Customer Services* before the official implementation of the experiment. Male and female students were grouped uniformly according to test results. The experimental group (one class) and control group (one class) each had 20 students. The differences between the experimental group and the control group in terms of means of various items did not reach statistical significance. Both groups were homogenous. This experiment eliminated influences of physical and psychological conditions of students and assured authenticity and reliability of experimental results.

3.2 Experimental steps

First, two classes were grouped. The mid-term exam scores (covering weeks 1–8 of the course) were used as pre-test results for an independent sample-T test. Pre-test results showed no significant difference. In other words, the classes with equilibrium levels were used as experimental and control classes thus determining the experimental and control groups, respectively. In the second half of the learning period (weeks 9–16), teachers adopted PBL officially with the experimental group, while the control group continued to use the traditional teaching method. Subsequently, all students had a final exam and their final exam scores were used as the representative of learning outcome measurement. Later, a statistical analysis was conducted and a comparison test between the experimental group and the control group was implemented. The final exam scores were used as the post-test results for independent sample-T test, whose results were used to verify the effectiveness of PBL. To assure accuracy of experimental results, the author controlled disturbance factors that may influence experimental effects uniformly before the experiment, such as teachers, teaching duration, and homework.

4 Results analysis

4.1 Comparison of pre-test results between experimental and control groups

The author set experimental and control groups, on which the PBL and traditional teaching modes were applied, respectively. This requires students of two groups to maintain a homogenous independent learning ability before the experiment to eliminate influences of students' differences in experimental results. The pre-test results (mid-term exam scores, weeks 1–8) of students were compared before the experiment.

Table 1. Pre-test T-test

	Groups (mean ± standard deviation)		t	p
	Experimental Group (n = 20)	Control Group (n = 20)		
Pre-test results	65.75±2.79	64.75±3.13	1.067	0.293

Note: *p < 0.05, **p < 0.01.

Table 1 shows that differences between the experimental group and the control group in terms of mean of various items not reaching reached statistical significance according to the T-test of pre-test results. In other words, the P value was higher than 0.05. Both groups were homogenous, enabling the elimination of disturbances of physical and psychological conditions of students on experimental results. This laid a solid foundation to guarantee objectivity of experimental results.

4.2 Pre-test and post-test paired sample T-test

Table 2. Paired sample T-test results

Name	Pairing (mean ± standard deviation)		Difference (Pair 1 − Pair 2)	t	p
	Pair 1	Pair 2			
Pre-test results of experimental group + post-test results of experimental group	64.35 ± 2.52	81.30 ± 6.04	−16.95	−11.367	0.000**
Pre-test results of control group + post-test results of control group	65.85 ± 2.68	74.85 ± 4.32	−9	−9.096	0.000**

Note: *p < 0.05, **p < 0.01.

Table 3. Effect size indexes of paired sample-T test

Name	Mean Difference	Difference 95% CI	d*f*	Difference Standard Deviation
Pre-test results of experimental group + post-test results of experimental group	−16.95	−20.071–−13.829	19	6.669
Pre-test results of control group + post-test results of control group	−9	−11.071– −6.929	19	4.425

Generally, differences in experimental data were investigated by paired T-test. Tables 2 and 3 show that the paired T-tests between the pre-test results and post-test results of the experimental group all indicated differences ($p < 0.05$). The difference between pre-test results and post-test results of the experimental group was significant on the 0.01 level ($t = -11.367$, $p = 0.000$). According to a detailed comparison of differences, the mean pre-test result of the experimental group (64.35) was significantly lower than the post-test result (81.30). Paired data all presented differences, indicating that PBL improved final-exam scores of the experimental group significantly. This is mainly because PBL increased the real effective teachers–students interaction and students–students interaction in the online classroom. PBL also brought diversified teaching methods for online teaching and stimulated learning efficacy of students. Students can show more active, positive, and engaged learning state than in a traditional classroom, and their learning outcomes are relatively obvious.

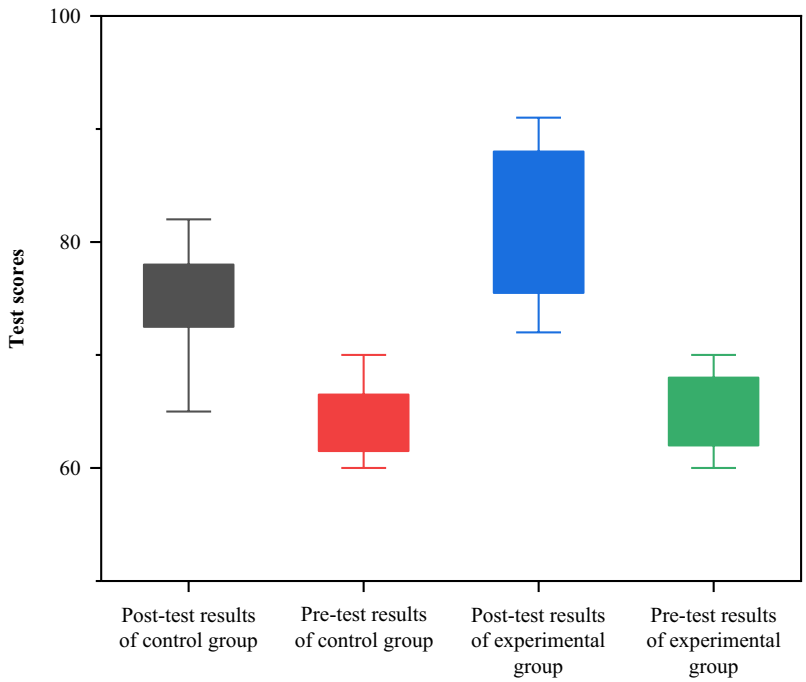

Fig. 1. End-of-term scores of the experimental group were compared before and after

Figure 1 shows that after the final-exam scores of the experimental group were compared with the mid-term results, the average scores improved significantly. This indicated that PBL is an effective teaching method and it at least assured no negative effects on final-exam scores of students. On this basis, horizontal comparison of final-exam scores between the experimental and control groups was further carried out. The final-exam scores of the former were higher than those of the latter, but such a difference did not show statistical significance. This might be because teachers have used PBL for a short period (only for a half-semester, from weeks 9 to 16), thereby failing to develop

its effects fully. The positive effect of PBL mode on academic performances of students is also influenced by other extra variables. PBL could effectively facilitate the independent learning ability of students. Such improvement in independent learning ability is not directly equal to improvement in academic performances. The academic performances of students are obviously influenced by extra student factors such as individual knowledge basis, intelligence conditions, and degree of preparation for the exam.

4.3 Covariance test

Table 4. Covariance analysis results

Difference Source	Quadratic Sum	d*f*	Mean Square	F	p
Intercept	33627.992	1	33627.992	1804.997	0.000**
Groups	476.1	1	476.1	25.555	0.000**
Gender	394.971	1	394.971	21.2	0.000**
Residual	689.329	37	18.631		

Note: *p < 0.05, **p < 0.01.

Table 4 shows that gender was included in the model as a covariable for the covariance analysis to study the influences of PBL on post-test results and prevent disturbances of other factors on the model. Obviously, gender has influences on academic performances. This might be because male students are more interested in professional knowledge requiring manual operation when learning E-commerce, making them significantly better than female students.

Table 5. Non-parameteric test results

	Gender, Median M (P25, P75)		Mann–Whitney Test Statistical U-Value	Mann–Whitney Test Statistical z-Value	p
	Males (n = 28)	Females (n = 12)			
Post-test results	80.000 (75.0,86.0)	73.500 (72.0,76.8)	64.5	−3.067	0.002**

Note: *p < 0.05, **p < 0.01.

Gender differences in one item of post-test results were investigated by a non-parametric test. Table 5 shows that the Mann–Whitney statistical analysis was used investigate differences between two gender groups (1.0, 2.0). Different gender samples all showed significantly different post-test results ($p < 0.05$). According to specific analysis, p value of gender to post-test results was significant at the 0.01 level ($p = 0.002 < 0.01$). According to a specific comparison of median differences, the median of final-exam scores of male students (80.000) was far higher than that of female students (73.500). According to the summary and analysis, Mann–Whitney statistical analysis was applied. Results showed that different gender samples showed significant differences in post-test results. This might be because learning efficacy of female students in the course was poor and they easily accumulated learning fatigue. This conclusion also inspires university teachers to consider gender differences for

relatively difficult subjects and even explore teaching reform of "one student, one scheme" to improve learning outcomes of female students in engineering courses.

5 Discussions

In this study, the influences of PBL on academic performances of students were investigated through comparative analysis between pre- and post-test results of the experimental group. Results showed that PBL improved academic performances of the experimental group significantly. This is enough to prove that such a new teaching mode can improve the academic performances of students significantly. Possible reasons for this ability are as follows. PBL emphasizes the dominant role of students and stimulates their learning enthusiasm. Teaching E-commerce for undergraduates has long applied the cramming teaching mode. Such a traditional teaching model often centers on teachers. It starts with teachers in the teaching process and controls each link of the teaching process but puts students in the role of passive knowledge receivers. Psychological states of students, such as initiative and enthusiasm, are not the core problems of concern in the whole teaching activity. The primary task of the teaching process is to realize the teaching objective. The spirits of exploration and curiosity students are compressed and ignored. PBL mode changes such a situation. Students again become the subject of teaching activities. They are supported and encouraged to learn positively and actively and develop their own ability to solve learning problems that teachers set for them. In this process, the enthusiasm and initiative of students are respected highly. By solving pre-setting problems, students show their ability in problem solving, experience realization of individual values, further stimulate their interests in independent problem solving, and extend such emotions consciously to activities out of the classroom. Thus, space is created to further develop the independent learning ability of students. Final-exam scores of students are also an important index to measure the teaching effect of a new teaching method. In this experiment, the average academic performances of the experimental group have been improved significantly, indicating that PBL is an effective teaching method. The researcher further carried out a horizontal comparison of academic performances between the experimental and control groups and found that the final-exam scores of the former were higher than those of the latter. However, such a difference did not reach the statistical significance level possibly because the external validity of research conclusions was relatively low due to the small sample size. The PBL mode was also used for a short period (only for a half-semester) and the teaching effect of PBL mode had not yet been developed fully. However, academic performances of students are obviously influenced by extra student factors such as individual knowledge basis, intelligence conditions, and degree of preparation for exams. These variables will be considered and controlled in future studies.

6 Conclusions

China's higher education is facing opportunities and challenges of online learning in the background of the COVID-19 epidemic. Owing to rapid scientific and technological development, teachers are empowered to make innovations in education mode, drive changes in classroom teaching, and update philosophies of education and

teaching modes. These are important directions to improve online teaching effects. PBL establishes the corresponding learning scenario based on real-world experience and advocates student-oriented teaching. PBL is a way to provide teaching activities around core problems. It can effectively solve the physical spatial separation problem between teaching and learning in online learning and improve the learning efficacy of learners. In this study, a comparative experiment was carried out based on the course *Cross-border E-commerce Customer Services* for sophomore E-commerce majors at Huanghuai University in Zhumadian City, Henan Province, China. Results show the following. (1) The difference between pre- and post-test results of the experimental group is significant at the 0.01 level ($t = -11.367$, $p = 0.000$). (2) Academic performances of the experimental group are significantly better than those of the control group, indicating that PBL is more beneficial to improve learning outcomes of students than traditional teaching methods. (3) Significant gender differences are observed in post-test results ($p = 0.002 < 0.01$). The median of final-exam scores of male students is far higher than that of female students. Suggestions for future researchers include expanding the research scope, research levels, and research object types of PBL teaching experiments.

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8 References

[1] Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. Educational Psychology Review, 16(3): 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

[2] Qomariyah, S. N. (2019). Effect of problem based learning model to improve student learning outcomes. International Journal of Educational Research Review, 4(2): 217–222. https://doi.org/10.24331/ijere.518056

[3] Belland, B. R., French, B. F., & Ertmer, P. A. (2009). Validity and problem-based learning research: A review of instruments used to assess intended learning outcomes. Interdisciplinary. Journal of Problem-based Learning, 3(1): 59–89. https://doi.org/10.7771/1541-5015.1059

[4] Distlehorst, L. H., Dawson, E., Robbs, R. S., & Barrows, H. S. (2005). Problem-based learning outcomes: the glass half-full. Academic Medicine, 80(3): 294–299. https://doi.org/10.1097/00001888-200503000-00020

[5] Preeti, B., Ashish, A., & Shriram, G. (2013). Problem based learning (PBL)-an effective approach to improve learning outcomes in medical teaching. Journal of Clinical and Diagnostic Research, 7(12): 2896–2897. https://doi.org/10.7860/JCDR/2013/7339.3787

[6] Wong, D. K. P., & Lam, D. O. B. (2007). Problem-based learning in social work: A study of student learning outcomes. Research on Social Work Practice, 17(1): 55–65. https://doi.org/10.1177/1049731506293364

[7] Steele, D. J., Medder, J. D., & Turner, P. (2000). A comparison of learning outcomes and attitudes in student-versus faculty-led problem-based learning: An experimental study. Medical Education, 34(1): 23–29. https://doi.org/10.1046/j.1365-2923.2000.00460.x

[8] Mulyanto, H., Gunarhadi, G., & Indriayu, M. (2018). The effect of problem based learning model on student mathematics learning outcomes viewed from critical thinking skills. International Journal of Educational Research Review, 3(2): 37–45. https://doi.org/10.24331/ijere.408454

[9] Prosser, M. (2004). A student learning perspective on teaching and learning, with implications for problem-based learning. European Journal of Dental Education, 8(2): 51–58. https://doi.org/10.1111/j.1600-0579.2003.00336.x

[10] Timor, A. R., Ambiyar, A., Dakhi, O., Verawadina, U., & Zagoto, M. M. (2021). Effectiveness of problem-based model learning on learning outcomes and student learning motivation in basic electronic subjects. International Journal of Multi Science, 1(10): 1–8.

[11] Dupri, D., Candra, O., Candra, A., & Suryani, D. A. (2020). The implementation of problem based learning model in improving cooperation and learning outcomes in physical education. Jurnal Pendidikan Jasmani Dan Olahraga, 5(1): 87–90. https://doi.org/10.17509/jpjo.v5i1.22531

[12] Khusaini, K., Lestari, S., & Agustin, N. A. (2018). The application of problem-based learning methods to improve economic learning outcomes and motivation. Dinamika Pendidikan, 13(2): 218–227. https://doi.org/10.15294/dp.v13i2.16634

[13] Reinsini, C. E., Susila, I. W., & Cholik, M. (2021). Application of problem-based learning to enhance students learning outcomes in basic competencies of maintaining brake systems. International Journal for Educational and Vocational Studies, 3(2): 139–145. https://doi.org/10.29103/ijevs.v3i2.3470

[14] Albanese, M. A., & Dast, L. (2014). Problem-based learning: Outcomes evidence from the health professions. Journal on Excellence in College Teaching, 25(3/4): 239–252.

[15] Stentoft, D. (2017). From saying to doing interdisciplinary learning: Is problem-based learning the answer?. Active Learning in Higher Education, 18(1): 51–61. https://doi.org/10.1177/1469787417693510

[16] Khatiban, M., & Sangestani, G. (2014). The effects of using problem-based learning in the clinical nursing education on the students' outcomes in Iran: A quasi-experimental study. Nurse Education in Practice, 14(6): 698–703. https://doi.org/10.1016/j.nepr.2014.10.002

[17] Goni, A. M., Tumurang, H., & Ester, K. (2022). Problem Based Learning (PBL) Model and Mathematics Learning Outcomes Students. Specialusis Ugdymas, 1(43): 8277–8284.

[18] Miller, S. K. (2003). A comparison of student outcomes following problem-based learning instruction versus traditional lecture learning in a graduate pharmacology course. Journal of the American Academy of Nurse Practitioners, 15(12): 550–556. https://doi.org/10.1111/j.1745-7599.2003.tb00347.x

[19] Aslam, L. K., Suparji, S., & Rijanto, T. (2021). The effect of problem based learning model on learning outcomes in the vocational high school students. International Journal for Educational and Vocational Studies, 3(4): 264–267. https://doi.org/10.29103/ijevs.v3i4.3958

[20] Utami, I., Burhanuddin, S., & Sahabuddin, S. (2022). Implementation of a scientific approach using Problem Based Learning (PBL) models to improve learning outcomes of overhand pass in volleyball game. Competitor: Jurnal Pendidikan Kepelatihan Olahraga, 14(1): 115–134. https://doi.org/10.26858/cjpko.v14i1.32521

[21] Winning, T., Skinner, V., Townsend, G., Drummond, B., & Kieser, J. (2004). Developing problem-based learning packages internationally: An evaluation of outcomes. Innovations in Education and Teaching International, 41(2): 125–144. https://doi.org/10.1080/1470329042000208666

[22] AlHaqwi, A. I. (2014). Learning outcomes and tutoring in problem based-learning: How do undergraduate medical students perceive them?. International Journal of Health Sciences, 8(2): 125–132. https://doi.org/10.12816/0006078

[23] Dharma, I. M. A., & Lestari, N. A. P. (2022). The impact of problem-based learning models on social studies learning outcomes and critical thinking skills for fifth grade elementary school students. Jurnal Ilmiah Sekolah Dasar, 6(2): 263–269. https://doi.org/10.23887/jisd.v6i2.46140
[24] Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Educational Psychologist, 42(2): 99–107. https://doi.org/10.1080/00461520701263368
[25] McPhee, A. D. (2002). Problem-based learning in initial teacher education: Taking the agenda forward. The Journal of Educational Enquiry, 3(1): 60–78.

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EEG Spectral Feature Markers as an Indicator of Human Cognitive Process

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Abstract—Information technologies allow using modern and timely effective analyses of EEG waves and the methods of data processing that allows effective usage of this method into pedagogically and psychologically oriented research. Aim of this study was to develop and validate method of EEG signal spectral properties usage in the investigations of the process of cognition in the process of the perception of music by the choice of professional studies. 23 research participants took part in the research – the students at the University of Latvia, the division of participants "non-musician" and "musician". The EEG recording synchronized with the musical signal using the generated synchronization signal that given to one of the unipolar input channels of the EEG equipment. The research analyses the basic rhythm of EEG the changes of the maximum frequency and the wave frequency power in the processes connected with the perception and cognition of music for 15 seconds long intervals. During the time of listening to the chorus songs, the range frequency of the range rhythm of alpha and beta does not change to the musicians but during the time of listening to the instrumental music it increases but it was more vivid in the range of beta frequency. Non-musicians reacted differently – while listening to chorus songs and instrumental music the frequency of alfa waves of EEG increased, but the beta wave frequency decreased. EEG as a method of investigation is recommended for pedagogical research to evaluate the neurological functions in the cognitive processes.

Keywords—cognition, education, music, neuroscience, power of EEG frequency

1 Introduction

Different studies have been carried out on the perception of music in recent years, showing the mechanisms and functions of the brain involved in the processing of signals of a given modality. The interdisciplinary research in neuroscience, psychology, biology, and music pedagogy made it possible to understand brain functions regarding music. These data made a great contribution to modern music education. Results of these studies could be helpful to music educators and musicians for the study and communication about music [1].

Nowadays there has been an increasing number of studies on music perception and performance, and their correlation with processes taking place in the central nervous system. The increase in the number of scientific papers on music is linked to the fact that research into music contributes to a better understanding of the structure and functioning of the human brain [2]. Furthermore, studies have shown that music education helps students to develop learning abilities, improve their academic performance and develop a range of skills and knowledge that are essential for lifelong success [3]. An approach for learning music with the intelligent classroom teaching system has been developed. The teaching system of intelligent classroom has different modules, and this system should have managed by database system, which can help to assist and deepen the teaching and understanding of music [4].

Music plays an integral part in forming the self-identity of adolescents and young people's as well as making their group identity based on their music preferences. Results of neuroscience studies allow producing the developmental model that explain the neural link between adolescents' behaviour and brain development. The musical and social choices are possible to explain based on the research of adolescents during brain development [5]. Learning of music is closely linked to memory and language. Memory functions as interacting systems, which leads to encoding information, storing it, and making it available for retrieval. Nervous system gives ability to acquire different skills and knowledge. Language plays a direct role in human cognition. Language allows to combine meanings by constructing relational units and correlational networks [6]. For acquirement of music important is also mobilization of different human functions to perform various tasks.

Many studies have shown the behavioural peculiarities of musicians and adolescents during music training in processing sounds and speech by changing signal properties (temporal and/or spectral). These effects are often associated with auditory cortex functional and structural changes, but it is oversimplified. However, it is necessary to move from the functions of local brain structures to neural networks and brain oscillatory dynamics [7]. The human brain possibly contains different neuronal networks with specialization for the processing of music. Brain specialization for music depends on the recruitment of "free" neurons and development of their connections during music lessons in the infants and adolescents' brain. Music could modify neurons to suit the processing of certain information, and thus it is associated with the specialization of neurons to perform certain functions. This type of specialization is closely linked to human culture and its impact on cognitive processes. The neural networks that are specific for music correspond to musical capabilities, and they are developing in different people of the same culture. These abilities need to be universal in different cultures and they help to develop musical competence. Depending on the nature of the music, different neuronal networks may be involved in its perception [8].

Over the past decade, much experimental evidence has highlighted the importance of automatically activated neural networks in the auditory cortex in musically significant forms of cognition [9]. The research suggest that the brain produces temporarily individualized neuronal responses to the sounds of speech and music. These responses are even stronger than the brain response to other natural sounds [10]. Music, like language, consists of a series of sequential events that are perceived by hearing and require complex information processing [11]. Based on the results of the research a comparative model of neural networks that describe similar and different features of music and

language was developed. Brown with colleagues considers that "the model assumes that music and language show parallel combined generativity for complex sound structures (phonology) but distinctly different informational content (semantics)" [12]. Another model for research of music based on the assumption of participants classified as musicians and non-musicians was used in different studies in which compares brain functions in both groups. These studies show the role of music in the development of human cognitive abilities [13]. Activation of neuronal patterns in response to music can show whether a participant has music education [14]. The acquisition of music changes the perception of hearing and the related organization of the brain, so it characterizes the plasticity of the brain. Processes related to the perception of music are also connected with motor and auditory perception and speech. Musicians are better and faster at the recognition of artificial language compared to non-musicians [15]. The results of the research suggest that music training can transform the synchronization of the neural networks involved in the processes of verbal memory [16].

Extensive information on the influence of music on the peculiarities of brain function and the role of different areas of the cerebral cortex in the understanding of music has been provided using the electroencephalography method. An electroencephalogram (EEG) is a recording of the dynamic of the oscillations of electric potentials of neurons in the brain. Spectral analysis of EEG signals helps to get important information about the effects of music on the human brain [17]. EEG and Event-Related Potential (ERP) methods are also used to study the relationship between computer language and neural processes. It was found that the embedded system (programmable system which have a fixed functionality) leads to the changes in the electroencephalograms of computer linguists [18]. Music stimuli induce motor system activities, and it has a powerful emotional trigger effect [19]. The analysis of working memory task between professional pianists and control group people, showed significant differences in EEG under different electrodes. These differences are due to the peculiarities of perception of words and sounds. Significant differences were observed also for the iconic memory tasks in the right hemisphere of these two groups [20]. EEG recording of frontal and parietal brain lobes while listening to music showed the importance of these lobes in music perception [21]. It was found that EEG high frequency beta and gamma waves carry information about musical mode [22].

2 Methods

2.1 Participants

The study was performed with 23 volunteers (ages of 19–24) from the University of Latvia (LU), Faculty of Education, Psychology and Art. Two experimental groups were recruited, "musicians" from students of musical pedagogy program and "non-musicians" from students of other study programs without any active musical relationship. Musician group contained 12 participants, from them there were 8 females and 4 males (mean age of respondents was 21.83 ± 2.48 years). The non-musician group contained 13 female participants (mean age 23.92 ± 5.54). The experiment was performed in a special quiet room and during recording EEG participants assumed a comfortable position in a chair, during experiment light was turned off.

2.2 Procedure

Music stimuli in the present study were compiled from different genres – 3 representing Latvian chorus songs and 3 representing orchestral music. The first minute of each music's sounds was recorded on one audio file mixed with silence in such manner – silence 1 minute, then stimulus 1 minute (see Figure 1), for data analysis 15 seconds EEG recorded intervals before and during stimulus was used. For auditory stimulus presentation Observer XT version 10.5 (Noldus Information Technology) and RealPlayer (RealNetworks, Inc) software's were used for purpose of the audio signal synchronization via unipolar input channel on the EEG headbox. Participants heard the sound in the ears loudspeakers (Samsung). After the experiment was completed, the research goal was explained to participant, if he (she) has questions. All procedures had been accepted by the local LU ethical review board.

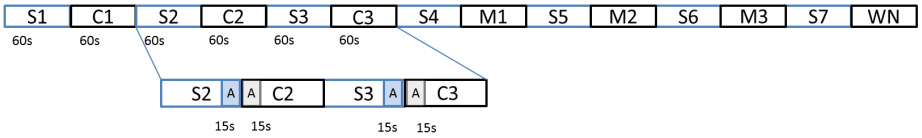


Fig. 1. Diagram of the experiment and data analysis

Notes: S1 – S7 – silence, the 60s; C1 – C3 – chorus songs, 60s; M1 – M3 – instrumental music, 60s; WN – white noise, 60s. A – data of the recorded EEG for further analysis, 15s.

2.3 EEG recordings and data preprocessing

EEG was recorded with a sample rate of 512 Hz. Cut-off frequencies were 0.1–100 Hz. 19 standard electrodes of the 10–20 system were used. Electrodes were fixed to the scalp with electrolyte gel at electrode positions, and generally impedances were < 5 kOhm. A ground electrode was placed at the forehead. Schwarzer EEG-29T recording system with Coherence version 6.1.3.417 application software (Natus Europe GmbH) was used.

Recorded EEG data were analyzed offline using Matlab 2020a (The MathWorks, Inc) using EEGLAB (http://sccn.ucsd.edu/eeglab) with some custom scripts. The scalp EEG was re-referenced to the computed average reference. 50 Hz noise in EEG signals was rejected using bandpass filters with value 48–52 Hz. Then EEG signals with performance errors or remaining artefacts exceeding ± 100 μV in any channel were rejected using ICA procedure (based on online EEGLAB tutorial https://eeglab.org/tutorials/06_RejectArtifacts/RunICA.html) from data before processing. All cleaned EEG trials were inspected visually before further computation. EEG waves spectral properties were calculated with standard EEGLAB function SPECTOPO and then power was calculated for each wave's bands using the handwritten script in Matlab. Data statistical analysis (ANOVA) were performed using Statistica (TIBCO Software Inc., data analysis software system, version 13, http://tibco.com).

3 Results and discussion

The analyses of the basic rhythms of EEG – delta, theta, alpha, beta and gamma frequency ranges and power in the processes connected with the perception and cognition of music for experimental groups was carried out. In this study, the changes in the wavelength ranges of the maximum frequency and the wave frequency range power, which is calculated as the integral range was analysed. Multiple factors statistical analysis was performed in the three-way repeated-measures analysis of variance (ANOVA). Factors selected for analysis were – the first factor groups" with two levels – musician's vs non-musicians, the second factor EEG waves with five levels – delta, theta, alpha, beta and gamma, the third factor – stimulus with four levels – silence before the chorus, silence before music, chorus and instrumental music.

3.1 EEG spectral analysis ANOVA

For analyses, the following classically connected with perception and cognition of music and language regions of interest (ROI) were selected – Broca's area with two electrodes F7 and F3 (left hemisphere) and opposite (right) hemisphere electrodes F8 and F4, Wernicke's area with T5 and P3 as well as two opposite side T6 and P4 electrodes and auditory cortex areas with T3 and T4 electrodes.

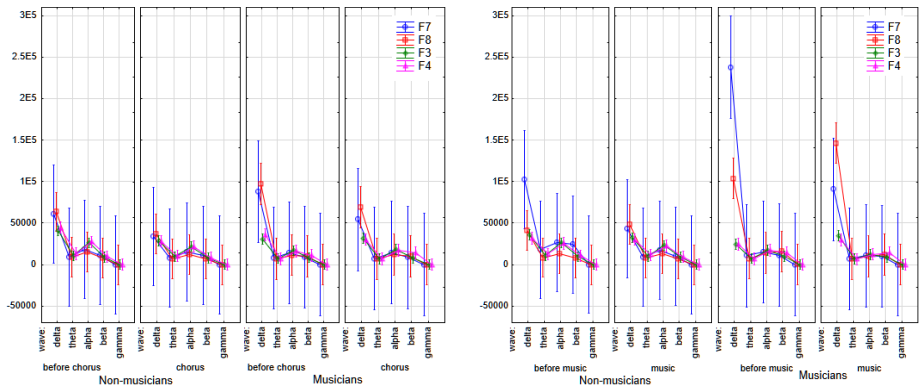
In both lexical regions (Broca's and Wernicke's area) and auditory cortex first – Groups factor has statistically significant influence $F = 5.76$, $p < 0.001$ (see Table 1) with higher Broca's area dominance comparing both zones. The second finding from ANOVA was that in all ROI two factors contribution – Groups and EEG waves are statistically significant, with prevalence into sound processing area $F = 6.39$, $p < 0.01$ (see Table 1). This indicates that musicians and non-musicians processed audio stimulus in a different way. More detail data analysis (mean and standard deviation) is described below where each ROI is analysed (see Figures 2–4).

Table 1. ANOVA Tests of significance for experimental factors (groups, EEG waves, stimulus) for Broca, Wernicke and auditory cortex ROI

Factors	Values	F	Effects Df	p
Intercept	0.51	139.87	10	0.001
Groups	0.96	5.76	10	0.01
EEG waves	0.45	32.53	40	0.01
Stimulus	0.98	0.90	30	0.62
Groups*EEG waves	0.84	6.39	40	0.01
Groups*Stimulus	0.98	0.74	30	0.85
EEG waves*Stimulus	0.94	0.76	120	0.98
Groups*EEG waves*Stimulus	0.95	0.59	120	0.99

3.2 EEG wave band on the different ROI analysis

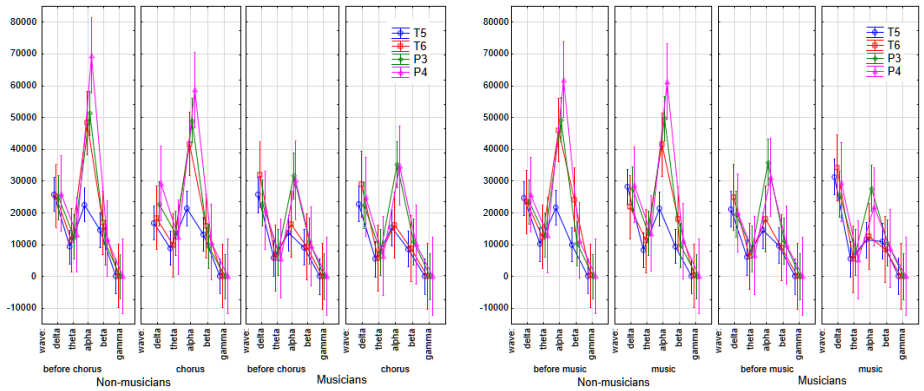
The main difference between two groups was on delta EEG band on the Broca's area in cases of instrumental music stimulus presentation with two electrodes F7 237712.2 ± 31366.2 μV^2 (mean ± standard error) before music and 90530.13 ± 31366.2 μV^2 during music listening in musicians group comparing with 02613.6 ± 30135.67 μV^2 before music and 43217.6 ± 30135.67 μV^2 during music listening in non-musicians' group, same tendency observed in opposite hemisphere under F8 electrode 103946.01 ± 12634.14 μV^2 before and 146516.01 ± 12634.14 μV^2 during music listening in the group of musicians and in the group of non-musicians 41171.3 ± 12138.49 μV^2 before and 48821.6 ± 12138.49 μV^2 during listening music. But in the case of the choral stimulus, no differences between two experimental groups were observed (see Figure 2).



(a) **(b)**

Fig. 2. Non-musicians vs musicians example of EEG waves spectral density under different stimulus condition on the Broca area electrodes (a- chorus song, b- instrumental music)

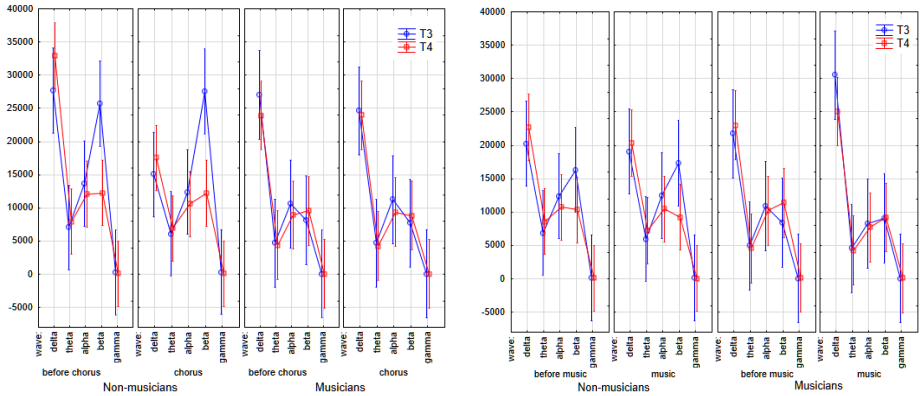
In Wernicke's area, the main differences between the two groups were on alpha EEG band in all stimulus presentation cases in the non-musicians group. Also mean values in P3 are higher than mean values in T5 in all groups, and this difference in non-musicians' group are clearly presented (see Figure 3). For P3 in silence before chorus 51377.35 ± 3545.36 μV^2 for non-musicians, 31718.58 ± 3690.13 μV^2 for musician's and during the listening chorus for non-musicians 48955.57 ± 3545.36 μV^2, 35253.75 ± 3690.13 μV^2 for musician's, same in silence before instrumental 49294.1 ± 3545.36 μV^2 for non-musicians, 35949.9 ± 3690.13 μV^2 for musician's and during listening instrumental music 49633.33 ± 3545.36 μV^2 for non-musicians, 27773.77 ± 3690.13 μV^2 for musician's groups. Also, under electrodes, P4 and T6 non-musicians group showed higher values than musicians.



(a) **(b)**

Fig. 3. Non-musician's vs musicians example of EEG waves spectral density under different stimulus condition on the wernicke area electrodes (a- chorus song, b- instrumental music)

In Auditory areas, main differences between the two groups were on beta EEG band in all stimulus cases and observed values are higher in the non-musicians' group under T3 electrode (see Figure 4). For silence before chorus 25715.83 ± 3252.51 μV^2 in non-musicians and 8136.88 ± 3385.32 μV^2 in musicians and during listening chorus 27561.97 ± 3252.51 μV^2 and 7679.93 ± 3385.32 μV^2 in both groups. The similar tendency under instrumental music, 16319.91 ± 3252.51 μV^2 and 8392.84 ± 3385.32 μV^2 before the stimulus and 17311.94 ± 3252.51 μV^2 and 9046.22 ± 3385.32 μV^2 in non-musicians and musicians' groups. Interesting that under sound stimulus (choral or instrumental) musicians group showed higher values in delta waves band under both electrodes – T3 24627.57 ± 3385.32 μV^2 in the choral 30517.85 ± 3385.32 μV^2 in instrumental music listening in comparison with non-musicians 15056.09 ± 3252.51 μV^2 in the choral and 19044.78 ± 3252.51 μV^2 during listening instrumental music and T4 23943.54 ± 2629.95 μV^2 chorus music 25047.25 ± 2629.95 μV^2 instrumental for musicians' group against non-musician peoples 17513.51 ± 2526.77 μV^2 choruses and 20325.78 ± 2526.77 μV^2 instrumental music. Comparing power values of the electrodes for musician T4 beta band is higher but for non-musician T3 values are higher and this difference is presented.



(a) **(b)**

Fig. 4. Non-musician vs musicians example of EEG waves spectral density under different stimulus condition on the auditory area electrodes (a- chorus song, b- instrumental music)

3.3 Discussion

Recent scientific studies have shown that Broca's area (which functions are related to the speech) is structurally and functionally heterogeneous area of the brain. Some parts of Broca's area share neurocognitive functions, while others are connected to other areas of the brain and are involved in other functions. From the opinion of Fedorenko and Blank there is a fundamental difference between the two sub-regions of Broca's area, which probably play different roles in cognition: the first is related to language and the second to various other functions and their coordination. It is possible that these two regions of Broca's area carry out linguistic and cognitive processing in different ways [23]. Musicians have been found to have a higher sensitivity index in a certain Broca's area.

In our study main differences between groups in delta waves, diapason was observed, that possible indicate higher remembering" activity during listening to music in musicians' group in comparison with non-musicians.

Elmer group source-based EEG study with ROI over inferior parietal lobe and Broca's area suggest that musicians have better sensitivity index (d') during auditory presented pseudowords. This change goes parallel with increased theta waves coherence in the left hemisphere. Non-musicians had higher functional connectivity in the right hemisphere. There were no differences between both groups during a passive listening control or in the rest condition. These results show task-specific differences between musical perception and word learning [24]. The literature suggests that musicians differ from non-musicians in several specific skills, which may range from right-hemisphere expansion in novices to left-hemisphere dominance in music professionals. Well known that musicians have stronger bilateral neural connectivity and brain plasticity caused by extended musical training, and there is a difference between recognition of the music and other auditory stimuli like the voice in comparison with non-musicians. Sound discrimination ability, as well as musical memory, seems to be distributed with a prevalence in the left hemisphere, but both hemispheres are involved [25].

In our study, it was observed that in Broca's area – musicians have a higher asymmetry between left- (F7) and right- (F8) hemispheres in case of listening to instrumental music in delta waves diapason. In Wernicke's area opposite picture was observed – non-musicians have higher hemisphere asymmetry in both electrodes of the left hemisphere – T5 and P3, and for the right hemisphere in the T6 and P4 electrodes in alpha waves diapason. The same findings were observed in auditory ROI – non-musicians have higher asymmetry in beta waves diapason in comparison with musician group during listening to different types of music.

The results of the research of Koelsch group indicate that different chord-sequences (consisted of five chords, which were specifically mixed) were differently recognized and separated in Wernicke area according to the chord's specifics [26]. This indicates that processing of music is very similar to the processing of speech and similar cortical networks that consist of front-lateral, anterior, and posterior temporal lobe structures are involved in the processing of this information. This result supports the point of view that musical elements of speech play a significant role in the processing of language, and both hemispheres are involved in this process.

Research has suggested that structural and functional brain plasticity results from long-term musical training, that produce differences in cognitive functions between musical educated and non-educated persons [27]. The research has shown that musicians in comparison with non-musicians, have a faster response speed, a higher response intensity, and a higher response power of beta waves [28]. The change in alpha rhythm found in our study correlate with studies in binaural beat stimulation that can modulate the strength of brain wave oscillations. The binaural beat is the presentation to every ear of two sinusoidal tones with small frequency mismatch what yields an auditory illusion of a beating. Brain frontal, temporal and parietal lobes are involved in the processing of binaural auditory beats. Alpha band network was modulated by low-frequency binaural beats and alpha oscillations seem to be involved in the perception of binaural beat illusion [29].

The musician's brain could be used as a model in the brain plasticity studies not only in music perception but also in speech and related studies.

4 Conclusion

The peculiarities of the brain bioelectrical activity during listening to a music show that musicians and non-musicians' processes audio stimulus in a different way. The main difference between musicians and non-musicians in the Broca's area is in beta EEG band. EEG values are higher in the non-musicians group. During sound stimulus (chorus or instrumental music) musicians group shows higher EEG values in delta waves band under T3 and T4 electrodes in the choral instrumental listening in comparison with non-musicians' group. EEG wave spectral analysis is an effective and reliable method for analyses the dynamics of neural processes in the brain during music listening tasks.

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6 References

[1] A. D. Peterson, "The Impact of Neuroscience on Music Education Advocacy and Philosophy," *Arts Education Policy Review*, vol. 112, no. 4, pp. 206–213, Aug., 2011. https://doi.org/10.1080/10632913.2011.592475

[2] I. Peretz, and R. J. Zatorre, "Preface," in *The Cognitive Neuroscience of Music,* I. Peretz, and. R. J. Zatorre, Eds. New York: Oxford University Press Inc., pp. 1–2, 2003. https://doi.org/10.1093/acprof:oso/9780198525202.001.0001

[3] Arts Education Partnership, "Music Matters: How Music Education Helps Students Learn, Achieve, and Succeed," *Arts Education Partnership (NJ1)*, ERIC Number: ED541070, 2011. [Online]. Available: https://eric.ed.gov/?q=source%3A%22Arts+Education+Partnership%22&id=ED541070 [Accessed: May 14, 2020].

[4] D. Lyu, and Z. Wang, "Design and Implementation of An Intelligent Classroom Teaching System for Music Class Based on Internet of Things," *International Journal of Emerging Technologies in Learning (iJET),* vol. 16, no. 18, pp. 171–184, Sep., 2021. https://doi.org/10.3991/ijet.v16i18.25665

[5] K. S. Thomas, "Music Preferences and the Adolescent Brain: A Review of Literature," *Update: Applications of Research in Music Education*, vol. 35, no. 1, pp. 47–53, Oct., 2016. https://doi.org/10.1177/8755123315576534

[6] A. Drigas, and E. Mitsea, "The 8 Pillars of Metacognition," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 15, no. 21, pp. 162–178, Nov., 2020. https://doi.org/10.3991/ijet.v15i21.14907

[7] S. Elmer, and L. Jäncke, "Relationships Between Music Training, Speech Processing, and Word Learning: A Network Perspective," *Annals of the New York Academy of Sciences*, vol. 1423, no. 1, pp. 10–18, Mar. 2018. https://doi.org/10.1111/nyas.13581

[8] I. Peretz, "Brain Specialization for Music: New Evidence from Congenital Amusia," in *The Cognitive Neuroscience of Music*, I. Peretz, and R. J. Zatorre, Eds. New York: Oxford University Press Inc., pp. 192–203, 2003. https://doi.org/10.1093/acprof:oso/9780198525202.003.0013

[9] M. Tervaniemi, "Musical Sound Processing: EEG and MEG Evidence," in *The Cognitive Neuroscience of Music*, I. Peretz and R. J. Zatorre Eds. New York: Oxford University Press Inc., pp. 294–309, 2003. https://doi.org/10.1093/acprof:oso/9780198525202.003.0019

[10] N. J. Zuk, E. S. Teoh, and E. C. Lalor, "EEG-based classification of natural sounds reveals specialized responses to speech and music," *Neuroimage,* vol. 210, Article 116558, Apr., 2020. https://doi.org/10.1016/j.neuroimage.2020.116558

[11] S. Samson, and N. Ehrlé, "Cerebral Substrates for Musical Temporal Processes," in *The Cognitive Neuroscience of Music*, I. Peretz and R. J. Zatorre Eds. New York: Oxford University Press Inc., pp. 204–216, 2003. https://doi.org/10.1093/acprof:oso/9780198525202.003.0014

[12] S. Brown, M. J. Martinez, and L. M. Parsons, "Music And Language Side by Side In The Brain: A Pet Study Of The Generation Of Melodies And Sentences," *European Journal of Neuroscience*, vol. 23, no. 10, pp. 2791–2803, May, 2019. https://doi.org/10.1111/j.1460-9568.2006.04785.x

[13] A. Collins, "Music Education and the Brain: What Does It Take to Make a Change?" *Update: Applications of Research in Music Education*, vol. 32, no. 2, pp. 4–10, May, 2014. https://doi.org/10.1177/8755123313502346

[14] E. Ribeiro, and C. E. Thomaz, "A Whole Brain EEG Analysis of Musicanship," *Music Perception,* vol. 37, no. 1, pp. 42–56, Sep., 2019. https://doi.org/10.1525/mp.2019.37.1.42

[15] C. Francois, F. Jaillet, S. Takerkart, and D. Schon, "Faster Sound Stream Segmentation in Musicians than in Nonmusicians," *PLoS ONE*, vol. 9, no. 7, Article e101340, Jul., 2014. https://doi.org/10.1371/journal.pone.0101340

[16] M. Cheung, A. Chan, Y. Liu, D. Law, and C. W. Y. Wong, "Music Training is Associated with Cortical Synchronization Reflected in Eeg Coherence During Verbal Memory Encoding," *PLoS ONE*, vol. 12, no. 3, Article e017490, Mar., 2017. https://doi.org/10.1371/journal.pone.0174906

[17] D. Kučikienė, and R. Praninskienė, "The Impact of Music on The Bioelectrical Oscillations of The Brain," *Acta Medica Lituanica,* vol. 25, no. 2, pp. 101–106, Aug., 2018. https://doi.org/10.6001/actamedica.v25i2.3763

[18] D. Danbing, "Experimental Study on Neural Feedback in Embedded System Teaching Processing Based on ERP Signal Analysis," *International Journal of Emerging Technologies in Learning (iJET),* vol. 14, no. 12, pp. 109–120, Jun., 2019. https://doi.org/10.3991/ijet.v14i12.10715

[19] J. Suto, and S. Oniga, "Music Stimuli Recognition in Electroencephalogram Signal," *Electronics & Electrical Engineering*, vol. 24, no. 4, pp. 68–71, Aug., 2018. https://doi.org/10.5755/j01.eie.24.4.21482

[20] S. Y. Boutorabi, and A. Sheikhani, "Evaluation of Electroencephalogram Signals of the Professional Pianists during Iconic Memory and Working Memory Tests Using Spectral Coherence," *Journal of Medical Signals & Sensors*, vol. 8, no. 2, Apr., pp. 87–94, 2018. https://doi.org/10.4103/2228-7477.232084

[21] Y. P. Lin, C. H. Wang, T. P. Jung, T. L. Wu, S. K. Jeng, J. R. Duann, and J. H. Chen, "EEG-Based Emotion Recognition in Music Listening," *IEEE Transactions on Biomedical Engineering,* vol. 57, no. 7, pp. 1798–1806, Jul., 2010. https://doi.org/10.1109/TBME.2010.2048568

[22] R. Jenni, M. S. Oechslin, and C. E. James, "Impact of Major and Minor Mode on EEG Frequency Range Activities of Music Processing as a Function of Expertise," *Neuroscience Letters,* vol. 647, pp. 159–164, Mar., 2017. https://doi.org/10.1016/j.neulet.2017.03.022

[23] E. Fedorenko, and I. A. Blank, "Broca's Area Is Not a Natural Kind," *Trends in Cognitive Sciences*, vol. 24, no. 4, pp. 270–284, Apr., 2020. https://doi.org/10.1016/j.tics.2020.01.001

[24] S. Elmer, J. Albrecht, S. A. Valizadeh, C. François, and A. Rodríguez-Fornells, "Theta Coherence Asymmetry in the Dorsal Stream of Musicians Facilitates Word Learning," *Scientific reports*, vol. 8, no. 1, pp. 45–65, Mar., 2018. https://doi.org/10.1038/s41598-018-22942-1

[25] G. Gizzi, and E. Albi, "The Music in the Brain Hemispheres," *The EuroBiotech Journal*, vol. 1, no. 4, pp. 259–263, Oct., 2017. https://doi.org/10.24190/ISSN2564-615X/2017/04.01

[26] S. Koelsch, T. Gunter, Y. Cramon, S. Zysset, G. Lohmann, and A. Friederici, "Bach Speaks: A Cortical Language-Network" Serves the Processing of Music," *NeuroImage*, vol. 17, no. 2, pp. 956–966, Oct., 2002. https://doi.org/10.1006/nimg.2002.1154

[27] A. C. Rodrigues, M. L. Loureiro, and P. Caramelli, "Long-Term Musical Training may Improve Different forms of Visual Attention Ability," *Brain and Cognition*, vol. 82, no. 3, pp. 229–235, Aug., 2013. https://doi.org/10.1016/j.bandc.2013.04.009

[28] C. C. Hsu, C. W. Cheng, and Y. S. Chiu, "Analyze the Beta Waves of ElectroencephaLogram Signals from Young Musicians and Non-Musicians in Major Scale Working Memory Task," *Neuroscience Letters*, vol. 640, pp. 42–46, Feb., 2017. https://doi.org/10.1016/j.neulet.2017.01.022

[29] C. I. Ioannou, E. Pereda, J. P. Lindsen, and J. Bhattacharya, "Electrical Brain Responses to an Auditory Illusion and the Impact of Musical Expertise," *PLoS ONE*, vol. 10, no. 6, Article e0129486, Jun., 2015. https://doi.org/10.1371/journal.pone.0129486

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Enhancement of Online Education in Engineering College Based on Mobile Wireless Communication Networks and IOT

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Abstract—The field of Engineering is that which needs a high level of analytical thinking, intuitive knowledge, and technical know-how. The area of communication engineering deals with different components including, wireless mobile services, radio, broadband, web and satellites. There is a rapid decline in the quality of students produced by engineering faculties as a result of sufficient and quality methods and frameworks of student assessment. The production of high-potential engineers is limited by the utilization of old and traditional education methodology and frameworks. The student presentation estimation system in engineering institution is a motionless manual. Usually, the assessment of student's performance using the traditional system is limited to the use of students' performance scores, while failing to evaluate their performance based on activities or practical applications. In addition, such systems do not take cognizance of individual knowledge of students that connects to different activities within the learning environment. Recently, engineering institutions have started paying attention to evaluation solutions that are based on wireless networks and Internet of Things (IoT). Therefore, in this study, an automated system has been proposed for the assessment of engineering students. The proposed system is designed based on IoT and wireless communication networks with the aim of improving the process of virtual education. The data used in this study has been collected through the use of different IoT sensors within the premises of the college, and pre-processed using normalization. After the data was pre-processed, it was stored in cloud. In order to enable the classification of student's activity, an Adaptive Layered Bayesian Belief Network (AL-BBN) classifier is proposed in this work. The student's scores have been calculated using fuzzy logic, while Multi-Gradient Boosting Decision Tree (MGBDT) was proposed for decision making. The use of python simulation tool is employed in the implementation of the proposed system, and the evaluation of the performance benchmarks was done as well. Based on the findings of the study, the proposed conceptual model outperformed the existing ones in terms of improving the process of online learning.

Keywords—Internet of Things (IoT), Online education, Adaptive Layered Bayesian Belief Network (AL-BBN), fuzzy logic, Multi-Gradient Boosting Decision Tree (MGBDT)

1 Introduction

One of the key contributors to national development is the educational sector, which offers a wide range of learning locations and settings. The functionality and productivity of educational institutions have been significantly impacted on by the emergence of technology [1–3]. A key purpose of global computing technologies is to expand the engagement of students. It also aims at collecting data from a wide range of sources and incorporating them into different activity solutions, which is vital to the provision of ratings that are based on the daily activities of students based on an educational perspective. Regardless of the fact that there are huge technological advancements that have been made in the area of education, the assessment of students is still carried out manually. This is prone to human error as key features could be omitted when the performance of students is computed. The IoT is an internet of networked, distinct from others items that is gaining traction. It is basically aimed at developing intelligent spaces/environments as well as self-aware objects. The emergence of the IoT has resulted in the alteration of the global computing [4, 5] asides the numerous areas that surround different sensors. In more recent times, major new trends are emerging, particularly, in the area of combining sensors and device systems with technological systems. This is coupled with the interactions between device-to-device and technological systems, which helps in solving most problems associated with device and protocol. It is expected that the synergy between contextual data analytics and digital applications like machine-to-machine communications can promote the transformation of different industries. Also, it expected that the advancement of IoT innovation can be enhanced by the emergence of cloud computing as well as its use in the fog paradigm, considering the increased utilization of smart products. The interest in this study is motivated by these developments, stimulating the eagerness to examine extant work, develop novel models, and unearth novel IoT applications. The advancement in online education has been supported by the continuous technological advancement in the area of wireless communication networks, which have attracted the interest of professionals and academics, and they're already being used in nautical applications globally. Worthy of note is the fact that the current situation has resulted in the forced transition from face-to-face educational paradigm to online paradigm. Even though this paradigm is assumed to be simply embraced by learners, a closer examination shows that this paradigm births a significant variation. The productivity of learners can be greatly impacted on by changes made to mode of studying. Given that knowledge is owned by teachers, they are regarded as key players in the conventional learning system [6, 7]. Recently, there has been rapid advancement in the area of Mobile Wireless Communication Networks. The efficiency of wireless communication has been on the increase, which in turn allows for the deployment of several phases of cellular phone technology that is currently used by numerous people [8, 9]. This trend began with 5G network that was majorly employed in voice conversations, but served as the foundation of all mobile generations that emerged afterwards. In every phase, novel technologies are

introduced, while new features and functions are supported. The basic overview of Internet of Things is graphically represented in Figure 1 below.

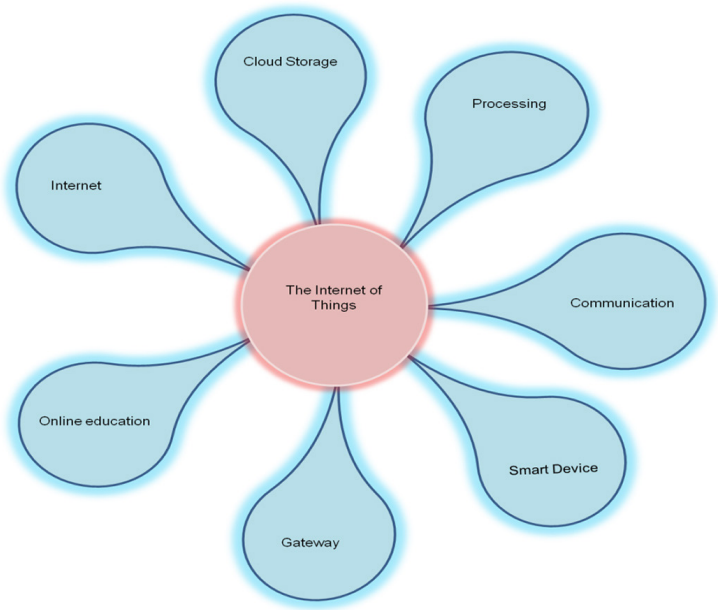

Fig. 1. General representation of Internet of Things

Investigations on IoT (Internet of Things) technology have focused on determining if it can be used in improving virtual teaching and learning. In the present study, an approach that supports decision-making among administrators of educational institutions is proposed. It is expected that with this approach, they will be able to use data obtained from the IoT to make well-informed decisions in the education sector. For educational institutions to be able to make decisions based on data, they can make use of real-time data stream which can be analysed and used to feed their learning analytic system. More so, the performances of the management of higher institutions are influenced by the ease with which academic platforms can be accessed through the internet. The key contribution of the proposed approach is that, it demonstrates to educational institutions that virtual teaching and learning can be supported and improved by using data obtained through the Internet of Things. The application of IoT in educational institutions is increasingly becoming popular, with institutions using the internet for the collection, storage, and transmission of information [10]. The critical role of technology has been experienced in the education sector, especially in terms of student connection and education. Virtual education has been significantly influenced by the Internet of Things, which has changed the conventional methods of teaching as well as the architectural setup of educational institutions. The concept of IoT is regarded in two-fold in terms of the roles it plays in virtual education, given that it can be used as a technology for the enhancement of educational infrastructure, and it can also be studied as a course [11–13]. The revolution of virtual education can be enabled at all levels of education through the use of IoT technology. This technology offers great benefits to

different stakeholders at every level, including teachers and students. The use of Internet of Things has been employed in the areas of teaching and research. The incorporation of the Internet of Things into education allows the easy interaction between people and things in the academia. Figure 2 is a representation of an IoT enabled teaching model.

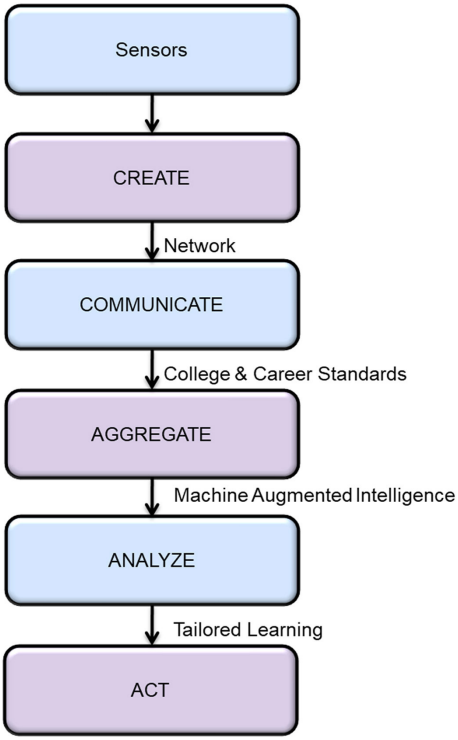

Fig. 2. Internet of Things enabled teaching

There is still need for the further improvement of the wireless communications, given the increasing need for connectivity between devices and the internet of things. In the nearest future, the paradigms of IoT wireless communications network will be needing approaches like dynamic spectrum access, spectrum sharing, optimal routing and extraction of signal intelligence. The recent upsurge in the demand for IoT wireless communications can be attributed to the unique nature of the Internet of Things wireless communication networks coupled with the latest ubiquity of machine learning. Given the high number of Internet of Things' devices, huge interactions, especially through wireless communication networks, it becomes important to have a networking architecture that is characterized by scalability. Particularly, the daily lives of humans are gradually being pinned around the IoT, giving room for unique access to information. In addition, the IoT enables the improvement of the virtual learning, enhancing more accessibility. At the moment, improved results in learning are being recorded due to the early efforts in IoT-based education. Learning and teaching resources have become increasingly accessible to people in different parts of the world through wireless or

wired network, thereby increasing the potentials of education for everyone. Through IoT-based learning, students and teachers in different parts of the world can be able to obtain local and international information that can improve teaching and learning outcomes. Virtual education is regarded as a promising alternative for the application of IoT. Recently, the application of IoT technology has enabled the integration of instructional materials into the development of repositories that are scalable and rich in media content. The subject of Internet of Things in education has been extensively studied. The critical role of IoT in virtual education is illustrated in Figure 3 below.

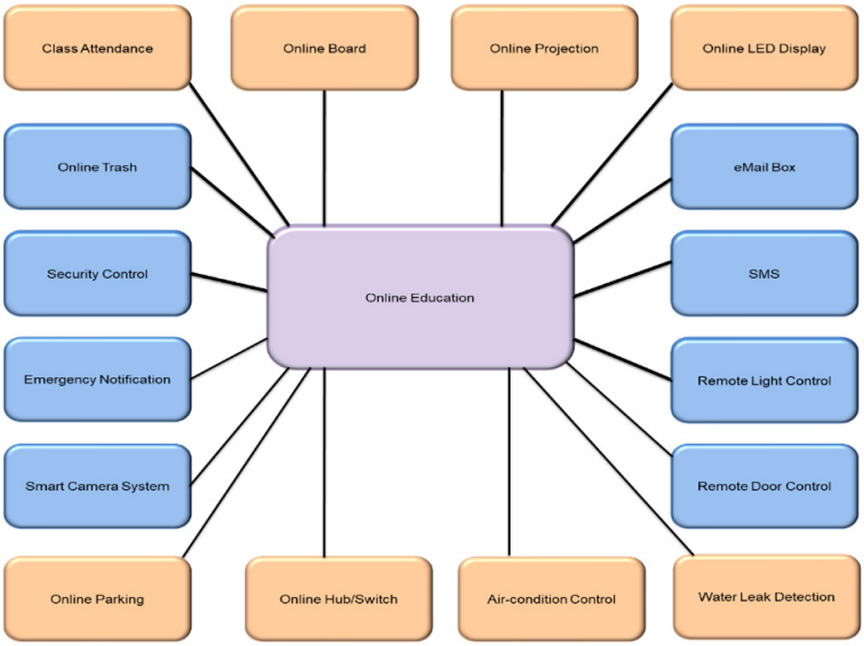

Fig. 3. IoT in online education

Huge advancements in telecommunications, cloud technology, detectors, nanotechnology, and big data will be recorded because of the impact of IoT. Communication between humans in different locations have been made possible and easy due to the presence of Internet of Things coupled with current trends in technological advancements. Also, a great number of intelligent systems have been created with the help of IoT. Quite a number of areas have been revolutionized because of the application of IoT in those areas. One of those areas is higher education, in which improved learning, experimentation, and management is being recorded due to the use of IoT [14, 15]. Thus in this work, a Multi-Gradient Boosting Decision Tree (MGBDT) algorithm and Adaptive Layered Bayesian Belief Network (AL-BBN) are presented as ideas for action development for optimal mobile wireless communication networks and IoT. The remaining parts of the paper are structured as follows: Part II. Review of Related Works and Problem Statement; (III) Proposed Work; (IV). Performance Analysis; (V) Conclusion

2 Related works

In the study carried out in [16], the challenges of educational system as well as the possible ways of addressing them through the use of IoT technology and were investigated the author examines educational system difficulties and how to fix them using Network infrastructure and IoT technology. In their work, they designed an algorithm that enables a modern approach to learning, and named it "IoT-based Centralized Double Stage Education". The algorithm allows for contemporary technologies and instructional strategies to be integrated. More so, the investigation of security challenges was done considering the physical layer due to the fact that core network safety systems are characterised by complete privacy, minor computer complexity, consumption of resources, and good adaption to change in channel. [17]. Their investigation focused on resource allocation, safety of intercept coding, processing of data, multi-node collaboration, alongside identification and extraction of application layer key. The aim of this investigation is to find ways through which the increasing security challenges can be tackled. The authors in [18, 19] beamed the flashlight on the present contributions of IoT to education, while highlighting a wide range of obstacles that can hinder or challenge experimental endeavours in the future. This study was a review study that focused on the use of IoT in education, vocational learning, clinical advancement, green IoT, and wearable technology. In [20, 21], the researchers proposed an online education system (OES), which checkmates abnormal behaviour of users. The system is able to flag consumers with unruly behaviour; the system exposes the private information of such consumers. This is the strategy used by the system to achieve system security. The aim of this is to make the user return to appropriate behaviour. The result of the system test based on reliability and safety parameters, the proposed system provides more security than existing ones. The security of the system enables stem education through the deployment of resource-constrained IoT devices. It was also reported that only little latency is required for communication and computation. In addition, efforts were made by [22, 23] to enhance the process of learning; the researchers integrated Learning management systems with AI "artificial intelligence" so that the process of learning can be improved. As part of the new normal, this is aimed at the creation of a standard educational shift that allows students to learn virtually and to be able to gain access to virtual assistants that can support their academic endeavours. The present level of research and practice in the area of engineering education was evaluated in study [24, 25]. Who also investigated the implication of industrial research. This was done considering the new trending services through wearable technologies, mobile computing, deep learning, and internet of things. A discussion on the ideas and history of internet of things was presented in [26, 27] alongside the idea of educational administration, education, and related issues. The application of such modern technologies can enable the identification of difficulties that exist within the education sector, and help decision makers in taking the right steps within a smart environment. To this end, FHM University of Applied Sciences, a well-recognized education in Germany, was investigated as a case study of an experimental implementation in the area of IoT. Another educational system was designed by the authors in [28–30], and the system was designed to imitate the intellectual intelligence of learning things. It is a learning system that is based on IoT, and designed to complement conventional methods of education alongside top-notch learning approaches. The use of this system can be employed on a wide range of applications and devices allowing interaction and opinion-sharing with consumers

through the internet of things. The critical role of internet of things in enhancing the process of education, particularly learning was analysed by the authors in [31, 32]. In their study, they highlighted the application of IoT in different areas of education, including, distant learning, medicine, science, consumer green education amongst many others. The emergence of the internet, transformations in terms of human-to-machine, human-to-human interactions have occurred, and these have been transformed to worldwide communications network. In [33], the author proposes a strategy for developing a long-term educational environment that is financially, socially, and ecologically responsible. In addition to technology, a better IoT-supported educational environment necessitates increased collaboration among institutions, staff, and students. The vision of a completely reformed field of education, digitally assisted, enriched, and financially, economically, and socially economic health is only conceivable with the full commitment of every stakeholder and respective desire to help and team up. In [34], the use of blockchain technologies in education was systematically evaluated with the aim of providing in-depth insight on the critical application and role of blockchain in education. They also focused on highlighting its application in the future developments of the education sector. Blockchain technology has huge potentials in the area of education, and as such more efforts should be geared towards exploring such potentials. These authors, through their research have set the platform for decision makers and academics to further explore other areas in which this technology can be applied. The author in [35], proposed the use of a wide range of sensor devices in an educational system. The proposed system was found to be efficient in terms of its scalability in addressing the increasing sensor populations. They described the architecture and implementation of the IoT from a software perspective. They also provided a description of the proposed system's features, carried out an analysis of the lessons learned, while highlighting future trends of their work. The authors in [36] carried out an investigation of the basic principles, features, classifications, technologies, and challenges associated with the internet of things. In their work, the crucial role played by IoT in the development of a smart educational system was demonstrated. They also highlighted the contribution of IoT in decision-making by enabling sound judgement and capacity building which are critical to the daily activities of humans. Also, major utilities in different industries can be expanded and improved upon through the use of IoT. By improving those utilities, applications can be developed through a new ecosystem by means of a world-wide distributed local wireless system of intelligent items. In the work done by [37], a device referred to as wrist-based wearable for Education 4.0 (fitness tracker) was proposed, and the benefits that can be derived from the use of wearable device were highlighted. The authors also designed a questionnaire to evaluate the experiences of users in terms of their acceptance of modern electronic technology in higher education. Their experimental results showed the key procedures and sensors for education 4.0. They also demonstrated through their results that their proposed fitness trackers designed with a built-in sensor is capable of collecting a huge amount of real-time data while kids are studying. The researchers in [38] show the importance of the current education technology in enabling the productivity of students and teachers. They also demonstrated that it is time saving for teachers, and requires less efforts. In this study, it was revealed that the use of Learning Management systems helps students to acquire more knowledge within a shorter period of time. It was noted in the study that, interaction between teachers and students, teachers and teachers, and students and students is enabled through the proposed method. While showing the benefits that can be derived by

integrating an LMS with higher education, the authors also urged other higher institutions to adopt this technology.

3 Problem statement

There is a wide range of devices that can be used by students to accomplish their academic goals and tasks, including computers, phones, and tablets. These devices offer them the benefit of participating in classroom activities virtually. In addition, IoT facilitates interaction and communication between instructors and students. Although IoT devices may have the simplest applications, such as registering entrance and exit at a security door, there more complex applications of such devices as they are designed with more sophisticated components. Additionally, the transmission of critical data to IoT systems can impact on all other things related to it in a negative way.

4 Proposed methodology

In the current work, a quality IoT strategy has been developed by using an Adaptive Layered Bayesian Belief Network (AL-BBN) alongside Multi-Gradient Boosting Decision Tree (MGBDT) algorithm within the internal environment. The purpose of this strategy is to increase data that can facilitate online learning. Figure 4 below shows the functional flow of this study.

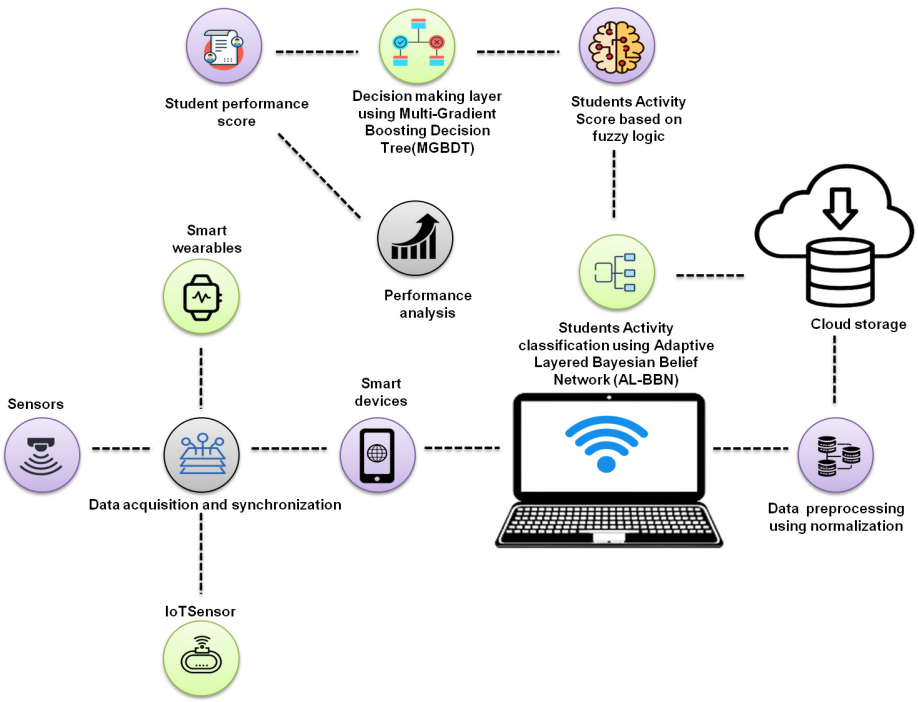

Fig. 4. Schematic representation of proposed work

4.1 Data acquisition and synchronization

Data such as students' geographical location and their daily interaction are collected through a data acquisition system. The data which is gathered enables the incorporation of energy-efficient sensors, intelligent systems, as well as other monitoring devices. A personal sensor network composes of GPS sensors, radio frequency identification (RFID), and other IoT devices. The purpose of designing this system is to enable the collection of students' information, daily engagements of both staff and students, and their locations. More so, both unstructured and structured data are collected from the personal sensor network by the gateway. After the data is collected, it is forwarded to a cloud storage database for further analysis. The features of the dataset are represented in Table 1 below.

Table 1. Personal attributes of student

S.no	Features	Explanation
1	SID	Student identification number
2	Name	Student name
3	Age	Age of the student
4	Sex	Male or Female
5	Address	Permanent address of the student
6	Family member name	Name of the family member
7	Family member mobile number	Family member mobile number
8	Student data	Student previous performance information

4.2 Data Pre-processing using normalization

The selection of the target data should be made from the unprocessed collection of financial data so that the performance can be boosted. It is important that this data be prepared to enable its usability. After the target data has been processed, it is analysed and then the results generated through the use of data mining methods. The purpose of transforming data is to alter the pattern and types of characteristics. The pre-processing of data is a step that is crucial to data processing and extraction. There are chances that data which is falsified will be found among the semi-structured, structured and unstructured datasets that are unprocessed. Thus, it is necessary for data to be processed so that it can be void of noises, and can be standardized. The elimination of noisy images from the dataset requires the use of image retrieval methods. The normalization of the dataset may be carried out at the stage of pre-processing. The arithmetical representation of D-count is given be Equation (1) as follows:

$$D = [(N - \beta) / \tau] \tag{1}$$

Where, β denotes the information's mean and τ represents the standard deviation, while D is represented as,

$$D = \frac{N - \bar{N}}{R} \tag{2}$$

Here $\bar{N}$ is the specimen's mean, and R denotes the standard deviation of the specimen. Below is the representation of the random specimen:

$$D_s = \delta_0 + \delta_1 N_t + \rho_t \tag{3}$$

The defects that are depending on τ^2 are represented by t.

Ensuring that, as seen below, the defects should not depend on one another.

$$l_n \sim \sqrt{U} \frac{l}{\sqrt{l^2 + p - 1}} \tag{4}$$

Here, l represents the random parameter.

Then the movements of the variables are normalised using standard deviation. The momentary scale deviance is determined using the formula below (5).

$$\mathrm{NNR} = \frac{\mu^{\mathrm{nnr}}}{\theta^{\mathrm{nnr}}} \tag{5}$$

Here, momentary scale is denoted by mms. $\mu^{\mathrm{nnr}} = \mathrm{Va}\,(\mathrm{n} - \beta)\,\hat{}\,\mathrm{NNR}$ (6)

N represents random variable, while Va denotes predicted values.

$$\theta^{\mathrm{nnr}} = \left(\sqrt{\mathrm{Va}\left(\mathrm{n} - \beta\right)\,\hat{}\,\mathrm{NNR}}\right)\hat{}\,2 \tag{7}$$

$$l_p = \frac{nnr}{\bar{N}} \tag{8}$$

The coefficient of variance is denoted as l_p.

Each parameter should be fixed at zero so that characteristic scaling can be paused. This approach is referred to as "unison-based normalizing approach." After normalization, the formula will be as follows:

$$N' = \frac{(l - l_{min})}{(l_{max} - l_{min})} \tag{9}$$

Upon completion of the process of data normalization, the data may be saved and the dataset's anomalies and length can be maintained. This stage is aimed at minimizing or eliminating data delays. Afterwards, the dataset that has been subjected to the process of normalization can be used as input data in the subsequent stages of the process. The dataset for students' virtual education is saved in the cloud, which is referred to as an Infrastructure as a Service (IaaS) provider. Here, data is gathered from different sources and can be retrieved at any time. The use of cloud storage repository is employed in saving the time-stamped data, and this data is later on retrieved for analysis. The classification of students' activities is done appropriately based on the different hypotheses highlighted in the categorization section. In addition, students' personal information is

saved in the cloud repository, where each student is assigned a unique number through which they can be identified. The unique number is connected to the daily IoT-based activities within the institution.

4.3 Students Activity Classification using Adaptive Layered Bayesian Belief Network (AL-BBN)

In the methodology that is proposed in this study, there are two main categories of activities including, rare and monotonous activities. The later refers to those activities that involve the daily monitoring of students' progress using data from IoT sensors and hardware devices. The use of activity models can be employed in defining a wide array of students' activities. In this work, the correlations between independent variables and student attrition (which is the dependent variable), are captured and described using AL-BBN. AL-BBNs are complex mathematical models that show explicitly and naturally show the link prediction structural correlation across different models in an array of variables and variable groups. The AL-BBN chain rule is an approach that can be used to conveniently represent complex probability distributions, whereby each i_x represents a variable and Tz_{i_x} indicates the parents of the same (i_x) variable.

$$T(i_1,\ldots,i_n) = \prod_{x=1}^{n} T(i_x | Tz_{i_x}) \tag{10}$$

Some of the important activities of students that can be captured include participation of students in different forums and discussions, participation of students in study cohorts, college involvement in interactions that are key to the theme, and terms of membership of physical activities. The Bayes rule is the conditioned stimulus, and this rule involves the computation of the possibility of each provided target number or class of value. After the computation, the structure possessing the best estimated prediction is selected for the next stage. Lastly, this replica is aimed at identifying provisional correlations between student attrition predictors. For a variable i_x, a suitable representation of the students is required:

$$Tz_{i_x} = \{B, i_{\delta(x)}\} \tag{11}$$

Due to the fact that exponential growth is exhibited by the amount of conditional estimations that must be created for each root, it becomes necessary for an intelligent and professional AL-BBN engineer to commit a good amount of time to one or more domain experts so as to be able to build a moderate-sized network manually. The example below shows that B serves as the base classifier in the second fall that has been recorded. These utilizing techniques how much material is supplied when the category variable is known.

$$X_T(i_x;i_y) = \sum_{i_x,i_y} T(i_x,i_y) log \frac{T(i_x,i_y)}{T(i_x)T(i_y)}, \mathrm{x} \neq \mathrm{y} \tag{12}$$

The ordering, which is determined by the relationship amongst each pair of variables, only includes edges amongst predictor variables. An edge's weight in a graph is determined by mutual information which denotes the relationship between two variables. The following formula defines mutual information between two random variables i_x = Fall student active and i_y = Spring student active:

$$X_T(i_x : i_y \mid B) = \sum_{i_x, i_y, B} T(i_x, i_y, B) log \frac{T(i_x, i_y \mid B)}{T(i_x \mid B) T(i_{y|B})} \text{x} \neq \text{y} \tag{13}$$

Where the tree is a function over Tz_{i_x} is the set of parents for each i_y, and B is the class variable Tz_{i_x} that has no students.

4.4 Students activity score based on fuzzy logic

There is a relationship between each illustration and a period. The data which provides details about the activities of students is known as temporal data. Dissimilar activities-related sensory input is provided in the form of behavior metrics at different timestamps. Through the process of fuzzification, a collection of terms and fuzzy language concepts are created based on the exact set of inputs provided. Subsequently, the use of membership function is employed in creating a set of fuzzy logic, and followed by the establishment of the final inference. Intra-class deviation, Inter-class volatility, and feature-based time of each component for each sub-band are all fuzzy logic input elements provided to the student's activity. The sub-band specific feature subsets are selected by using fuzzy logic with the most suitable classifiers.

$$e : S^m \rightarrow [0, h]^n. \tag{14}$$

The following production rules guide the fuzzy logic:

$$S_i : IFr_1 \wedge y_1 = B_{1i} ANDr_2 \wedge y_2 = B_{2i} ANDr_n \wedge y_n = B_{ni} THENclass = d_i, i = 1, \ldots, S,$$

where I denotes the rule index, S represents the number of rules, B_{Ki} is a fuzzy term characterizing the *k*-th quality in the *i*-th rule (k = 1, … , m); d_i is the resultant class, R = (r_1, r_2, …, r_n) is the binary vector of features, and line $r_1 \wedge r_k$ shows if a feature is present (r_k = 1) or absent (r_k = 0) in the classifier.

There is no exact quantity at the timestamp axis, considering the fact that there is difference in timestamp according to student. A tensor which is referred to as the student-activity data tensor ($R_g P_s$) has been designed with the aim of achieving this purpose. The mathematical representation of the daily $R_g P_s$ of a student is given as follows:

$$R_g P_s = [R_1, R_2, R_3, \ldots, R_m] \tag{15}$$

In the observation table, the class label is defined $\{(y_p; d_p), p = 1, z\}$ as follows:

$$class = d_t, t = \underset{1 \le i \le n}{\operatorname{argmax}}\{\beta_i\} \tag{16}$$

$$\mu_j(y_p) = \mu_{Bi1}(y_{p1}) \ldots \mu_{Bin}(y_{pn}) = \prod_{k=1}^{m} \mu_{Bik}(y_{pk}) \tag{17}$$

$$\beta_t(y_p) = S_{iD_j=classt}^{\Sigma} \mu_t(y_p) = S_{iD_j=classt}^{\Sigma} \prod_{k=1}^{m} \mu_{Bik}(y_{pk}) \tag{18}$$

Where $m_{Bik}(y_{pk})$ denotes the fuzzy term Bik's membership function value at point y_{pk}.

$$F(\theta, R) = \frac{\sum_{p=1}^{z} \begin{cases} 1, IFd_p = arg \max\limits_{1 \le i \le n} e_i(y_p; \theta, R) \\ 0, OTHERWISE \end{cases}}{z} \tag{19}$$

Where $e(y_p; \theta, R)$ denotes the output of fuzzy logic with fuzzy terms θ parameters and R at point y_p. The key challenge of designing a fuzzy logic is to ascertain the maximum of the function in space R and $\theta = (\theta^1, \theta^2, \ldots, \theta^D)$:

$$\begin{cases} F(\theta, R) \to max \\ \theta_{min}^j \le \theta^j \le \theta_{max}^j, j = \overline{1, D} \\ R_i \in \{0,1\} i = \overline{1, n} \end{cases} \tag{20}$$

Where θ_{min}^j, θ_{max}^j denotes the upper and bottom bounds of each parameter's fuzzy logic, respectively. This is an NP-hard problem, and in this study a proposal is made to resolve the problem by dividing it into two tasks which are student activity and fuzzy term parameter. Each activity (Z_y), where y is the amount of actions from 1 to n, and the students must complete *t*. The probability assessment of actions Z_y at day f can be expressed as U_y^f, where $1 \le f \le t$ is the element of working days in a college term. Using the formula below, a student's score for each activity R (Z_y) can be calculated:

$$R(Z_y) \frac{\sum_{f=1}^{t} U_y^f}{t} \tag{21}$$

Activities that are of great significance are considered as monotonous activities and have a U_y^f score that is calculated on a regular basis. While on the other hand, the balance of the events set is made up of activities that occur occasionally.

The fuzzy logic algorithm is presented in Algorithm 1 below

Algorithm 1: fuzzy logic algorithm

```
Step 1 Initialization
Initialize (Pop)
Archive.add (Pop)
Set Operators Prob (1.0)
window = Stagnation = 0
Step 2 primary loop
if the stopping requirement is not met,
Step 2.1 Parents' choice
for x = 1 to |Parents| do
ifRandomDouble (0, 1) ≤ β then
    Parents[x] ← TournamentSSD (Archive)
else
Parents[x] ← TournamentSSD (Pop)
end if
end for
Step 2.Reprint
Operator ← Roulette (OpProb)
Of fspring ← Operator (Parents)
Consider your options (Offspring)
UpdateUse = OpUse (Operator)
window++
Step 2.3 Update on the Archive
if ! (Archive.add (Offspring)) then
    Stagnation = Update Stagnation ()
end if
Step 2.4 Invoke the Fuzzy Inference System (FIS)
if window == windowSize then
UpdateOpProb(OpUse, Stagnation)
    Stagnation = 0 window
end if
Step 2.5 Population Update
NewPop ← Pop.add (Offspring)
fast non dominated sortSSD (NewPop)
P op ← RemoveWorstSolution (NewPop)
end while
Step 3 Output
return Archive
```

4.5 Decision making layer using Multi-Gradient Boosting Decision Tree (MGBDT)

The results obtained from the previous classification of decision tree are used in training each decision tree. The linear nature of the Multi-Gradient Boosting Decision Tree, makes the parallel training of the decision tree challenging. The second S_2 tree training optimization target is the sum of the first S_1 decision tree's outcome and the remaining S-value, and the method's final outcomes are the sums of each decision tree's outcome. Equation (13), in other words:

$$\hat{S} = S_1 + S_2 + S_3 \tag{22}$$

There are two loss functions possessed by the MGBDT that are often utilized for iterative optimization as shown in Equation (13). Alternatively, the effect can be optimized instantly, whereas, the other alternative can be the optimization of the gradient's decent significance. There is a difference between MGBDT and classic boosting. If MGBDT is sub-optimized, the target is optimal. The booster is a resembling device.

The estimated value of the many samples i as a node average power, which may be represented as Equation, is the integral gain μ of a node split (14),

$$\mu = \left(\sum_{y=1}^{e} i_y\right)/e \tag{23}$$

Consequently, the node's mistake can be written as Equation (15),

$$\text{Error} = \sum(i_x - v)^2 \tag{24}$$

In the process of node division, it is compulsory to select the feature which has the high tear gain for segment, and the tear winning L is determined using the following formula:

$$\text{L} = Q - Q_x \tag{25}$$

Based on Equation (17), the difference can be thought of as a less function, or Q_x:

$$Q_x = \sum_{n\in f}(i_n - \mu_f)^2 \sum_{e\in P}(i_e - \mu_P)^2 \tag{26}$$

Consequently, every splitting node problem will be focused on identifying a variable that is capable of increasing the split gain the most Q and Q_x are separated and expanded as in formula (18):

$$L = \left(sum_f^2 / \|F\| + sum_P^2 / \|P\|\right) - sum^2 / \left(\|total\|\right) \tag{27}$$

sum^2 represents the total of squares of all variations, as stated in Equation (18), where sum_f^2 and sum_p^2 are the total of the squares of all variants in the sub tree, respectively. Consequently, only L needs improvement. As mentioned earlier, the tree nodes in each tree node in the MGBDT are not together, rather, they are separated in isolation. Each trained forest is aimed at summing up the original trees and rate of presentation. The information entropy can be calculated using the training set. The n class y = 1, 2, … n is defined by Q, which holds the number of data samples. Q_y is the number of data samples.

$$\text{Y}(q_{1,}q_2,\ldots q_n) = -\sum_{y=1}^{n} w_y log_i(w_y) \tag{28}$$

E is the tree's root, and E contains e values $\{e_1, e_2, \ldots \ldots e_e\}$ The training set S is divided into subsets $\{S_1, S_2, \ldots \ldots S_e\}$, with S_x denoting a specific subset and e_x denoting the value of e. S_{yx} represents the element of samples in S_x that belong to Q_y.

$$K(E) = \sum_{x=1}^{e} \frac{S_{1x} + S_{2x} + \ldots S_{nx}}{S} Y(s_{1x}, s_{2x}, \ldots s_{nx}) \tag{29}$$

$$Y(s_{1x} + s_{2x} + \ldots s_{nx}) = -\sum_{y=1}^{n} w_{yx} \log_2(w_{yx}) \tag{30}$$

$$Gain(E) = Y(s_{1x} + s_{2x} + \ldots s_{nx}) - K(E) \tag{31}$$

The purpose of using MGBDT algorithm in this research is to enable decision-making on the performance of college students' performance. Factors such as data extraction, data treatment, selection of feature, training model, and prediction of unknown data have been prioritized. The MGBDT algorithm is represented by Algorithm 2.

Algorithm 2: MGBDT algorithm

Input: The training data set $G \epsilon S^n$, size of training set e=|G|, sample data $i_x \epsilon G$, x = 1, 2, …e, number of regression trees N, the maximum depth of each tree F.

Output: Trained model $Q = \left\{ SP_p = q_{z(.)}^{(p)}, p = 1, 2, .., N \right\}$

Initialization: Q = ø, p = 0, p is the current number of regression trees

While p<N: For all $i_x \epsilon G$, calculate the corresponding d_x and l_x according to

$$d_p = \partial H / \partial \hat{j}_x^{p-1}(i_x) - \left[j_x - \hat{j}_p(i_x) \right] \text{ and } l_x = \partial^2 H / \partial^2 \hat{j}_x^{p-1}(i_x);$$

Initialize the p th regression tree SP_p = ø and the current depth of regression tree f = 0;

While f<F:

Tranverse every leaf node N_y in SP_p, find the best split for each leaf node according to

$$split^* = \underset{split \in r}{argmin} \frac{D_H^2}{L_H} + \frac{D_S^2}{L_S} - \frac{(D_H + D_S)^2}{L_H + L_S}$$

where $DH = \sum_{i_x \in N_{y,h}} d_x$ and $LH = \sum_{i_x \in N_{y,h}} l_x$, and D_S, L_S are similar.

Split N_y into left child N_y^H and right child, N_y^S, then add them into SP_p;

Traverse all the leaf nodes of SP_p, calculate the predicted value of N_y;

Add SP_p, into set Q;

Return Q.

5 Performance analysis

The newly proposed IoT and Adaptive Layered Bayesian Belief Network (AL-BBN) models are functional to Selective Multi-Gradient Boosting Decision Tree (MGBDT) algorithm applications, according to this section. The performance of the proposed approaches was analysed using performance parameters like precision, recall, accuracy, and score. In analysing the performances of the models, they were compared with extant approaches like Naïve Bayes, Artificial Neural Network, Logistic Regression, and Decision Tree.

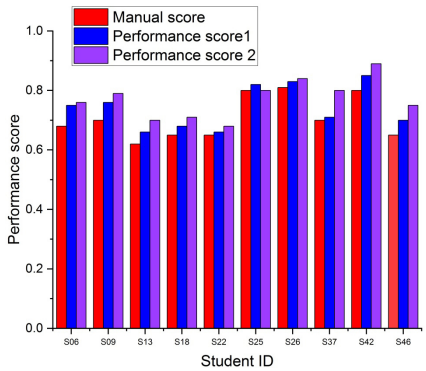

Fig. 5a. Performance score computation using proposed methodology

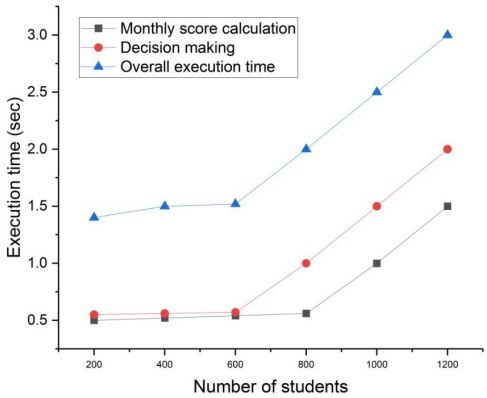

Fig. 5b. Proposed system component based execution time (in seconds) for each day

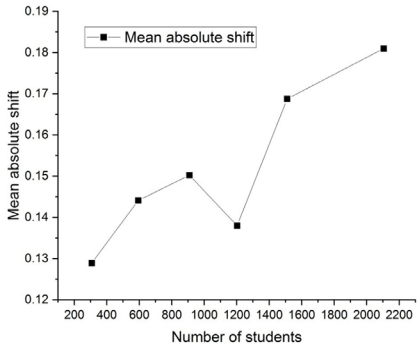

Fig. 5c. Proposed system stability

Figure 5. (a) The proposed mechanism for calculating performance scores, (b) proposed system component-based execution time (in seconds) for each day, (c) proposed system stability. Figure 5a Ten students from the same class were graded based on

their monthly performance over a period of three months. The performance of the first month was done using a manual system of grading, while that of the last two months was done using the approach proposed in this work. The effecting duration of numerous components required for the computation of the daily scores of students' performance is presented in Figure 5b. From Figure 5b, it can be clearly seen that the time required for the data mining stage is much longer than that of the recognition stage. Increase in the number of dataset based on the increase in the percentage of students' results in the relative shifting of the mean absolute value as shown in Figure 5c.

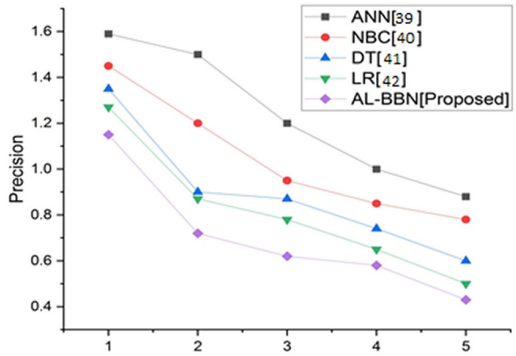

Fig. 6. Precision comparison

Precision refers to a quantity in decimal numbers that comes with the whole number and is unrelated to the accuracy. Practically, the concepts of accuracy and precision are synonymous, and as such, can be easily interchanged. The comparison of the proposed techniques with extant techniques based on precision is presented in Figure 6.

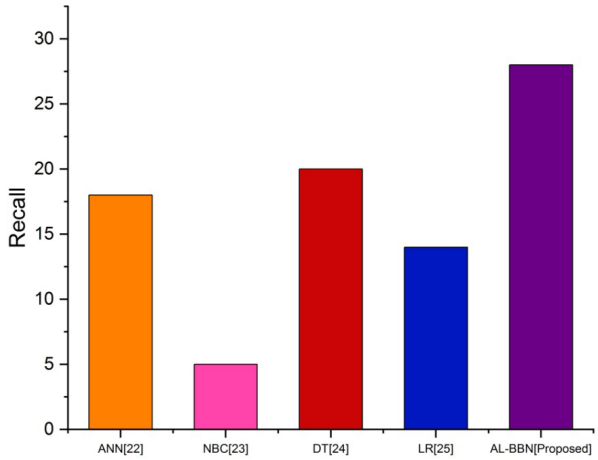

Fig. 7. Recall comparison

A user holds recall when recalling a visit or repeating a sonnet after reading its title. Here, a multiple-choice test was used given that is easier than an essay and more preferred by people. The administered test was based on recall remembrance. The result

of the comparison between the extant approaches and proposed approach based on the recall parameter is shown in Figure 7:

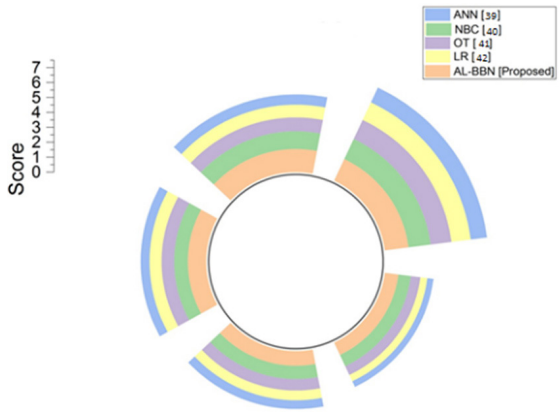

Fig. 8. Score comparison

Figure 8: Score of comparison between proposed approach and existing approaches.

$$score = \frac{tp}{tp + 0.5(fp + fn)} \tag{32}$$

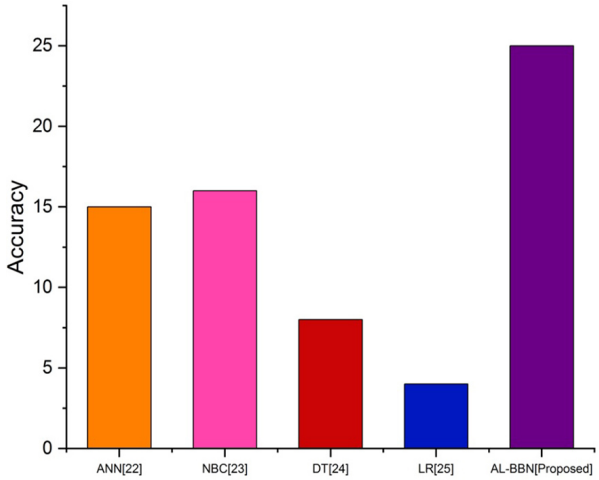

Fig. 9. Accuracy comparison

Accuracy provides the categorization with the required educational information. Figure 9: results of the comparison between the proposed approach and extant approach based on accuracy.

$$Ac = \frac{(tp + tn)}{(tp + tn + fp + fn)} \tag{33}$$

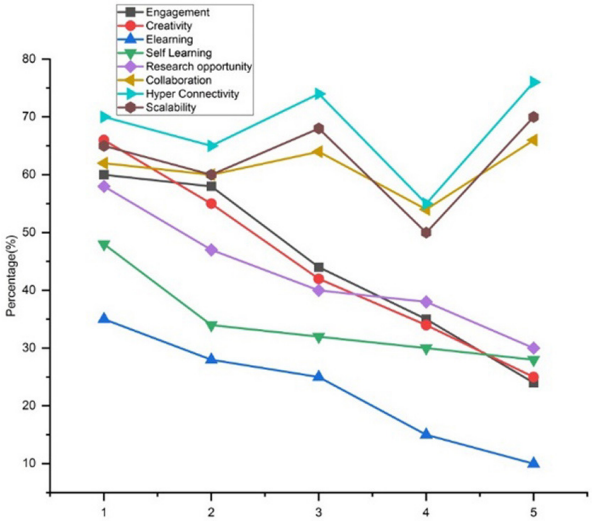

Fig. 10. Comparison between the predictions of teacher-based and student version

Figure 10 shows the results of the graphical comparison, with the two scenarios overlapping in three elements (research opportunity, e-learning, and hyper-connectivity). The organizations opine that the variables of virtual education IoT ecosystem are significantly influenced by the Internet of Things. Based on the student's view the most critical component in virtual learning is self-learning, however, it is not of much relevance in the eyes of the teacher. Also, the influence of IoT use in virtual education on the issue of cooperation is another difference between the two perspectives. It is believed by teachers that the IoT enables effectiveness in terms of teamwork, and cooperation, but students do not value the Internet of Things in that regards.

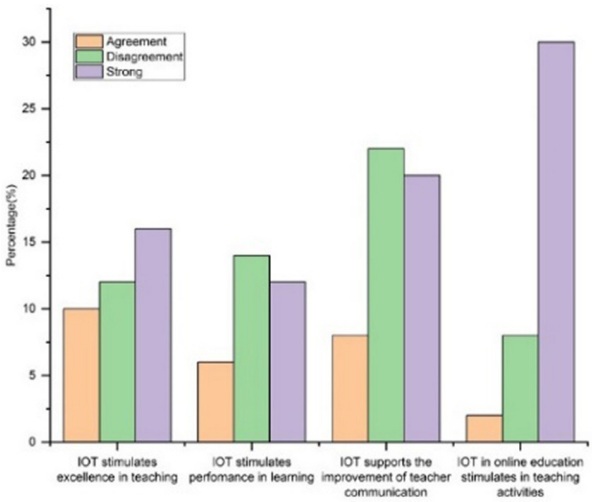

Fig. 11. Impact of the IoT in online education

Figure 11 presents the impact of IoT on virtual education. The findings revealed that IoT enables excellent performance in teaching, with high percentage in comparison to the disagreement and agreement. More so, the findings show that in terms of improvement in teacher communication, most respondents disagreed that the IoT enables improved communication. Meanwhile, a high percentage of the respondents agree that IoT enables teaching activities.

6 Discussion

Here, the usefulness of the approach proposed in this study is estimated in contrast to the IoT that was previously mentioned for the given data. It was also found that the method proposed in this study performs as good as that of global standard approaches like ANN [39], NBC [40], DT [41], and LR [42]. In ANN [39], the selected projection technique directly impacts on the connection's performance. The ANN should first be converted into numerical characters before it can be used to solve any problem. In the study of [40], the NBC 'zero-frequency problem,' occurs anytime the lowest error is assigned by the system to the predictor data whose category is not found in the dataset. Therefore, a mild strategy should be used in solving this problem. In the study of [41], it was demonstrated that the logistic regression may be significantly reshaped by a small piece of data, which can in turn increase insecurity for the system. In comparison with other approaches, the estimation of a decision tree can be extraordinarily complex durion. It takes a loger period of time to retrain a decision tree. The authors in [42] revealed that the key limitation of crucial limitation of logistic regression is the condition of proportionality between the logistic regression variables. Predictor accuracy (coefficient size) as well as connection direction are also revealed (positive or negative). However, the aforementioned limitations can be solved through the use of the proposed technique. In this part, the analyses of the experiments have been presented for MGBTDT algorithm and AL-BBN. Based on the evaluation, it can be concluded that the proposed approach demonstrated superior performance in terms of IoT as compared to ANN [22], NBC [40], DT [41], and LR [42].

7 Conclusion

The proposed system demonstrates an experimental configuration concentrating on the AL-BNN in a IoT virtualized environment. The MGBDT algorithm was presented to initiate, solve, and test the problem's intents. Consequently, the results revealed that improvements were achieved in the IoT method. The extant approaches include Naïve Bayes Classifier, Artificial neural network (ANN), Logistic Regression, and Decision tree (DT). Lastly, the performance parameters of the study are examined in comparison with those of other models with the aim of determining the most effective one. In addition, the procedures of data migration needed to meet the requirement of the future generations can be deployed.

8 References

[1] M. Vaezi, Z. Ding, and H. V. Poor, *Multiple Access Techniques for 5G Wireless Networks and Beyond*. Springer, 2019. https://doi.org/10.1007/978-3-319-92090-0

[2] B. Majeed and H. Alrikabi, "Tactical Thinking and its Relationship With Solving Mathematical Problems Among Mathematics Department Students," *International Journal of Emerging Technologies in Learning (iJET),* vol. 16, no. 9, pp. 247–262, 2021. https://doi.org/10.3991/ijet.v16i09.22203

[3] D. Turnbull, R. Chugh, and J. Luck, "Transitioning to E-Learning During the COVID-19 Pandemic: How have Higher Education Institutions responded to the challenge?," *Education and Information Technologies,* vol. 26, no. 5, pp. 6401–6419, 2021. https://doi.org/10.1007/s10639-021-10633-w

[4] W. Ejaz and A. Anpalagan, "Internet of Things for Smart Cities: Overview and Key Challenges," *Internet of Things for Smart Cities,* pp. 1–15, 2019. https://doi.org/10.1007/978-3-319-95037-2_1

[5] H. T. S. alim and N. A. asim, "Design and Implementation of Smart City Applications Based on the Internet of Things," *International Journal of Interactive Mobile Technologies (iJIM),* vol. 15, no. 13, pp. 4–15, 2021. https://doi.org/10.3991/ijim.v15i13.22331

[6] W. Villegas-Ch, M. Román-Cañizares, and X. Palacios-Pacheco, "Improvement of an Online Education Model with the Integration of Machine Learning and Data Analysis in an LMS," *Applied Sciences,* vol. 10, no. 15, p. 5371, 2020. https://doi.org/10.3390/app10155371

[7] L. F. Jawad, B. H. Majeed, and H. T. ALRikabi, "The Impact of Teaching by Using STEM Approach in the Development of Creative Thinking and Mathematical Achievement Among the Students of the Fourth Scientific Class," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 13, pp. 172–188, 2021. https://doi.org/10.3991/ijim.v15i13.24185

[8] A. A. Salih, S. Zeebaree, A. S. Abdulraheem, R. R. Zebari, M. Sadeeq, and O. M. Ahmed, "Evolution of Mobile Wireless Communication to 5G Revolution," *Technology Reports of Kansai University,* vol. 62, no. 5, pp. 2139–2151, 2020.

[9] H. T. Salim, A. H. M. Alaidi, A. S. Abdalrada, and F. T. Abed, "Analysis the Efficient Energy Prediction for 5G Wireless Communication Technologies," *International Journal of Emerging Technologies in Learning (iJET),* vol. 14, no. 08, pp. 23–37, 2019. https://doi.org/10.3991/ijet.v14i08.10485

[10] R. Salah Khairy, A. Saleh Hussein, and H. TH. Salim ALRikabi, "The Detection of Counterfeit Banknotes Using Ensemble Learning Techniques of AdaBoost and Voting," *International Journal of Intelligent Engineering and Systems,* vol. 14, no. 1, pp. 326–339, 2021. https://doi.org/10.22266/ijies2021.0228.31

[11] D. Abdul-Rahman and H. Salim, "Enhancement of Educational Services by Using the Internet of Things Applications for Talent and Intelligent Schools," *Periodicals of Engineering and Natural Sciences (PEN),* vol. 8, no. 4, pp. 2358–2366, 2020.

[12] D. K. Abdul-Rahman Al-Malah, S. Ibrahim Hamed, and H. T. Alrikabi, "The Interactive Role Using the Mozabook Digital Education Application and its Effect on Enhancing the Performance of eLearning," *International Journal of Emerging Technologies in Learning (iJET),* vol. 15, no. 20, pp. 21–41, 2020. https://doi.org/10.3991/ijet.v15i20.17101

[13] B. H. Majeed, L. F. Jawad, and H. T. ALRikabi, "Computational Thinking (CT) Among University Students," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 10, 2022. https://doi.org/10.3991/ijim.v16i10.30043

[14] M. Al-Emran, S. I. Malik, and M. N. Al-Kabi, "A Survey of Internet of Things (IoT) in Education: Opportunities and Challenges," in *Toward Social Internet of Things (SIoT): Enabling Technologies, Architectures and Applications*: Springer, pp. 197–209, 2020. https://doi.org/10.1007/978-3-030-24513-9_12

[15] G. Pappas, J. Siegel, I. N. Vogiatzakis, and K. Politopoulos, "Gamification and the Internet of Things in Education," in *Handbook on Intelligent Techniques in the Educational Process*: Springer, pp. 317–339, 2022. https://doi.org/10.1007/978-3-031-04662-9_15

[16] K. Khujamatov, E. Reypnazarov, N. Akhmedov, and D. Khasanov, "IoT Based Centralized Double Stage Education," in *2020 International Conference on Information Science and Communications Technologies (ICISCT)*, 2020: IEEE, pp. 1–5. https://doi.org/10.1109/ICISCT50599.2020.9351410

[17] S. Zhang, J. Liu, T. K. Rodrigues, and N. Kato, "Deep Learning Techniques for Advancing 6G Communications in the Physical Layer," *IEEE Wireless Communications,* vol. 28, no. 5, pp. 141–147, 2021. https://doi.org/10.1109/MWC.001.2000516

[18] H. T. H. Haider TH. Salim ALRikabi, "Secure Chaos of 5G Wireless Communication System Based on IOT Applications," *International Journal of Online and Biomedical Engineering(iJOE)*, vol. 18, no. 12, pp. 89–102, 2022. https://doi.org/10.3991/ijoe.v18i12.33817

[19] S. F. Shetu, M. M. Rahman, A. Ahmed, M. F. Mahin, M. A. U. Akib, and M. Saifuzzaman, "Impactful e-learning Framework: A New Hybrid Form of Education," *Current Research in Behavioral Sciences,* vol. 2, p. 100038, 2021. https://doi.org/10.1016/j.crbeha.2021.100038

[20] S. Jegadeesan, M. S. Obaidat, P. Vijayakumar, M. Azees, and M. Karuppiah, "Efficient Privacy-Preserving Anonymous Authentication Scheme for Human Predictive Online Education System," *Cluster Computing,* pp. 1–15, 2021. https://doi.org/10.1007/s10586-021-03390-5

[21] M. El-Hajj, A. Fadlallah, M. Chamoun, and A. Serhrouchni, "A Survey of Internet of Things (IoT) Authentication Schemes," *Sensors,* vol. 19, no. 5, p. 1141, 2019. https://doi.org/10.3390/s19051141

[22] S. Pervez, S. ur Rehman, and G. Alandjani, "Role of Internet of Things (IoT) In Higher Education," *Proceedings of ADVED,* pp. 792–800, 2018.

[23] B. Hasan and L. Fouad, "The Impact of CATs on Mathematical Thinking and Logical Thinking Among Fourth-Class Scientific Students," *International Journal of Emerging Technologies in Learning (iJET),* vol. 16, no. 10, pp. 194–211, 2021. https://doi.org/10.3991/ijet.v16i10.22515

[24] A. Siddhpura, V. Indumathi, and M. Siddhpura, "Current State of Research in Application of Disruptive Technologies in Engineering Education," *Procedia Computer Science,* vol. 172, pp. 494–501, 2020. https://doi.org/10.1016/j.procs.2020.05.163

[25] D. Al-Malah, H. Alrikabi, and H. A. Mutar, "Cloud Computing and its Impact on Online Education," *IOP Conference Series: Materials Science and Engineering,* vol. 1094, p. 012024, 2021. https://doi.org/10.1088/1757-899X/1094/1/012024

[26] H. D. Mohammadian, "IoT–A Solution for Educational Management Challenges," in *2019 IEEE Global Engineering Education Conference (EDUCON)*, 2019: IEEE, pp. 1400–1406. https://doi.org/10.1109/EDUCON.2019.8725213

[27] N. A. Jasim and A. Z. Abass, "Smart Learning based on Moodle E-learning Platform and Development of Digital Skills for University Students," *International Journal of Recent Contributions from Engineering, Science & IT (iJES),* vol. 10, no. 1, 2022. https://doi.org/10.3991/ijes.v10i01.28995

[28] M. S. Satu, S. Roy, F. Akhter, and M. Whaiduzzaman, "IoLT: An IoT Based Collaborative Blended Learning Platform in Higher Education," in *2018 International Conference on Innovation in Engineering and technology (ICIET)*, 2018: IEEE, pp. 1–6. https://doi.org/10.1109/CIET.2018.8660931

[29] N. Alseelawi, H. T. Hazim, and H. T. Salim ALRikabi, "A Novel Method of Multimodal Medical Image Fusion Based on Hybrid Approach of NSCT and DTCWT," *International Journal of Online & Biomedical Engineering,* vol. 18, no. 3, 2022. https://doi.org/10.3991/ijoe.v18i03.28011

[30] I. A. Aljazaery, J. S. Qateef, A. H. M. Alaidi, and R. a. M. Al_airaji, "Face Patterns Analysis and Recognition System Based on Quantum Neural Network QNN," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 8, 2022. https://doi.org/10.3991/ijim.v16i08.30107

[31] D. D. Ramlowat and B. K. Pattanayak, "Exploring the Internet of Things (IoT) in Education: A Review," *Information systems design and intelligent applications,* pp. 245–255, 2019. https://doi.org/10.1007/978-981-13-3338-5_23

[32] H. T. Salim, and H. Tauma, "Enhanced Data Security of Communication System using Combined Encryption and Steganography," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 16, pp. 144–157, 2021. https://doi.org/10.3991/ijim.v15i16.24557

[33] M. Maksimović, "IOT Concept Application in Educational Sector using Collaboration," *Facta Universitatis. Series: Teaching, Learning and Teacher Education,* vol. 1, no. 2, pp. 137–150, 2018. https://doi.org/10.22190/FUTLTE1702137M

[34] S. Baskar, P. M. Shakeel, R. Kumar, M. Burhanuddin, and R. Sampath, "A Dynamic and Interoperable Communication Framework for Controlling the Operations of Wearable Sensors in Smart Healthcare Applications," *Computer Communications,* vol. 149, pp. 17–26, 2020. https://doi.org/10.1016/j.comcom.2019.10.004

[35] K. Gunasekera, A. N. Borrero, F. Vasuian, and K. P. Bryceson, "Experiences in Building an IoT Infrastructure for Agriculture Education," *Procedia Computer Science,* vol. 135, pp. 155–162, 2018. https://doi.org/10.1016/j.procs.2018.08.161

[36] M. Abdel-Basset, G. Manogaran, M. Mohamed, and E. Rushdy, "Internet of Things in Smart Education Environment: Supportive Framework in the Decision-Making Process," *Concurrency and Computation: Practice and Experience,* vol. 31, no. 10, p. e4515, 2019. https://doi.org/10.1002/cpe.4515

[37] M. I. Ciolacu, L. Binder, P. Svasta, I. Tache, and D. Stoichescu, "Education 4.0–Jump to Innovation with IoT in Higher Education," in *2019 IEEE 25th International Symposium for Design and Technology in Electronic Packaging (SIITME)*, 2019: IEEE, pp. 135–141. https://doi.org/10.1109/SIITME47687.2019.8990825

[38] A. Alaidi, O. Yahya, and H. Alrikabi, "Using Modern Education Technique in Wasit University," *International Journal of Interactive Mobile Technologies,* vol. 14, no. 6, pp. 82–94, 2020. https://doi.org/10.3991/ijim.v14i06.11539

[39] M. Pineng, "Using Artificial Neural Network for System Education Eye Disease Recognition Web-Based," in *Journal of Biomimetics, Biomaterials and Biomedical Engineering*, 2022, vol. 55: Trans Tech Publ, pp. 262–274. https://doi.org/10.4028/p-7z9xpt

[40] R. Ardianto, T. Rivanie, Y. Alkhalifi, F. S. Nugraha, and W. Gata, "Sentiment Analysis on E-Sports for Education Curriculum using Naive Bayes and Support Vector Machine," *Jurnal Ilmu Komputer dan Informasi,* vol. 13, no. 2, pp. 109–122, 2020. https://doi.org/10.21609/jiki.v13i2.885

[41] A. Hamoud, A. S. Hashim, and W. A. Awadh, "Predicting Student Performance in Higher Education Institutions using Decision Tree Analysis," *International Journal of Interactive Multimedia and Artificial Intelligence,* vol. 5, pp. 26–31, 2018. https://doi.org/10.9781/ijimai.2018.02.004

[42] H. d. l. Fuente-Mella, B. Umaña-Hermosilla, M. Fonseca-Fuentes, and C. Elórtegui-Gómez, "Multinomial Logistic Regression to Estimate the Financial Education and Financial Knowledge of University Students in Chile," *Information,* vol. 12, no. 9, p. 379, 2021. https://doi.org/10.3390/info12090379

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A Career Recommendation Method for College Students Based on Occupational Values

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Abstract—The numerous recruitment information and the information asymmetry between college majors and work posts make it difficult for college students to seize the job opportunities that conform to their occupational values, and the employment success rate is always at a low level. The effect of current college student career recommendation systems is usually unsatisfactory, and the existing systems haven't fully considered the role of college students' occupational values in instructing their employment. To fill in this research blank, this paper studied a career recommendation method for college students based on occupational values. At first, the paper proposed a collaborative filtering algorithm based on the features of collect students' occupational values, introduced a few features that can affect their occupational values, assigned weight values to these features, and gave the method for determining the weight. Then, based on the principle of the Kruskal's algorithm (the minimum spanning forest), this paper modified the K-Means algorithm and clustered the features of occupational values. At last, the paper elaborated in detail the principle of generating career recommendation results for college students based on occupational values, and used experimental results to verify the correctness of the proposed career recommendation algorithm.

Keywords—occupational values, employment, college students, clustering analysis, collaborative filtering algorithm

1 Introduction

For college students upon graduation, the career choice is a big choice to make. If they cannot master the effective job information or well prepare themselves for employment, then they would face a muddy choice when determining their career direction in the future [1–12]. At this time, the occupational values are playing a significant role in instructing the career decisions of college students who do not have a clear career goal, especially in aspects of career expectation, career selection, job search, job training, and job satisfaction [13–19]. The numerous recruitment information and the information asymmetry between college majors and work posts make it difficult for college students to seize the job opportunities that conform to their occupational values, and the employment success rate is always at a low level, so it's a meaningful work find

an objective, effective, and personalized career recommendation method for college students based on their own occupational values.

Li and Xu [20] used an intelligent optimization algorithm to design and develop a college student employment management system. They surveyed college students' requirements for employment services provided by career instruction center, summarized the required functions of employment management system, divided the system according to user types, and designed the corresponding system function modules. To figure out the trends and status of college students' employment, Qi [21] proposed a college student employment data clustering and mining method based on feature selection, and used it to analyze the employment market of college students and gave the employment data structure; then on this basis, the employment data of college students were subjected to normalized compression, and the sparse scoring method was adopted for data feature selection based on the preprocessed data of college student employment; after that, the online clustering algorithm was adopted to conduct deep mining and clustering on the employment data of college students. To cope with the uneven distribution and poor accuracy of employment resources, Qi [22] applied social network mining to the design of the employment resource allocation algorithm for college students, the author constructed a long-term evolution system and performed interference suppression on it using inter-cell interference randomization technology, inter-cell interference cancellation technology, and inter-cell interference coordination technology, then experiment was carried out to prove that the proposed method can optimize the allocation of employment resources to a certain extent with shorter task scheduling time and higher resource allocation accuracy and efficiency. Bulankina et al. [23] reviewed existing studies and the axiological approach, in their paper, the authors considered the strategies of pluralistic concepts of socio-culture spaces in post-modernism, and discussed the axiological ideas supporting the value spheres of teachers and foreign language teachers. Chang and Lin [24] discussed the role of career development motives in the relationship between job values and job satisfaction. They sampled administrators of four private science and technology universities in northern Taiwan, the 242 effective data attained from questionnaire survey were then analyzed by a structural equation model, and the results suggest that work values have a significant impact on career development motives and job satisfaction.

Most of the existing college student career recommendation systems can hardly gain an ideal effect and they fail to fully considered the role of collect students' occupational values in instructing their employment. To fill in this research blank, this paper attempts to explore a career recommendation method for college students based on their occupational values. In the second chapter, this paper proposes a collaborative filtering algorithm based on the features of college students' occupational values, introduces a few features that can affect their occupational values, assigns weight values to these features, and gave the method for determining the weight. In the third chapter, this paper modifies the K-Means algorithm based on the principle of the Kruskal's algorithm (the minimum spanning forest), and clusters the features of occupational values. In the fourth chapter, this paper elaborates on the principle of generating career recommendation results for college students based on occupational values, and uses experimental results to verify the correctness of the proposed career recommendation algorithm.

2 Career recommendation model and feature weight of occupational values

The process of recommending suitable employer units for college students is to search for companies and job positions with the highest similarity to their career goals. Figure 1 gives the principle of conventional career recommendation for college students. Here, this paper proposes a collaborative filtering algorithm based on the feature attributes of college students' occupational values. A few features of the said occupational values and their corresponding weights of influence are introduced. The first thing is to calculate the distance between the features of college students' occupational values; then, through clustering analysis, the nearest employment set of college students that fits the features of their occupational values is found; at last, in the set, career recommendation is given according to the scores of employer units based on college students' occupational values. The proposed career recommendation algorithm generates neighbor sets with similar features of college students' occupational values, then looks for students with similar occupational values, career goals, and job post interests from the neighbor sets of similar features of occupational values, so the career recommendation quality is good.

The data form of the constructed career recommendation model is described as follows: assuming x represents the number of college students searching for jobs; y represents the number of different types of employer units; S represents the set of scores of different-type employer units given by college students based on their occupational values, wherein $S = (s_{ij})_{x \times y}$ and s_{ij} represents the score of a type of employer unit j given by college student i; in this paper, the scores are divided into six levels, that is $s_{ij} \in \{0, 1, 2, 3, 4, 5\}$, wherein the score level of employer units that do not conform to the occupational values of colleges students is rated as 0, and the score level of those that conform very much to the occupational values of colleges students is rated as 5.

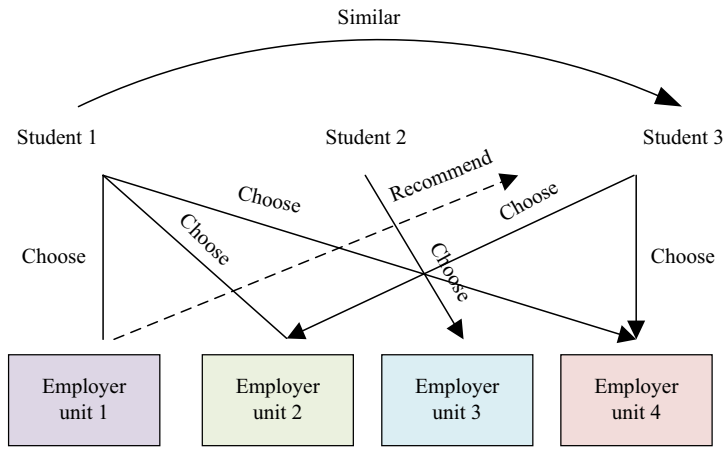

Fig. 1. Principle of conventional career recommendation for college students

After that, the scores of the employer units are clustered, according to the Pearson similarity, the college student who has the most similar score with the target student u is found out, the specific calculation formula of similarity degree is given below:

$$PVC-sim(v,u)=\sum_{i\in I_{vu}}(s_{vi}-s'_v)(s_{ui}-s'_u)/\sqrt{\sum_{i\in I_{vu}}(s_{vi}-s'_v)^2}\sqrt{\sum_{i\in I_{vu}}(s_{ui}-s'_u)^2} \quad (1)$$

Assuming: $NNES(v) = \{v_1, v_2,\ldots,v_l\}$ represents the set of nearest neighbors (namely college students hunting for jobs), and there is $v\notin NNES(v)$, $l\in[1,n)$; $PVC–sim(v, v_1)$, $I \le l$ represents the similarity of the features of occupational values of college students v and v_1; ES_v and ES_u are the sets of scores of employer units given by college students v and u, and the intersection of the two is $ES_{vu} = ES_v \cap ES_u$; $s'_v = \sum_{i\in Iv} s_{vi} / |I_v|$ and $s'_u = \sum_{i\in Iu} s_{ui} / |I_u|$ are the average scores of employer units given by college students v and u; $|ES_v|$ and $|ES_u|$ represent the number of employer units.

Each feature of colleges students' occupational values can affect their career path after graduation to varying degrees, and the conventional college student career recommendation algorithms fail to comprehensive consider the different weights of these features. To distinguish the influence process and importance of each feature on college students' selection of employers, this paper measures the influence degrees of these features based on the rate of information gain and determines the weight coefficient of each attribute. The specific steps of the feature weights of college students' occupational values are:

Assuming: R represents the set of college students hunting for jobs; m represents the number of types of their career path after graduation, denoted as $Z = \{R_1, R_2, ..., R_m\}$; $R_j = Z_j$ represents the number of the samples of college students' career path; $|R|$ represents the total number of college students in R; $GU(R_j)$ represents the probability that a college student would take the j-th type of career path after graduation, and it meets $GU(R_j) = Z_j/|R|$, then, the information entropy of the employment system of college students can be calculated by the following formula:

$$F(R)=-\sum_{j=1}^{m}GU(R_j)log_2GU(R_j) \quad (2)$$

Assuming: $GU(R_j)$ is the probability that R belongs to career path type j; R contains multiple feature attributes of occupational values; a feature Y has p kinds of values, namely $Y = \{y_1, y_2, ..., y_p\}$; if $Y = yl$, then it's assumed that Y_{jl} represents the number of samples belonging to the j-th type of career path, and $GU(R_j|Y = y_l) = Y_{jl}/|R_j|$ represents the corresponding probability of attribution; let A_l represent the set of record set of $Y = y_l$, then the conditional entropy of Y can be calculated by the following formula:

$$F(A_l)=-\sum_{j=1}^{m}GU(R_j\mid Y=y_l)log_2GU(R_j\mid Y=y_l) \quad (3)$$

Assuming: $GU(R_j|Y = y_l)$ represents the probability of the j-th type of career path after graduation when $Y = y_l$, then when the feature Y is met, the information entropy of the career recommendation system can be calculated by the following formula:

$$F(R/Y) = -\sum_{l=1}^{p} GU(Y = y_l)F(A_l) \tag{4}$$

The following formula calculates the information gain:

$$Gain(Y) = F(R) - F(R \mid Y) \tag{5}$$

The information gain rate of the system increases with the decrease of its information entropy, that is, the uncertainty of the career recommendation system for college students decreases with the increase of the amount of information provided by Y. To measure the importance of the feature attributes of college students' occupational values, assuming: $SG(Y)$ represents the amount of information contributed by Y to the career recommendation system; $SL(Y)$ represents the amount of segmented information of Y, then the formula for calculating the information gain rate $GR(Y)$ is:

$$GR(Y) = SG(Y) / SL(Y) \tag{6}$$

The calculation formula of $SL(Y)$ is:

$$Split(Y) = \sum_{j=1}^{p} GU(R_j \mid Y = y_l) log_2 GU(R_j \mid Y = y_l) \tag{7}$$

The information gain of all the features of occupational values is summed, and the weight coefficient of the features of occupational values can be calculated by the following formula:

$$\omega(A) = GainRatio(A) / \sum_{a=1}^{k} GainRatio(A) \tag{8}$$

3 Clustering of the features of occupational values

The features of college students' occupational values can indicate their similarities in terms of career goal, job selection, job hunting, job training, and job satisfaction to a large extent. Introducing these features can break through the limits brought by measuring the similarity degree solely based on the scores of employer units given by students. Assuming: a_{nm} represents the m-th attribute of the n-th college student in the vector, $A = \{A_1, A_2, \ldots, A_m\}$ is the vector formed by the features of occupational values of each college student, then there is:

$$\begin{pmatrix} A_{11} & A_{12} & A_{13} & \cdots & A_{1m} \\ A_{12} & A_{22} & A_{23} & \cdots & A_{2m} \\ A_{31} & A_{32} & A_{33} & \cdots & A_{3m} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ A_{n1} & A_{n1} & A_{n1} & \cdots & A_{nm} \end{pmatrix} \tag{9}$$

Assuming: $V = \{A_{v1}, A_{v2}, \ldots, A_{vm}\}$ and $U = \{A_{u1}, A_{u2}, \ldots, A_{um}\}$ represent the n-dimensional and m-dimensional eigenvectors of college students v and u, then the feature distance between v and u can be attained by the following formula:

$$\delta_{vu} = \sqrt{\sum_{l}^{m} \left| a_{vl} - a_{ul} \right|^2} \tag{10}$$

The similarity of the features of college students' occupational values *F-sim* can be attained based on distance and similarity coefficient:

$$F - sim_{vu} = 1/(1+\delta_{vu}) = 1/\left(1+\sqrt{\sum_{l}^{m} \left| a_{vl} - a_{ul} \right|^2}\right) \tag{11}$$

To enable the clustering analysis to get close to reality as much as possible, this paper introduces the feature weight of college students' occupational values $\omega = \{\omega_1, \omega_2, \ldots, \omega_L\}$, then, the feature distance of the occupational values of college students v and u after introducing the weight can be calculated by the following formula:

$$\delta_{vu} = \sqrt{\sum_{l}^{m} \omega_l \left| a_{vl} - a_{ul} \right|^2} \tag{12}$$

The modified similarity of college students' occupational values is:

$$F - sim^*_{vu} = 1/(1+\delta_{vu}) = 1/\left(1+\sqrt{\sum_{l}^{m} \omega_l \left| a_{vl} - a_{ul} \right|^2}\right) \tag{13}$$

To minimize the feature distance of the occupational values of college students with a same type of career path and maximize the feature distance of the occupational values of college students with different types of career path, this paper referred to the principle of the Kruskal's algorithm (the minimum spanning forest) to modify the K-Means algorithm.

Assuming: $R = \{r_1, r_2, \ldots, r_m\}$ represents the set of college students hunting for jobs; $A = \{A_1, A_2, \ldots, A_m\}$ represents the set of features of college students' occupational values; $r_1, r_2, \ldots, r_l$ represent the classes of output clusters; $x_1, x_2, \ldots, x_l$ represent the cluster center values of each class; l represents the number of clusters, then the execution flow of the modified K-Means clustering algorithm is:

STEP 1: College students u and v are taken as nodes that satisfy $v, u \in R$, then (v, u) represents the connecting edge between u and v, A represents the eigenvector of college students' occupational values, then by taking the feature distance of college students' occupational values as the weight value of each connecting edge, a weighted undirected connection graph can be created and denoted as $QM = (U, O)$, a sub-graph with n nodes and no edges is the time-space of the initial state, which can be expressed as $QM_0 = (u, \{\})$.

STEP 2: Select the edge with the smallest weight, if the nodes of the edge are within QM, then this connecting edge is put into QM, after that, select the edge with the smallest weight from the remaining edges, until both nodes of an edge are within QM, then

the edge is put into *QM*, and all edges in *QM* are built into a loop. These nodes belong to the same type of career path R_i, then they are deleted from *QM*; again, from the remaining edges, the edge with the smallest weight is selected until the types of all nodes have been attained.

STEP 3: Repeat STEP 2 until all nodes form *L* types of career path R_i, $i \in [k,l]$. Assuming: $|R_i|$ represents the number of college students in R_i, $xm = \Sigma_{r \in ri} R/|R_i|$ represents the centers of *L* types of career path; at this same, the generated *L* types of career path is the initial number of clusters of college students hunting for jobs, and the corresponding center of the career path types is the initial cluster center.

STEP 4: For college students $r \in R$, calculate their distance from each career path cluster center, and divide those with the shortest distance from the career path cluster center.

STEP 5: Assign the mean value of each type of career path to the cluster center of each career path.

STEP 6: $O = \sum_i^l \sum_{r \in ri} \left| r - x_m \right|^2$ represents the squared error criterion function, repeat STEP 4 and STEP 5 until *O* is 0, then the clustering terminates.

Figure 2 shows the flow of clustering algorithm for college students' employment features.

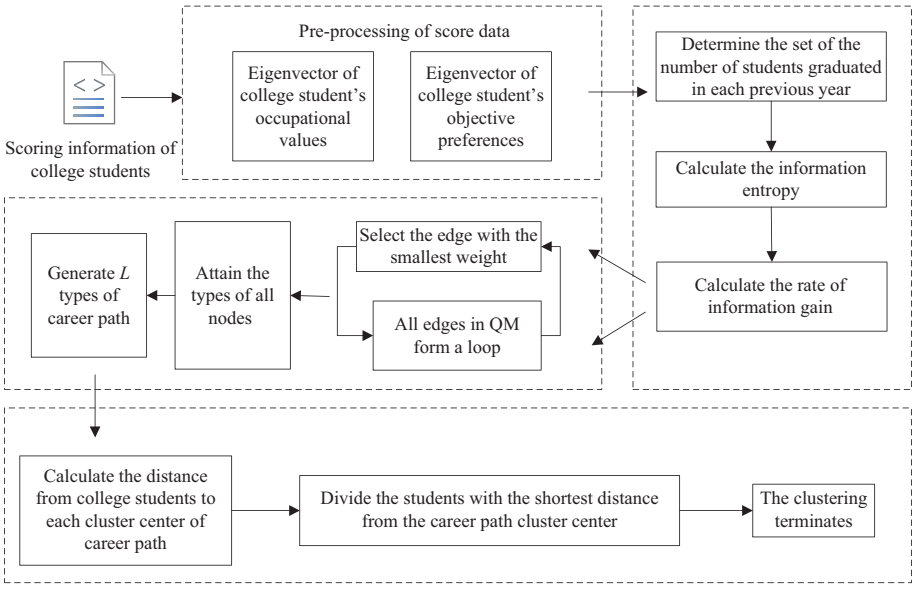

Fig. 2. Flow of clustering algorithm for college students' employment features

4 Generation principle of recommendation results

Clustering the feature matrix of college students' occupational values only classifies students with different features of occupational values into different types of career path, however, the types of the personal career path of college students can not be taken

as the only criterion for judging the career recommendation results. In the decisions of the employment of college students, there're other objective factors such as the viewpoints of the students' families and friends. So, only by continuing to study the objective influencing factors of the employment of college students on the basis of the scores of employer units given by students according to their occupational values, can we find the best-matched employers for them and give the final career recommendations.

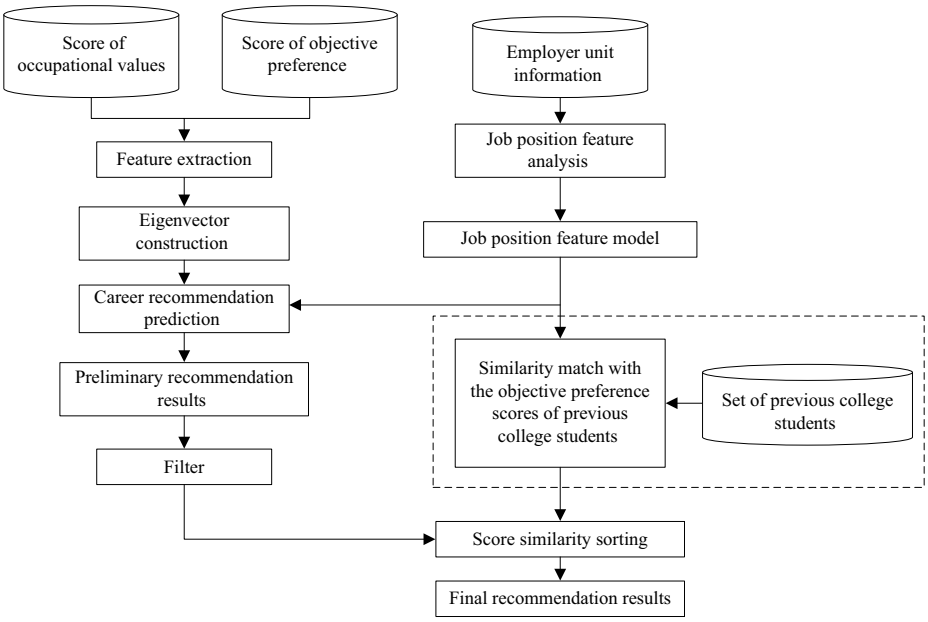

Fig. 3. Generation flow of the recommendation results

Assuming: $S = \{S_1, S_2, ..., S_m\}$ represents the vector constructed by the scores of college students' occupational values; S_m represents the scores of different-type employer units given by college students; s_{nl} represents the n-th college student's objective preference score for the l-th type of employer units, then there is:

$$\begin{pmatrix} s_{11} & s_{12} & s_{13} & \cdots & s_{1m} \\ s_{12} & s_{22} & s_{23} & \cdots & s_{2m} \\ s_{31} & s_{32} & s_{33} & \cdots & s_{3m} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ s_{n1} & s_{n1} & s_{n1} & \cdots & s_{nm} \end{pmatrix} \tag{14}$$

The ideal of the career recommendation algorithm proposed in this paper is based on the sum of objective preference scores of all kinds of employer units given by target college students, the employer unit with the closest comprehensive score given by previous college students will be recommended to the target student. Details of the algorithm flow are given below:

Assuming: $S_{vu} = S_v \cap S_u$ is the intersection of the scores of all types of employer units given by college students v and u; $|S_v|$ and $|S_u|$ are respectively the number of comprehensive scores of S_v and S_u; then, the comprehensive scores of employer units s_v^* and s_u^* given by v and u can be calculated by the following formulas:

$$\bar{s}_v = \sum_{i=1}^{S_v} s_{ci} / \left|S_v\right| \tag{15}$$

$$\bar{s}_u = \sum_{i=1}^{S_u} s_{ci} / \left|S_u\right| \tag{16}$$

The definition of the similarity between college students v and u is:

$$sim(v,u) = \frac{\sum_{i \in S_{vu}} (s_{vi} - \bar{s}_v)(s_u - \bar{s}_u)}{\sqrt{\sum_{i \in S_{vu}} (s_{vi} - \bar{s}_v)^2} \sqrt{\sum_{i \in S_v} (s_{ui} - \bar{s}_u)^2}} \tag{17}$$

Through clustering, after a target college student has been classified to a type of career path with the most similar features of his/her occupational values, within this career path type, the similarity between this student and the objective preference scores of previous college students is calculated, then the scores are sorted according to similarity degree, and the employer units with the closest comprehensive score (given by previous college students) is recommended to this target student. Figure 3 gives the generation flow of the recommendation results.

5 Experimental results and analysis

The reliability values of each variable of the features of occupational values are given in Table 1. The Cronbach α coefficient of each variable (income and wealth, interest and specialty, power and status, freedom and independence, self-growth, self-realization, interpersonal relationships, physical and mental health, environmental comfort, job stability, pursuit of new ideas, and social needs) is 0.916, which means that the reliability values of these variables are all greater than 0.7, indicating that the consistency of the evaluation items is ideal.

Table 1. Reliability of feature variables of occupational values

Item	Number of the Item	*Cronbach α* Coefficient
Income and wealth	8	0.847
Interest and specialty	5	0.816
Power and status	9	0.802
Freedom and independence	23	0.936
Self-growth	9	0.825
Self-realization	5	0.819
Interpersonal relationships	8	0.937
Physical and mental health	2	0.748
Environmental comfort	7	0.853
Job stability	5	0.948
Pursuit of new ideas	6	0.884
Social needs	8	0.827
Total	12	0.916

Table 2 shows the difference analysis results of the occupational values of different-type career path. The analysis is conducted from four perspectives of occupational values: the interest type, belief type, ideal type, economy type. For college students graduated in different years between 2010 and 2020, there are significant differences in the influence of their occupational values on their career path after graduation. College students who pay more attention to ideals and performance, social relationship and sense of achievement generally choose to become employees of public institutions or work as civil servants; those who pay more attention to money tend to prefer directional employment or starting a business by themselves; and those who pay more attention to the quality of life or interests and hobbies tend to prefer flexible employment or become self-employed.

Table 2. Differences in occupational values of different career path types

Type of Career Path		Interest Type	Belief Type	Ideal Type	Economy Type
Unemployed or starting a business by oneself	2010	4.36	3.08	3.13	3.69
	2020	4.18	3.52	3.46	3.27
	Difference	–0.15**	0.02*	0.06	0.01
Directional employment	2010	4.72	3.69	3.25	3.18
	2020	4.04	3.11	3.50	3.42
	Difference	0.01	–0.03	–0.06**	–0.04**
Public institutions employee or civil servant	2010	4.25	3.41	3.62	3.19
	2020	4.06	3.12	3.27	3.84
	Difference	–0.05**	–0.16*	0.07	–0.26**
Self-employed or flexible employment	2010	4.96	3.52	3.84	3.59
	2020	4.36	3.60	3.49	3.25
	Difference	–0.02*	–0.07***	0.03**	–0.14*

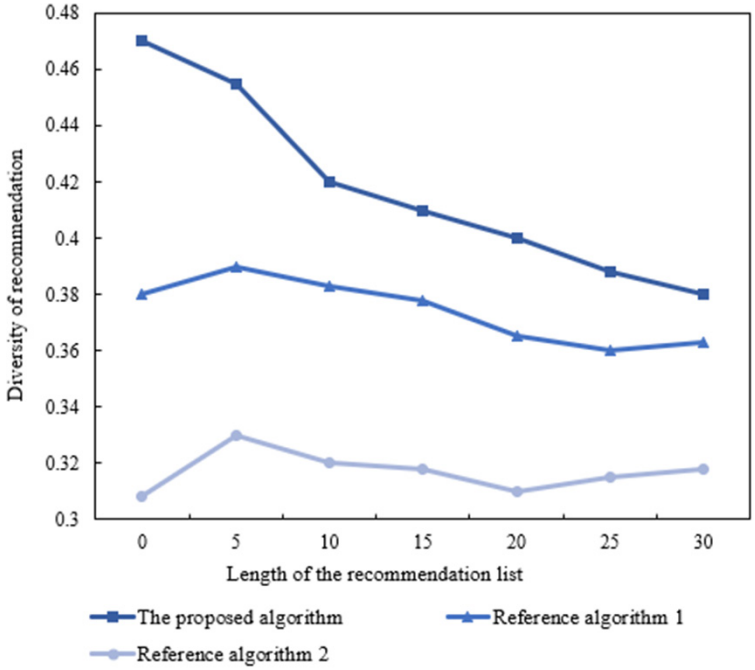

Fig. 4. Comparison of recommendation diversity of different recommendation algorithms

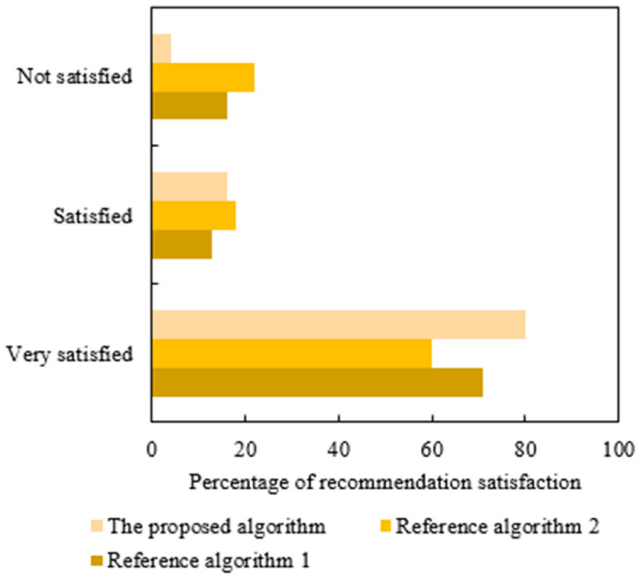

Fig. 5. Comparison of college students' employment satisfaction of different recommendation algorithms

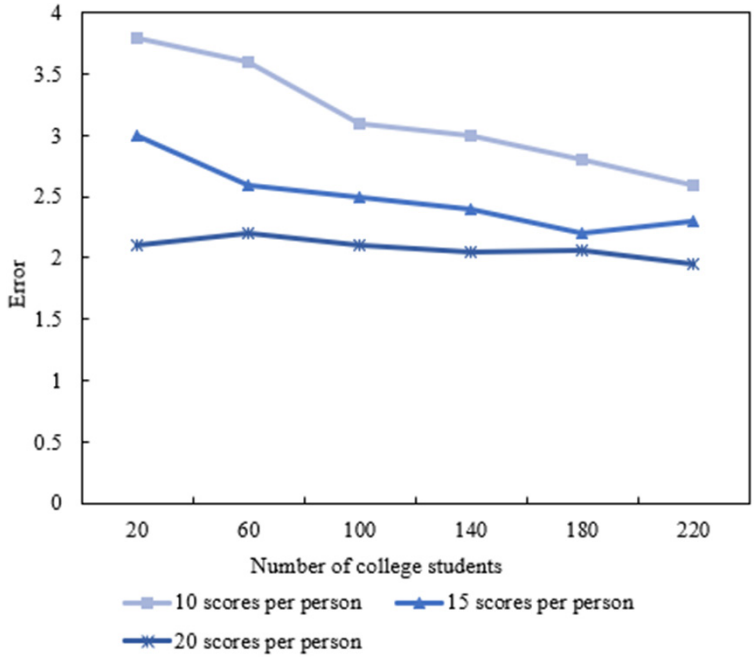

Fig. 6. Comparison of recommendation errors for different employer unit rating items

Figure 4 compares the recommendation diversity of different recommendation algorithms. The reference algorithm 1 is a career recommendation algorithm based solely on the scores of occupational values; the reference algorithm 2 is a career recommendation algorithm based solely on the scores of objective references. Results of comparative experiment show that the proposed algorithm that integrates the occupational values scores with objective preference scores has achieved a higher recommendation diversity, reaching 38% to 47%. Due to the processing the modified *K-Means* clustering algorithm, the difference between recommended employer units always stays at a high level. With the increase of the length of recommendation list, the recommendation diversity of the proposed algorithm is higher than that of reference algorithms 1 and 2, and its advantage is even more obvious in case of shorter recommendation lists.

Figure 5 compares the employment satisfaction of college students of different recommendation algorithms. Students participated in the experimental research could choose between three options of "very satisfied", "satisfied", and "not satisfied". Among all the satisfaction feedback, the proposed algorithm has gotten a higher proportion of satisfaction, indicating that comprehensively applying occupational values scores and objective preference scores to the career recommendation of college students is effective, and students' satisfaction with the career recommendation has been greatly improved.

This paper compares the recommendation errors of different employer units under the conditions of 10 scores per person, 15 scores per person, and 20 scores per person (Figure 6). Although the recommendation error is higher under the conditions of less

student number and employer rating items, the advantage of the proposed algorithm is obvious still. The more the students, the more the rating items, the better the quality of the recommendation results of the proposed algorithm.

6 Conclusion

This paper studied a career recommendation method for college students based on occupational values. At first, the paper proposed a collaborative filtering algorithm based on the features of college students' occupational values, introduced a few features that can affect college students' occupational values, assigned weight values to these features, and gave the method for determining the weight. Then, based on the principle of the Kruskal's algorithm (the minimum spanning forest), this paper modified the K-Means algorithm and clustered the features of occupational values, elaborated on the principle of generating the career recommendation results based on occupational values, used experimental results to verify the correctness of the proposed career recommendation algorithm, and gave the reliability analysis results. In the experiment, difference analysis was conducted on the occupational values of college students taking different career paths after graduation and the corresponding analysis results were given. The recommendation diversity and student satisfaction of different recommendation algorithms were compared. At last, this paper compared the recommendation errors under the conditions of different employer unit rating items, and the results showed that the more the student number and rating items, the higher the quality of career recommendation results of the proposed algorithm.

7 Acknowledgment

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8 References

[1] Adebayo, O., Asani, E., Peace, A., Joyce, A. (2020). Impact of agricultural education on students' career choice: A survey. International Journal of Emerging Technologies in Learning, 15(3): 51–61. https://doi.org/10.3991/ijet.v15i03.11260

[2] Aymane, O., Abdelillah, B., Abdallah, E.K., Mourad, E.Y. (2020). Toward an adaptive educational hypermedia system (AEHS-JS) based on the overlay modeling and Felder and Silverman's learning styles model for job seekers. International Journal of Emerging Technologies in Learning, 15(8): 235–254. https://doi.org/10.3991/ijet.v15i08.10574

[3] Dhar, J., Jodder, A.K. (2020). An effective recommendation system to forecast the best educational program using machine learning classification algorithms. Ingénierie des Systèmes d'Information, 25(5): 559–568. https://doi.org/10.18280/isi.250502

[4] Saadoon, K.J., Muhlis, M., Mohammed, R.O. (2022). Architecture students' satisfaction in Iraqi private universities: TIU-S in focus. International Journal of Sustainable Development and Planning, 17(4): 1349–1354. https://doi.org/10.18280/ijsdp.170432
[5] Liu, Y., Li, A. (2022). Quantitative evaluation and path optimization of college students' employment policy based on text mining. Wireless Communications and Mobile Computing, 2022: 3812215. https://doi.org/10.1155/2022/3812215
[6] Zang, X. (2022). Accessibility analysis model of college students' employment education resources based on mobile search algorithm. Journal of Interconnection Networks, 2146010. https://doi.org/10.1142/S0219265921460105
[7] Li, N., Feng, L., Zeng, S., Bo, H. (2022). Analysis on the regional spatial distribution of employment of college students and evaluation of employment quality. International Journal of Emerging Technologies in Learning, 17(19): 242–258. https://doi.org/10.3991/ijet.v17i19.34519
[8] Wu, D. (2022). Prediction of employment index for college students by deep neural network. Mathematical Problems in Engineering, 2022: 3170454. https://doi.org/10.1155/2022/3170454
[9] Cheng, P. (2022). Employment data screening and destination prediction of college students based on deep learning. Wireless Communications and Mobile Computing, 2022: 7173771. https://doi.org/10.1155/2022/7173771
[10] Chai, W. (2022). Analysis on the social environment of college students' rural employment and entrepreneurship. Computational Intelligence and Neuroscience, 2022: 3475897. https://doi.org/10.1155/2022/3475897
[11] Du, H. (2022). Research on the data driven intelligent employment information service system for college students. In International Conference on Computer Application and Information Security (ICCAIS 2021), pp. 638–643. https://doi.org/10.1117/12.2637662
[12] Gu, L., Chen, X. (2022). Study on discrete dynamic modeling of college students' innovative employment security mechanism under the environment of internet of things. Computational Intelligence and Neuroscience, 2022: 4637180. https://doi.org/10.1155/2022/4637180
[13] Hwangbo, B., Denise R.S., Cassandra, M. (2019). Developing a conceptual model of construction employees' professional values. Proceedings of the 8th Research in Engineering Education Symposium, REES 2019 – Making Connections, pp. 833–835.
[14] Frezza, S., Daniels, M., Wilkin, A. (2019). Assessing students' IT professional values in a global project setting. ACM Transactions on Computing Education (TOCE), 19(2): 1–34. https://doi.org/10.1145/3231710
[15] Edström, K. (2018). Academic and professional values in engineering education: Engaging with history to explore a persistent tension. Engineering Studies, 10(1): 38–65. https://doi.org/10.1080/19378629.2018.1424860
[16] Rabia, S.A., Ismaile, S., Househ, M. (2017). Professional values among female nursing students in Saudi Arabia. Informatics Empowers Healthcare Transformation, 238: 231–234.
[17] Leonard, J., Albores, P., Higson, H. (2016). Virtuous or vicious cycle? Inscribing diverse professional values in lecture capture systems. In 22nd Americas Conference on Information Systems: Surfing the IT Innovation Wave, AMCIS 2016. Association for Information Systems.
[18] DeMonbrun, M., Brown, M. (2014). Emphasizing professional skills and professional values: Investigating the role of faculty's gender and departmental gender diversity. In 2014 IEEE Frontiers in Education Conference (FIE) Proceedings, Madrid, Spain, pp. 1–8. https://doi.org/10.1109/FIE.2014.7044119
[19] Nieboer, M.E., van Hoof, J., Van Hout, A.M., Aarts, S., Wouters, E.J.M. (2014). Professional values, technology and future health care: The view of health care professionals in The Netherlands. Technology in Society, 39: 10–17. https://doi.org/10.1016/j.techsoc.2014.05.003

[20] Li, J., Xu, Z.Y. (2021). Design and realization of college student employment management system based on intelligent optimization algorithm. ACM International Conference Proceeding Series, October 21, 2021, pp. 7–11. https://doi.org/10.1145/3516529.3516531
[21] Qi, M.B. (2021). Clustering mining method of college students' employment data based on feature selection. In International Conference on Advanced Hybrid Information Processing, pp. 105–115. https://doi.org/10.1007/978-3-030-94551-0_9
[22] Qi, M.B. (2021). An algorithm of employment resource allocation for college students based on social network mining. In International Conference on Advanced Hybrid Information Processing, pp. 254–265. https://doi.org/10.1007/978-3-030-94551-0_21
[23] Bulankina, N., Malahova, N., Egorova, E., Seredintseva, A., Tsybaneva, V. (2020). Dominant values of professional development education spaces of cross-border regions in the aspect of postmodernism. In E3S Web of Conferences, pp. 22017. https://doi.org/10.1051/e3sconf/202021022017
[24] Chang, J.C., Lin, K.M. (2017). Exploring the role of professional development motivation between work values and job satisfaction. In 2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Singapore, pp. 2291–2295. https://doi.org/10.1109/IEEM.2017.8290300

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Prediction of Students Performance Level Using Integrated Approach of ML Algorithms

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Abstract—In this paper, the efficacy of machine learning (ML) techniques for predicting the academic success of students is investigated. In issues pertaining to higher education, as well as machine learning, deep learning, and its linkages to educational data, predicting student achievement is essential. The choice of courses and the development of effective future study plans for students can be easier with the help of the capacity to forecast a student's success. In addition to predicting student achievement, it makes it easier for instructors and administrators to keep an eye on children so that they can offer support and integrate trainings for the greatest outcomes. In this study, we define the idea of predicting the student performance in education and its several iterations. We discuss a number of ML approaches, such as the Fuzzy C-Means, the Multi-Layer Perceptron (MPL), the Logistic Regression (LR), and the Random Forest (RF) algorithms, for predicting student achievement in the classroom. The models for forecasting student performance that are now in use and those that have been proposed in this paper are carefully investigated. The paper examines different combinations of the algorithms including FCM – MLP, FCM – LR, and FCM – RF, and provides the detailed results of each combination. These strategies are assessed using quantitative standards including accuracy, detection rate, and false alarm rate.

Keywords—Machine Learning (ML), Fuzzy C-Means (FCM), Multi-Layer Perceptron (MPL), Logistic Regression (LR), and Random Forest (RF) Algorithms

1 Introduction

Today, major emphasis is being made on predicting student performance as a result of the relevance of that type of issue in the development of nations all over the world. This is due to the fact that the educational process leads to the production of a generation capable of leading the country and march towards development in all aspects of life. The efficacy of academic institutions, which are in charge of shaping future generations in accordance with the various stages of people's lives in each nation, is also reflected in the evaluation of students' performance. As a result, one of the most urgent needs

that motivates governments to make significant efforts is to advance the educational process. In this regard, the students' performance can be monitored by using technological approaches such as the machine learning (ML) approach which can predict the features of students' performance. ML is a method for finding hidden information by studying numerous data sources in fields including business, social, medical, and education. The more data there is, such as in large databases, the better the forecast [1]. Several ML techniques are in use right now, particularly in the field of industry. Some approaches necessitate the use of supervised learning techniques, whereas others necessitate the use of unsupervised learning techniques. On structured or labeled data, the supervised learning approach works. Beyond that, supervised learning applies what it has learnt from past data to new data (new data). It gives the machine model training data and forecasts whether it's a circle or a square, for example. For subcategory classification and regression, this supervised learning method is used. Unsupervised learning makes use of unstructured or hidden data and necessitates the machine being given a diverse set of inputs. Unsupervised learning evaluates data before classifying it; as a result, we get different data in each group after classification, and each group is distinct from the others [2].

In order to gather the essential information, it is possible to study the knowledge provided by various educational data resources. A new field called Educational Data Mining (EDM) was established as a method of identifying essential information [3]. Sharing statistics and integrating deep learning with exploration create the best learning environment. The importance of EMD has rapidly increased in recent years because of increase in data collected, according to educational data obtained from various e-learning systems and the expansion of traditional educational systems. The abundance of data across numerous domains and their relationships with one another demonstrate the power of EMD. It is focused with the extraction of traits from vast volumes of data provided by the institute to assist the educational process [4]. Academic institutions work to create a student model that can predict each student's characteristics and performance [5]. From those vast datasets, we need to classify the useful information and process it for predicting the desired parameters [6–7].

2 Literature review

The use of the ML approach to forecasting students' performance based on their history and term exam results has proven to be useful in predicting different levels of performance. Using such ML algorithms, it is possible to anticipate which pupils are likely to fail and as a result deliver a solution to students in a timely manner. It can also assist the educational institutes in identifying high-achieving students and assisting in offering scholarships. Ioannis E. Livieris, et al. in [8] predict student success in mathematics. The authors created an Artificial Neural Network (ANN) classifier. They discovered that the modified spectral Perry trained artificial neural network performs superior classification than other classifiers in their testing. S. Kotsiantis, et al. [9] studied the use of ML techniques in remote learning for the prediction of student dropout. This study made a significant contribution since it was a trailblazer in the field of educational data

mining. Although ML techniques had been used in other fields, he and his colleagues were the first to use them in an academic setting. Rather of using class performance data, an algorithm was given demographic data and numerous project assignments. Moucary, et al. in [10] proposed a hybrid technique K-Means Clustering and Artificial Neural Network (ANN) for students pursuing higher education while learning a new foreign language as a method of teaching and communication. To begin, a neural network was used to forecast the students' performance, and then the K-Means technique was used to group them into a certain cluster. This clustering assisted instructors in identifying a student's skills throughout the early stages of their academic careers.

A data mining-based prediction model for student performance with a few characteristics called student behavioral features is introduced in [11–12]. Three distinct classifiers were used to evaluate the model including Nave Bayesian (NB), ANN, and Decision Tree (DT). Ensemble approaches such as Random Forest (RF), Bagging, and Boosting were utilized to increase the classifier's performance. When behavioral elements were eliminated, the model's accuracy increased by up to 22.1%. After employing ensemble approaches, the accuracy climbed to 25.8%. The authors in [12] recommended prediction model structure that provides characteristics that result in less variation in information acquisition. Because ML algorithms break down problems and solve them one at a time, it's possible that when one condition fails, other crucial attributes are lost. This has an impact on the model's overall performance. To do so, the model must allow end-to-end functionality. Shaymaa E. Sorour et al. in [13] used DT and RF to create an interpretable model. They used a technique called remark data-mining to forecast grades and extracted rules. In reference [14], the authors used Neuro-Fuzzy to predict and classify student academic success based on CGPA. Quadriet et al. in [15] used J48 to forecast the dropout rate of students based on their CGPA. The elements impacting the pupils' performance were found by Christian et al. in [16] using the NB method. The authors looked at the schooling, particular, induction, and educational data of students. Muslihah Wook et al. in [17] anticipated academic achievement of pupils by using the classification approaches such as ANN and DT. Furthermore, Shaleenaet et al. in [18] used DT classifiers for identifying and predicting dropout students ratio as well as a discussion of the topic of class imbalance. Another study in [19] used the deep neural network (DNN) and ANN algorithms to improve the DL prediction model and implementation technique. V. Vijayalakshmi et al. in [20] adopted ML and DL techniques in the domain of education system on student performance to test the performance of their suggested strategy.

Most of the reported techniques have achieved the results of predicting the students' performance with complex structures and the results still need to be improved. In this paper, by examining both supervised and unsupervised learning methods, followed by the Fuzzy C-Means (FCM) clustering approach, and classification techniques i.e., Multi-Layer Perceptron (MLP), Logistic Regression (LR), and Random Forest (RF) algorithms, we predict the student's performance based on education parameters. Different combinations of the considered algorithms are investigated. Most of the combinations justified improved accuracy, precision, recall, f1-score, classifier, prediction, and clusters in a rapid, precise, and accurate manner.

3 Proposed methodology

This section describes the proposed method which begins with an algorithm, subsequently loads data from a database, and finally, prepares the information. The information is pre-processed, normalized, and standardized. The standardized approach works by first normalizing data to convert floating frequency values to the same (0.1543648795), then doing standardized analysis and calculating the result. Then we use the Fuzzy C-Means clustering technique and the classification algorithms including Multi-Layer Perceptron, Logistic Regression, and Random Forest supervised classification algorithms to design and create the target model. The sample size for the test is 25%, whereas the sample size for the implementation training is 75%. Figure 1 illustrates a flowchart that can assist in understanding the research activity and outlining the job breakdown structure concisely. In this illustration, we initially retrieve data from the database to prepare data, then actually begin pre-processing the data in the data pre-processing section using standardized data cleaning techniques, then work on clustering and classification implementing 75% processed training data and 25% test data for model validation.

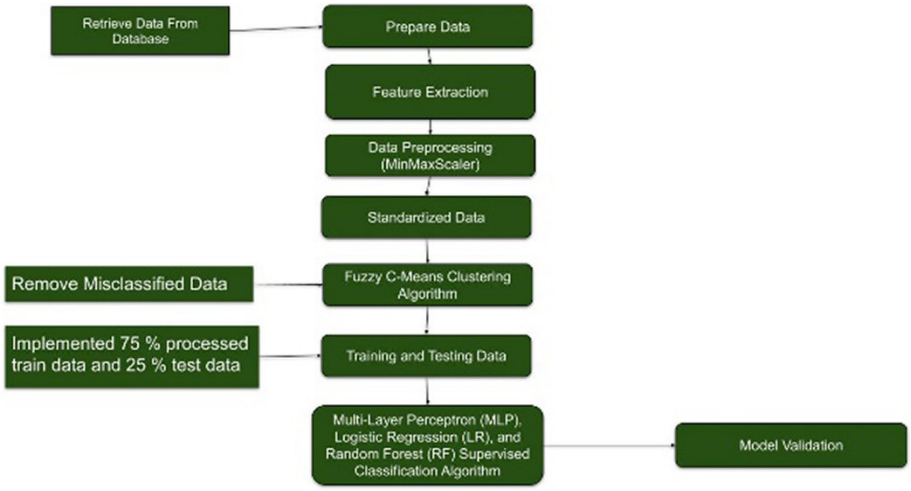

Fig. 1. Proposed method for students performance prediction

The proposed method consists of the following two subsections: 1) Pre-processing, and 2) Classification.

3.1 Preprocessing

In preprocessing phase, to obtain meaningful data, we clean the data and use it for clustering. As explained below, this is done in two stages i.e., data collection, and clustering by using the Fuzzy C-means clustering technique; and then further process the data in the classification phase.

Data collection. The dataset of the international high education students performance, has been collected from the Kaggle website, which had previously been utilized by the researchers in [20]. The dataset contains a total of 480 tuples and 17 properties, each of which represents a student's performance metric. The dataset contains 305 male and 175 female students sample records from international, with one target class (which denotes each class's status separately) and a total of 128 Low Class, 211 Medium Class, and 142 High Class. The actual international high education students performance dataset feature description is shown in Table 1 [21].

Table 1. Actual dataset for international high education students performance

Gender	Nationality	Place of Birth	Stage ID	Grade ID	Section ID	Topic
M	KW	KuwaIT	lowerlevel	G-04	A	IT
M	KW	KuwaIT	lowerlevel	G-04	A	IT
M	KW	KuwaIT	lowerlevel	G-04	A	IT
M	KW	KuwaIT	lowerlevel	G-04	A	IT
M	KW	KuwaIT	lowerlevel	G-04	A	IT
Semester	**Relation**	**Raised Hands**	**Visited Resources**	**Announcements View**	**Discussion**	**Parent Answering Survey**
F	Father	15	16	2	20	Yes
F	Father	20	20	3	25	Yes
F	Father	10	7	0	30	No
F	Father	30	25	5	35	No
F	Father	40	50	12	50	No

Parent School Satisfaction	Student Absence Days	Class
Good	Under-7	M
Good	Under-7	M
Bad	Above-7	L
Bad	Above-7	L
Bad	Above-7	M

Table 2 displays the preprocessed dataset that has been cleaned and standardized, and prepared for the clustering and classification phases to predict the students performance. Moreover, Figure 2 shows the mixed data chart of the corresponding cleaned data before clustering.

Table 2. Preprocessed dataset for international high education students performance

Gender	Nationality	Place of Birth	Stage ID	Grade ID	Section ID	Topic
0.276542	0.456038	0.416909	0.675114	0.664516	0.959812	0.820159
0.595424	0.976172	0.329478	0.635595	0.804943	0.677397	0.132544
0.181578	0.429730	0.063652	0.445259	0.907755	0.918585	0.755372
0.830483	0.088741	0.159844	0.527569	0.263223	0.741383	0.871822
0.210892	0.701391	0.766264	0.172061	0.103681	0.024694	0.419428
Semester	**Relation**	**Raised Hands**	**Visited Resources**	**Announcements View**	**Discussion**	**Parent Answering Survey**
0.609305	0.522702	0.782175	0.892479	0.164947	0.646486	0.145420
0.169182	0.336317	0.587580	0.624576	0.543965	0.676087	0.104618
0.045972	0.292576	0.704262	0.028200	0.060382	0.371900	0.112741
0.152801	0.884067	0.992723	0.117836	0.414137	0.987809	0.355952
0.949947	0.700166	0.426451	0.145548	0.839285	0.519597	0.009649

Parent School Satisfaction	Student Absence Days	Class
0.667879	0.930874	0.996918
0.115494	0.212968	0.871445
0.355699	0.400581	0.200401
0.783681	0.098311	0.266751
0.763605	0.616193	0.617324

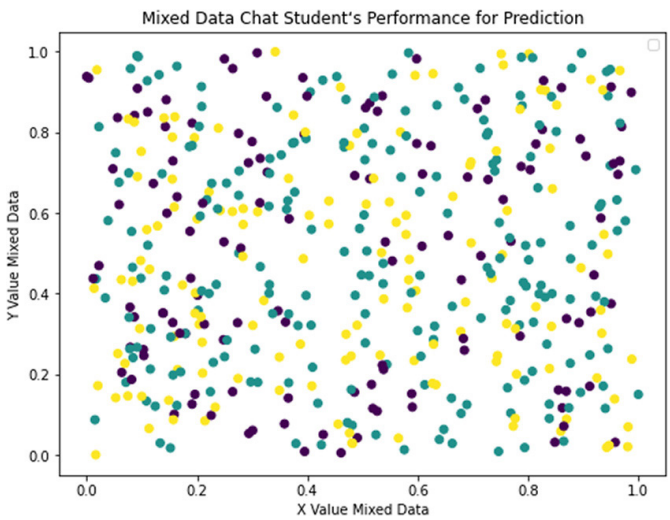

Fig. 2. The mixed data chart before applying the clustering technique

Fuzzy C-means clustering technique. Clustering is the most common type of unsupervised learning approach, having a wide range of applications and implementations in a variety of industries. Clustering is the process of splitting and processing data on

behalf of an information machine, resulting in a collection of data known as clustering, with each cluster given a unique identification number (ID). For data clustering, the Fuzzy C-means (FCM) clustering approach is the most often employed. FCM is a soft cluster method in which individually facts argument is given a probability or possibility score that indicates whether it belongs to that cluster. It accomplishes this by introducing new uncorrelated variables in a sequence that maximizes variance. This logic is instantly applied to the data matrix, resulting in a membership matrix that shows the degree of connection between the samples and each cluster.

Taking into consideration the space amongst the centroid and the target value, this method assigns participation to each data point corresponding to each centroid. The data belongs to the cluster more if it is near to the centroid. The actual number for each data point should be one [22]. After each cycle, the following formula is used to change participation and cluster centroid.

$$\mu ij = 1 / \sum_{k=1}^{c} (d_{ij}/d_{ik})^{(2/m-1)}, \tag{1}$$

$$\mathrm{v}j = \frac{\left(\sum_{i=1}^{n} (\mu ij)^m x_i\right)}{\left(\sum_{i=1}^{n} (\mu ij)^m\right)}, \forall j = 1,2,3,\ldots c, \tag{2}$$

where, 'n', 'vj', 'm', 'c', 'μij', and 'dij' denote the number of data points, cluster center, the fluffiness directory, the number of cluster centers, the connection between the *ith* data and the *jth* cluster center, and the Euclidean distance between the *ith* data and the *jth* cluster center, respectively.

The core impartial of the fuzzy c-means approach is to decrease the Euclidean distance given below

$$J(U,V) = \sum_{i=1}^{n} \sum_{j=1}^{c} (\mu ij)^m \left\| x_i - v_j \right\|^2. \tag{3}$$

The Euclidean distance amongst both the *ith* data point and the *jth* cluster center is signified by '$\|xi - vj\|$'. There are a few mathematical functions that used for FCM algorithm such as the Euclidean, Manhattan, and Hamming distances. This method is constructed on categorization. Some of these approaches are as follows:

$$\text{Euclidean} \quad \sqrt{\sum_{i=1}^{k} (xi - yi)2} \tag{4}$$

$$\text{Manhattan} \quad \sum_{\mathrm{i}=1}^{\mathrm{k}} \left|\mathrm{xi} - \mathrm{yi}\right| \tag{5}$$

$$\text{Minkowski} \quad \left(\sum_{\mathrm{i}=1}^{\mathrm{k}} \left(\left|\mathrm{xi} - \mathrm{yi}\right|\right)\mathrm{q}\right) 1/\mathrm{q} \tag{6}$$

FCM methodology steps:

Let X = {x1, x2, x3..., xn} represent a set of data points and V = {v1, v2, v3..., vc} represent a set of centers, then

1. Randomly select 'c' cluster centroids
2. O use the following formula to calculate the fuzzy participation 'μij':

$$\mu ij = 1 / \sum_{k=1}^{c} (d_{ij}/d_{ik})^{(2/m-1)} \tag{7}$$

3. Compute the fuzzy centroids '*vj*' as follows:

$$\mathrm{v}j = \left(\sum_{i=1}^{n} (\mu ij)^m x_i \right) / \left(\sum_{i=1}^{n} (\mu ij)^m \right), \forall j = 1, 2, 3, \ldots c \tag{8}$$

4. Repeat steps 2 and 3 until the smallest 'j' value is attained or ||U(k + 1) – U(k)|| < β is achieved, whereas the repetition step is signified by the letter '*k*.', the completion criteria between [0, 1] is 'β', the fuzzy relationship matrix is well-defined as '$U = (ij)$ $n*c$', and the impartial function is represented by the letter '*J*.'

The student's performance prediction and clusters dataset is clearly well-defined as a 17-dimensional dataset, with three features based on student's performance prediction values and one feature target property cluster number (see Table 3). The FCM Clustering centroid value briefly defined is given below, whereas Figure 3 shows the three clusters after the unstructured dataset has been converted to structured data. This graph depicts two clusters: red and green, with centroid values specified by the yellow star (*). Figure 4 shows FCM determined sum of squared error line chart.

FCM Clustering Centroid Value.

```
array([[0.49492933, 0.4917658 , 0.51983247,
0.47320961, 0.49158729, 0.52289268, 0.5230012 ,
0.47840191, 0.50558121, 0.51672337, 0.49937354,
0.51753685, 0.49081544, 0.48903864, 0.51368392,
0.48831137, 0.51521064],
[0.4949292 , 0.49176579, 0.51983274, 0.47320943,
 0.49158728, 0.52289266, 0.52300126, 0.47840171,
0.50558125, 0.51672342, 0.49937341, 0.51753673,
0.49081553, 0.48903883, 0.51368394,
0.48831103, 0.51521079],
[0.49492982, 0.49176602, 0.51983238, 0.4732094 ,
 0.49158729, 0.52289266, 0.5230013 , 0.47840182,
0.50558108, 0.51672348, 0.49937376, 0.51753657,
0.49081558, 0.48903829, 0.513684,
0.48831106, 0.51521069]])
```

Table 3. FCM three clusters preprocessed for international high education students performance dataset

Gender	Nationality	Place of Birth	Stage ID	Grade ID
0.276542	0.456038	0.416909	0.675114	0.664516
0.595424	0.976172	0.329478	0.635595	0.804943
0.181578	0.429730	0.063652	0.445259	0.907755
0.830483	0.088741	0.159844	0.527569	0.263223
0.210892	0.701391	0.766264	0.172061	0.103681
Section ID	**Topic**	**Semester**	**Relation**	**Raised Hands**
0.959812	0.820159	0.609305	0.522702	0.782175
0.677397	0.132544	0.169182	0.336317	0.587580
0.918585	0.755372	0.045972	0.292576	0.704262
0.741383	0.871822	0.152801	0.884067	0.992723
0.024694	0.419428	0.949947	0.700166	0.426451
Visited Resources	**Announcements View**	**Discussion**	**Parent Answering Survey**	**Parent School Satisfaction**
0.892479	0.164947	0.646486	0.145420	0.667879
0.624576	0.543965	0.676087	0.104618	0.115494
0.028200	0.060382	0.371900	0.112741	0.355699
0.117836	0.414137	0.987809	0.355952	0.783681
0.145548	0.839285	0.519597	0.009649	0.763605

Student Absence Days	Class	Clusters
0.930874	0.996918	2
0.212968	0.871445	2
0.400581	0.200401	2
0.098311	0.266751	2
0.616193	0.617324	0

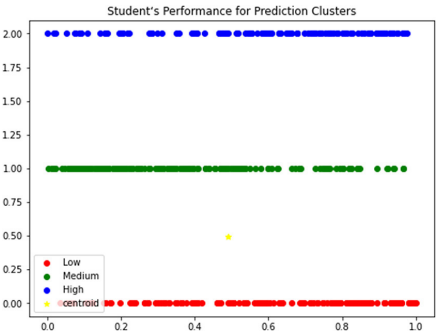

Fig. 3. The FCM three clusters

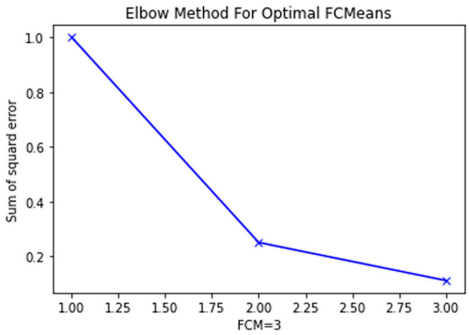

Fig. 4. The FCM sum of squared error line chart

A concern value is produced based on the degree of divergence from particular dimensions and thereby, the based on student's performance prediction result is classified as valid or suspect, or predictions.

3.2 Classification

The classification is a supervised learning strategy that determines the category of observations using training data. The process of learning from a dataset of observations and then categorising the observations into one of several classes or groupings is known as classification. In our dataset, we test the following classification methods to see which one performs better.

Multi-layer perceptron algorithm. A multi-layer perceptron (MLP) is a sophisticated optimization technique. It's finished up of countless perceptron. The algorithm consists of three layers: an input layer that receives data, an output layer that takes a decision or guesses about the input, and an endless number of hidden layers that act as MLP's true processing arrangement. MLP may approximate any continuous function with a varied number of hidden layers. This technique effectively estimates each and every linear method. It classifies collections that are not conditionally independent. Participants achieve this by creating machine learning and predicting models for challenging facts using a more elastic and complicated infrastructure, and this strategy is widely used to deal with supervised learning challenges [23]. This method, like the Sigmoid, Linear, Cost Linear, and Non-linear Regression, is built around classification, as given below.

$$\text{Sigmoid} \quad \mathrm{S}(z) = \frac{1}{(1+\mathrm{e}^{-z})} \tag{9}$$

$$\text{Linear Logistic Regression} \quad y = e\,\wedge\,(b0 + b1 * x) / (1 + e\,\wedge\,(b0 + b1 * x)) \tag{10}$$

$$\begin{aligned} \text{Cost Linear Logistic} \quad & (Cost\,(h\theta(x), y)) = -log\,(h\theta(x)), if\ y = 1\, and \\ \text{Regression} \quad & (Cost\,(h\theta(x), y)) = -log\,(1 - h\theta(x)), if\ y = 0 \end{aligned} \tag{11}$$

$$\text{Nonlinear Logistic Regression} \quad \mathrm{Y} = \mathrm{f}(\mathrm{X}, \beta) + \varepsilon \tag{12}$$

The main steps of MLP algorithm are given below.

1. The MLP, like the perceptron, advances facts by calculating the partial derivatives of the input records and the parameters that appear between the input and hidden layer. This sampling distribution generates a value in the hidden layer. However, unlike an activation function, we do not increment this value.
2. The MLP employs activation functions in each of their estimated layers. There are various processing mechanisms to evaluate, such as rectified linear units (ReLU), the sigmoid, and the mechanisms. Any of these methods is used to transfer the measured output to the visible layer.

3. After the expected outcome at the invisible layer has been generated through the activation function, extract the partial derivatives with the required values and transmit them to another layer inside the MLP.
4. Repeat the above procedures two – three times till the final output is acquired.
5. The estimates will be used at the output to acquire results for either a feed-forward technique corresponding to the activation methods chosen for only the MLP (in the scenario of training data), or a selection obtained from the results (in the situation of testing data).
6. End.

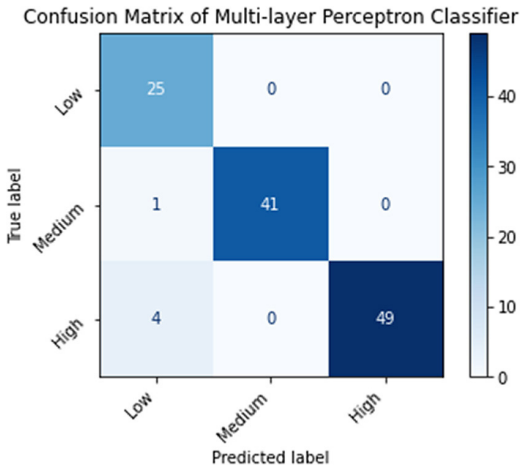

Fig. 5. Confusion matrix of MLP

The MLP labels the old data values and predicts the value of the new data. We try to make predictions fit the labels during preparation. Figure 5 shows the result of that MLP confusion matrix. As of this paper, the confusion matrix has the meaning as [[A B][C D]], whereas

- A is the frequency of correctly predicted negative instances,
- B is the quantity of inaccurate guesses that a positive occurrence has.
- C is the number of inaccurate predictions that a negative occurrence has, and
- D is the frequency of right predictions of a positive case.

We used the matrix of MLP Algorithm for assessing the model accuracy and model loss concepts. This will increase the approximated prediction approach's accuracy while also ensuring that the patterns of student's performance prediction are fulfilled on a frequent basis. The achieved model accuracy is 0.9583 and further discussed in Section 5 of Results.

Logistic regression algorithm. The logistic regression (LR) is a ML approach used for classification procedures. It is a probability hypothesis-based predictive analytic technique. A LR model is functionally equivalent to a linear regression model. However, LR employs an additional complicated cost-function, known as the sigmoid-function or

often as the logistic-method, rather than a linear function. The LR hypothesis limits the differential equation to values amongst 0 and 1. As an outcome, linear-functions flop to characterize it since they might have values more than one or even less than zero, which is not possible under the LR assumption.

The LR algorithm's major steps are given below and the detail about the LR and its mathematical functions can be found in [24]:

1. Initialize all parameters *(B_0, B_1, etc.)*.
2. Compute (predict) dependent variable *($h_\theta(x)$)*.
3. Compute cost function *(Cost ($h_\theta(x)$,y))* or any Logistic Regression function.
4. Compute gradient for the cost function.
5. Update all parameters.
6. Repeat steps 2 to 5.
7. End.

The LR model's true and predicted labels are shown in confusion matrix in Figure 6. We apply the LR algorithm on our above dataset and label the old data values. It predicts the value of data – where we tried to make our predictions fit the labels during preparation with the use of the LR algorithm. Figure 6 shows the result of that matrix. This will increase the approximated prediction approach's accuracy while ensuring that the patterns of students' performance prediction are fulfilled on a frequent basis. Furthermore, the achieved model accuracy is 0.9583, identical to MLP, and further discussed in Section 5 of Results.

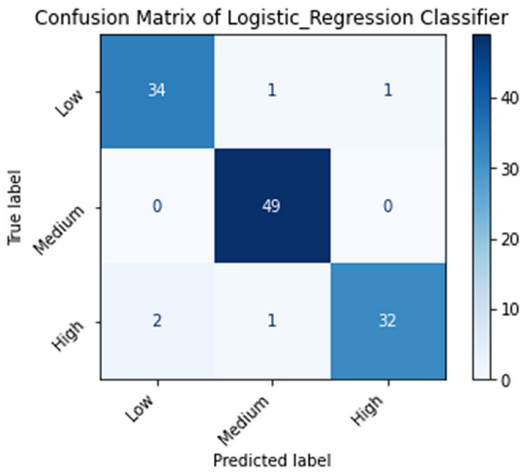

Fig. 6. Confusion matrix of LR algorithm

Random forest algorithm. A random forest (RF) is a ML technique that is use to resolve the classifier issues. It makes use of different classifiers, a sort of difficult resolving system, that makes use of classifying approaches. That's the technique of merging numerous categories to solve complicated issues and enhance the effectiveness of the system. The RF approach, which is built on classification tree predictions,

decides the effectiveness. It makes assumptions by approximating or calculating the results of numerous trees. The quality of the output increases even as number of nodes increases [25–26].

The RF algorithm is based on the following steps:

1. Initiate by randomly picking observations through facts.
2. The program will instead create a tree structure for every instance. The outcomes for every tree structure will then be produced.
3. Throughout this stage, every generated came as a result would be selected or decided on.
4. Lastly, select the most preferred forecasting outcome as unique of the most predicted results.

Moreover, the RF algorithm uses specific mathematical functions. This approach, as well as Mean Squared Error (MSE), Gini (Coefficient, Index, or Ratio), and Entropy [27], may be used by the RF algorithm such as given below.

$$\text{Mean Squared Error (MSE)} \quad \frac{1}{N} = \sqrt{\sum_{i=1}^{N} (xi - yi)^2} \tag{13}$$

$$\text{Gini Coefficient} \quad Gini = 1\sum_{i=1}^{C} (p_i)^2 \tag{14}$$

$$\text{Entropy} \quad \text{Entropy} = \sum_{i=1}^{c} -p_i * \log_2(p_i) \tag{15}$$

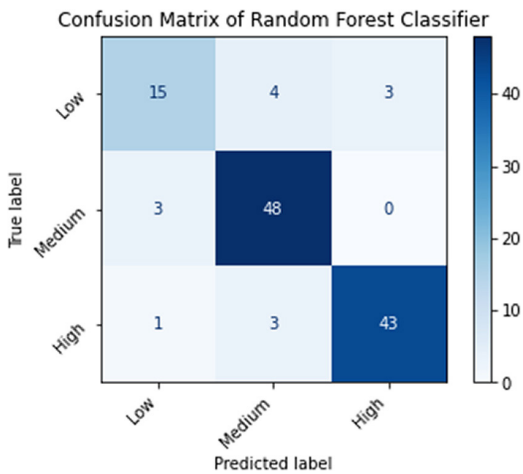

Fig. 7. Confusion matrix of RF algorithm

We apply the RF algorithm on our dataset and label the old data values. It predicts the value of data – where we tried to make our predictions fit the labels during preparation

with the use of the RF approach. Figure 7 shows the confusion matrix. Moreover, the achieved model accuracy is 0.8833 and further discussed in Section 5 of Results.

4 Experimental setup

Python is a high-level scripting language that's mostly used for general-purpose programming and machine learning methods, as well as web development and database management. We have used the Anaconda Navigator –>Jupiter Notebook GUI framework from the Python tool. All the desired algorithms i.e., FCM, MLP, LR, and RF, have been simulated in Python programming language. The dataset is mostly used to assess student performance. This dataset has 480 tuples (rows) and 17 dimensional characteristics (columns). We simulate the programs of different combinations of the algorithms. The first program simulated FCM and MLP schemes, the second program simulated FCM and LR schemes, and the third program simulated FCM and RF schemes. The configuration of the computer used is as follows:

- Second Generation Intel (R) Core (TM) i5-2520M CPU @ 2.50 GHz.
- RAM 4.00 GB.
- The system is a 64-bit operating system.
- Windows 10 (Home).
- 500 GB hard disk.

5 Results and discussions

ML is a scientific approach in which CPUs learn how to resolve complications without being explicitly programmed. DL is now persuasive the ML competition, owing to better-quality processes, computation power, and immense datasets. Nonetheless, conventional ML algorithms hold a prominent place in the sector. This research employs a novel technique designed on the integration of FCM. The performance of the classifier was then compared against other supervised ML algorithms to choose the best classifier. In this study, ML supervised approaches have been considered which include MLP, LR, and RF (classification techniques), as well as FCM (clustering technique). Furthermore, we combine the algorithms to get the best accurate combination for predicting the student's performance. We have formed the different combinations which include FCM – MLP, FCM – LR, and FCM – RF, and simulated the programs. The achieved results are compared with the conventional algorithms such as K-Nearest Neighbor (KNN), Support Vector Machine (SVM), and Deep Neural Network (DNN). Tables 4 and 5 show the acquired accuracy and other performance characteristics. The observed results are also shown in Figures 8 and 9. It is apparent from the results that the combinations FCM – MLP, and FCM – LR are reached at their maximum outcome in terms of accuracy i.e., 95.833%. However, the combination FCM – RF is ranked second having accuracy of 88.33%.

Table 4. Model accuracy for the combination of algorithms for students performance prediction

Algorithms	Accuracy (%)	Algorithms	Accuracy (%)
K-Nearest Neighbor (KNN) [20]	69.00	Support Vector Machine (SVM) [20]	75.00
Random Forest (RF) [20]	79.00	Deep Neural Network (DNN) [20]	84.00
FCM – MLP **Proposed Method**.	95.833333	FCM – LR **Proposed Method**.	95.833333
FCM – RF **Proposed Method**.	88.333333		

Table 5. Parameter score for the combination of algorithms for students performance prediction

S/No.	Parameter Score (%)	FCM – MLP	FCM – LR	FCM – RF
1	Accuracy	0.95833333	0.95833333	0.88333333
2	Precision	0.95833333	0.95833333	0.88333333
3	Recall	0.95833333	0.95833333	0.88333333
4	Sensitivity	0.99555555	0.97142857	0.78947368
5	Specificity	0.97619047	0.99333333	0.94117647
6	F1-Score	0.95833333	0.95833333	0.88333333

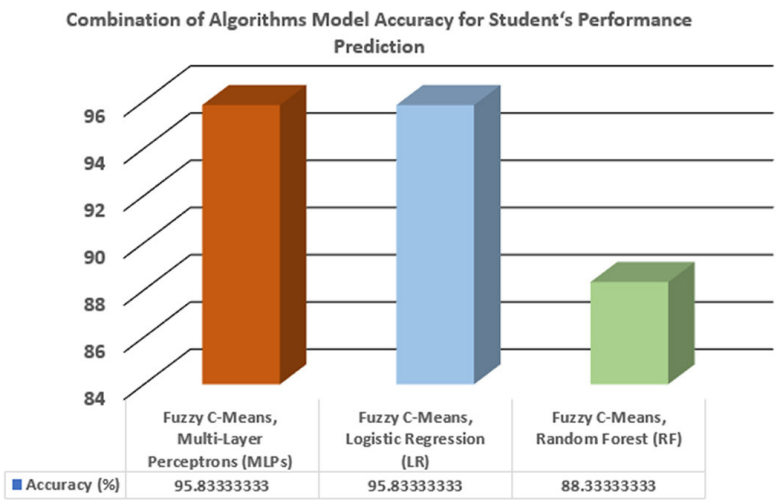

Fig. 8. Model accuracy for various combined algorithms for students' performance prediction

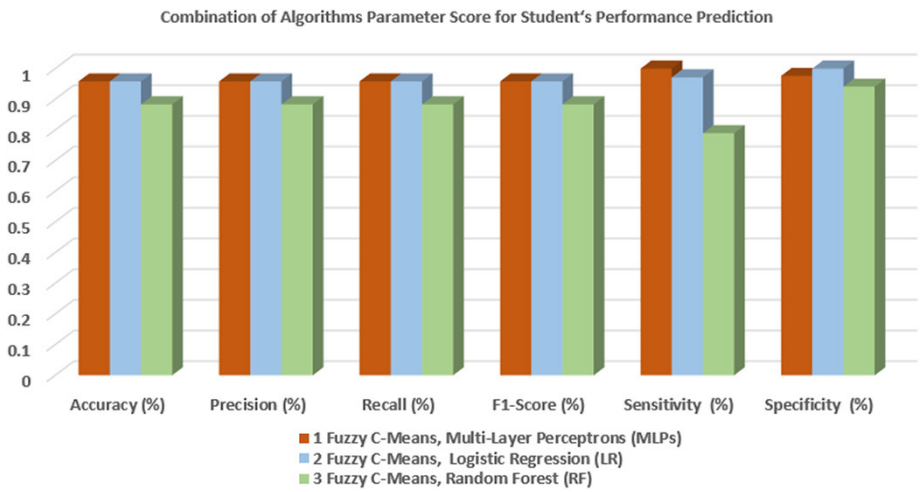

Fig. 9. Parameter score for various combinations of algorithms for students' performance prediction

6 Conclusion

The effectiveness of ML algorithms for predicting student performance has been examined in this study. The considered dataset of high education students in this study was evaluated using a range of algorithms including the fuzzy C-means (FCM), Multi-Layer Perceptron (MLP), Logistic Regression (LR), and Random Forest (RF). Initially, the dataset was preprocessed and clusters were formed using FCM technique. Later, the preprocessed data was classified by using a number of classification algorithms such as MLP, LR, and RF. The FCM technique has been particularly combined with each classification algorithm to improve the precision. As a result of combining each classification algorithm with the FCM, the achieved accuracy is 95.833%, 95.833%, and 88.333%, for the combinations FCM – MLP, FCM – RF, and FCM – LR, respectively. It is concluded that the combination of FCM with MLP, and FCM with LR yields the most accurate results.

7 References

[1] W. Zhu, L. Xie, J. Han, and X. Guo, "The application of deep learning in cancer prognosis prediction," Cancers, National Library of Medicine vol. 12, no. 3, p. 603, 2020. https://doi.org/10.3390/cancers12030603

[2] Machine Learning Mastery, https://machinelearningmastery.com/supervised-and-unsupervised-machine-learning-algorithms/, accessed on 2021-12-23.

[3] B. Bakhshinategh, O. R. Zaiane, S. El-Atia, and D. Ipperciel, "Educational data mining applications and tasks: a survey of the last 10 years," Education and Information Technologies (Educ Inf Technol), vol. 23, no. 1, pp. 537–553, 2018. https://doi.org/10.1007/s10639-017-9616-z

[4] P. Chen, Y. Lu, V. W. Zheng, X. Chen, and B. Yang, "KnowEdu: a system to construct knowledge graph for education," IEEE Access, vol. 6, pp. 31553–31563, 2018. https://doi.org/10.1109/ACCESS.2018.2839607

[5] Q. E. Aissaoui, Y. E. A. E. Madani, L. Oughdir, A. Dakkak, and Y. E. Allioui, "A multiple linear regression-based approach to predict student performance," in Proceedings of the International Conference on Advanced Intelligent Systems for Sustainable Development, Springer, Cham, Switzerland, January 2020. https://doi.org/10.1007/978-3-030-36653-7_2

[6] Datavedas, Classification-Problems, https://www.datavedas.com/wp-content/uploads/2018/05/3.1.1.2-CLASSIFICATION-PROBLEMS-1.png/, accessed on 2021-01-01.

[7] Researchgate, Document Clustering, https://www.researchgate.net/profile/Laith-Aaligah/publication/322455242/figure/fig1/AS:582970224644096@1516002340891/An-example-of-the-document-clustering.png/, accessed on 2022-01-02.

[8] I. D. Livieris, et al., "Predicting students' performance using artificial neural networks," 8th PanHellenic Conference on International Participation Information and Communication Technologies, International Journal of Computer Science and Mobile computing pp. 321–328, 2012.

[9] S. Kotsiantis, et al., "Preventing student dropout in distance learning systems using machine learning techniques," Applied Artificial Intelligence, vol.18, no.5, pp. 411–426, 2003. https://doi.org/10.1080/08839510490442058

[10] C. E. Moucary, M. Khair, and W. Zakhem, "Improving student's performance using data clustering and neural networks in foreign-language based higher education," The Research Bulletin of Jordan ACM, vol. 2, no.3 , pp. 27–34, 2011.

[11] Yi, Hongsuk, H. Jung, and S. Bae, "Deep Neural Networks for traffic flow prediction," in IEEE – International Conference on Big Data and Smart Computing (BigComp), pp. 328–331, 2017. https://doi.org/10.1109/BIGCOMP.2017.7881687

[12] E. A. Amrieh, T. Hamtini, and I. Aljarah, "Mining educational data to predict student's academic performance using ensemble methods," International Journal of Database Theory and Application, vol. 9, no. 8, pp. 119–136, 2016. https://doi.org/10.14257/ijdta.2016.9.8.13

[13] S. E. Shaymaa and M. Tsunenori, "Building an interpretable model of predicting student performance using comment data mining," IEEE 5th International Congress on Advanced Applied Informatics (IIAI-AAI), 2016.

[14] N. Buniyamin, M. B. Usamah, and A. Pauziah Mohd, "Educational data mining for prediction and classification of engineering student's achievement." IEEE 7th International Conference on Engineering Education (ICEED), 2015. https://doi.org/10.1109/ICEED.2015.7451491

[15] M. N. Quadri and N. V. Kalyankar. "Drop out feature of student data for academic performance using decision tree techniques." Global Journal of Computer Science and Technology, 2010.

[16] C. Tjioe Marvin and A. Mewati, "Exploration of classification using NBTree for predicting students' performance," in IEEE 2014 International Conference on Data and Software Engineering (ICODSE), 2014.

[17] M. Wook, Y. H. Yahaya, N. Wahab, M. R. M. Isa, N. F. Awang, and H. Y. Seong, "Predicting NDUM student's academic performance using data mining techniques," 2009 Second International Conference on Computer and Electrical Engineering, 2009, pp. 357–361, https://doi.org/10.1109/ICCEE.2009.168

[18] K. P. Shaleena and S. Paul, "Data mining techniques for predicting student performance," 2015 IEEE International Conference on Engineering and Technology (ICETECH), 2015, pp. 1–3, https://doi.org/10.1109/ICETECH.2015.7275025

[19] Bendangnuksung and P. Prabu,"Students'performance prediction using deep neural network", International Journal of Applied Engineering Research, vol.13, no.2, pp. 1171–1176, 2018.

[20] V. Vijayalakshmi and K. Venkatachalapathy, "Comparison of predicting student's performance using machine learning algorithms" I.J. Intelligent Systems and Applications, 12, 34–45, 2019. https://doi.org/10.5815/ijisa.2019.12.04
[21] A Students' Academic Performance Dataset, https://www.kaggle.com/datasets/aljarah/xAPI-Edu-Data, accessed on 2022-04-22.
[22] Data Clustering Algorithms, fuzzy-c-means-clustering-algorithm, https://sites.google.com/site/dataclusteringalgorithms/fuzzy-c-means-clustering-algorithm, accessed on 2022-04-30.
[23] Multi-Layer Perceptrons (MLPs) Algorithm, https://wiki.pathmind.com/multilayer-perceptron, accessed on 2022-05-5.
[24] Towards Data Science, Logistic Regression, https://towardsdatascience.com/introduction-to-logistic-regression-66248243c148/, accessed on 2022-05-12.
[25] Random-Forest-in-Machine-Learning, https://www.section.io/engineering-education/introduction-to-random-forest-in-machine-learning/, accessed on 2022-04-18.
[26] Tutorials-Point-Random-Forest, https://www.tutorialspoint.com/machine_learning_with_python/machine_learning_with_python_classification_algorithms_random_forest.htm, accessed on 2022-05-28.
[27] Random-Forest-Algorithm, https://medium.com/capital-one-tech/random-forest-algorithm-for-machine-learning-c4b2c8cc9feb, accessed on 2022-05-30

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The Degree of Practicing Creative Thinking Skills by Basic School Teachers in Emirate of Sharjah from their Point of View

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Abstract—This study aimed at finding out the degree of practicing creative thinking skills by basic school teachers in Emirate of Sharjah, from their point of view. The descriptive – survey methodology was used in the study. The study sample consisted of (50) female teachers of the basic stage. A questionnaire was developed to collect the study data. It consisted of (22) items, distributed on five domains: (fluency, flexibility, sensitivity to problems, taking risk and enriching detail skills). Validity and reliability of the tool were assured. The findings showed that the degree of practicing creative thinking skills by basic female school teachers was high from their point of view. There were no statistically significant differences at ($\alpha \leq 0.05$) in the degree of practicing creative thinking skills by the basic female school teachers in Al – Sharjah Emirate attributed to academic qualification and experience variables. Among the recommendations of the study was: Supporting the effectiveness of practicing creative thinking skills of the basic female school teachers in Emirate of Sharjah.

Keywords—skills, creative thinking, Emirate of Sharjah, basic school teachers

1 Introduction

Thinking is a vital activity that characterizes the human being as a complex mental activity. It is a characteristic of the individual's awareness of the events and things going on around him in his life [1]. Thinking is a mental process that a person practices during his life in light of his efforts to solve the problems or situations he faces based on his experiences and motives. In view of the problems and challenges we face in all fields and disciplines, the need has become urgent that requires the use of thinking processes, especially creative thinking, to meet the challenges and the huge explosion of knowledge, and for more fruitful education to employ the higher mental capacities to creative thinking in a way that develops ideas, performance and abilities in line with the requirement so advanced education that develops ambition, confidence and skills, to the maximum event possible, while proving the ability to employ creative thinking

through communication, through the free expression of what is going on in the mind of the individual, with the discovery of things from several aspects in a creative way. As well as the individual's discovery of himself and others and their understanding and solving the gaps through his creative thinking that pushes him strongly towards the right and peaceful direction to reach a result. Creativity, and then creative thinking, is not limited to a specific category of individuals or to a field or specialty. This is because human beings are creative and distinguished in every society, and teachers who have creative thinking form the main basis for moving towards progress and prosperity. The role of the teacher is effective in diagnosing strengths and weaknesses, developing his style of creative thinking, and raising its level, because he is the person most capable of making change for the better and integrating his work and ideas within the framework of creative thinking through the appropriate use of the skills of this type of thinking.

2 Research problem

The use of creative thinking skills is very important in light of the rapid developments and tremendous achievements in order to improve performance and excellence in various areas of life, which will contribute to overcoming many obstacles facing the teacher while carrying out his educational tasks by unleashing thinking and creativity the best conditions for excellence and creativity. Since the skills of creative thinking empower teachers to deal and harmonize with all parties of the educational process at a high level of positivity, the short coming in using them will negatively affect the achievement of the goals of the educational process. Hence the problem of the study emerged by answering the following question:

What is the degree of practicing creative thinking skills by basic school teachers in the Emirate of Sharjah from their point of view?

2.1 Research aim and its questions

The aim of the current research is to find out the degree of practicing creative thinking skills by basic school teachers in Al – Sharjah Emirate in the United Arab Emirates (UAE) by answering the following two questions:

RQ1: What is the degree of practicing creative thinking skills by basic school teachers from their point of view?

RQ1: Are there any significant differences at ($\alpha \leq 0.05$) in the degree of practicing creative thinking skills by basic school teachers in the Emirate of Sharjah attributed to experience and academic qualification variables?

2.2 Research importance

– It is hoped that the results of this research will encourage the competent authorities in the Ministry of Education to prepare training programs that work to develop the creative thinking skills to teachers to reach excellence and success in the educational process.

– It is hoped that the results of this research will benefit educators in addressing some teaching problems in a creative manner.
– It is hoped from the results of this research the link between educational administration and educational psychology through the psychological variable represented in creative thinking.
– It is hoped that the results of this research provide a theoretical framework on the usefulness and importance of creative thinking skills for teachers, and it will be a starting point for research conducted at other levels of study.

2.3 Delimitations of the research

The current research was limited to basic school teachers with all their specializations in the Emirate of Sharjah in the United Arab Emirates for the current academic year 2020–2021.

2.4 Definition of terms

The research included a number of terms that were defined conceptually and operationally, as follows:

- Thinking: A complex concept consisting of three elements represented in complex cognitive processes, the highest of which is problem solving, and the least are understanding and application with knowledge of the content of the material, with the availability of preparedness and various personal factors, specially attitudes and tendencies [2, 3].
- Creative thinking: is a purposeful activity that results in new innovative ideas that are not familiar with theoretical or applied situations in one of the educational or life fields so that these solutions and products are characterized by modernity, novelty, and complexity [4–6].
- The operational definition of creative thinking skills: The ability of the teacher and the extent of his flexibility to interact with all those in charge of the educational process in its creative nature, which can be measured through the answers of the subjects of the research sample to the items of the questionnaire developed by the researcher and used in this research.

3 Theoretical literature

3.1 Creative thinking concept

Creativity (language) means the one who invents a thing: he created it, and found it [7]. Guilford defined creative thinking as it was referred to in [8] as the ability to find multiple and diverse solutions, i.e. the ability to develop ideas. While [9, 10] had defined creative thinking as producing a new and appropriate answer, product, or solution to an open – ended problem. As for [11], he defined creative thinking as the

ability to imagine with creative participation, both physically and mentally, in various activities in an unusually successful manner while solving problems with the use of tools from skilled people to develop new methods and ideas.

3.2 Levels of creative thinking

Taylor classified creative thinking into five levels, according to [12] mentioned, as follows:

1. Expressive creativity: Refers to free and independent expression to develop an idea regardless of its quality and without the need for skills or originality.
2. Productive creativity: refers to the product of the growth of the expressive level to lead to the production of complete works characterized by the restriction and control of free activity.
3. Inventive creativity: Refers to invention and discovery involving flexibility in perceiving new relationships between previously separate parts.
4. Innovative creativity: Requires a strong and high ability to abstract visualization of things to be improved by the creator.
5. Emergent creativity: It is the highest level of creativity that includes the conception of a new principle or access to a theory or law.

3.3 Factors affecting creative thinking

The main factors affecting creative thinking according to [13, 14] are as follows:

1. Intelligence: A condition for creativity in a certain percentage, but it is not sufficient to develop creativity.
2. Flexibility in thinking: It refers to the ability to move from one idea to another and look from multiple angles and directions.
3. Convergent and divergent thinking: It is closely related to the stored information and the form in which it is, with an awareness of the relationships between them.
4. Motivation: It is expressed by the integration of internal and external motives, which is consisted a stimulus for creative thinking that stems from the congruence of social and personal needs.
5. The family: Is the first influencer in shaping the child's personality elements and learning methods, through which the child learns to be traditional or creative, independent of his patterns of thinking and behavior.
6. The school: The school plays a major role in nurturing and developing creativity, whether by paying attention to depositing and finding appropriate educational programs or by providing incentives for creative students to motivate them to complete to achieve more creativity.

3.4 The importance of creative thinking

In [15, 16], they pointed out and explained the importance of creative thinking with the following points:

1. Develops the individual's ability to elicit new ideas and develops sensitivity to the problems of others.
2. Contributes to realization of the creative self, and the development of creative products with the development of talents and a better understanding of the world.
3. It leads to openness to new ideas, responding effectively to opportunities, challenges, responsibilities, managing risks, and adapting to changes.
4. Stimulates the tendency to cooperate with others to discover ideas.
5. Contributes to motivate schools to be a suitable environment for discovering talents and working to develop them through specialized programs.
6. Contributes to the development of learning methods and patterns to become more effective.
7. Contributes to the development of the individual's ability to deal with challenges and life situations in a more creative way.
8. It helps the individual to reach a successful solution to the problem in a creative way.

Advantages of creative thinking

Creative thinking, as [11] pointed out, has the following advantages:

1. The presence of high flexibility in the ideas that are presented.
2. There is a typical way of human thinking.
3. Find new ways to solve different problems.
4. Researching the details and getting into the depth of the problems to come up with drastic solutions.
5. Rapid response to emergency problems and to find quick solutions.

3.5 Creative thinking skills

Creative thinking skills are determined as follows:

1. Fluency skill: It means the speed or ease in issuing ideas or solutions to problems in accordance with the requirements of the real environment, so that the idea are organized, accurate and issued by knowledge. Fluency is measured by the ability to produce the largest possible number of solutions or ideas in a specific time. Fluency also represents the quantitative aspect of creativity [17, 18].
2. Flexibility skill: It means the ability to change the direction of thinking and generate various ideas to solve a problem or change a viewpoint towards the problem being treated and look at it from different angles.
3. Problem sensitivity skill: It means the ability to perceive weaknesses or shortcomings in a situation or something, which the average individual does not notice in most cases [19, 20].

4. The skill of enriching the details: It means the ability to add new and diverse details to an idea or to solve a problem that would help develop and enrich it [21, 22].
5. The skill of accepting risk: is intended to take the initiative in adopting new ideas and methods, and searching for solutions to them at the same time, when the response is capable of bearing the risk resulting from the work he is doing, and is ready to face the resulting responsibility [23, 24].

3.6 Stage of creative thinking

The creative thinking process consists of six stages [25]:

1. The stage of inspiration is the stage of generating large numbers of ideas that are characterized by being uninhibited, and characterized by spontaneity, experience, intuition and risk taking.
2. Illustration stage is a stage that focuses on the goals by asking the following main questions:
   – What am I trying to achieve here?
   – What am I trying to say?
   – What is the exact problem I am trying to solve?
   – What would I like the work done to look like?
   – How can I invest the ideas I have in my hands?
   – Where does this idea lead me and what can I make of it?
3. Extraction stage: is the stage of carefully examining the generated ideas and determining what is suitable for them to work, where the ideas are scrutinized from the inspiration stage, and in light of the results from the illustration stage, the best ideas are selected for further development or integrated into better ideas.
4. Nomination stage: This stage is carried out with sincere determination for the best ideas that have been selected. Here the real work is done with seriousness and persistent effort towards achieving the goal.
5. Evaluation stage: In this stage, the work is examined and previewed in search of strengths and weaknesses in order to invest and reinforce the strengths. This stage is required to return to the nomination stage to respond positively to the proposals for modification and improvement.
6. The stage of developing ideas: It is the stage of devotion to other work and leaving the current work, and thinking about it from time to time without losing sight of the mind.

3.7 Obstacles to creative thinking

Some obstacles that prevent the development of creative thinking:

– Family obstacles: They are the most important influences that affect the child's personality, including the low standard of living of the family, and the educational level of the parents, and their neglect of the interests and desires of their children [26].

- Personal obstacles: These obstacles are represented in personality weakness, lack of self – confidence, compliance with others, and lack of awareness of environmental stimuli.
- Emotional obstacles: that conflict with the freedom to explore and process ideas. Despite our ability to use concepts and ideas flexibility and fluently, these obstacles prevent us from conveying ideas to others in a manner that meets acceptance and satisfaction [27].
- School obstacles that include the teacher, his culture, teaching methods, attitudes and ideas toward the teaching profession, his relationship with students, the effectiveness of school administration, its policies and leadership styles, and its role in encouraging students to acquire creative thinking skills, and discouraging students to think and use their diverse mental abilities [19].

4 Related work

In [28], they conducted a study aimed at examining the effectiveness of a training program based on the self – questioning strategy in developing creative thinking skills (fluency, flexibility and originality) among tenth grade students in Azraq camp for Syrian refugees in Jordan. The study sample consisted of (40) female students distributed into two groups: experimental and control. The Torrance scale of creative thinking was used. The results of the study indicated that there were statistically significant differences between the performance means of the experimental and control groups, in favor of the experimental group. Also, [29] conducted a study aimed at investigating the effect of age and gender variables on creative abilities of seventh, eighth and ninth grades of the Sahab pioneering center. The study sample consisted of (60) male and female students. The Torrance test for verbal and formal creative thinking was applied. The results showed that there were no statistically significant differences according to the gender variable at ($\alpha \leq 0.05$) on the dimensions of fluency, flexibility and originality. There were also no statistically significant differences at ($\alpha \leq 0.05$) due to the age variable on the students' achievement in the verbal and formal tests. Moreover, [30] conducted a study aimed at developing an educational unit from the eighth grade geography book in light of the habits of mind and measuring its effect on the creative thinking of female students in Jordan. The sample of the study consisted of (83) female students distributed into two groups: experimental and control. The findings of the study indicated that there were statistically significant differences between the performance means of the experimental and control groups, in favor of the experimental group. The results also indicated a weakness in the activities related to creative thinking skills. Likewise, the aim of the study of [31] was to search for the creative thinking skills of the tenth grade students in mathematics. The sample of the study consisted of (35) students. The quantitative and qualitative methodologies were used in this study. The findings showed that the students had different skills in mathematics and creative thinking. Furthermore, Adam and Mujib (2020) carried out a study aimed at improving students' critical and creative thinking skills, through a multivariate analysis of the experiments and gender model. The study sample consisted of (328) participants from five different universities in Indonesia. The multi – skills lab

activity model and the high – level thinking lab were used, with gender as an influencing factor in the successful learning process. A quasi – experimental methodology was used. The result showed that the experience affected the learning outcomes more than the gender variable. The results indicated that the multi – skills lab activity model improves students' critical and creative thinking skills better than the high – level thinking lab. Also, [32, 33] conducted a study aimed at determining the effect of the generative learning model for the skills of solving mathematical problems, and the skills of mathematical creative thinking of fifth grade students. The study sample consisted of (75) students. Data were collected using essay tests to solve mathematical problems and the skills of mathematical creative thinking. Data were analyzed using the natural state test and harmonization test as well as assumptions using SPSS. The results showed that there was an effect of the generative learning model on mathematical problems. While [34] carried out a study aimed at testing the effectiveness of learning methods on creative thinking skills and finding out the interaction between multimedia and learning styles in influencing creative thinking skills. The total sample consisted of (74) male and female students in the tenth grade, who were divided into two groups, experimental and control. The quasi – experimental methodology was used. The data on creative thinking skills were tested using (N – Gain). The learning methods were quantitatively analyzed to find out the effectiveness of the research variables. One-way Analysis of Variance (ANOVA) was used in manipulating data. The results showed that interactive multimedia had an effect on students' creative thinking skills. The learning styles and interactions of the two independent variables did not affect the creative thinking skills of the students.

5 Methodology

The survey descriptive methodology was used as the appropriate methodology for this research. The questionnaire was used as a means of data collection.

5.1 Research population

The research population consisted of all female basic school teachers working in private schools in Emirate of Sharjah, for the current academic year (2020 / 2021).

5.2 Research sample

A random sample of basic female school teachers in the Emirate of Sharjah was selected using the simple random sampling method. Their number reached (50) female teachers, representing the basic female school teachers in the Emirate of Sharjah.

5.3 Research tool (Creative thinking skills questionnaire)

The tool of the research was developed by reviewing the theoretical literature related to the subject of the research, and related previous studies such as: [35, 36]. The questionnaire, in its initial form, consisted of (22) items distributed into five domains.

5.4 Validity of the research tool

The validity of the research tool was confirmed using face validity, by presenting the research tool in its initial form, to a number of arbitrators in educational, psychological and administrative sciences, from professors working in UAE universities. They were asked to express their opinion regarding the items of the questionnaire in terms of clarity and accuracy of its formulation, and whether the items need to be modified and the proposed amendment. An approval rate of 80% or more of the arbitrators was for the item for adoption in the questionnaire. The arbitrators' notes regarding the linguistic formulation of some items were also taken into consideration.

5.5 Reliability of the research tool

To verify the reliability of the research tool, Cronbach Alpha equation was used to find out the internal consistency of the tool, as well as using the half split method. They were applied to a pilot sample from the research population and from outside the research sample. It consisted of (10) female school teachers. The reliability coefficient values, using Cronbach – Alpha equation ranged between (0.90–0.97). As for the reliability coefficients by the split – half method, they ranged between (0.76–0.95). These values are acceptable in this type of research. Table 1 shows that.

Table 1. The reliability coefficients of the research tool using Cronbach Alpha equation and the split half method

No.	Skills	Reliability Coefficient Using Cronbach – Alpha	Reliability Coefficient Using Split – Half Method
1	Fluency	0.91	0.72
2	Flexibility	0.90	0.83
3	Sensitivity to problems	0.97	0.93
4	Enrichment with details	0.91	0.95
5	Accept the risk	0.95	0.94
Total		**–**	**0.95**

6 Results and their discussion

6.1 Firsts: Results related to the answer to the first question: What is the degree of practicing creative thinking skills by basic school teachers from their point of view?

To answer this question, means and standard deviations were calculated. The rank and degree of practice were determined, for the domains of practice of the teachers of the basic stage of creative thinking skills in the Emirate of Sharjah from their point of view. Table 2 shows that.

Table 2. Means, standard deviations, ranks and the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah from their point of view in descending order

No.	Skills	Mean	Standard Deviation	Rank	Degree of Practice
4	Enrichment with details	3.93	0.72	1	High
2	Flexibility	3.88	0.63	2	High
3	Sensitivity to problems	3.82	0.70	3	High
1	Fluency	3.75	0.60	4	High
5	Accept the risk	3.61	0.90	5	Medium
Total score		**3.79**	**0.61**	**–**	**High**

It is noticed from Table 2 that the mean of the degree to which basic school teachers in the Emirate of Sharjah practice creative thinking skills from their point of view was high. Its mean was (3.79) and a standard deviation of (0.61). The skill of enrichment in details ranked first with a mean of (3.93) and a standard deviation of (0.72) and a high degree. In the last rank came "Accept the risk" skill, with a mean of (3.61) and a standard deviation of (0.90) and a medium degree. This result may be attributed to the fact that teachers have adapted to technological developments, communication technology, diversity in methods of dealing with others, presentation of the study material and practice of creative thinking to a high degree. As for the items of each skill, the results were as follows:

1. Enrichment with details skill

Means, standard deviations, determination of ranks and the degree of practicing "Enrichment with details" items by basic stage teachers in the Emirate of Sharjah from their point of view were found. Table 3 shows that.

Table 3. Means, standard deviations, ranks and the degree of practicing "Enrichment with details" items by basic stage teachers in the Emirate of Sharjah from their point of view in descending order

No.	Items	Mean	Standard Deviation	Rank	Degree of Practice
18	Expand and enrich the main and secondary ideas	3.96	0.77	1	High
19	Presenting multiple evidence to support the opinion	3.84	0.82	2	High
Total score		**3.93**	**0.72**	**–**	**High**

Table 3 shows that the degree of practicing the skill of "Enriching with details" by basic school teachers in the Emirate of Sharjah, from their point of view was high. The mean was (3.93) with a standard deviation of (0.72). The two items of this domain came to a high degree. Item (18) came in the first rank which states that "Expand and enrich the main and secondary ideas". Its mean was (3.96) and a standard deviation of (0.77). While item (19) which stated "Presenting multiple evidence to support the opinion" came in the second and last rank. Its mean was (3.84) and a standard deviation of (0.82).

This high result may be attributed to the fact that basic school teachers pay attention to the details. They clarify and explain these details to student, as well providing relevant knowledge and information to facilitate the students' understanding of the details related to the subject matter. This result may be due to teachers seeking to expand their students' perceptions with information that develops their creativity through their use of various teaching methods.

2. Flexibility skill

Means, standard deviations, determination of ranks and the degree of practicing "flexibility" items by basic school teachers in Emirate of Sharjah from their point of view were found, as shown in Table 4.

Table 4. Means, standard deviations, ranks and the degree of practicing "flexibility" items by basic school teachers in the Emirate of Sharjah from their point of view in descending order

No.	Items	Mean	Standard Deviation	Rank	Degree of Practice
11	The ability to see things from different angles	4.02	0.87	1	High
13	Use a variety of methods to express an idea	4.00	0.97	2	High
9	Flexibility to change a situation when he is convinced that it is incorrect	3.91	0.87	3	High
10	Flexibility in work performance	3.80	0.87	4	High
12	Respecting the views of teachers	3.67	0.80	5	Medium
Total score		**3.88**	**0.63**	**–**	**High**

Table 4 showed that the degree of practicing the skill of "flexibility" by basic school teachers in the Emirate of Sharjah from their point of view was high. Its mean was (3.88) and a standard deviation of (0.63). The means ranged between (4.02–3.67). In the first rank came item (11) which states "the ability to see things from different angles". Its mean was (4.02) with a standard deviation of (0.87), and at a high degree. While item (12) that states "Respecting the views of teachers" came in the last rank with a mean (3.67) and a standard deviation of (0.80). This result may be attributed to the fact that teachers have the ability to look at the situations they face during their school day from different angles to form a clear vision that enables them to make a rational decision about those situations. This result may be due to the fact that teachers use different methods when they want to express ideas related to the topic of the lesson to facilitate students' awareness of those ideas of concepts. This result may be attributed to teachers respecting the views of other teachers, when they present ideas and views that seem different, which may lead to the presentation of many ideas, some of which may be useful in developing the educational process.

3. Sensitivity to problems

Means, standard deviations, determination of ranks and degree of practicing the items of "sensitivity to problems" skill by basic school teachers in the Emirate of Sharjah from their point of view were calculated. Table 5 shows that.

Table 5. Means, standard deviations, ranks and the degree of practicing "sensitivity to problems" by basic school teachers in al – Sharjah Emirate from their point of view in descending order

No.	Items	Mean	Standard Deviation	Rank	Degree of Practice
16	Detailed insight into problems	3.88	0.63	1	High
17	Demonstrate enthusiasm in dealing with problems	3.84	0.65	2	High
14	Have patience to solve complex problems	3.80	0.69	3	High
15	Knowing the shortcomings of the work	3.77	0.80	4	High
Total score		**3.82**	**0.70**	**–**	**High**

Table 5 shows that the degree of practicing the "sensitivity to problems" domain by basic school teachers in the Emirate of Sharjah from their point of view was high. The mean was (3.82) with a standard deviation of (0.70). All the items of this skill came in the high degree. The means ranged between (3.88 – 3.77). Item (16) came in the first rank, which states "Detailed insight into problems". Its mean was (3.88) and a standard deviation of (0.63). Item (15) that states "Knowing the shortcomings of the work" came in the last rank. Its mean was (3.77) and a standard deviation of (0.80). This result may be attributed to the fact that teachers have a high sense and a comprehensive awareness of the problems they face when performing their educational work. They also have an accurate perception of the problems and in detail to take note of them and work to address them as soon as possible. This high result may be due to the teachers having enough enthusiasm that motivates them to deal with problems in a positive way that leads to solve or overcome them. As well as, the teachers being patient and knowing the weaknesses related to the work they practice.

4. Fluency

Means and standard deviations were calculated. Ranks and degrees were determined for practicing the fluency skill items by basic stage teachers in the Emirate of Sharjah, from their point of view. Table 6 shows that.

Table 6. Means, standard deviations, ranks and the degree of practicing "Fluency" skill by basic school teachers in the Emirate of Sharjah from their point of view in descending order

No.	Items	Mean	Standard Deviation	Rank	Degree of Practice
3	Excellence in discussion with high skill, to convince others of new ideas	3.91	0.67	1	High
8	Performs his job in a sophisticated and developed style	3.89	0.71	2	High
7	Constantly looking for new ideas	3.80	0.84	3	High
5	Talk about some topics broadly and with great confidence	3.78	0.90	4	High
6	Monitoring opportunities to develop them, in order to invest them in work	3.76	0.80	5	High

(Continued)

Table 6. Means, standard deviations, ranks and the degree of practicing "Fluency" skill by basic school teachers in the Emirate of Sharjah from their point of view in descending order *(Continued)*

No.	Items	Mean	Standard Deviation	Rank	Degree of Practice
2	Encouraging the spirit of teamwork to develop students' style	3.71	0.76	6	High
1	Providing teachers with new ideas to improve their performance	3.67	0.83	7	Medium
4	Accepts constructive criticism to develop his style	3.64	0.86	8	Medium
Total score		**3.75**	**0.60**	**–**	**High**

It is noted from Table 6 that the degree of practicing the items of "Fluency" skill by basic stage teachers in Al – Sharjah Emirate from their point of view was high. Its mean was (3.75) and a standard deviation of (0.60). The items of this domain came in the high and medium degrees. The means ranged between (3.91–3.64). Item (3) which states "Excellence in discussion with high skill to convince others of new ideas", came in the first rank. Its mean was (3.91) and a standard deviation of (0.67) with a high degree. While item (4) that states "Accepts constructive criticism to develop his style" came in the last rank. The mean was (3.64) and a standard deviation of (0.86) with a medium degree. This high result may be attributed to the fact that basic stage teachers in the Emirate of Sharjah are highly skilled in terms of expression and discussion with others to convince them of the new ideas they present, and they have verbal fluency that enables them to employ their communication with other in an effective manner. This helps them achieve their goals effectively, because they possess accurate knowledge. This result may be due to teachers' acceptance of constructive criticism offered by others, in order to develop their own style of dealing and expressing the subjects they are assigned to teach.

5. Accept the risk skill

Means and standard deviation were calculated. Ranks and degrees were determined for practicing "accept the risk" skill items by basic stage teachers in Al – Sharjah Emirate, from their point of view. Table 7 illustrates that.

Table 7. Means, standard deviations, ranks and the degree of practicing "accept the risk" skill by basic stage teachers in Al – Sharjah Emirate from their point of view in descending order

No.	Items	Mean	Standard Deviation	Rank	Degree of Practice
20	The ability to adjust his style to meet an emergency situation	3.85	0.61	1	High
22	Adopting ideas and alternatives to confront the problem	3.60	0.94	2	High
21	Adopting the creative ideas presented by teachers	3.42	0.92	3	Medium
Total score		**3.61**	**0.90**	**–**	**Medium**

Table 7 shows that the degree of practicing the items of "accept the risk" skill by basic stage teachers in the Emirate of Sharjah from their point of view was medium. The mean was (3.61) and a standard deviation of (0.90). The items of this domain ranged between (3.85 – 3.42). Item (20) that states "The ability to adjust his style to meet an emergency situation" came in the first rank. Its mean was (3.85) and a standard deviation of (0.61) with a high degree. While item (21) which states "Adopting the creative ideas presented by teachers" came in the last rank. The mean was (3.42) and a standard deviation of (0.92), with a medium degree. This result may be due to the fact that basic stage teachers in the Emirate of Sharjah have the ability to adapt their style to the nature of the situation they are facing, especially the emergency situation, which is usually surprising and requires a quick and appropriate solution. It also needs deep thinking about that situation, and familiarity with all its aspects, in order to be able property and rationally handle the situation that the teacher is going through, when performing the tasks assigned to him. This result may be attributed to the teacher's adoption of creative ideas, suggestions and alternatives that teachers put forward to face some problems during the school day. This may help the teacher and the school administration to overcome many of the daily problems within the school.

Second: Are there any significant differences at ($\alpha \leq 0.05$) in the degree of practicing creative thinking skills by basic school teachers in the Emirate of Sharjah attributed to experience and academic qualification variables?

This question was answered in light of its two variables (experience and academic qualification), as follows:

1. Experience variable

Means and standard deviations of creative thinking skills were calculated according to the variable of experience. Table 8 shows that.

Table 8. Means and standard deviations of the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah according to the experience variable

No.	Skills	Level of Experience	Sample Size	Mean	Standard Deviation
1	Fluency	Less than 5 years	25	3.88	0.81
		From 5 – less than 10 years	10	3.90	0.60
		10 years and above	15	3.85	0.61
		Total	50	3.88	0.63
2	Flexibility	Less than 5 years	25	3.85	0.60
		From 5 – less than 10 years	10	3.73	0.52
		10 years and above	15	3.68	0.68
		Total	50	3.78	0.60
3	Sensitivity to problems	Less than 5 years	25	3.86	0.55
		From 5 – less than 10 years	10	3.98	0.74
		10 years and above	15	3.67	0.88
		Total	50	3.82	0.69

(Continued)

Table 8. Means and standard deviations of the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah according to the experience variable *(Continued)*

No.	Skills	Level of Experience	Sample Size	Mean	Standard Deviation
4	Enrichment with details	Less than 5 years	25	3.82	0.71
		From 5 – less than 10 years	10	3.95	0.71
		10 years and above	15	3.84	0.65
		Total	50	3.85	0.68
5	Accept the risk	Less than 5 years	25	3.70	0.74
		From 5 – less than 10 years	10	3.45	1.50
		10 years and above	15	3.23	1.31
		Total	50	3.51	0.93
	Total score	**Less than 5 years**	**25**	**3.88**	**0.57**
		From 5 – less than 10 years	**10**	**3.88**	**0.66**
		10 years and above	**15**	**3.71**	**0.68**
		Total	**50**	**3.79**	**0.61**

It is noticed from Table 8 that there were apparent differences between the values of the means to the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah, from their point of view, according to the variable of teacher experience. Teachers of the two categories of experience (Less than five years, and from five to less than ten years) obtained the highest mean of (3.88). To determine if the differences were statistically significant at ($\alpha \leq 0.05$), One – way analysis of variance (ANOVA) was applied. The results were as shown in Table 9.

Table 9. One – way ANOVA to find out the significance of the differences in the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah according to the teachers' experience variable

Source of Variation		Sum of Squares	Df	Mean Squares	F – Value	Level of Significance
Fluency skill	Between groups	0.281	2	0.141	0.378	0.688
	Within groups	5.633	47	0.372		
	Total	5.914	49			
Flexibility skill	Between groups	0.026	2	0.013	0.031	0.969
	Within groups	7.317	47	0.412		
	Total	7.347	49			
Sensitivity to problems skill	Between groups	0.1010	2	0.051	0.106	0.900
	Within groups	0.0692	47	0.478		
	Total	0.1702	49			

(Continued)

Table 9. One – way ANOVA to find out the significance of the differences in the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah according to the teachers' experience variable *(Continued)*

Source of Variation		Sum of Squares	Df	Mean Squares	F – Value	Level of Significance
Enrichment with details skill	Between groups	0.560	2	0.280	0.573	0.568
	Within groups	0.5412	47	0.489		
	Total	0.1012	49			
Accept the risk	Between groups	1.930	2	0.965	1.726	0.182
	Within groups	16.278	47	0.559		
	Total		49			
Total score	Between groups	0.142	2	0.071	0.184	0.833
	Within groups	6.226	47	0.386		
	Total		49			

The results in Table 9 showed that there were no statistically significant differences at ($\alpha \leq 0.05$) in the degree to which the basic stage teachers in the Emirate of Sharjah practice creative thinking skills according to the variable of teacher experience. The F – value for the total score was (0.184) at (0.833) level of significance. It is inferred from this result that the teacher's experience variable does not affect the responses of teachers in the Emirate of Sharjah, when they practice creative thinking skills. This result may indicate the agreement of these teachers to describe their practice of creative thinking skills, regardless of the length of their experience, whether long or short. It seems that these five skills are clear to teachers, who are fully aware of them despite their different experiences.

2. Academic qualification variable

Means and standard deviation were calculated to the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah. The (t-test) for two independent samples was also used to find out the significance of the differences among teachers according to their academic qualification. Table 10 clarifies that.

Table 10. Means, and standard deviations of the degree of practicing creative thinking skills by basic stage teachers in Al – Sharjah Emirate and t-test for two independent sample according to teachers' academic qualification

No	Skills	Levels of Academic Qualification	Sample Size	Mean	S.D.	T-value	Level of Significance
1	Fluency	Bachelor	43	3.84	0.61	0.341	0.186
		Master	07	3.54	0.53		
2	Flexibility	Bachelor	43	3.94	0.57	0.301	0.20
		Master	07	3.64	0.80		
3	Sensitivity to problems	Bachelor	43	3.92	0.64	0.441	0.157
		Master	07	3.56	0.77		
4	Enrichment with details	Bachelor	43	3.85	0.70	0.64	0.525
		Master	07	3.69	0.68		
5	Accept the risk	Bachelor	43	3.53	0.93	0.30	0.765
		Master	07	3.42	0.99		
	Total score	**Bachelor**	**43**	**3.85**	**0.59**	**0.241**	**0.221**
		Master	**07**	**3.57**	**0.68**		

The results in Table 10 showed that there were no statistically significant differences at ($\alpha \leq 0.05$) in the degree of practicing creative thinking skills by basic stage teachers in the Emirate of Sharjah, according to teachers' academic qualification, for the total score and all domains of skills. The t – value for the total score was (0.241) at (0.221) level of significance. This result may be attributed to the fact that the educational qualification variable for teachers is not influential in making a statistically significant difference according to the level of qualification. This may indicate that teachers agree in describing their use of creative thinking skills despite their different academic qualifications (bachelor or master).

7 References

[1] B. H. Majeed, and L. F. Jawad, "Computational Thinking (CT) among university students," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 10, 2022. https://doi.org/10.3991/ijim.v16i10.30043

[2] J. Saadeh, "Teaching thinking skills with hundreds of practical examples," ed: Amman: Dar Al Shorouk, 2011.

[3] L. F. Jouad, B. Hassan, and H.Salim, "Tactical thinking and its relationship with solving mathematical problems among mathematics department students," *International Journal of Emerging Technologies in Learning (iJET),* vol. 16, no. 9, pp. 247–262, 2021. https://doi.org/10.3991/ijet.v16i09.22203

[4] B. M. Hamadneh, "Level of job creativity among learning disabilities teachers from their perspective in Kingdom of Saudi Arabia," *Journal of Education and Practice,* vol. 7, no. 9, pp. 40–46, 2016.

[5] D. K. Al-Malah, and H. Salim, "Enhancement of educational services by using the internet of things applications for talent and intelligent schools," *Periodicals of Engineering and Natural Sciences (PEN),* vol. 8, no. 4, pp. 2358–2366, 2020.

[6] A. H. M. Alaidi, and O. H. Yahya, "Using modern education technique in Wasit university," *International Journal of Interactive Mobile Technologies,* vol. 14, no. 6, pp. 82–94, 2020. https://doi.org/10.3991/ijim.v14i06.11539

[7] A. J. bn Manzur, *Islamic Heritage Revival House*, 3rd ed. Beirut, Lebanon: Arabs tong, Beirut, 1999.

[8] M. Karwowski, D. M. Jankowska, and W. Szwajkowski, "Creativity, imagination, and early mathematics education," in *Creativity and giftedness*: Springer, 2017, pp. 7–22. https://doi.org/10.1007/978-3-319-38840-3_2

[9] T. M. Amabile, "Motivating creativity in organizations: On doing what you love and loving what you do," *California management review,* vol. 40, no. 1, pp. 39–58, 1997. https://doi.org/10.2307/41165921

[10] D. Abdul-Rahman Al-Malah, and H. ALRikabi, "The interactive role using the Mozabook digital education application and its effect on enhancing the performance of eLearning," *International Journal of Emerging Technologies in Learning (iJET),* vol. 15, no. 20, pp. 21–41, 2020. https://doi.org/10.3991/ijet.v15i20.17101

[11] A. Ciltas, "The effect of the mathematical modeling method on the level of creative thinking," *The New Educational Review,* vol. 30, no. 4, pp. 103–113, 2012.

[12] M. Al-Abed, and S. Shahwan, *Effective thinking strategies, Cordoba for Publishing and Distribution*, 1st ed. Riyadh, Saudi Arabia, 2013.

[13] M. Habib, *Creativity development*, 1st ed. Angelo Library, Cairo, Egypt, 2000.

[14] L. F. Jawad, B. H. Majeed, and H. T. ALRikabi, "The impact of CATs on mathematical thinking and logical thinking among fourth-class scientific students," *International Journal of Emerging Technologies in Learning,* vol. 16, no. 10, 2021. https://doi.org/10.3991/ijet.v16i10.22515

[15] F. Al Salem, *Creativity, National Foundation for Studies and Research*, 3rd ed. Baghdad, Iraq, 2012.

[16] L. Fouad, and B. Majeed, "The impact of teaching by using STEM approach in the development of creative thinking and mathematical achievement among the students of the fourth scientific class," *International Journal of Interactive Mobile Technologies (iJIM),* vol. 15, no. 13, pp. 172–188, 2021. https://doi.org/10.3991/ijim.v15i13.24185

[17] J. Khairallah, *Administrative creativity, Dar Osama for Publishing and Distribution*, 4th ed. Amman, Jordan, 2009.

[18] H. T. Hazim, and H. Tuama Hazim, "Secure Chaos of 5G wireless communication system based on IOT applications," *International Journal of Online and Biomedical Engineering (iJOE),* vol. 18, no. 12, pp. 89–102, 2022. https://doi.org/10.3991/ijoe.v18i12.33817

[19] N. Abu Hammad, *Personal life skills, Dar Al Masirah for Publishing and Distribution*, 4th ed. Amman, Jordan, 2017.

[20] D. Al-Malah, H. Alrikabi, and H. A. Mutar, "Cloud computing and its impact on online education," *IOP Conference Series: Materials Science and Engineering,* vol. 1094, p. 012024, 2021. https://doi.org/10.1088/1757-899X/1094/1/012024

[21] F. Jarwan, "Teaching thinking: Concepts and applications," *Al Ain, UAE: University Book House,* 1999.

[22] N. A. Jasim, H. T. S. AlRikabi, and M. S. Farhan, "Internet of Things (IoT) application in the assessment of learning process," in *IOP Conference Series: Materials Science and Engineering*, 2021, vol. 1184, no. 1: IOP Publishing, p. 012002. https://doi.org/10.1088/1757-899X/1184/1/012002

[23] S. Al Nimr, "Administrative creativity: A behavioral study, Arab Manager," vol. 14, no. 117, pp. 1–22, 1992.

[24] H. Alrikabi, "Enhanced data security of communication system using combined encryption and steganography," *International Journal of Interactive Mobile Technologies,* vol. 15, no. 16, pp. 144–157, 2021. https://doi.org/10.3991/ijim.v15i16.24557

[25] G. Betty, "How to develop your ability to think creatively," *Translated by Sami Tayseer Suleiman, Amman: International Ideas House,* 2014.
[26] A. I. Al Mutairi, "The difficulties of applying creative thinking in teaching Islamic education, from the point of view of teachers for the intermediate stage in the State of Kuwait," *Master dissertation, Middle East University, Amman, Jordan,* 2014.
[27] W. Al Ayasra, *Creative thinking and problem solving skills, Amman: Dar Osama for Publishing and Distribution*, 2nd ed. Amman, Jordan, 2013.
[28] W. A. Y. Ehsian, R, "The effectiveness of a training program based on a self – questioning strategy in developing the creative thinking skills of tenth grade female students in Azraq camp for Syrian refugees in Jordan," *Dirasat (Educational Sciences),* vol. 47, no. 3, pp. 123–142, 2020.
[29] Y. A. Al Qutaish, "The impact of creative abilities of students in the leading centers for the gifted and distinguished Sahab's Pioneer for gifted and talented in light of some variables," *The Islamic University of Education and Psychology Studies Journal,* vol. 29, no. 2, pp. 526–541, 2021.
[30] M. Al Zahrani, "The evaluation of learning activities in my (Immortal language) book for third intermediate grade in light of creative thinking skills," *The Youth Researchers Journal,* vol. 28, no. 4, 2020.
[31] M. Arifin, H. Suyitno, and N. R. Dewi, "Mathematics creative thinking skills in problem-based learning model reviewed from learnersâ€™ curiosity and gender," *Journal of Primary Education,* vol. 9, no. 5, pp. 511–517, 2020. https://doi.org/10.15294/jpe.v9i5.43223
[32] K. Kusairi, S. Syaiful, and H. Haryanto, "Generative learning model in mathematics: A solution to improve problem solving and creative thinking skill," *Indonesian Journal of Science and Mathematics Education,* vol. 3, no. 3, pp. 254–261, 2020. https://doi.org/10.24042/ijsme.v3i2.6378
[33] H. T. Salim ALRikabi, I. A. Aljazaery, J. S. Qateef, A. H. M. Alaidi, and R. a. M. Al_airaji, "Face patterns analysis and recognition system based on quantum neural network QNN," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 8, 2022. https://doi.org/10.3991/ijim.v16i08.30107
[34] S. Yulianci, N. Nurjumiati, and A. A. Adiansha, "The effect of interactive multimedia and learning styles on students' physics creative thinking skills," *Jurnal Penelitian Pendidikan IPA,* vol. 7, no. 1, pp. 87–91, 2021. https://doi.org/10.29303/jppipa.v7i1.529
[35] F. Al-qablan, "The practice of science degree teachers in creative thinking skills in the schools of Jerash Governorate," *British Journal of Education,* vol. 5, no. 1, pp. 27–37, 2017.
[36] E. Al-Mishrfi, *Teaching creative thinking to kindergarten children*, 2nd ed. Cairo, Egypt: The Egyptian Lebanese house, 2005.

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An Analysis of the Categories and Structures of Expertise for Students' Cognitive States

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Abstract—Knowledge networks play an important role in the process of knowledge acquisition and sharing by students. An analysis of their complex structural features is required for the connectivity between students and knowledge. Existing research lacks insight into the internal structural features of knowledge networks constructed from expertise. There is also a lack of effective methods for constructing personalised knowledge networks for students' cognitive states. This paper analyses the categories and structures of expertise for students' cognitive states, and presents in detail a grey prediction algorithm to identify students' cognitive states. Then, the paper presents a typological description of the knowledge nodes in the expertise network for students' cognitive states, and analyses the knowledge network structure from the perspectives of paths and statistical properties. After that, the paper gives a method for analysing the knowledge flow of the expertise network. The experimental results validate the effectiveness of the proposed method.

Keywords—cognitive states, categories of expertise, knowledge network structure analysis

1 Introduction

With the development and popularity of the Internet, online learning methods that meet personalised learning needs for students are increasingly accepted and recognised [1–8]. However, there are differences in the needs of students with different cognitive levels for learning resources [9–12]. To prevent students from becoming "knowledge lost" when faced with a huge load of learning resources, it is necessary to predict students' cognitive levels and correlate them with the appropriate expertise for their learning [13–15]. Knowledge networks play an important role in how students acquire and share knowledge. Connecting students to knowledge requires an analysis of its complex structural features [16–21].

In terms of student cognitive level assessment, Hou [22] introduced the concept of Teaching for Ability (TFA) based on traditional Internet teaching, using big data to calculate students' cognitive abilities and using the assessment results of students' cognitive abilities to drive a tailored Internet learning programme for each student on a case-by-case basis. Educational programmes for students with low cognitive

ability were identified in the data analysis. In terms of knowledge association, Xu and Jiang [23] proposed a personalised recommendation algorithm for online educational resources based on knowledge association. Firstly, online educational resources were collected based on association rules. Secondly, the firefly algorithm was used to classify the online educational resources. Then, a vector space function was constructed to filter the classified online education resources. Online learning platforms are prone to information overload, as they contain a large number of diverse resources. To address this problem, Jia et al. [24] explored collaborative filtering recommendation (CFR) for online learning resources based on a knowledge association model. Knowledge units were extracted from the semantic information of online learning resources (OLRs) to build a knowledge association model for OLR recommendations. A CFR algorithm was designed to combine semantic adjacency with learning interests, and was used to quantify the semantic similarity of OLRs. In terms of knowledge structure analysis, Prasetya et al. [25] aimed to investigate the impact of extended scratch-build (ESB) concept mappings on student learning outcomes, including comprehension, mapping size and quality of knowledge structure. ESB is an extended open-ended technique that requires students to link pre-existing original concept maps to new additional maps on related material topics. ESB extends concept mappings by adding new propositions and linking them to previously existing mappings. In this way, it extends the concept mapping to enhance meaningful learning.

The existing research results can serve as reference for further in-depth research. However, there are still some problems to be solved, such as the lack of in-depth exploration for the internal structural characteristics of the organisation of knowledge networks constructed by expertise. There is also a lack of effective methods for constructing personalised knowledge networks oriented to students' cognitive states. This provides some opportunities for the research in this paper. In response, this article conducts an analysis of the categories and structures of expertise for students' cognitive states. Chapter 2 describes in detail the grey prediction algorithm for student cognitive state identification. Chapter 3 describes the categories of knowledge nodes within the expertise network for students' cognitive states, and then analyses the structure of the knowledge network from the perspectives of paths and statistical properties. The paper finally presents a method for analysing the knowledge flow of the expertise network. The experimental results validate the effectiveness of the proposed method.

2 Grey prediction of students' cognitive state

Figure 1 provides statistics on the influential elements of expertise cognition, with the core elements including the object of study, functional values, knowledge architecture and cognitive paths. As shown in the figure, the connotations of students' expertise cognition are interpreted as classifying, connecting, reinforcing and innovating expertise, i.e., selecting the cognitive paths that match their cognitive state to carry out the relevant research, while interpreting and analysing the categories of expertise to construct their knowledge network architecture.

This paper summarised the cognitive state of students' participation in the online learning process as the process shown in Figure 2. On the basis of known expertise,

the network is associated with unknown expertise that meets the students' cognitive states. Then, it is internalised to reconstruct the expertise network, which is constantly optimised, modified while providing students with expertise that meets their current cognitive state as they continue to learn. Accordingly, the network is gradually rationalised and more science-based.

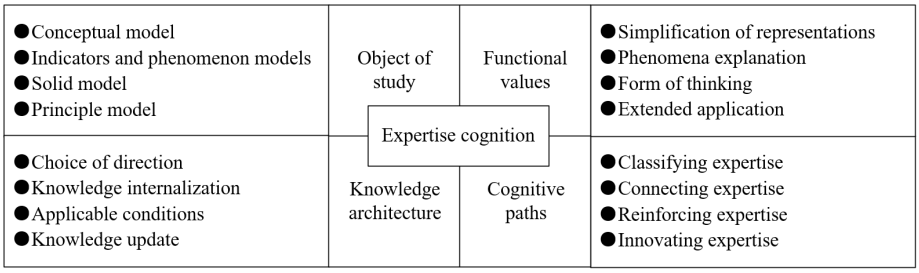

Fig. 1. Influential elements of expertise cognition

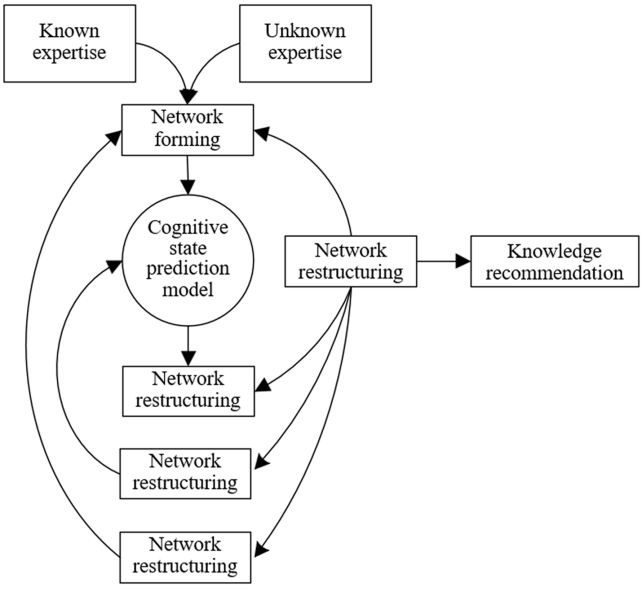

Fig. 2. Schematic diagram of the principle of cognitive state enhancement

This paper uses a grey prediction method to identify the cognitive states of students participating in online learning. The method further obtains the patterns of change in students' cognitive states by at first identifying the degree of development trends of the various factors influencing students' cognitive states and then generating the original influencing factor data for processing. Specifically, based on the obtained regular sequence of influencing factor data, the paper constructed a differential equation model for predicting the future evolution trend of students' cognitive states, which takes the form of a single-series first order linear differential equation model $GM(1,1)$.

Assuming that the non-negative canonical parameter is represented by μ and the penalty term is represented by $\lambda\sum_{j=1}^{p}\left|\beta_j\right|\mu\sum_{j=1}^{t}\left|\gamma_j\right|$, the traditional *Lasso* parameter estimate is defined through the following equation.

$$\hat{\gamma}(lasso) = \underset{\gamma}{argmin}^2 \left\| b - \sum_{j=1}^{t} a_j \gamma_j \right\|^2 + \mu \sum_{j=1}^{t} \left|\gamma_j\right| \tag{1}$$

To make the coefficients somewhat adaptive, weights are assigned to the different coefficients in this paper. Assuming weights $\hat{\omega}_j = \frac{1}{\left|\hat{\beta}_j\right|^{\gamma}} \hat{\theta}_j = \frac{1}{\left|\hat{\gamma}_j\right|^{\alpha}}$, ($\alpha$>0), j = 1, 2, …, t, the following equation gives the definition of an optimised *Lasso* parameter estimate.

$$\hat{\gamma}^{*(n)}(lasso) = \underset{\gamma}{argmin}^2 \left\| b - \sum_{j=1}^{t} a_j \gamma_j \right\|^2 + \mu_m \sum_{j=1}^{t} \hat{\theta} \left|\gamma_j\right| \tag{2}$$

Let each factor variable $A^{(0)} = \{A^{(0)}(i), i = 1, 2, \ldots, m\}$ be a non-negative monotonic raw data series, and the grey prediction model of students' cognitive states is constructed based on the following steps. Firstly, the cumulative sequence $A(1) = \{A(1)(l), l = 1, 2, \ldots, m\}$ is obtained by performing one accumulation on $A^{(0)}$. The following equation gives the first order linear differential equation constructed based on $A^{(1)}$.

$$\frac{dA^{(1)}}{dp} + \beta A^{(1)} = v \tag{3}$$

$$\hat{A}^{(1)}(l+1) = \left[\hat{A}^{(1)}(1) - \frac{\hat{v}}{\hat{\beta}}\right] o^{-\hat{\beta}l} + \frac{\hat{v}}{\hat{\beta}} \tag{4}$$

The single-series first order linear differential equation model is obtained as a cumulative quantity. Hence, after the cumulative reduction process, the resulting data $\hat{A}(1)(l + 1)$ can be reduced to $\hat{A}(0)(l + 1)$, the grey prediction model for the corresponding original sequence of influence factor data $A(0)$ is expressed as

$$\hat{A}^{(0)}(l+1) = (o^{-\hat{\beta}} - 1)\left[A^0(m) - \frac{\hat{v}}{\hat{\beta}}\right] o^{-\hat{\beta}l} \tag{5}$$

The above modelling process leads to $\hat{A}(0)$ and the residuals. Make the variance of $A(0)$ and the residual sequence O denoted by R_1^2 and R_2^2 respectively, which results in the following

$$R_1^2 = \frac{1}{m}\sum_{l=1}^{m}\left[a^{(0)}(l) - \bar{a}\right]^2 \tag{6}$$

$$R_2^2 = \frac{1}{m}\sum_{l=1}^{m}\left[o(l)-\bar{o}\right]^2 \tag{7}$$

Based on $\bar{x} = \frac{1}{n}\sum_{k=1}^{n} x^{(0)}(k)$, $\bar{e} = \frac{1}{n}\sum_{k=1}^{n} e(k)$, $\bar{a} = \frac{1}{m}\sum_{l=1}^{m} a^{(0)}(l)$, $\bar{o} = \frac{1}{m}\sum_{l=1}^{m} o(l)$, we could further calculate the posterior difference ratio $D = R_2/R_1$ and the small error probability $FR = FR\{|o(l) - \bar{o}| < 0.75R_1\}$.

3 Structural analysis of expertise networks for students' cognitive states

Traditional approaches to knowledge network structure analysis ignore the type and content of knowledge expertise and only analyse the network topology. In this paper, we first described the categories of knowledge nodes within the expertise network for students' cognitive states, and then analysed the knowledge network structure from two perspectives: pathways and statistical characteristics. Figure 3 shows a schematic diagram of the expertise network architecture.

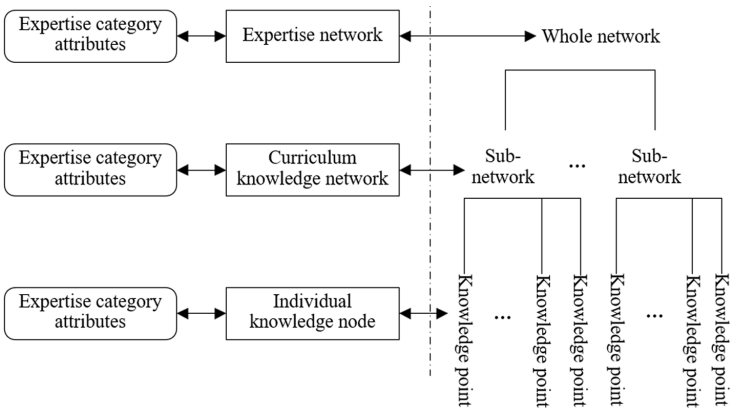

Fig. 3. Schematic diagram of the expertise network architecture

3.1 Description of expertise categories

The constructed expertise network is built based on n expertise nodes belonging to m majors. The expertise nodes are labelled as unknown or perceived by the students. As the nodes of the expertise network are majors, they cannot accurately characterise the knowledge flow between majors if they cannot be categorised as a specific major. The statistical results of expertise can be characterised by an $m \times m$ network adjacency matrix:

$$H' = \begin{bmatrix} x_{1,1} & x_{1,2} & \cdots & x_{1,m} \\ x_{2,1} & x_{2,2} & \cdots & x_{2,m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m,1} & x_{m,2} & \cdots & x_{m,m} \end{bmatrix} \tag{8}$$

Assume that the number of associations in which the j-th student's unknown expertise is associated by the i-th student's known expertise is denoted by x_{ij} $(i, j = 1, 2, \ldots, n)$. To make it easy to construct connections between expertise and students, the main diagonal element of the matrix is made to be the number of associations of intra-expertise, often the maximum value of the elements of each row and column of the matrix. It can be assumed that the number of connections to intra-expertise is maximum for each major. Suppose that the intensity of knowledge flow from student-known major i to student-unknown major j is given by q_{ij} $(i, j = 1, 2, \ldots, m)$, the matrix of knowledge relations between majors can be obtained by dividing each row of the matrix with x_{ij}:

$$H = [q_{ij}] = [x_{ij}/x_{ii}] \tag{9}$$

It can be shown that H can characterize the knowledge flow among majors, and the knowledge flow intensity can be measured by the set of network weights. Let the network $H = (U,P)$, the set of network expertise nodes is denoted by $U = \{u_1, u_2, u_3, \ldots, u_M\}$, the set of edges is denoted by $P = \{p_{ij}|i, j = 1, 2, \ldots, M\}$, and the number of nodes in the network is denoted by $M = |U|$. The number of edges connected to node u_i $(i = 1, 2, \ldots, M)$ is characterized by its degree l_i, with the entry degree denoted by l_l^{in} and the exit degree denoted by l_i^{out}. The degree of entry is used to characterize the knowledge inflow relationship, while the degree of exit is used to characterize the knowledge outflow relationship. The weighted network can be represented by $H = (U,P,Q)$, where $Q = \{q_{ij}|i, j = 1, 2, \ldots, M\}$ and the weights of edge p_{ij} are denoted by q_{ij}.

3.2 Path-based analysis of the structure of expertise networks

In this paper, the network is structurally analysed from the perspective of the paths between the knowledge nodes of the expertise network for students' cognitive states. We selected the structural analysis indicators such as the average shortest path and diameter, the mediated nature of the network and the efficiency of the network for that structural analysis.

The length of the shortest path between nodes i and j in an expertise network is the number of connected edges on the shortest path, which is denoted by c_{ij}. The weights of the weighted network use the harmonic mean and are denoted by $c_{ij}^c = q_{il}q_{lj}/(q_{il}+q_{lj})$. The mean value of the shortest path between nodes in the expertise network is denoted by K. It is clear that in an expertise network for students' cognitive states, the amount of

association between two expertise nodes will gradually become larger as the student's learning process progresses. Also, the possibility of knowledge flow increases gradually. Assuming that the set of connected edges on the shortest paths of nodes i and j is denoted by E_{ij}, the expression for the weights is

$$c_{ij}^{c} = 1 / \sum_{q_E \in E_{ij}} \frac{1}{q_e} \tag{10}$$

The failure of a node may cause a change in the shortest distance through that node. In this paper, the number of shortest paths through a node is measured using a betweenness. Assuming that the number of shortest paths between nodes j and s is denoted by m_{js} and the number of shortest paths between j and s through node i is denoted by $m_{js}(i)$, then we defined:

$$y_i = \sum_{j,s=1,j\neq l}^{M} \frac{m_{js}(i)}{m_{js}} \tag{11}$$

The distance between knowledge nodes is an important factor affecting students' ability to perform expertise students and thus obtain cognitive state enhancement. In this paper, we characterized students' cognitive states enhancement ability through network efficiency. Assuming that the shortest path length between nodes i and j is represented by c_{ij}, we have the network efficiency calculation equation as follows:

$$G(H) = \frac{\sum_{i\neq j} g_{ij}}{m(m-1)} = \frac{1}{m(m-1)} \sum_{i\neq j} \frac{1}{c_{ij}} \tag{12}$$

Suppose the set of connected edges on the shortest path of nodes i and j is denoted by K_{ij} and the weights of any edge on the corresponding path are denoted by q_s. Introducing the weights, we have:

$$G(H) = \frac{1}{m(m-1)} \sum_{i\neq j} \left(\sum_{q_s \in K_{ij}} \frac{1}{q_s} \right) \tag{13}$$

Assuming that the expertise network after removing node u_i and its connecting edges is represented by $H \backslash u_i$, the network knowledge node efficiency is defined as below based on the network efficiency of the above equation:

$$G(u_i) = G(H) - G(H \backslash u_i) \tag{14}$$

3.3 Analysis of the structure of expertise networks based on statistical properties

In this paper, the network is structurally analysed from the perspective of knowledge node or edge statistics of the expertise network for students' cognitive states. We selected structural analysis indicators such as density and average degree of the network, degree distribution and relevance, hierarchy and circularity.

This paper quantifies the number of connectivity relationships between nodes in a network based on density and average degree. Assuming that the number of edges in a network of expertise is denoted by $|P|$, the density of the network is denoted by N, and the average degree of the network is denoted by $\langle l \rangle$, the value of N is obtained as below by comparing $|P|$ with the number of possible edges:

$$N = \frac{2|P|}{m(m-1)} \tag{15}$$

$\langle l \rangle$ is obtained by calculating the average value of degree l:

$$\langle l \rangle = \frac{1}{m}\sum_{i=1}^{m} l_i \tag{16}$$

Assume that the density of the expertise network H is denoted by N_H, the density of the strongly connected network W is denoted by N_W, and the average degree of H is denoted by $\langle l \rangle_H$. To characterize the distribution status of the node degrees of the network, this paper defines the node in-degree distribution $E(l^{in})$ and the out-degree distribution $E(l^{out})$ of H. $E(l^{in})$ and $E(l^{out})$ are usually represented by a cumulative degree distribution function to eliminate the effect of network size. Assuming that the probability distribution of expertise nodes with degree not less than l is represented by E_l, we have

$$E_l = \sum_{l'=l}^{\infty} E(l') \tag{17}$$

This paper quantifies the relevance of the network based on the *Pearson* correlation coefficient. Assuming that the number of edges of the network is represented by N_{ED} and the degree of the two nodes of the i-th edge is represented by j_i and l_i, we have the correlation coefficient calculation formula:

$$s = \frac{N_{ED}^{-1}\sum_i j_i l_i - \left[N_{ED}^{-1}\sum_i \frac{1}{2}\left(j_i + l_i\right)\right]^2}{N_{ED}^{-1}\sum_i \frac{1}{2}\left(j_i^2 + l_i^2\right) - \left[N_{ED}^{-1}\sum_i \frac{1}{2}\left(j_i + l_i\right)\right]^2} \tag{18}$$

The closeness of the connection between neighbours of an expertise node can be quantified by the node aggregation factor, and denoted by D_i. Assuming that the number of edges between neighbours of node i is denoted by K_i and the number of neighbouring nodes by l_i, the formula is:

$$D_i = \frac{2K}{l_i\ (l_i - 1)} \tag{19}$$

The aggregation coefficient of the whole expertise network is the mean of the aggregation coefficients of all nodes and satisfies $D = \sum D_i/M$. To better measure the relationship between the network nodes and other nodes, this paper introduces the node local loop coefficient metric. Suppose the degree of node i is denoted by l_i, any neighbouring node pair of node i is denoted by $\langle kn \rangle$, and the length of the minimum circle through node i and its neighbouring nodes k and n is denoted by R^i_{ln}, then we have:

$$g_i = \frac{2}{l_i\ (l_i - 1)} \sum_{\langle kn \rangle} \frac{1}{R^i_{kn}} \tag{20}$$

The recurrent coefficient of the whole expertise network is the mean of the local recurrent coefficients of the nodes, satisfying $G = \langle g_i \rangle$.

3.4 Knowledge flow analysis

Since the expertise network for students' cognitive states is considered as a directed weighted network. Assuming that the ratio of out- and in-degrees of nodes is represented by h_i, the ratio of outgoing and incoming weights is represented by h'_i, the sum of outgoing and incoming weights of node i is represented by $\sum q_{ij}$ and $\sum q_{ji}$, and the position of nodes in the expertise network can be determined based on h_i and h'_i, we have:

$$h_i = \frac{l_i^{out}}{l_i^{in}} \tag{21}$$

$$h'_i = \frac{\sum_{j \in \Psi} q_{ij}}{\sum_{j \in \Psi} q_{ji}} \tag{22}$$

4 Experimental results and analysis

Figure 4 shows the distribution of students' cognitive levels across the different online learning stages. As can be seen from the figure, the samples used to predict students' cognitive levels is mostly concentrated at Level 2, Level 3 and Level 4, which indicates that most students at different online learning stages are able to have a good understanding of the expertise they are studying and can explain some relevant common professional issues. Overall, the cognitive levels of students at different online learning stages generally conform to the overall distribution. The figure also indicates that students at all cognitive levels show an ability growth as they progress through the recommended stages of study.

The average betweenness of nodes in the expertise network was calculated to be 50.197, i.e., each expertise node can be considered to be a node on approximately 50.197 shortest paths. Table 1 shows the ranking of the course sub-network nodes in terms of their betweennesses, with the expertise nodes BE-1 to BE-10 playing a more important role in the expertise network in terms of knowledge connectivity compared to the other nodes.

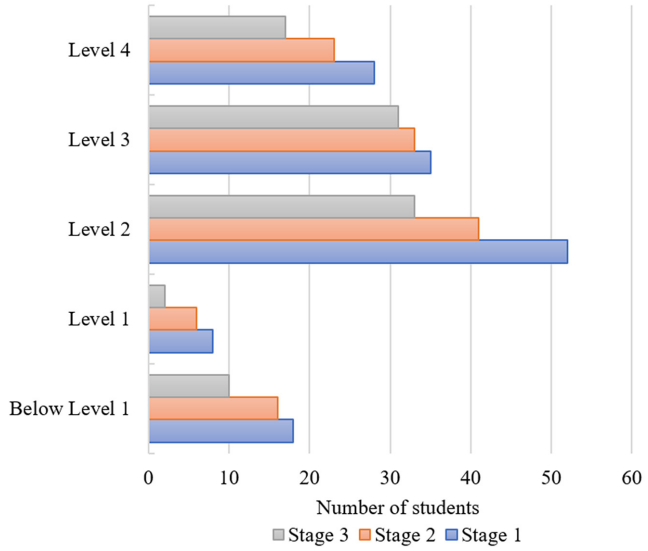

Fig. 4. Distribution of students' cognitive levels at different learning stages

Table 1. Ranking of betweennesses for course sub-network nodes

Sub-Network Node Number	Betweenness	Sub-Network Node Number	Betweenness
BE-1	362.591	BE-6	249.617
BE-2	285.427	BE-7	248.526
BE-3	271.963	BE-8	234.158
BE-4	265.681	BE-9	226.952
BE-5	253.627	BE-10	193.625

Table 2. Efficiency ranking of course sub-network nodes

Sub-Network Node Number	Efficiency	$G(u_i)/G(H)$
EF-1	0.00325	0.092
EF-2	0.00262	0.069
EF-3	0.00245	0.051
EF-4	0.00232	0.044
EF-5	0.00158	0.037

Table 3. Degree ranking of course sub-network nodes

Sub-Network Node Number	Degree	Sub-Network Node Number	Degree
DE-1	94	DE-6	65
DE-2	85	DE-7	53
DE-3	81	DE-8	49
DE-4	74	DE-9	44
DE-5	71	DE-10	21

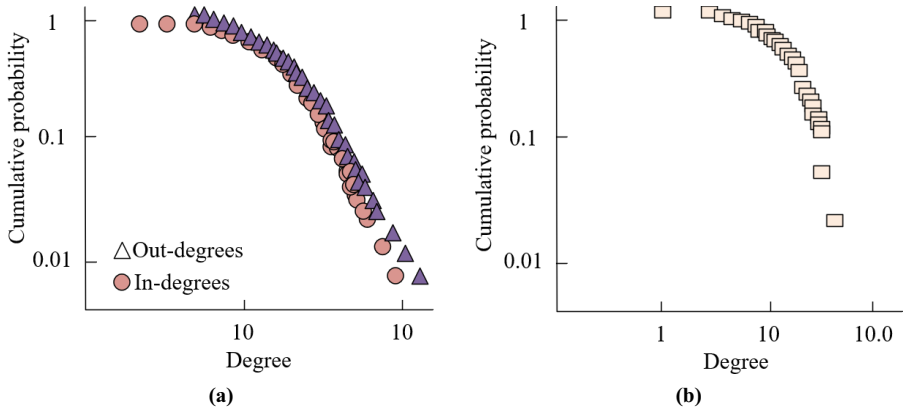

Fig. 5. Distribution of node degrees for different course sub-networks

Table 2 shows the efficiency ranking of the course sub-network nodes, with the third column showing the reduction ratio in the efficiency of the course sub-network after removing the expertise node u_i, i.e., the extent to which this expertise node affects the network efficiency of the expertise network. EF-1 has the highest network efficiency of 0.00325. The failure of this expertise node would result in a reduction in network efficiency of more than 9.2%. Table 3 shows the degree ranking of the course sub-network nodes. The expertise nodes in the table have a more frequent knowledge flow with other course sub-network nodes.

Figure 5a gives the cumulative distribution of out- and in-degrees for course sub-network 1 in a double logarithmic coordinate system. Figure 5b gives the cumulative degree distribution for course sub-network 2 in a double logarithmic coordinate system. From Figure 5, the out-degree and in-degree distributions of course sub-network 1 and the tail of the degree distribution of course sub-network 2 can be judged to obey the power-law distribution. Analysis reveals that the out-degree of course sub-network 1 obeys a power-law distribution with an exponent of 1.862, the in-degree obeys a power-law distribution with an exponent of 2.334, and the degree distribution of course sub-network 2 obeys a power-law distribution with an exponent of 2.077. The above distribution results indicate that some course sub-networks in the expertise network have very large out- or in-degrees with other course sub-networks, i.e., there is more frequent knowledge flow with each other, and there are also course sub-networks that only have knowledge exchange with a few course sub-networks. Course sub-network 2

is a strongly connected network, and the results of the inter-degree correlation analysis are given in Figure 6. As can be seen from the figure, the interrelationships between the nodes in course sub-network 2 are more obvious.

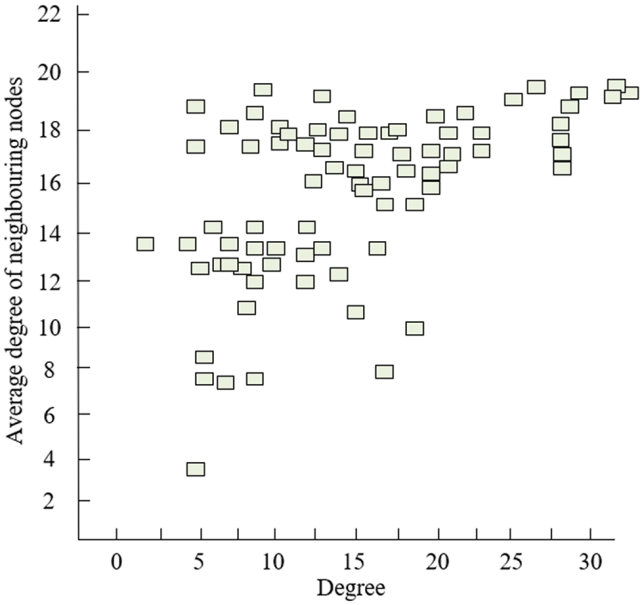

Fig. 6. Inter-degree correlation of the course sub-network

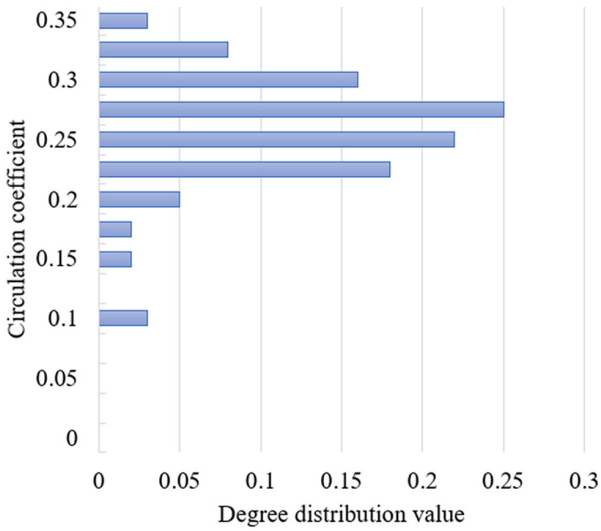

Fig. 7. Distribution of local circulation coefficients for the course sub-network

Figure 7 illustrates the distribution of local circulation coefficients for the course sub-network. The figure reveals that the local loop coefficients of the nodes in the expertise network take values in the range of [0.1,0.35], with over 80% of the nodes in the range of [0.2,0.35], while the loop coefficient of the expertise network is 0.291. This verifies that the constructed expertise network contains a large number of sub-networks and loops.

5 Conclusion

This paper analyses the categories and structures of expertise for students' cognitive states, and presents in detail a grey prediction algorithm to identify students' cognitive states. Then, the paper presents a typological description of the knowledge nodes in the expertise network for students' cognitive states, and analyses the knowledge network structure from the perspectives of paths and statistical properties. After that, the paper gives a method for analysing the knowledge flow of the expertise network. The experimental results present the distribution of students' cognitive levels at different learning stages, while ranking the course sub-network nodes according to their betweenness, efficiency and degree, along with the corresponding analysis results. The paper also presents the cumulative distribution of out- and in-degrees of the course sub-networks in a double logarithmic coordinate system. The distribution shows that some of the course sub-networks in the expertise network have very large out- or in-degrees with other course sub-networks, i.e., there is a more frequent knowledge flow with each other. By presenting the distribution of the local loop coefficients of the course sub-networks, the paper verifies that the constructed expertise network contains a large number of sub-networks and loops.

6 References

[1] Mingsiritham, K., Chanyawudhiwan, G. (2020). Experiment of the prototype of online learning resources on Massive Open Online Course (MOOC) to develop life skills in using technology media for hearing impaired students. International Journal of Emerging Technologies in Learning, 15(3): 242–249. https://doi.org/10.3991/ijet.v15i03.12059

[2] Halvoník, D., Kapusta, J. (2020). Framework for e-learning materials optimization. International Journal of Emerging Technologies in Learning, 15(11): 67–77. https://doi.org/10.3991/ijet.v15i11.12721

[3] Afifi, S., Santoso, H.B., Hasani, L.M. (2022). Investigating students' online self-regulated learning skills and their e-learning experience in a prophetic communication course. Ingénierie des Systèmes d'Information, 27(3): 387–397. https://doi.org/10.18280/isi.270304

[4] Wang, S.Y. (2021). Online learning behavior analysis based on image emotion recognition. Traitement du Signal, 38(3): 865–873. https://doi.org/10.1134/S105466182103024X

[5] Sun, Y., Chai, R.Q. (2020). An early-warning model for online learners based on user portrait. Ingénierie des Systèmes d'Information, 25(4): 535–541. https://doi.org/10.18280/isi.250418

[6] Naveed, Q.N., Ahmad, N., Qamar, S., et al. (2019). Relationship modeling for OSN-based e-learning deployment. In 2019 IEEE 6th International Conference on Engineering Technologies and Applied Sciences (ICETAS), Kuala Lumpur, Malaysia, pp. 1–7. https://doi.org/10.1109/ICETAS48360.2019.9117275

[7] Xue, C., Zeng, X. (2020). Design of a web-based personalized e-learning platform. Journal of Physics: Conference Series, 1634(1): 012023. https://doi.org/10.1088/1742-6596/1634/1/012023

[8] Agrawal, V., Agarwal, S., Agrawal, A.M. (2020). Modelling of factors of e-learning: An ISM approach. International Journal of Continuing Engineering Education and Life Long Learning, 30(3): 327–349. https://doi.org/10.1504/IJCEELL.2020.108563

[9] Xie, T., Zhang, R., Wu, H., Qiu, H. (2022). Research on the changes of college students' cognitive level under the broadcast teaching mode during the COVID-19 pandemic period. In Proceedings of the 7th International Conference on Distance Education and Learning, Beijing, China, pp. 253–260. https://doi.org/10.1145/3543321.3543363

[10] Yang, Q.F., Chang, S.C., Hwang, G.J., Zou, D. (2020). Balancing cognitive complexity and gaming level: Effects of a cognitive complexity-based competition game on EFL students' English vocabulary learning performance, anxiety and behaviors. Computers & Education, 148: 103808. https://doi.org/10.1016/j.compedu.2020.103808

[11] Sumandya, I.W., Handayani, I.G.A., Mahendra, I.W.E. (2020). Developing realistics mathematics education (RME) based mathematics teaching video to advance higher order thinking skills (HOTs) in cognitive level of vocational school students. In Journal of Physics: Conference Series, 1503(1): 012015. https://doi.org/10.1088/1742-6596/1503/1/012015

[12] Viriyavejakul, C. (2019). Analysis of fake news and the level of cognitive perception of undergraduate students in the university in Thailand. In International Conference on Innovative Technologies and Learning, Tromsø, Norway, pp. 772–780. https://doi.org/10.1007/978-3-030-35343-8_80

[13] Wang, Y., Zhao, E., Wang, W. (2022). A knowledge graph completion method based on fusing association information. IEEE Access, 10: 50500–50507. https://doi.org/10.1109/ACCESS.2022.3174110

[14] Zhang, Z., Huang, J., Tan, Q. (2022). Association rules enhanced knowledge graph attention network. Knowledge-Based Systems, 239: 108038. https://doi.org/10.1016/j.knosys.2021.108038

[15] Wang, L., Zhang, H., Guo, S., Yuan, D. (2022). Deployment and association of multiple UAVs in UAV-assisted cellular networks with the knowledge of statistical user position. IEEE Transactions on Wireless Communications, 21(8): 6553–6567. https://doi.org/10.1109/TWC.2022.3150429

[16] Jiang, Q., Gong, D. (2022). Multi association semantics-based user matching algorithm without prior knowledge. In The International Conference on Image, Vision and Intelligent Systems (ICIVIS 2021), Changsha, China, pp. 321–331. https://doi.org/10.1007/978-981-16-6963-7_30

[17] Zheng, Z., Xu, W., Xu, Y., Xue, Q. (2022). Mapping knowledge structure and themes trends of biodegradable Mg-based alloy for orthopedic application: A comprehensive bibliometric analysis. Frontiers in Bioengineering and Biotechnology, 10: 940700. https://doi.org/10.3389/fbioe.2022.940700

[18] Wang, Z., Gao, Y., Li, W. (2022). A comprehensive quantitative and biological neural network optimization model of sports industry structure based on knowledge mapping. Computational Intelligence and Neuroscience, 2022: 1158509. https://doi.org/10.1155/2022/1158509

[19] Liu, H., Chen, H., Hong, R., Liu, H., You, W. (2020). Mapping knowledge structure and research trends of emergency evacuation studies. Safety Science, 121: 348–361. https://doi.org/10.1016/j.ssci.2019.09.020

[20] Kapuza, A., Koponen, I.T., Tyumeneva, Y. (2020). The network approach to assess the structure of knowledge: Storage, distribution and retrieval as three measures in analysing concept maps. British Journal of Educational Technology, 51(6): 2574–2591. https://doi.org/10.1111/bjet.12938

[21] Liu, H., Li, Y., Chen, J., Tao, Y., Xia, W. (2020). A structure mapping–based representation of knowledge transfer in conceptual design process. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 234(3): 400–420. https://doi.org/10.1177/0954405419883070

[22] Hou, Q. (2021). Research on the diagnosis of students' cognitive level based on deep learning. Security and Communication Networks, 2021: 6106955. https://doi.org/10.1155/2021/6106955

[23] Xu, Z., Jiang, S. (2022). Study on personalized recommendation algorithm of online educational resources based on knowledge association. Computational Intelligence and Neuroscience, 2022: 2192459. https://doi.org/10.1155/2022/2192459

[24] Jia, H., Yang, L., Cui, B. (2022). Collaborative filtering recommendation of online learning resources based on knowledge association model. International Journal of Emerging Technologies in Learning (iJET), 17(2): 158–172. https://doi.org/10.3991/ijet.v17i02.29013

[25] Prasetya, D.D., Hirashima, T., Hayashi, Y. (2020). Study on extended scratch-build concept map to enhance students' understanding and promote quality of knowledge structure. International Journal of Advanced Computer Science and Applications, 11(4): 144–153. https://doi.org/10.14569/IJACSA.2020.0110420

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Conceptual Statistical Assessment Using JSXGraph

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Abstract—Traditionally online assessments tend to focus on topics that require students to input algebraic and numeric responses. As such there is a paucity of questions that test students' knowledge of statistics, and what questions there are in our experience focus on computing specific values (mean, standard deviation, and so on). Through making use of a technology called JSXGraph that is supported within the STACK environment for online assessment of mathematical knowledge, we have developed statistics questions that aim to test conceptual knowledge. For example, by requiring students to adjust the bars in a graph in order to produce a dataset that has a required mean, median, mode and range. With careful design this approach enables open-ended questions that have more than one correct answer. In this paper we describe the questions we have designed, and report responses from a sample of students.

Keywords—statistics, conceptual understanding, online assessment

1 Procedural and conceptual understanding

A long-standing distinction in the mathematics education research literature is between procedural and conceptual understanding [1]. The former is often defined in terms of facts and procedures, and tends to be straightforward to assess [2]. For example, if we want to know if a student can calculate the arithmetic average (mean) given a set of numerical data we can ask them to do so and check their answer. Conceptual understanding is often defined in terms of knowledge of fundamental mathematical ideas and how they connect together. This can be difficult to assess, especially in online contexts, as it does not lend itself to traditional test items [3].

At Loughborough University we have had success developing online tests for assessing procedural knowledge of statistics. For example, the authors have worked with colleagues from Loughborough's School of Business and Economics to develop test items such as that shown in Figure 1. Such items have been used to assess the procedural knowledge of hundreds of students across various statistical topics such as hypothesis testing, sampling, and regression. Online assessments can also be used to support student learning of statistical procedures [4], which is important given the reported student difficulties in this area [5]. For example, we recently embedded test items in online interactive worksheets as part of the Helping Engineers Learn Mathematics (HELM) project developed by the universities of Loughborough and Edinburgh [6]. These online resources allow students to practice statistical procedures, and receive instant feedback.

An airline has recently carried out a survey of how long it takes to disembark passenger from its Boeing 737 planes. The table below shows the numbers of passengers travelling on a sample of 8 planes and the disembarkation times.

	Number of Passengers (x)	Disembarkation Time (y)	x^2	xy	y^2
	71	5.4	5041	383.4	29.16
	83	5.85	6889	485.55	34.2225
	85	5.11	7225	434.35	26.1121
	61	5.31	3721	323.91	28.1961
	94	5.87	8836	551.78	34.4569
	102	5.9	10404	601.8	34.81
	60	4.38	3600	262.8	19.1844
	117	6.04	13689	706.68	36.4816
Totals					

Complete the table and calculate the Pearson correlation coefficient, *r*, for these data. Do not round your answers for the table. Give *r* to 3 significant figures.

r =

Fig. 1. A test item for assessing students' procedural knowledge of correlation coefficients in a business context. (Designed by the first author)

Assessments of students' conceptual understanding of statistics often focus on interpreting (rather than computing) results, and their automation is challenging. For this project we turned to the ingenious paper-based learning activities developed by the late, great mathematical educator Malcolm Swan. In particular, we were inspired by Swan's [7] collaborative card-based activities, see Figure 2, which are used in lectures by the second author. Swan's intention is for students to discuss in small groups how the representation of data as bar charts and as summary statistics (mean and so on) relate to one another. Successfully matching the cards requires thinking strategically, qualitatively, and quantitatively about different representations of mathematical objects and this promotes conceptual understanding [8].

During the global pandemic that started in 2020 the second author developed online drag-and-drop versions of these activities for remote teaching, see Figure 3. However, the drag-and-drop versions were sub-optimal because they did not work well through mobile browsers as, once the statistics are dragged onto the bar charts the latter could no longer be seen, the cards could not be written on by students to fill the blanks, and different versions (e.g., with varied datasets, or similar questions addressing related topics) could not readily be produced. We therefore sought a technology that could be harnessed to address these limitations.

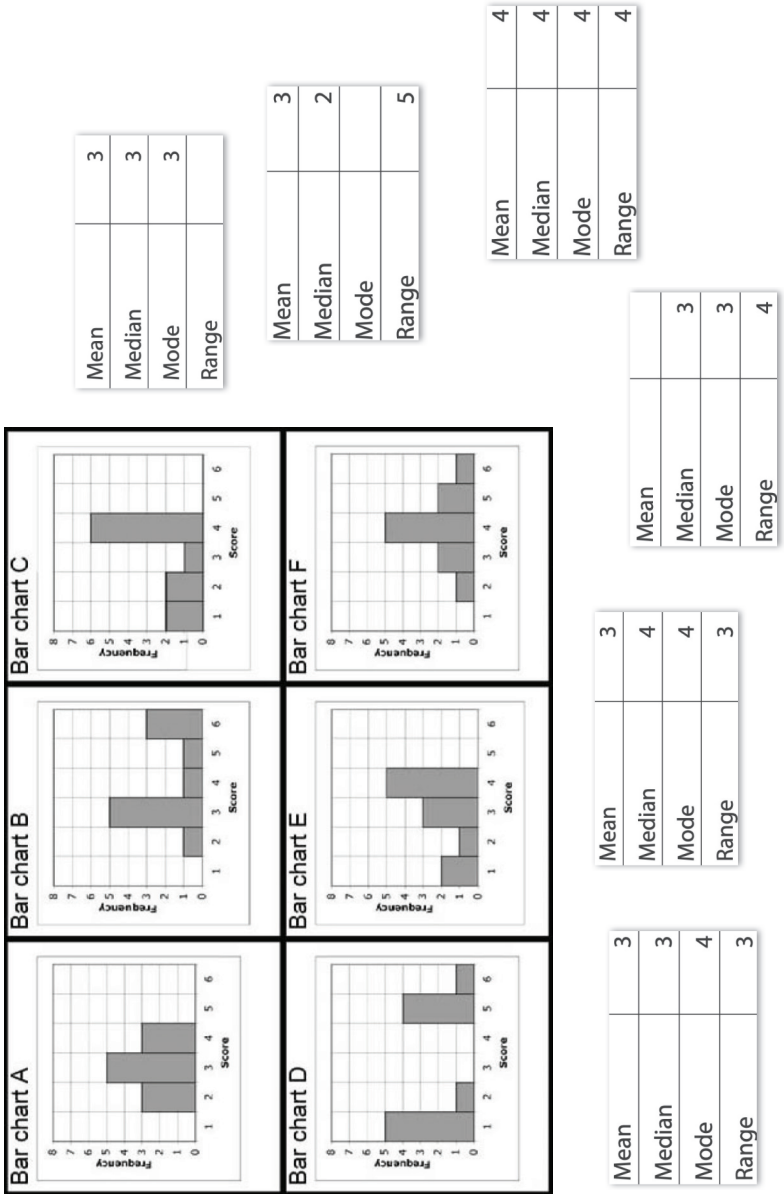


Fig. 2. Paper-based learning activities designed to promote conceptual understanding of statistics, in this case averages and range. (Designed by Malcolm Swan [7])

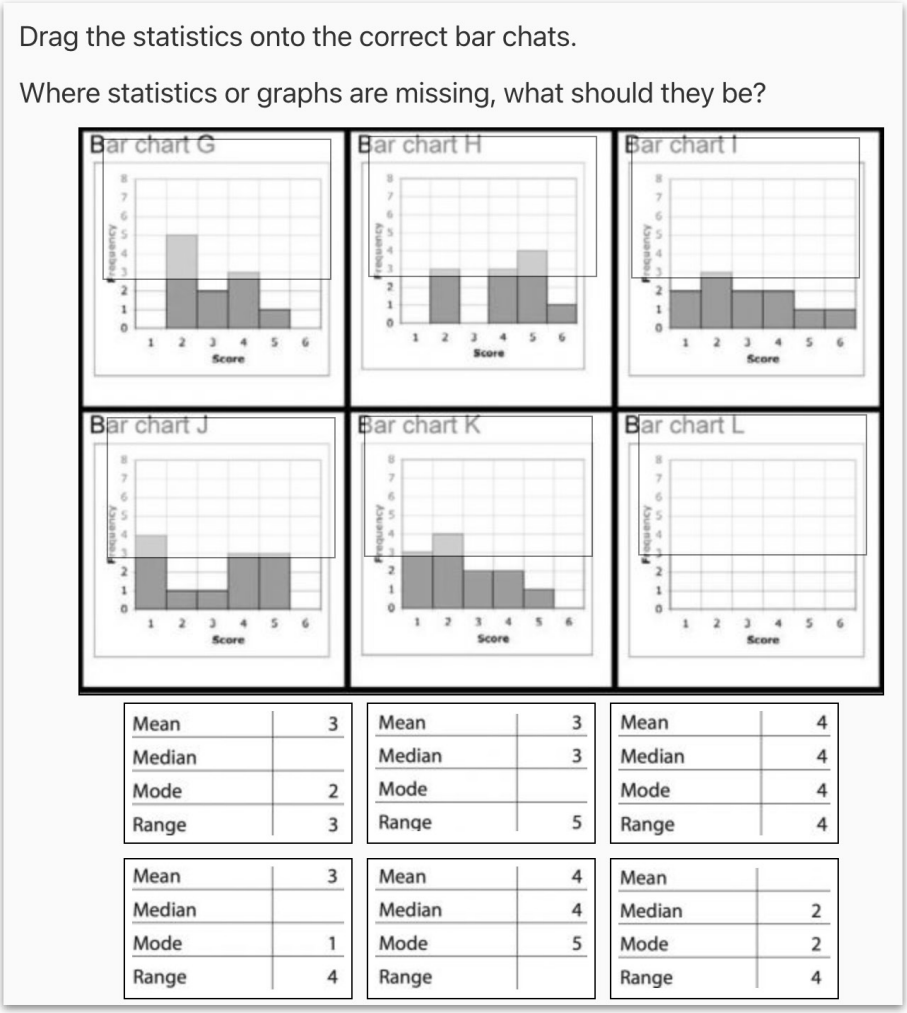


Fig. 3. Drag-and-drop version of Swan's [7] statistical learning activity

2 STACK and JSXGraph

The program we have used to create such resources is the System for Teaching and Assessment using a Computer Algebra Kernel, better known as STACK [9]. It is available for the Moodle Virtual Learning Environment and can produce online mathematics questions that can be used as standalone learning resources or part of a formal assessment.

A key feature of STACK is to generate randomised question variants within the constraints set by the question author. This creates a more rigorous test environment when such questions are used as part of a formal assessment as the correct answers from one of test will not necessarily be the correct answers to another test, thus making it harder for cheating to occur.

Another useful feature in STACK is that questions with both numerical and algebraic answers can be marked. Furthermore, feedback can be given instantly on completion of a question. This can range from a simple "correct" or "incorrect" statement, to a more tailored response which is dependent on the answer given. Fully worked solutions to the question can also be displayed. Students can reflect upon the feedback received and, if permitted by the author, re-attempt the question. As the feedback is immediate, the marking of formal assessments set through STACK is far more efficient than marking the test would otherwise be with a human, which would require significantly more time and money.

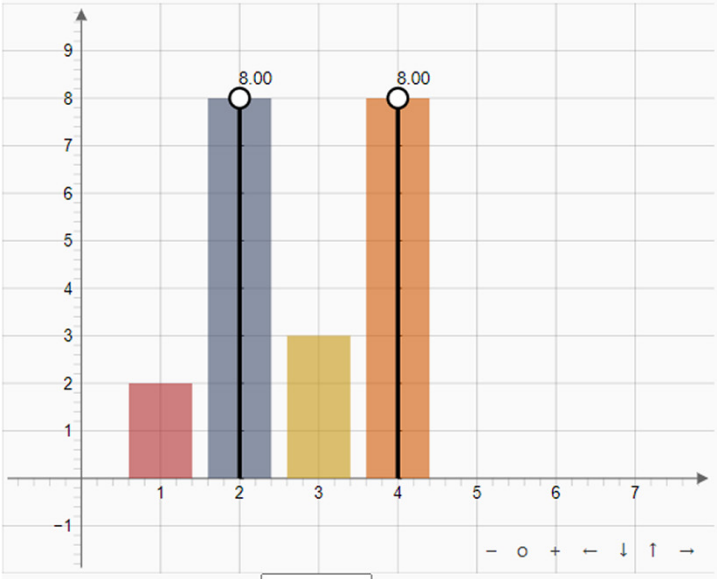
Recently, it has been possible to implement JSXGraph into STACK thanks to its compatibility with Moodle. JSXGraph is a web-based JavaScript program which has the ability to plot interactive graphs and mathematical functions [10]. This allows graphs to be plotted and edited by the student in real time through the use of, for example, sliders which control certain parameters of the function plotted. When implemented into a STACK question, the value of the slider can be submitted as the answer to a question and subsequently marked by STACK in the usual manner.

3 Conceptual statistics test questions

We now present the questions that we constructed by implementing the JSXGraph feature into STACK. The aim was to create interactive learning resources that students could use in a learning environment, such as during a lecture or in their own study time, to improve their understanding of statistics.

An example of such activity is shown in Figure 4. Here the students are given the mean, median, mode and range of some unknown data and their task is to move the two moveable bars in the bar chart such that the chart conveys the given statistics. The bars themselves are controlled by a slider which, in Figure 4, are set by default to a numerical value of 8. The student can simply click and hold the white circle to drag the bar to the desired position. The value of the slider will be displayed in the appropriate answer box as the student moves them. It will be these values that will be scored by STACK when the student submits their answer.

Change the bars corresponding to a scores of 2 and 4 such that the data in the bar chart has the statistics given in the table below.



Frequency of score 2 = ☐

Frequency of score 4 = ☐

Mean	3
Median	3
Mode	4
Range	3

Fig. 4. An interactive bar chart using JSXGraph embedded in STACK

When presented with this task, the student must carefully consider what each statistic means and how it relates to the bar chart. A particular case that can arise when there are two moveable bars is the possibility of multiple correct answers. This is the case in the question presented in Figure 4. Indeed, to satisfy the condition of the mean equaling 3 we arrive at the equation

$$\frac{11+2x+4y}{5+x+y}=3, \tag{1}$$

Where x and y are the user answers corresponding to "Frequency score of 2" and "Frequency score of 4" respectively as given in the question. This leads to the condition for a correct mean of

$$y=x+4. \tag{2}$$

It can be seen that, if this condition is used correctly, the mode will always be 4 as required and the range will be 3 accordingly. If students did not take this algebraic approach to solve the question, the feedback given on a correct answer asked them to consider if there were any other correct answers. It was hoped then that students would try to find other solutions thus getting a better understanding of the question.

An alternative question that we made was one which involved the students moving two nodes connected by a straight line. The task was to draw the correct regression line for data shown in the form of a scatter plot. An example of this question type is shown in Figure 5.

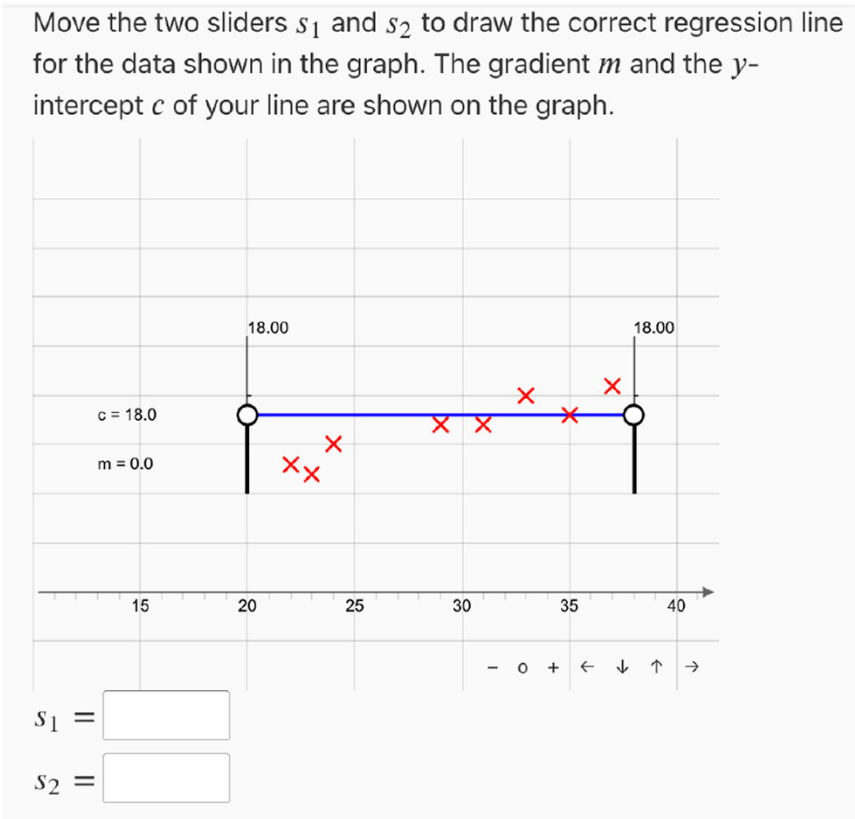


Fig. 5. An interactive straight line on a scatter graph using JSXGraph embedded in STACK

As the students move the nodes on the sliders, the y–intercept and gradient of the line (given by c and m respectively in Figure 5) are displayed in real time. As before, the values of the sliders are displayed in the boxes s_1 and s_2 respectively and are the values that will be scored on submission. Here, it is highly unlikely that the student will draw the true regression line, so it is important for a suitable tolerance to be determined and set accordingly within the coding of the question by the author. The discretisation of the sliders must also be carefully considered here as making the intervals of the slider smaller increases the number of possible answers that the student can give, hence making it more difficult for them to draw the true regression line.

4 Student responses to the test questions

We explored the performance of JSXGraph-based conceptual questions as compared to STACK-based procedural questions using opportunistic data from a practice (non-graded, optional) test administered as part of a mathematics refresher module. The test was attempted by 37 students in their first year of university. The test included five conceptual questions, all of which required students to drag one or two bars, similar to the question shown in Figure 4. The test also included five procedural questions that involved calculating the mean, median and/or mode for a presented set of data. The items contained between 1 and 3 responses each, shown as number of parts in Table 1, and each was scored out of a total maximum score of 1.

Table 1. Items, number of parts, and scores (max for each item = 1)

Item Name	Number of Parts	Mean Score
Conceptual items		
C1	2	0.82
C2	2	0.73
C3	2	0.75
C4	2	0.70
C5	3	057
Procedural items		
P1	2	0.95
P2	2	0.89
P3	2	0.91
P4	3	0.93
P5	1	0.85

We conducted a series of analyses to evaluate the validity of the conceptual items. First, we investigated the internal consistency of each set of items by calculating Cronbach's alpha, using the guideline that a value ≥ 0.70 indicates satisfactory internal consistency [11]. For the conceptual items we found $\alpha = 0.81$ and for the procedural items we found $\alpha = 0.73$. This suggests satisfactory internal consistency for both sets of items, meaning each set can be considered to measure a unidimensional construct.

Second, we calculated a total conceptual score and a total procedural score for each student, and then calculated the Spearman Rank Order correlation coefficient between them. We found a modest and significant correlation, $\rho = 0.50$, $p = 0.01$, suggesting the two sets of items assessed related but not identical constructs. This result is consistent with all the items assessing statistical knowledge, but differing as to whether the focus is on conceptual or procedural understanding [3].

Third, we explored students' performance on each set of items, as shown in the mean score column in Table 1. Overall, the students scored highly on the test, and all the procedural item scores (range 0.85 to 0.95) were higher than all conceptual item scores (range 0.57 to 0.82). A Wilcoxon signed-rank test showed this difference was

statistically significant, $p = 0.01$. This analysis of student performance is consistent procedural understanding being generally more accessible by students than conceptual understanding [1].

Taken together, the above series of analyses provide supportive evidence that the JSXGraph-based items validly assessed conceptual understanding of statistics.

5 Conclusion

We have demonstrated how the use of an innovative technology, namely JSXGraph embedded in the STACK system, can be used to develop items for assessing students' conceptual understanding of mathematics, at least for the case of simple statistics. We achieved this by taking research-informed paper-based tasks in the mathematics literature [7], and adapting them into items that can be automatically marked within a Virtual Learning Environment. To investigate the validity of the items we calculated internal consistency, and compared an opportunistic sample of students' performance on the items to their performance on procedural items. Our results provided supportive evidence that the JSXGraph-based items validly and successfully assessed conceptual, rather than procedural, understanding of simple statistics.

We are currently conducting further developmental work and analyses of student responses towards generating a suite of items that automated the assessment of conceptual understanding across a range of statistical topics and contexts.

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7 References

[1] R. Skemp, "Relational understanding and instrumental understanding", *Mathematics Teaching*, vol. 77, 1976, Accessed: Jan. 02, 2013.

[2] J. R. Star, "Reconceptualizing procedural knowledge", *Journal for Research in Mathematics Education*, vol. 36, pp. 404–411, 2005.

[3] N. M. Crooks and M. W. Alibali, "Defining and measuring conceptual knowledge in mathematics", *Developmental Review*, vol. 34, no. 4, pp. 344–377, Dec. 2014. https://doi.org/10.1016/j.dr.2014.10.001

[4] S. Krishnasamy, L. S. Ling, and T. C. Kim, "Improving Learning Experience of Probability and Statistics using Multimedia System", *International Journal of Emerging Technologies in Learning (iJET),* vol. 15, no. 01, pp. pp. 77–87, Jan. 2020. https://doi.org/10.3991/ijet.v15i01.11349

[5] N. Chandrasena Premawardhena, "ICT in the foreign language classroom in Sri Lanka: A journey through a decade", 10th World Conference on Computers in Education (WCCE 2013), Nicolaus Copernicus University, July 2–5, 2013, Torun, Poland. pp. 223–224.

[6] K. Zerva, I. Nicholson, and A. Mateo, "Translating the HELM workbooks to STACK", *STACK Assessment*, 2021. [Online]. Available: https://stack-assessment.org/CaseStudies/2021/HELM/. [Accessed Oct. 21, 2022].

[7] M. Swan, Improving Learning in Mathematics: Challenges and Strategies. Department for Education and Skills (UK), Standards Unit, 2005.

[8] M. Swan, "Learning GCSE mathematics through discussion: what are the effects on students?", *Journal of Further and Higher Education*, vol. 30, no. 3, pp. 229–241, 2006. https://doi.org/10.1080/03098770600802263

[9] C. Sangwin, Computer Aided Assessment of Mathematics. Oxford University Press, 2013. https://doi.org/10.1093/acprof:oso/9780199660353.001.0001

[10] M. Gerhäuser, B. Valentin, and A. Wassermann, "JSXGraph-Dynamic Mathematics with JavaScript", *International Journal for Technology in Mathematics Education*, vol. 17, no. 4, 2010.

[11] L. J. Cronbach, "Coefficient alpha and the internal structure of tests", *Psychometrika*, vol. 16, no. 3, pp. 297–334, 1951. https://doi.org/10.1007/BF02310555

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Analysis of STACK Answer Data Using Pen-Stroke Data from a Calculation Notebook and Item Response Theory

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Abstract—One of the most significant features of STACK, an automatic assessment system for mathematics, is that it can automatically classify correct, semi-correct, and incorrect answers using a Potential Response Tree and provide appropriate feedback for each. However, answers provided by students are only the results of their calculations, and if they are semi-correct or wrong, it is necessary to check the notes describing the calculations to determine where mistakes have been made. We developed a function that allows students to submit their notes at the same time as their STACK answers, thereby creating an environment that allows teachers to check where students have made mistakes and where they have stumbled. The note submission can be in the form of saving the results of calculations made with a digital pen on a tablet. This study examines a method of analysing answer data by visualising and analysing pen-stroke data from notes submitted using the latter method and linking this to correct/incorrect data. From pen-stroke data, two types of visualisation were achieved on the submitted notes. One was to colour-code the strokes according to the writing speed of the digital pen, and the other was to display the strokes as thicker if the stagnant time during which nothing was written was above a threshold value. The difficulty of the problem was surmised from those data. Then, item response theory was used to verify whether the difficulty was correctly estimated.

Keywords—automatic assessment system for mathematics, pen-stroke data analysis, item response theory

1 Introduction

In recent years, the development of information technology has accelerated informatisation in the education sector, resulting in more attention being paid to e-learning than ever before, as lectures are delivered online and home study is conducted with on-demand materials. One important function of e-learning is online testing, but the majority of test formats are true/false, multiple-choice, or numerical input. However, for online tests of science and mathematics, when the answer method is multiple-choice, it is possible to guess the answer to some extent from the options, and even if the calculation method is not known, it may be possible to guess the correct answer. For example,

in integral questions, it is possible to find the correct answer by differentiating all the functions given as options, even if one does not understand how to calculate the integral. Where answers are multiple-choice, it may be possible to assess overall ability by assigning a large number of questions, but it is difficult to ascertain exactly how well students understand individual questions. On the other hand, in the case of an answer format in which formulae are entered, it is expected that the actual ability of the respondent can be measured as it is impossible to answer a question if the calculation method is not understood. In the case of a formula input format, it is also expected that it is possible to obtain information on areas where students who have taken the online test lacked sufficient understanding by analysing wrong answers.

Automatic formula scoring systems include STACK [1], Möbius [2], WeBWorK [3] and Numbas [4]. This paper examines a method for estimating students' abilities using answer data from STACK, which is the most widely used system in Japan. Specifically, this paper uses the function for submitting notes in which calculations are made to provide answers, which will be introduced in the next section, and features of the answers are extracted from the written data of the notes to estimate the difficulty level of the questions and the students' level of understanding. Furthermore, from the correct and incorrect information from the online test, the ability values of the students who took the test, and the difficulty level of the questions estimated using item response theory are calculated with the aim of confirming the validity of the findings from the data in the notes.

The paper is structured as follows. Section 2 briefly introduces STACK, and Section 3 introduces the methods utilised in this study. Section 4 gives examples of the application of these methods to real answer data. Section 5 provides a summary and discussion.

2 Brief review of STACK

In STACK and other automatic formula scoring systems, a correct or incorrect evaluation is made by entering a formula as a solution, such as in a problem-solving ordinary differential equation, as shown in Figure 1. If the left-hand side of Figure 1 is the correct answer and the integral constant is missing, as in the right-hand side of Figure 1, partial points can be given. This kind of partial point evaluation of answers can be achieved with a function called Potential Response Tree.

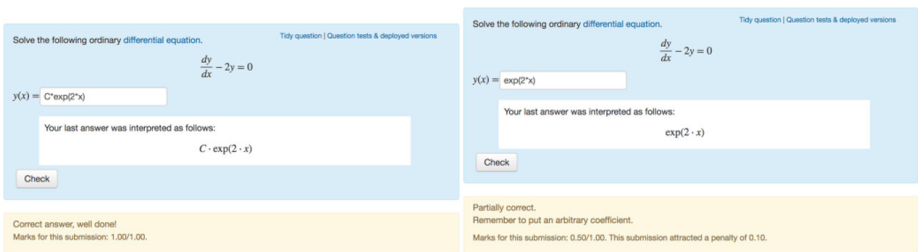


Fig. 1. Example of STACK

The potential response tree is an algorithm that enables the classification of student answers by evaluating the answers step by step and from several perspectives by means of a dichotomous tree. For example, in the potential response tree in Figure 2, first, at node 1, it is determined whether the student's answer satisfies the differential equation or not, and if it is true, it proceeds to node 2; but if it is false, it is scored as 0. At node 2, it is determined whether the student's answer is one that neglects an arbitrary constant, and if true, a partial score of 0.5 points is awarded; but if false, it proceeds to node 3. At node 3, it is determined whether the student's answer is a trivial one, and if true, it is awarded 0.1 partial points; but if it is false, 1 point is awarded because it is a correct answer.

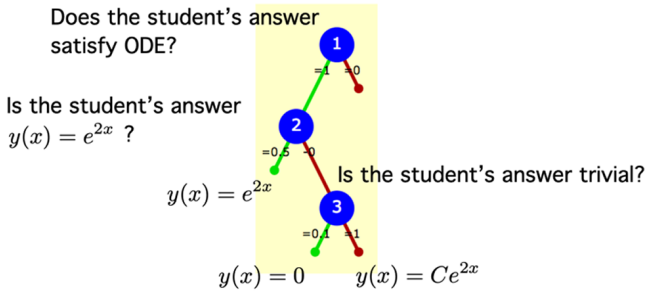
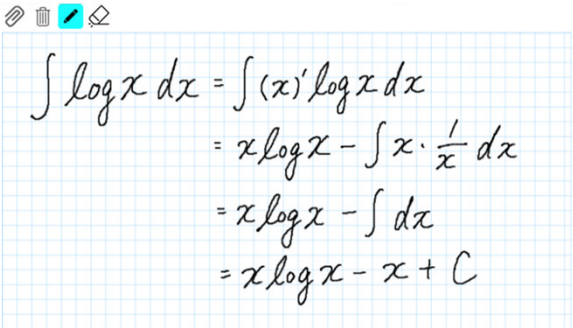


Fig. 2. An example of a potential response tree of STACK for assessing the question about ordinary differential equations

3 Pen-stroke data analysis and item response theory

Nakamura and Nakahara developed a function that allows the submission of notebooks containing not only answers but also notes describing the calculation process, which can be linked to and managed in relation to questions and answers [5]. Notes can be submitted either by attaching handwritten notes with photographs or by writing on a tablet with a digital pen. An example of a notebook written on a tablet with a digital pen is shown in Figure 3 (left). In the upper left-hand corner of the notebook, there are buttons for selecting the end of the note, erase all, pen, and eraser. The digital pen is used to write answers on the grid. The pen-stroke data contains the pen-strokes written by the students in chronological order. Figure 3 (right) shows a part of the recorded data. Action indicates the state of the pen, such as writing start, writing in progress, or selecting the eraser; X and Y are the coordinates of the pen nib; Time indicates the UNIX time when the Action was performed.



Action	X	Y	Time
start-drawing	66	38	1639025496916
move-drawing	66	37	1639025496927
move-drawing	65	33	1639025496938
move-drawing	73	214	1639025502317
changetoeraser	0	0	1639025507711
start-erasing	81	204	1639025508124
move-erasing	80	204	1639025508136
move-erasing	67	207	1639025508609
changetopen	0	0	1639025509592
start-drawing	455	96	1639025510342
move-drawing	455	95	1639025510351
move-drawing	724	531	1639025547555
allclear	0	0	1639025571671
start-drawing	101	66	1639025572372
move-drawing	695	819	1639025693828
savenote	0	0	1639025706243

Fig. 3. An example of a note submitted and a part of the recorded data

The pen stroke data shown in Figure 3 is used to visualise the writing speed and stagnation points. Based on the writing speed obtained, colour is added for each speed. The lower the speed, the bluer the colour; the higher the speed, the redder the colour. If more than 2 seconds have elapsed between the end of a stroke and the start of the next stroke, the post-stagnation stroke is displayed in bold as a stagnation point. Two seconds or more is a length that can be perceived as stagnation by humans [6].

According to previous empirical findings, students who rewrite more often are less certain, but students who write slower but rewrite less tend to solve problems more carefully and accurately. However, this assessment is subjective, and so, an objective evaluation is required. We, therefore, used item response theory to estimate students' ability and question difficulty from the correctness and incorrectness data of the test and compared them with the findings from the pen-stroke data to check the consistency.

4 Analysis of answer data

The visualisation method described in section 3 was applied to the answer data of three students who answered six differential and integral calculus questions. The correct/incorrect data and the number of times the eraser was used by each student for each question are summarised in Table 1. Figure 4 shows the notes of two of the students' answers to Question/Item 3. The number of times the total erasure and eraser were used in this question was 2 for student 1, 0 for student 2 (left of Figure 4), and 4 for student 3 (right of Figure 4). The results for the colour of the letters show that student 2 changed his writing speed frequently. The thickness of the first stroke of the equal sign also changed. Student 3's colour did not change much, indicating that the student's writing speed is almost constant. The thickness of the letters changes in only one place, and the thickness is not much different from normal. The number of times the eraser was used was higher for the question with more incorrect answers than for the question with more correct answers. Student 2 solved the questions after thinking about how to solve them is indicated by the speed changing rapidly and there being some stagnation.

However, student 3 solved the questions after thinking about how to solve them while writing the answers, which is indicated by the speed not changing much and there being little stagnation. It is also possible that the speed and stagnation are related to the way the intermediate equation is written. It has also been assumed that the difficulty of a problem corresponds to the number of times it is eliminated. Therefore, Questions/Items 4, 5, and 6 could be guessed to be relatively difficult. Student 1 is predicted to be competent, as this student correctly answered question/item 6, which is estimated to be more difficult, although the student had to redraw it more often.

Table 1. Summary of correct and incorrect results for each question/item and the number of times the eraser was used in the questions of differentiation, integral, and story

	Differentiation				**Integral**						**Story**	
	Item1		**Item2**		**Item3**		**Item4**		**Item5**		**Item6**	
	1/0*	e**	1/0	e	1/0	e	1/0	e	1/0	e	1/0	e
Student1	1	0	1	0	1	2	0	5	1	7	1	32
Student2	0	0	0	0	1	0	0	4	0	12	0	14
Student3	1	2	1	0	0	4	0	3	0	8	0	12

Notes: *Results: 1; correct, 0; incorrect, **Number of times erasers are used.

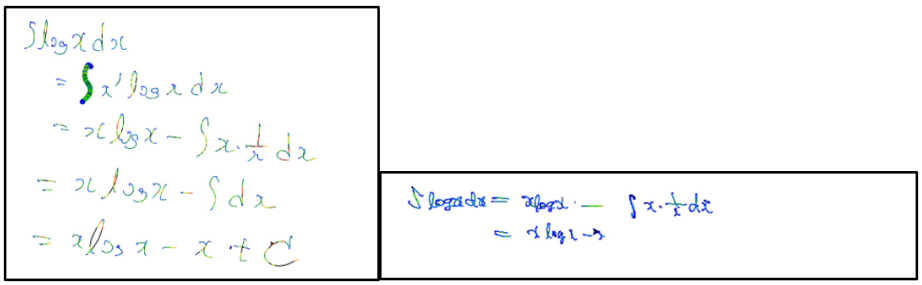


Fig. 4. An example of a note submitted and a part of the recorded data for student 2(left) and student 3(right)

Next, item response theory was used to estimate a student's ability and the difficulty of the problem. The ability values were Student 1 > Student 3 > Student 2, which was roughly inferred in the previous section. Based on the correct/incorrect data, the discriminative ability a and difficulty b of the equation

$$p_i(\theta) = \frac{1}{1+e^{-1.7a_i(\theta-b_i)}} \tag{1}$$

were estimated, where $p_i(\theta)$ is the probability of a student with ability θ answering question i correctly. Equation (1) with calculated a and b, which are called item response curves, are illustrated in Figure 5. This figure indicates that questions/items 4 and 6 are more difficult. The results predicted in previous paragraphs are here demonstrated objectively.

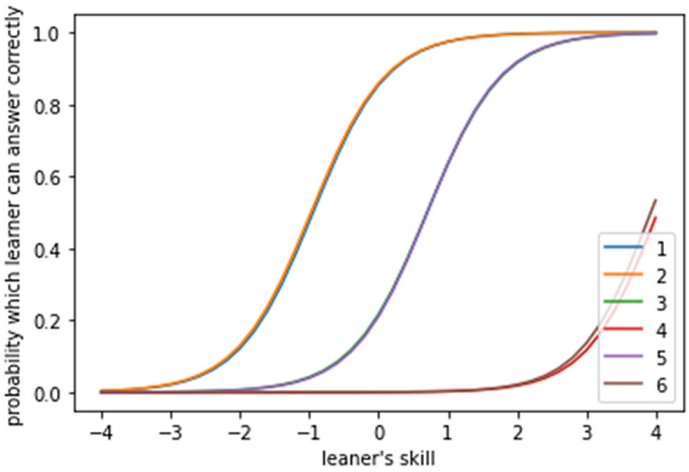


Fig. 5. Item response curves with calculated *a* and *b*

5 Summary

In this paper, which uses STACK, we visualised the solution process, writing speed, and stagnation points based on pen-stroke data obtained from the solution process of mathematical problems written on a tablet and also predicted students' ability and the difficulty level of problems. The results were matched to the results of item response theory, and qualitative results were obtained. However, due to the small number of data, it is difficult to qualify this as a general trend, and it will be necessary to increase the number of data and verify this trend in more detail in the future.

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7 References

[1] C. Sangwin, *Computer Aided Assessment of Mathematics*, Oxford University Press, 2013. https://doi.org/10.1093/acprof:oso/9780199660353.001.0001

[2] Möbius – DigitalEd. [Online]. Available: https://www.digitaled.com/mobius/. [Accessed Oct. 31, 2022].

[3] The WeBWorK Project. [Online]. Available: https://openwebwork.org/. [Accessed Oct. 31, 2022].

[4] Numbas. [Online]. Available: https://www.numbas.org.uk/. [Accessed Oct. 31, 2022].

[5] Y. Nakamura and T. Nakahara, "Note-Submission Function for Moodle Quiz and Collecting Pen-Stroke Data," in IADIS International Conference Mobile Learning 2019, 2019, pp. 163–164. https://doi.org/10.33965/ml2019_201903P001

[6] Masaaki Iiyama, Chihiro Nakatsuka, Yoshitaka Morimura, Atsushi Hashimoto, Masayuki Murakami, Michihiko Minoh, "Detecting Answer Stuck Point Using Time Intervals of Pen Strokes", *Jpn. Soc. Infor. & Sys. Edu*, vol. 34, no. 2, pp. 166–171, 2017.

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