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Short Paper

Cloud Computing Based E-learning in Malaysian Universities

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Lubna A. Hussein (✉), Mohd Faiz Hilmi
Universiti Sains Malaysia, Penang, Malaysia
lubnafatlawi@gmail.com

Abstract—Cloud computing is considered as a new innovation which essentially influences teaching and learning forms in the educational sector. Utilizing this innovation, not as it were, upgrades the quality of teaching and learning, but also diminishes overhead consumption of instructive education. In spite of the beneficial points of interest of cloud computing, in any case, its adoption is still distant from its full potential, particularly in university settings. However, not a large number of studies exist in regard to the adoption of cloud-based e-learning systems. Thus, this research is aimed to develop a theoretical research model for the adoption of cloud computing in Malaysian universities. For this purpose, the TAM model is used to represent the research framework. Moreover, a survey was conducted among 265 cloud-based e-learning participants and analysed via Structural Equation Modelling (SEM). The results indicate that the adoption of cloud-based e-learning is influenced by need and perceived usefulness, although innovativeness is not significant in the intention to adopt cloud-based e-learning.

Keywords—Cloud based e-learning, TAM model, innovativeness, Malaysian universities.

1 Introduction

One of the fundamental foundations holding strong ties with business-related organizations, particularly the government, is higher education [1, 2]. In addition to this, the future of the education system consists of a growing utilization of technology which holds a significant influence on the quality of teaching and works towards the betterment of learning in all educational stages. Nowadays, due to lower enrolment rates and less physical presence of students in classes, various colleges and universities provide the option of distance learning for certain courses and sometimes even degree programs. This also takes place via online platforms, with many other different teaching models.

One of the quickly ascending and novel topics in the field of IT is called cloud computing. This sector of information technology has become extremely appealing towards various educational institutions since it possesses beneficial features including geographic distribution, cost-effectiveness in regard to automated systems

as well as related open-source software. Generally, due to insufficient financial resources, educational institutions of smaller scale are not able to utilize IT to its full extent. However, cloud computing provides the capability of quality education in such institutions, particularly in remote areas with inadequate service and divided groups. Moreover, through strengthening the communication among students and educators located in a diverse geographical setting, it offers an opportunity to set up lively and interactive learning platforms, work actively in groups and discover more efficient and novel learning methods [3].

In order to address this gap, the aim of this study is to perform an empirical investigation regarding factors impacting cloud computing based e-learning systems in universities across Malaysia. By applying the TAM model, a theoretical framework is proposed in this research.

This paragraph gives a brief description regarding the organization of this paper. Prior to Section 3, entitled "Related Work", a summary of related studies is provided. In Section 4, the proposed theoretical framework is introduced. Section 5 consists of the research methodology. Furthermore, a detailed explanation is given regarding the testing of the model in Section 6. Ultimately, the final section includes the discussion and conclusion of this paper.

2 Background of the Study

2.1 E-learning

Ali [4] has defined e-learning as a technique using which users are enabled to advance their learning via a large number of tools namely personal computers, notebooks, mobile phones, laptops, tablets, etc. Furthermore, towards knowledge enhancement and, therefore, definite and more efficient performance, e-learning employs technologies involving information, communication and the Internet. Various applications, such as web-based learning, computer-based learning, virtual classrooms and digital collaboration, can be associated with e-learning [5].

Some of the benefits of e-learning for learners include saving the trouble of traveling between classrooms as done in traditional education, real-time broadcasting of the latest corresponding information such as policies, ideas and concepts as well as ensuring that the coursework remains up-to-date and updated as much as needed.

In spite of everything, because of various expenses related to network hardware such as servers, storage devices, etc, developing e-learning platforms can be extremely costly [6]. Aside from that, another major issue in this regard is a shortage in platform design as well as management staff [7].

2.2 Cloud computing

Cloud computing possesses a number of existing definitions. For instance, according to the National Institute of Standards and Technology (NIST), cloud computing is a “model for enabling convenient, on-demand network access to a

shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [8].

Sharing services and platforms such as Dropbox and Google Drive are the most commonly-used cases of cloud computing. Moreover, cloud computing has proven to be advantageous in fields differing from business. Also, considering the popularity of online learning which is increasing at an exponential rate, investigating ways through which one can overcome the challenges that companies and learning environments related to e-learning face becomes crucial [9]. Since cost efficiency is the most major power of cloud computing, utilizing such a technology aids in the enhancement of cost effectiveness regarding e-learning [7].

With the utilization of cloud computing, users are no longer required to invest in building and maintaining infrastructure related to information technology. When in need of computing resources such as application software, all that needs to be done is to obtain the corresponding facilities from another organization which acts as a third party, after which one can easily gain access to the aforementioned service through the Internet. In exchange, due to the usage of computing power, users can send their payment to the service providers. Simply put, users of the cloud environment are enabled to bring their expenses regarding hardware resources and maintenance in relation to information technology to a minimum as they are not required to purchase any hardware or software in order to run business-related applications [10].

2.3 Cloud-based E-learning systems

Cloud-based e-learning systems are the future of the e-learning technology and related infrastructure. A cloud-based e-learning system is stated to be a subdivision of cloud computing in regard to the field of education. Furthermore, towards strengthening the traditional e-learning infrastructure, it is in possession of all supplies including both hardware and software resources. After the virtualization of study materials related to e-learning systems in cloud servers, they will be ready to be rented from cloud vendors and utilized by learners and related educational businesses [10].

Through sharing pools of configurable resources namely servers, applications and services, cloud computing has overcome the challenge of high costs in regard to e-learning [7, 11].

As stated in previous research [12], implementing e-learning with the technology of cloud computing provides various benefits as follows:

- **Lower costs:** Using the cloud environment provided by their personal computers, mobile phones and tablets, users are enabled to run all related applications with minimum configuration of internet connection.
- **Enhanced performance:** No performance-related issues occur as client machines function because many of the corresponding applications and processes of cloud-based e-learning applications are already reserved in the cloud.

- **Immediate software updates:** E-learners always receive updates immediately. This is due to the fact that all software is updated automatically in the cloud source, as a result of cloud-based e-learning applications running with cloud power.
- **Strengthened compatibility regarding document formats:** E-learning applications running on cloud power possess much more enhanced compatibility with various formats of files and fonts which might not be read properly in certain personal computers or mobile phones.
- **Advantageous for learners:** Cloud-based e-learning provides a large number of benefits for students. For instance, almost all their student work can be done online, including taking courses, taking part in examinations, receiving feedback from their teachers as well as sending and receiving projects and assignments to and from their instructors.
- **Beneficial for instructors:** Various advantages can also be gained by teachers from cloud-based e-learning. Many of their tasks can be performed online, such as preparing test papers, composing learning resources of more advanced content for students via content management, assessing students' tests, homework and projects, sending feedback to students and communicating with them in online forums.

3 Related Work

Prior works of research exist on the subject of cloud computing. In spite of that, either these studies have been conceptual or the focus of a large number of them has been on the infrastructure related to cloud computing in the higher education. Also, cloud computing is currently being applied in various universities across developed nations, namely the United States and the United Kingdom [2, 13].

Previous research has taken place by Shahzad et al. [14] in which they have discussed the advantages and corresponding challenges regarding the utilization of cloud technologies in the Malaysian higher education system. According to their study, many benefits can be gained from this technology in institutions of higher education, particularly in regard to world ranking of these educational institutions. However, a number of challenges are simultaneously being faced by the technology of cloud computing, including problems related to security and privacy, inadequate professionalism and low Internet speeds in certain locations. Nevertheless, due to this technology's many beneficial factors such as the capability of solving problems at lower expenses as well as easier sharing, access and management of information, it has a tremendous potential to further be developed.

As mentioned in previous studies [15], a number of factors limiting the adoption of cloud computing in the Czech Republic include data security, IT governance, service availability as well as dependence on service providers.

According to a study in Bangladesh [16], some major factors contributing to the adoption of cloud computing in the University of Dhaka in Bangladesh consist of lack of adequate infrastructure, service availability and utility in education. Moreover, another work of research [17] refers to problems related to privacy and security as

challenges faced in the process of the utilization of cloud computing in Sudan's higher education.

Also, in a study in Vietnam [10], it was stated that factors such as performance expectancy (perceived usefulness), social impacts, hedonic motivation and habit all affect cloud-based e-learning adoption.

Furthermore, the readiness as well as basis for the adoption of cloud computing in the higher education was explored by a study in the United Arab Emirates [9]. It was established by this study that after feeling such a technology can be easily utilized, the probability of users adopting cloud services in their educational systems increases. Therefore, this determines that ease of use plays an important role in the corresponding attitudes and behaviours of university students. Also, another study exists regarding the advantages as well as challenges in the utilization of cloud computing in e-learning [18]. According to most aforementioned studies, security acts as an important factor in the adoption of cloud-based e-learning systems.

Towards a comparison between the Middle East and Europe, a work of research was carried out in which the adoption of cloud computing as well as its intercontinental variation was the main topic of discussion. The results indicated that European countries had a greater tendency to adopt upgraded technology, whereas the traditional technology was still favoured in the Middle East. In regard to the security issues remaining to be handled, specific centres are set up in Europe while Middle Eastern nations namely Oman and Qatar are dealing with security problems consisting of privacy, integrity and security. Moreover, in the Middle East, education via cloud computing is only going through its initial phase [19].

4 Research Framework

4.1 Technology acceptance model

Among the many theoretical models for explaining the adoption of particular systems or services, the TAM proposed by Davis is one of the most widely used frameworks [20]. The TAM model assumes that when someone is introduced to a new technology, his or her decision to use it will be influenced by a number of factors [21]. TAM is one of the most popular theories that are applied extensively in order to explain the factors responsible for the adoption of technology [22]. Many works of research have demonstrated that perceived usefulness and ease of use influence the ways users accept a new innovation or system. This suggests that computer usage is decided by a behavioural intention to use a system, which is jointly determined by perceived ease of use and perceived usefulness. Previous studies indicate that if an individual perceives a system to be easy to use, he or she is more likely to perceive the system to be useful as well [23, 24].

The TAM model has been widely employed in the context of cloud computing adoption [9, 25], learning management systems [21] and the examination of factors affecting mobile devices in the educational sector [26]. Although the TAM has been integrated within the educational and technology perspective since the 1980s, it is

extended and expanded in a different context whenever a new technology is introduced [9].

4.2 Hypothesis development

Figure 1 consists of a summary of the research model as well as the hypotheses. According to previous studies, security and trust are important factors in the adoption of new technology. Furthermore, the TAM is utilized in this study. Previous literature in the field of technology acceptance has proposed various factors including perceived ease of use (PEOU) and perceived usefulness (PU) and has proven their influence on the behavioural intention to use and adopt new technologies [27].

Perceived usefulness: Davis [20] defines perceived usefulness (PU) as the degree to which a person believes a system can enhance his or her job performance. According to this study, learners concluded that the corresponding cloud-based e-learning system was helpful in regard to their performance. Moreover, the individual learner would be more satisfied with e-learning [10]. Therefore, this study suggests the following hypothesis:

H1: Perceived usefulness has a positive effect on cloud-based e-learning intention.

Perceived ease of use: It is defined as the degree of ease associated with the usage of a system [10]. Simplicity in a system develops the users' ability to utilize the system towards the enhancement of their performance. Usage of the system increases performance but the evaluation of the effort it will take to use such a system is also important [28]. Therefore, this study suggests the following hypothesis:

H2: Perceived ease of use has a positive effect on cloud-based e-learning intention.

Trust and Security: The key goals of information security are to protect the confidentiality, integrity and availability of data regardless of the form the data may take [29]. Security is evaluated as a cloud-computing risk by universities and organizations. In the context of this study, students are expected to be more likely motivated to use cloud-based e-learning systems if they trust such systems. Therefore, this study suggests the following hypothesis:

H3: Trust and security have a positive effect on cloud-based e-learning intention.

Need: Universities need cloud computing due to ever-changing technological improvements and also to satisfy their technological needs [30]. In this respect, need is added to this study to represent the importance and need of cloud-based e-learning systems for students and lecturers. Therefore, this study suggests the following hypothesis:

H4: Need has a positive effect on cloud-based e-learning intention.

Innovativeness as a moderator: Agarwal and Prasad [31] proposed innovativeness in the domain of information technology as a new construct, developed from previous works including Rogers'. It is defined as the "willingness of an individual to try out any new information technology". Moreover, it is understood as a trait and conceptualized to be invariant across situational considerations. Many studies have employed innovativeness to adopt new technologies. For instance, it is used with the UTAUT2 Model [10]. A new contribution of this study to research of this kind is the utilization of innovativeness as a moderator with the TAM model,

along with need as a new variable which is added to this model, as mentioned above. Therefore, this study suggests the following hypothesis:

H5: Innovativeness will moderate the relationship between perceived usefulness and cloud based e-learning intention.

H6: Innovativeness will moderate the relationship between perceived ease of use and cloud based e-learning intention.

H7: Innovativeness will moderate the relationship between Trust and Security and cloud based e-learning intention.

H8: Innovativeness will moderate the relationship between Need and cloud based e-learning intention.

H9: Innovativeness has positive effect on cloud based e-learning intention.

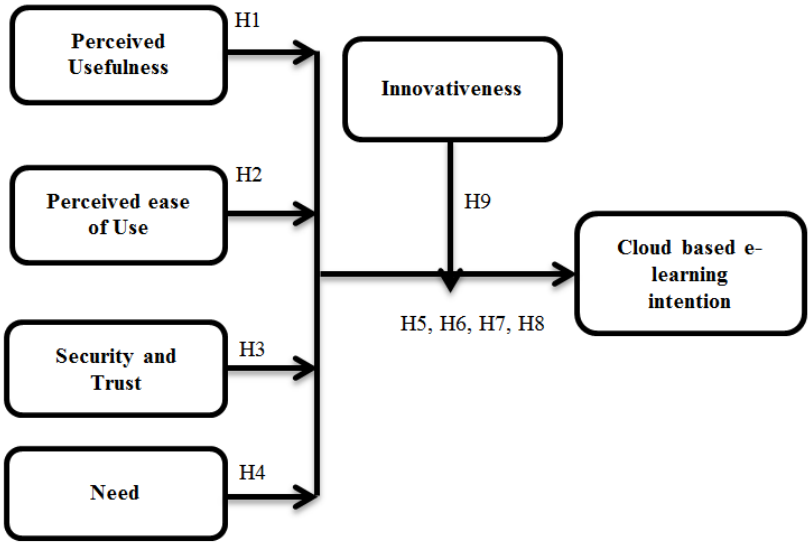

Fig. 1. Research Framework

5 Methodology

5.1 Population and sampling

The target population in this study is higher education students and lecturers in Malaysian universities. The participants in this study were lecturers and students from two important universities in Malaysia, Universiti Sains Malaysia (USM) and Universiti Utara Malaysia (UUM). The study used convenience sampling for data collection [32].

The sample size of 200 to 500 is considered sufficient for multivariate data analysis [33]. Also, researchers have asserted that a sample size larger than 30 and less than 500 is appropriate for many works of research [34].

5.2 Instrumentation

In this study, the survey questions are divided into two sections A and B. Section A consists of the demographic profile of the respondent. This section seeks information regarding respondents, including their gender, age, level of education, position and experience. Section B includes a set of 21 questions compiled to represent the constructs. Furthermore, perceived ease of use (PEU) and usefulness (PU), trust and security (TS), need (N), innovativeness (INN) as a moderator and finally, cloud computing-based e-learning intention (CCEI) are adopted from [10], [29], and [30].

The measurement of the items is done by using seven Likert-type scales. A seven-point scale is used to allow respondents in the universities to express how much they agree or disagree with a particular statement. Each point of the scale is defined as follows: 1= Strongly disagree, 2= Disagree, 3= Slightly disagree, 4= Neither agree nor disagree, 5= Slightly agree, 6= Agree, 7= Strongly agree.

The questionnaire is written in the English language and the contents are then proofread and checked for meaning and grammar. In order to ensure the validity of items in the measurement of the research variables, the questionnaire was sent to four experts for review. The experts' opinions are expected to enhance the conceptual research framework variables as well as the survey instrument and to consequently cause the research study to become more scientific and authentic.

5.3 Data collection

The data is collected by online using Google forms, 265 respondents were obtained. The demographic information of the respondents is summarized in Table 1.

Table 1. Profile of the respondents (n=265)

Variable	Description	Number of Respondents	%
Gender	Female	142	53.6
	Male	123	46.4
Age	19-23	124	46.8
	24-30	84	31.7
	31-40	50	18.9
	Above 40	7	2.6
Education	Bachelor's degree	240	90.6
	Master's degree	7	2.6
	PhD Degree	18	6.8
Position	Lecture	16	6.0
	Postgraduate	28	10.6
	Undergraduate	221	83.4
Experience	Good in Cloud Computing	40	15.1
	Average in Cloud Computing	176	66.4
	Bad in Cloud Computing	49	18.5

6 Data Analysis and Results

The quantitative data collected have been analyzed using Smart Partial Least Square M3 Version 3.2.7 and SPSS version 22. PLS-SEM is a technique to estimate causal relationship among variables. Following a two-stage analytical procedure, measurement model is analyzed first to assess the reliability and validity of the instrument and then hypotheses were tested through a structural model.

6.1 Descriptive statistics of the variables

The mean of all the six latent variables varies from 5.02 to 5.57, whereas the standard deviation varies from 1.039 to 1.363 on a seven-point Likert scale. However, the values of the mean of all the variables were found to be higher than the midpoint 3.50. The dispersion of values reported through standard deviation indicates that the highest value shown was from innovativeness and the lowest value shown was from perceived usefulness.

6.2 Measurement model assessment

The main loadings for all the question items explained are more than 0.7 for all the latent variables (model variables present in the framework). The minimum value of the main loading is 0.810 and the maximum value is 0.969. AVE to measures the level of variance captured by a construct versus the level due to measurement error, values above 0.7 are considered very good, whereas, the level of 0.5 is acceptable. It is found that all the AVE values are greater than 0.7, which shows that the convergent validity is very good. Meanwhile, the Composite Reliability is a less biased estimate of reliability than Cronbach's Alpha, the acceptable value of CR is 0.7 and above [35]. The values in Table 2 are shown to be larger than 0.7, which indicates high levels of internal reliability among latent variables.

Table 2. Results of measurement model assessment

Latent variable	Question Items	Main Loading	AVE	CR	Cronbach's Alpha
Cloud computing-based e-learning Intention	CCEI1	0.953	0.904	0.966	0.947
	CCEI2	0.943			
	CCEI3	0.956			
Innovativeness	INN1	0.829	0.702	0.904	0.858
	INN2	0.858			
	INN3	0.810			
	INN4	0.854			
Need	N1	0.966	0.937	0.967	0.932
	N2	0.969			
Perceived Ease of Use	PEU1	0.888	0.821	0.948	0.927
	PEU2	0.909			
	PEU3	0.938			

	PEU4	0.888			
Perceived Usefulness	PU1	0.898	0.819	0.948	0.926
	PU2	0.913			
	PU3	0.928			
	PU4	0.880			
Trust and Security	TS1	0.917	0.839	0.954	0.936
	TS2	0.928			
	TS3	0.911			
	TS4	0.909			

*CR: composite reliability, AVE: average variance extracted

With regard to convergent and discriminant validity, the test described by Fornell and Larcker [36] was applied. They state that the square root of the average variance extracted (diagonal elements in Table 3) should be higher than the correlations between the constructs (off-diagonal elements in Table 3). As this is given for all constructs it can be concluded that they are valid and work as intended.

Table 3. Discriminant validity of Fornell-Larcker Criterion (n=265)

	CCEI	**INN**	**N**	**PEU**	**PU**	**TS**
CCEI	**0.951**					
INN	0.708	**0.838**				
N	0.797	0.651	**0.968**			
PEU	0.706	0.699	0.704	**0.906**		
PU	0.788	0.661	0.762	0.800	**0.905**	
TS	0.615	0.655	0.653	0.653	0.632	**0.916**

One recent method for measuring the discriminant validity in PLS-SEM is the Heterotrait-Monotrait Ratio (HTMT) which was developed by Henseler et al. [37]. HTMT represents the estimate for the construct's correlation with the other constructs that should be smaller than one [38]. A correlation closer to one shows a lack of discriminant validity. Henseler et al. [37] suggested a threshold of 0.90 when the constructs are conceptually similar and 0.85 when the constructs are conceptually different. The results of HTMT assessment in Table 4 are indicating the discriminant validity of the constructs.

Table 4. Discriminant validity of Heterotrait-Monotrait Ratio (HTMT) (n=265)

	CCEI	**INN**	**N**	**PEU**	**PU**	**TS**
CCEI						
INN	0.782					
N	0.848	0.723				
PEU	0.752	0.780	0.756			
PU	0.839	0.736	0.818	0.862		
TS	0.652	0.729	0.698	0.700	0.674	

6.3 Structural model assessment

Testing the hypotheses and path coefficients in SmartPLS 3 entails the utilization of bootstrapping, a non-parametric statistical approach that draws many sub-samples from the sample data and examines models for each sub-sample [35]. For bootstrapping options, 5000 sub-samples, one-tailed in regard to the hypotheses, were proposed to be positive (+) and a significance level of 0.05 was employed. The results of hypothesis and direct relationship testing are presented in Table 5, showing that N and PU have a significant effect on CCEI. Regarding the moderating effect, the results demonstrate that INN*N -> CCEI is significant.

Table 5. Results of path analysis

Hypothesis	Path	Beta value	SE	t-value	p-values	Result
H9	INN -> CCEI	0.225	0.068	3.302	0.000	N/A
H4	N -> CCEI	0.427	0.088	4.857***	0.000	Supported
H2	PEU -> CCEI	-0.020	0.081	0.244	0.404	Not Supported
H1	PU -> CCEI	0.355	0.080	4.446***	0.000	Supported
H3	TS -> CCEI	-0.023	0.057	0.410	0.341	Not Supported
H8	INN*N -> CCEI	-0.152	0.065	2.325*	0.010	Supported
H6	INN*PEU -> CCEI	0.082	0.069	1.184	0.118	Not Supported
H5	INN*PU -> CCEI	0.017	0.066	0.255	0.400	Not Supported
H7	INN*TS -> CCEI	0.002	0.067	0.025	0.490	Not Supported

Note: *p<0.05, t>1.645, **p<0.01, t>2.33, ***p<0.001, t>3.06 (one tailed); SE: Standard Error

Coefficient of determination (R^2) refers to the effect of independent variables on the dependent variables. The R-squared value ranges from 0 to 1, with 1 defining perfect predictive accuracy. Hair et al. [39] proposed a rule of thumb for acceptable R^2 values with 0.75, 0.50, and 0.25 described as substantial, moderate and weak respectively.

Regarding the value of the coefficient of determination (R^2) for the direct effect of the latent variables (PU, PEU, TS, N and INN) on CCEI, a value of 0.741 is displayed in Figure 2. According to Hair et al. [39], R^2 estimates were substantial, which indicates the high quality of the proposed model.

6.4 Predictive relevance of the model (Q^2)

Predictive relevance statistics are used to measure the quality of the PLS path model, which is calculated via blindfolding procedures [40]. Also, cross-validated redundancy was performed. The Q^2 criterion recommends that the conceptual model can predict the endogenous latent constructs. In PLS, the Q^2 values measured must be greater than zero for a particular endogenous latent construct (independent). As shown in Figure 3, the Q^2 value for this study model was equal to 0.623, higher than the threshold limit. Therefore, it supports that the path model's predictive relevance was adequate for the endogenous construct.

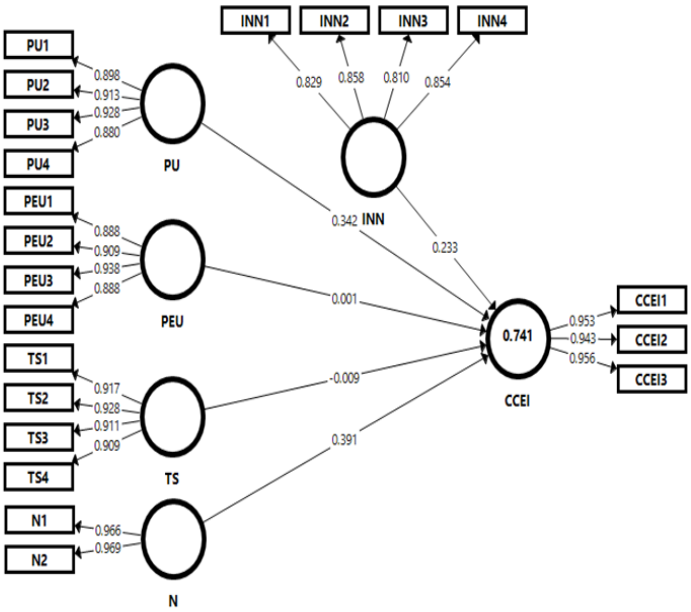

Fig. 2. PLS-Path analysis of R-square values (n=265)

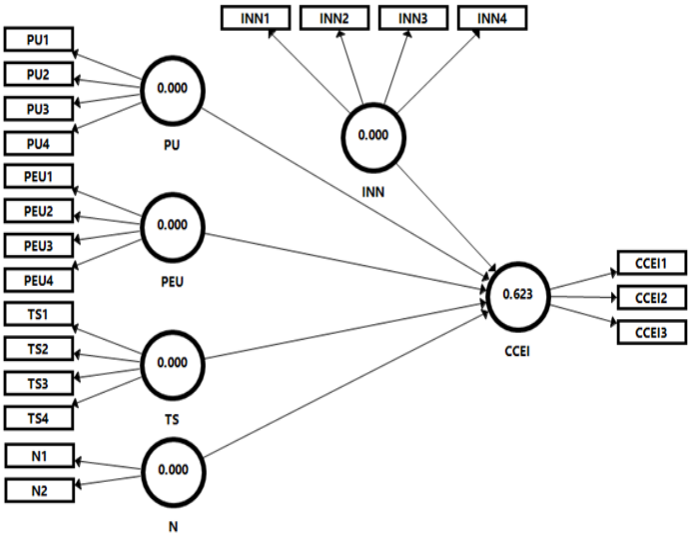

Fig. 3. Blindfolding (DV) (Q^2=0.623>0)

6.5 Goodness-of-fit index

The Goodness-of-Fit (GOF) of a statistical model is used to describe how well it fits into a set of observation's models [41]. The GOF values lie between 0 and 1, where values of 0.10 (small), 0.25 (medium), and 0.36 (large) indicate the global validation of the path model. The GOF is calculated by using the equation below:

GOF = SQRT ((Average AVE) * Average R Square))

It was calculated from Table 6 that the GOF index for this study model was measured as 0.781, is above 0.36 for an excellent PLS model for the data.

Table 6. Goodness of Fit (GOF)

Dependent Variables	Average of AVE	R Square	GoF
Cloud computing-based e-learning Intention	0.824	0.741	0.781

7 Discussion and Conclusion

The development in e-learning has produced innovative functions towards helping education and learning endeavours of teachers and students. Numerous educational frameworks and functions, particularly e-learning, have been introduced in recent years. Thus, understanding the intention of teachers and students towards using cloud-based e-learning applications is crucial. This study validated the proposed theoretical model for predicting the intention to use cloud-based e-learning among teachers and students in two Malaysian universities. Moreover, five important factors were taken into consideration, including perceived usefulness, perceived ease of use, trust and security, need and cloud computing-based e-learning intention with the moderating factor of innovativeness.

This study discovered that perceived usefulness has a positive and significant effect on cloud computing-based e-learning. Furthermore, the results support prior studies which have shown that perceived usefulness has a significant effect in adopting cloud computing in higher education [42]. According to these results, it is quite clear that if students and lecturers perceive cloud computing-based e-learning as a technology which will be beneficial to them, they will be generally open to using it as well as learning it in order to perform their tasks.

Another important finding of this study is that perceived ease of use holds no significance in cloud computing adoption, similar to another work of research [43]. As such, collectively, the insignificance of perceived ease of use suggests that resistance towards new technologies may not be as pivotal as it once was [44]. Another explanation for the insignificance of perceived ease of use is that current university students have grown up with computers all around them in their homes and schools. Moreover, they have experienced everything regarding computers, from large “old-fashioned” desktops to the latest phones which have all up-to-date computing capabilities and are yet small enough to fit in their pocket. Although these students may not actually understand the real technology behind the screen, they tend to be

more likely to accept cloud computing if their "perceived ease of use" is high, which means that less effort is required to learn how to use it [42].

Trust and security were found not to have a significant effect on cloud computing-based e-learning intention, since this study is still in an early stage for respondents. This finding suggests that it may be worthwhile for universities to educate students about the security of cloud computing-based e-learning before introducing it as part of their work.

Another essential and significant factor in this study is need. The technological needs of universities arise with the emergence of a competitive global environment. As mentioned in prior research [30], one of the five reasons for the usage of cloud computing services in businesses is that these services can support their various business needs.

As a moderating effect in this study, it was discovered that perceived usefulness and ease of use with innovativeness towards cloud computing-based e-learning systems are insignificant. With respect to the effect of perceived usefulness in the adoption of different technologies, perceived usefulness with innovativeness holds no effect. According to results from previous research, innovativeness captures an individual's willingness to try novel information technology [31]. Therefore, the effect of trying new technologies might perhaps reduce the importance of usefulness. This is due to the fact that cloud computing-based e-learning is still a relatively new topic and many might not comprehend the importance of it yet.

8 Acknowledgement

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10 Authors

Dr. Lubna A. Hussein is currently a Post-Doctoral at the School of Distance Education, Universiti Sains Malaysia (USM). Her PhD degree earned from the school of Computer Sciences in the field of Management Information Systems, Universiti Sains Malaysia (USM). Her area of research interested in business IT and Technology Adoption.

Dr. Mohd Faiz Hilmi is currently attached to the School of Distance Education, Universiti Sains Malaysia (USM). He received his DBA from Universiti Sains Malaysia, MBA from Universiti Utara Malaysia and a B.A. degree from Washington State University.

Prior to joining Universiti Sains Malaysia, he had 11 years of multifunctional accomplishments including as IT engineer, IT project/support coordinator, product data specialist and configuration manager in various multinationals corporations.

Companies and organizations he has been working with include MCMS, Advanced Micro Devices, Celestica, Intel and Motorola. His areas of research interest include Innovation and Technology Management.

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Applying Blended Problem-Based Learning to Accounting Studies in Higher Education; Optimizing the Utilization of Social Media for Learning

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Ahmad Nurkhin (✉), Kardoyo, Hengky Pramusinto,
Rediana Setiyani, Ratieh Widhiastuti
Universitas Negeri Semarang, Central Java, Indonesia
ahmadnurkhin@mail.unnes.ac.id

Abstract—This study aims to examine the implementation of blended problem-based learning in introductory courses on accounting, in order to improve students' critical and creative thinking skills and student learning outcomes. The research design carried out is classroom action research (CAR). The object in this study is accounting students at the Faculty of Economics, Universitas Negeri Semarang (UNNES). The research was conducted during September and October 2019. The procedure for carrying out CAR consists of planning, implementing, observing and reflecting. CAR is implemented in two cycles. The research data is gathered using documentation, observation and testing. For data analysis, quantitative and qualitative descriptive methods are used. The researchers carried out two cycles, with each cycle consisting of two lecture meetings. In the first cycle, researchers used Google Classroom, mind mapping, online quizzes, and Instagram social media to improve interaction and the quality of lectures by applying blended problem-based learning. The researchers focused on improving students' critical and creative thinking skills in the first cycle. The results show that the students have good critical and creative thinking skills. In the second cycle, the researchers still continued to use Google Classroom and combined it with face-to-face lectures using "make a note" assignments and group discussions. The researchers took quantitative measurements to see the success of the treatment. The results showed that students were able to obtain better grades than before being given the treatment.

Keywords—Blended learning, problem-based learning, blended problem-based learning, social media, accounting learning

1 Introduction

The use of information technology in the learning process has led to blended learning approaches being increasingly used in tertiary education around the world [1]. The increasing interest of educators in implementing blended learning is because it can combine variations of face-to-face learning and online learning. Nevertheless, there are challenges in implementing blended learning, including costs, intellectual property

rights, initial conceptions and perceptions, and the practice of blended learning itself [2]. The use of information technology in the learning process will facilitate students accessing educational products and services [3] and [4].

Blended learning is very useful for the learning process. Blended learning provides enormous flexibility for students when they study [5]. The blended learning strongly supports active and meaningful learning [6]. Blended learning facilitates the inclusion of online students, enhancing the financial viability of study abroad courses and programs [7].

Many researchers have demonstrated the application of blended learning in studying economics, accounting, and business. Research by [8] successfully implemented blended learning in property education. He also believes that blended learning can be applied to other material. Likewise, [7] who utilized online learning for international students. And [1] found positive outcomes from the application of blended learning, namely increased conceptual understanding, confidence in learning, and metacognitive reflection upon student learning. Other researcher, [9] succeeded in utilizing an online learning environment (OLE) to improve the ability of students to make presentations in Hong Kong and [10] applied micro lectures as the most effective model of blended learning. The results showed that most students were satisfied with the learning.

Social media can also be used to support learning. Research by [11] found positive results from educators and students who wanted to use mobile devices and social media applications for teaching and learning purposes. Likewise, [12] showed that students feel added value when using social media to carry out academic activities and also [13], [14], and [15] show that not many lecturers at the Faculty of Economics, Universitas Negeri Semarang (FE UNNES), utilize information technology in lectures; although [13] has shown the use of WhatsApp (an instant messaging app) for business English learning. Other researcher, [15] provides examples of the use of social media in accounting studies, such as YouTube, Instagram, Facebook, and instant messaging (WhatsApp, Telegram).

This research seeks to develop blended learning in accounting studies in tertiary institutions. The emphasis of blended learning in this study is on the use of social media as learning media. The learning method used is problem-based learning (PBL). The PBL method is considered to be in accordance with the characteristics of studying accounting. The previous research by [16] has developed a learning module based on the PBL approach for learning accounting education research methodologies.

Bearing this background in mind, the formulation of the problem that will be examined in this study is with regard to how blended-problem based learning is applied to the study of accounting. It is very important for the application of blended-problem based learning in accounting studies to be developed now. It is hoped that the development of PBL-based learning media will produce media that can be applied in lectures so as to improve the quality of the lecture process. In the end, students will be able to obtain better learning outcomes. The use of social media also needs to be implemented in the learning process, because students use it very often.

2 Literature Review

2.1 The concept of blended learning

Blended learning is a combination of face-to-face learning experiences, such as on campus classroom contacts, and online learning experiences [5]. A time-based blended learning model, which combined synchronous elements (face-to-face meetings, video conferences, chats, webinars) with several asynchronous elements (reading, assignments, taking notes, asynchronous research, discussions, and collaboration) [4]. Blended learning is a supplementary resource that complements traditional teaching. In blended learning, technology is used and student interaction is very high because it is a student-centered approach [17].

There are many advantages to using blended learning, including its potential to be transformative, to offer opportunities for institutions to develop technology, to enhance thinking skills in the community, and strongly support active and meaningful learning [6]. In addition, blended learning can increase the flexibility of access to learning, meaning that distance is not an obstacle preventing students from participating in learning [5].

2.2 The concept of problem based learning

Problem based learning (PBL) was first introduced by Barrows and Tamblyn in 1995 in an effort to improve the study of medicine. They stressed that PBL was interpreted as an effort to invite students to think and solve problems in real-life situations. PBL was designed to train medical students how to assess and solve clinical problems through systematic learning activities, to develop their clinical responses and reasoning. PBL is also known as problem-oriented learning [18]. There are several variations in the application of PBL. Aside from PBL, there is self-directed PBL and small-group PBL [19]. PBL can be applied to hybrid, blended, or online learning concepts [20].

PBL has been widely applied to the learning process for various fields, including business and economics. A researcher implemented PBL in entrepreneurial studies and stated that PBL was a very effective method. The experience gained by students was more realistic and relevant [21]. And other researcher, [22] found there to be a positive effect of implementing PBL in studying logistics and supply chain management (LSCM). Other result indicates that PBL is an effective complementary method in lean manufacturing. PBL can expose students to actual problems [23]. Likewise, [19] also successfully implemented PBL. It has positive implications because it can integrate theory and practice and is able to increase management students' motivation to learn.

2.3 Utilization of social media for learning

There are various forms of social media technology (SMT), namely blogs, wikis, Google apps, image sharing, social bookmarking, social networking, social news sites, VOIP and instant messaging, do-it-yourself networks, file sharing, video sharing, location-based applications, and microblogs [24]. Meanwhile, [25] divided SMTs into text-based, media sharing, social networking, mobile-based applications, virtual worlds and games, synchronous communication, and conferencing applications and mash-ups.

The social learning is very concerned with the use of social media in learning [26]. Social media technology is part of the routine of modern society in various ways, including support and even the replacement of software specifically designed for the acquisition and sharing of knowledge [27]. The adoption of the use of social media and the web in business and economic learning is considered to be very slow. Technology-based learning is only used as a support for face-to-face learning [28].

2.4 Development of blended problem-based learning in accounting studies; optimizing the use of social media for learning

Blended learning can be practiced in accounting studies in tertiary institutions. The combination of online learning with face-to-face learning results in a more interactive lecture approach. UNNES has implemented e-learning (E-LENA) over the last eight years. However, in practice, not many FE UNNES lecturers make good use of these features to support classroom learning. Some of the reasons that emerged include the difficulty lecturers face in applying various features of E-LENA, the considerable amount of time needed to utilize E-LENA, and lecturers finding it easier and more practical to apply face-to-face learning.

This study aims to design and apply the study of accounting utilizing blended learning and PBL approaches. The researchers call this blended problem-based learning. They also increased the use of social media to support the successful implementation of blended learning. Social media that were widely used by the students included YouTube, Instagram, WhatsApp, and Facebook.

Research by [15] showed that YouTube is the social media video format that is most used by students and lecturers for learning purposes. YouTube is often used as a source of information and media for the publication of students' work. In addition, [13] demonstrated the benefits of using WhatsApp as the most popular messaging medium in all circles for learning purposes.

The use of social media includes learning media, learning resources, and others. The group discussion feature in WhatsApp or Telegram was utilized to the maximum; likewise, with the existence of Facebook's life features, Instagram TV, IG story, and others. The interaction between students and lecturers, and between the students, increased and learning was more fun and exciting.

The previous studies by [29] showed that the intention of students to utilize mobile learning is very high. The researchers developed a variety of interactive and Android-based learning media as well as learning materials or resources that were easily acces-

sible from students' mobile phones. Thus, students found it easier to study, wherever and whenever. The interactive media in question was an IT-based media that combined images, video, sound, and others. Android-based learning media that are increasingly popular continue to be developed. In addition, researchers produced flip books to facilitate the students' access to learning modules.

The learning approach used in this research was PBL. This method is considered suitable to be applied to accounting studies. Students solved various cases and problems so it invited students from the lowest level to the highest level to think.

Other researcher, [30] successfully developed and implemented a combination of blended learning and face-to-face PBL. The method is called blended problem-based learning. And [18] found that students' learning attitudes were better, although the effect was statistically insignificant. They also found that the problem-solving attitude of the experimental class students was better than the students in the control class, and this effect was statistically significant. Also [31] combined PBL with 3D virtual worlds so as to create an experience for students in a more complex and realistic environment. And [32] tried to apply an online problem-based learning approach by integrating games. The results showed the learning to be fun and exciting and able to achieve the stated learning goals.

3 Method

The type and design of the research used is classroom action research (CAR). CAR is a form of reflective study involving steps which are carried out by actors to increase the rational stability of the carrying out of their tasks, and to deepen the understanding of conditions in learning practices [33]. CAR is intended to fix and improve the quality of learning and help empower teachers to solve learning problems in schools [34].

The object of the research was the accounting students at the Faculty of Economics, Universitas Negeri Semarang. The research was conducted during September and October, 2019. The subject for the development of material in this research was Introduction to Accounting in the first semester of the academic year 2019-2020.

Documentation, observation, and testing were the data collection methods used. These methods were used to obtain data about the implementation of the steps carried out on the class. The data analysis method used was quantitative descriptive analysis. The research was seeking to produce interactive learning designs and apply the variety of media and teaching materials that had been produced by utilizing a Google Classroom-based learning management system (LMS).

4 Result and Discussion

The research that was carried out sought to develop a blended problem-based learning design for an introductory course in accounting. Classroom action research (CAR) was carried out in this study by running two CAR cycles. The results of the study are described in the following explanation.

4.1 Results of the implementation of cycle I

Plan: Research into the application of blended PBL began with developing lecture tools such as SLP (semester learning plans) and the required teaching materials. In Cycle I, the target competency is for students to be able to describe the basic concepts of accounting. Learning or study materials include accounting as an information system, the users of accounting information, the designation of accountants, types of companies, and basic accounting assumptions. The researchers used Google Classroom as an e-learning application because it is considered the simplest and easiest to use by lecturers and students. The object of the research is students enrolled in the 2019 International Accounting Education Graduate Program. The researchers also used Instagram social media to publish the students work in the form of mind maps. Mind maps are used as media to translate lecture material into a chart that is more interesting and easier to understand. The plan for this first cycle was to have two meetings.

The design of lectures in the first cycle was arranged so that students were able to present their acquired understanding of the basic concepts of accounting, in the form of an interesting mind map. The first cycle's implementation plan was as follows: The students were formed into groups and asked to study the lecture material first, then to make a mind map based on material from various sources that had been studied, and then post the mind map on one of the group members' Instagram accounts. At the second meeting, each group presented the results of the mind map that had been made and explained the material in front of the class, which then continued with a discussion. At the end of the meeting, students worked on a quiz which was used as a means to evaluate the course.

For the evaluation in this first cycle, researchers used the Google Forms feature which is integrated with Google Classroom, in the form of an online quiz. The assessment criteria in the first cycle are the ability to explain accounting as an information system and the ability to explain who the users of accounting information are, the designation of accountants, types of companies, and the basic concepts of accounting.

Action: Blended PBL in the first cycle was implemented well during the two meetings. At the first meeting, students in groups solved "problems" by studying lecture material and compiling a mind map. The materials reviewed during the first and second meetings were the basic concepts of accounting and financial statements. Students used their reference books and searched for material from internet sources to be able to compile an interesting and easy to understand mind map. Students were required to gain a complete and comprehensive understanding of the basic concepts of accounting and financial reports. The researchers prepared materials (stationery etc.) in the form of cardboard and colored markers for students to use to make their mind maps. The researchers also prepared teaching materials, and these were uploaded to Google Classroom.

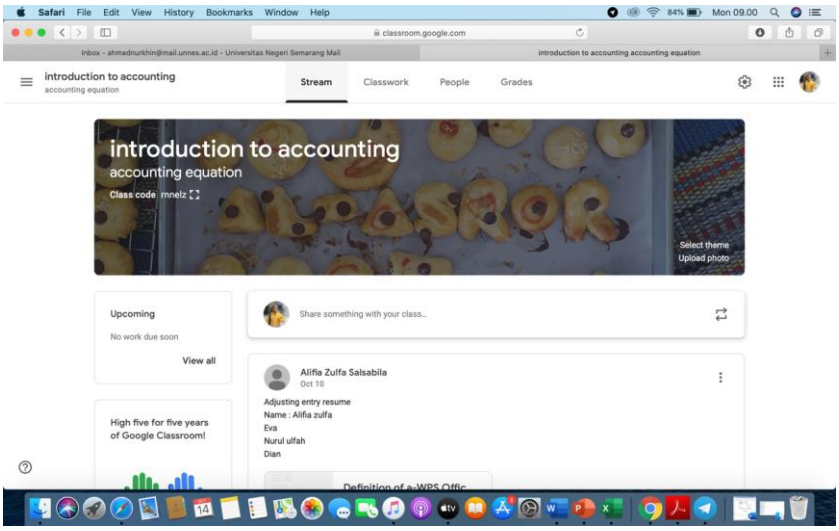

Fig. 1. Initial appearance of Google Classroom

The students were quite enthusiastic about learning the material and then together compiling the mind maps. They were also required to use critical and creative thinking skills to obtain sufficient material and record it down as a picture or chart (mind mapping). They could complete the task of compiling mind maps at the first meeting, which was a lecture which lasted for two hours. The researchers provided assistance and made observations while the lecture was in progress. At the end of the lecture, the students posted the completed mind maps to Instagram social media. The group work pictures and mind map results posted on group members' Instagram accounts can be seen in the following pictures.

Fig. 2. Group Discussion

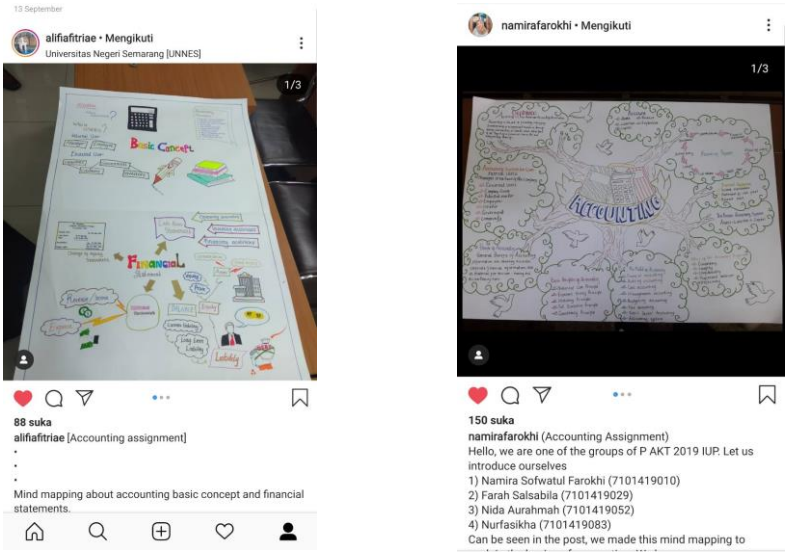

Fig. 3. Posting Work to an Instagram Account

Each group was asked to appoint one member to be the "presenter" at the second meeting. The presenter's qualifications were the ability to present material in front of the class, master the lecture material discussed, and have sufficient English language skills. The students who were appointed from each group had to study independently to prepare to present their explanations at the second meeting.

The second meeting began with presentations and questions and answers about the mind mapping that had been prepared by each group. The researchers had prepared rewards for the groups who were able to do the mind mapping and were able to present the results well. The students who represented each group took turns to become a "presenter" in front of the class with the mind mapping tools that had been prepared. The students were able to demonstrate their communication skills in front of the class quite well. This could be seen in the confidence they displayed and their mastery of the material discussed. They were able to use the time allotted (approximately 5-10 minutes) to explain the material in front of the class. There were students who added learning resources in the form of a short video and tips on understanding the material (concise elements of financial statements). This showed that the students had the ability to think critically and creatively in solving "problems" posed by the lecturer. The students were able to find the right sources and then were able to present them through the mind mapping, and explain them in front of the class.

Fig. 4. Students Presenting Their Work

The lecture process was continued by completing an online quiz that had been prepared by the lecturer (researcher). By utilizing one of the Google Forms that was integrated with Google Classroom, the researchers compiled online quizzes which could be done by the students quickly and accurately. The students were able to complete these online quizzes in just 10-15 minutes, with five multiple choice questions. There was a problem with the internet connection and English language skills were needed to complete this online quiz. However, in general, the students were able to complete it. The results of the online quiz can be seen in the following image.

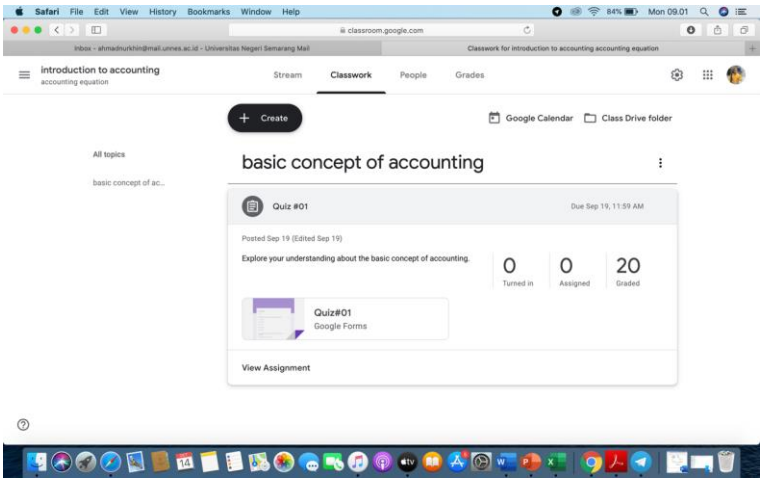

Fig. 5. Display of Online Quiz Timeline

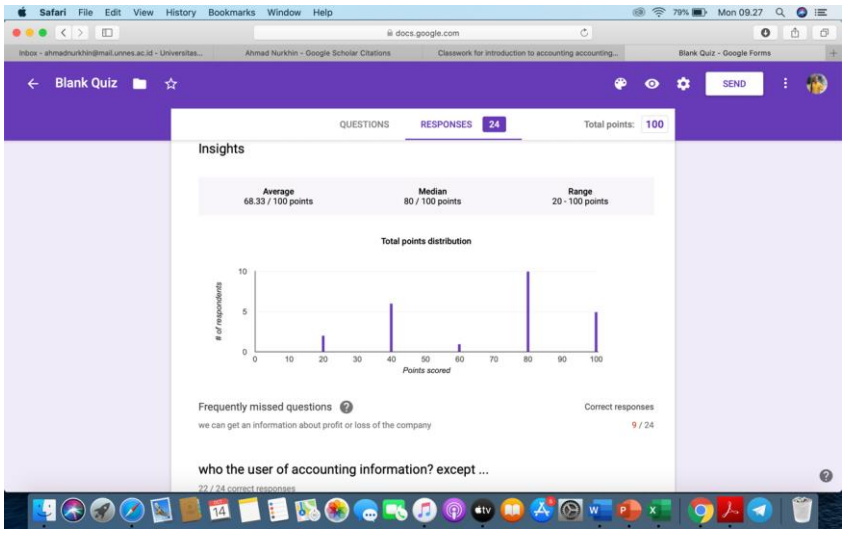

Fig. 6. Display of Online Quiz Results

The students and lecturers discussed the online quizzes together. The results of evaluations using online quizzes indicated that there were variations in the students' ability to understand the material about the basic concepts of accounting and financial statements. They had some difficulty in distinguishing between the different types of financial statements.

The lecturers continued the lecture by reviewing the material being studied and the learning process so far. The lecturers expressed appreciation for the performance and seriousness of students in solving problems through the online quiz. The lecturers gave rewards to all the students in the form of water bottles. The group that had the highest score, based on the results of the mind mapping and presentation, received a better reward than the other groups.

Observation: The observations that were made about the first cycle focused on the students' ability to engage in problem solving and their ability to think critically and creatively. The researchers observed the activeness and responses of students who attended the lecture and completed the assignments and other activities. The students were very enthusiastic about attending the lecture in the first cycle. The researchers provided an overview of the implementation of the lecture at the beginning, including activities and assignments. The students showed enthusiasm and were earnest about following the lecture process step by step. The students did not hesitate to ask about what to do.

In the first assignment, namely compiling mind maps as a medium for tackling problems that must be resolved, the students were able to work together with their respective groups to find learning resources and then turn them into mind maps. Each group was able to work well and able to complete the task correctly. Students' critical and creative thinking skills could be observed when they were searching for learning

resources, composing their mind maps, and presenting group work in front of the class.

The students' critical abilities were shown when they were searching for material from various sources via the internet. Each group read the material they found carefully, to gain a comprehensive understanding of the "problem" that had to be resolved, namely regarding the basic concepts of accounting and financial statements. They discussed the material obtained with the other members of their group. The aim was to understand the material being studied. Group members who understood more quickly were able to guide other group members.

The next thing to do was to make a mind map. Each group was able to discuss the mind mapping framework that would be created. Then each group member received their respective tasks to jointly complete the mind mapping project. The creative abilities of students were honed in completing the task of making the mind maps. This was evident from what they were able to complete. The mind maps made by the students were quite good and creative. The content or material listed in the mind maps was quite complete. The students were able to present the material well in the form of their mind maps.

The last observation the researcher made was at the presentation stage. Each group appointed their representatives as "presenters". Each group was able to present the mind mapping it had produced well and creatively. There were groups that added media such as videos and tips and tricks to understand the lecture material more easily. The students also demonstrated their confidence in presenting what they had produced in front of the class. They were very enthusiastic and confident. Their English language skills still need to be improved, but, despite this, they could be categorized as sufficient.

Reflection: The first cycle went well. However, there were some things that needed to be fixed. The researchers still needed to fully understand the method being applied. Implementing blended PBL is not easy. The students must be able to comprehend the "problems" that must be resolved in the face-to-face lectures combined with online lectures. The weakness seen in the first cycle was the researchers' mastery of utilizing Google Classroom. This was not surprising because the researchers had only just learned this feature of Google.

Utilization of the social media app called Instagram was quite appropriate as a medium for the publication of the work produced by the students. The students were also able to enjoy their lectures, starting with doing the mind mapping then presenting their work. The ability of the students, in terms of their cooperation and communication skills, fell within the good category. Likewise, the students' ability to think critically and creatively was categorized as good. Evaluation in the first cycle focused on measuring these abilities. An online quiz was taken by the students but it only measured the students' understanding after the treatment. Additionally, quantitative measurements of the students' cognitive abilities were needed for the implementation of the next cycle, both before and after the treatment had been given to the students.

4.2 Cycle II implementation results

Plan: The basic competency achieved in the second cycle was that the students were able to compile financial statements of service companies through the accounting cycle. Learning indicators included students being able to identify and analyze transactions, record transactions in a journal, categorize accounts, prepare a trial balance, prepare adjustments, and prepare financial reports. The design of the learning process in the second cycle was not too different from the implementation of the first cycle. However, in the second cycle, the researchers tended to implement the lecture method to provide an initial understanding of the material and also give emphasis to the material that students had learned. The researchers still used Google Classroom as an online learning medium.

The researchers carried out this second cycle in two lecture meetings. For the first meeting, the indicator was that the students would be able to analyze transaction documents, prepare a journal, categorize accounts, and prepare a trial balance. The second meeting discussed adjustments and work sheets and the preparation of the trial balance after adjustments. The material learned in the second cycle was very complex and required a fairly high degree of concentration by the students. The researchers had prepared teaching materials, practice questions, assignments, and evaluation questions, in order that the implementation of the second cycle would be interesting and pleasant.

Action: The blended PBL method applied in the second cycle can be described as follows in Table 1.

Table 1. Implementation of Blended PBL in the Second Cycle

Meeting	Description of Steps
First	The material presented was a journal, general ledger, and a trial balance. The researchers used the PBL method in the first meeting combined with the discussion lecture method. The researchers explained the material using the discussion lecture method for one hour of the lecture. They provided examples of problem solving. They provided practice questions to be solved by the students individually. The researchers discussed the matter of training with the students.
Second	The material discussed at the second meeting was about adjustments. The researchers applied blended PBL by utilizing Google Classroom. They provided learning materials for the students. As a group, the students were asked to study this material and then complete the "make a note" assignment. The students were invited to search for material from other sources in order to gain an easier and comprehensive understanding. They uploaded "make a note" tasks that had been completed according to the Google Classroom's time line. Researchers provided responses to these posts. The lecture continued with a quiz. The students individually completed the "problems" about adjustments in this quiz within 10 minutes. Corrections to the quiz were carried out together. Then the lecture continued with an explanation of the material by the researchers. After the quiz was finished, the researchers explained the material about adjustments with teaching materials that had been previously distributed. The researchers gave a second quiz after completing the explanation. However, the students were asked to pass on their understanding of the material just explained before the second quiz was carried out. The second quiz was also done individually and then discussed together. Students knew the progress of the results achieved in the first and second quizzes. Some students were satisfied because they understood enough, while others still lacked a good understanding. At the end of the meeting, the students solved the third "problem" about adjustments in

Meeting	Description of Steps
	groups. Group members who got good grades (meaning they understood the study materials) were obliged to provide an explanation to the other group members. The students were enthusiastic about solving problems in groups. Some students asked genuine questions that were not understood by other students.

The researchers twice gave a quiz during the second cycle, to find out about the students' understanding before and after the steps. Both quizzes discuss the "problem" of adjustments. The average value obtained by students on the first quiz was 37.5 and increased to 63.5 on the second quiz. There were four students (25%) who scored 0 on the first quiz. On the second quiz, there were no students who received a score of 0. However, there were two students who experienced a decline in their scores for the second quiz compared to the first quiz. Meanwhile, there were eight students (40%) who experienced a sharp increase in the scores they obtained on the second quiz compared to their scores from the first quiz. The results of the evaluation in the second cycle showed that the treatment given by the researchers was quite successful in terms of the increase in scores obtained by the students. However, the average score obtained on the second quiz (after treatment) still showed an unsatisfactory level of understanding.

Documentation of the implementation of the second cycle can be seen in the following pictures.

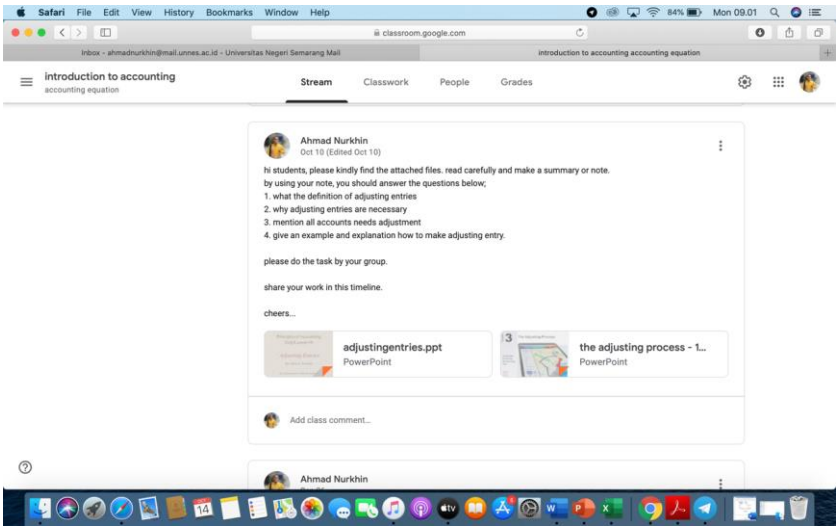

Fig. 7. Display of Posted Material and Assignments

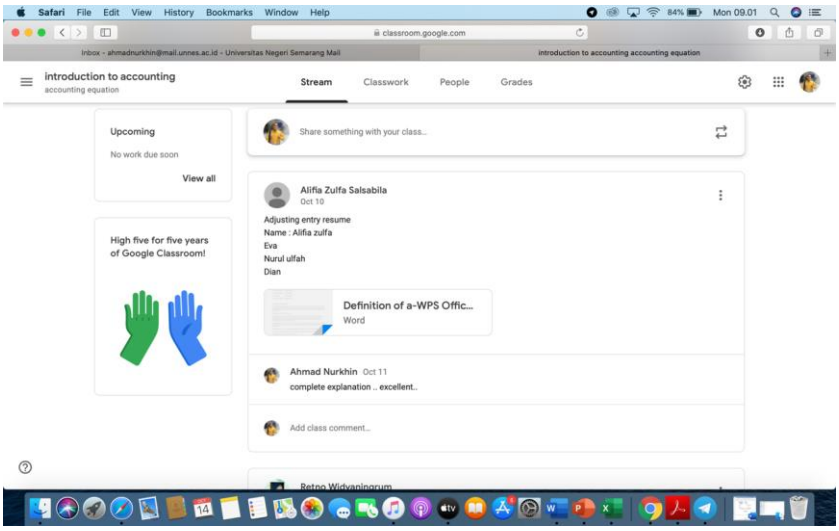

Fig. 8. Display of Student Postings on the "Make a Note" Assignments

Fig. 9. Students completing the quiz.

Observation: The observation of the implementation of the second cycle conducted by the researchers was intended to find the enthusiasm and level of student participation when attending lectures. The students were still very enthusiastic about attending lectures, because the activities and assignments were quite different and it was a

challenge for the students to complete them well. They were able to increase their confidence and not hesitate to ask their lecturers about problems they were experiencing. The students were able to complete their assignments in groups, similar to group learning, to understand the material about adjustments and then compile their "make a note" task together and post them to Google Classroom.

Reflection: The implementation of the second cycle in the application of blended problem-based learning ran well. The measurements of success were different from the first cycle. For the second cycle, the researchers used quantitative measurements to see the level of success. They found that the treatment given in the cycle was quite successful, although less than satisfactory. This can be seen in the increase in grades obtained by the students before and after the treatment.

The researchers still considered that the blended learning conducted in the second cycle was still not optimal. They only used Google Classroom to upload and post material and work from the students. There was no maximal interaction between lecturers and students, or between the students, through utilizing the existing features in Google Classroom. However, the researchers noted that the enthusiasm and the level of the students' participation in lectures had increased. The students were very motivated and enjoyed the lectures.

5 Conclusion

This research has been carried out by applying the blended PBL method to the Introduction to Accounting course in the first semester of the 2019-2020 academic year. Both stages of the research were carried out quite well and ran smoothly. The researchers carried out two cycles, and each cycle comprised two lecture meetings. In the first cycle, researchers used Google Classroom, mind mapping, online quizzes, and Instagram social media to improve interaction and the quality of lectures by applying blended problem-based learning.

The researchers focused on improving the students' critical and creative thinking skills in this first cycle. The results show that students had good critical and creative thinking skills. In the second cycle, researchers still continued to use Google Classroom and combined it with face-to-face lectures with "make a note" assignments and group discussions. The researchers conducted quantitative measurements to see the success of the treatment. The results showed that students were able to get better grades than before the treatment was given.

The researchers have demonstrated that blended PBL can improve the students' abilities. However, the application of blended problem-based learning in the second phase of research is still not optimal. Researchers should still be able to maximize the features of Google Classroom, so that learning is more interesting and enjoyable. In addition, they should be able to prepare better sources and teaching materials. It is hoped that future researchers will be able to improve the ability of online learning management systems so they can better implement blended PBL.

6 Acknowledgment

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8 Authors

Ahmad Nurkhin is a faculty member of the Faculty of Economics, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia. He works as a lecturer and researcher in the Department of Economic Education. His research fields are accounting education, Islamic accounting, and learning strategies and media.

Kardoyo is a faculty member of the Faculty of Economics, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia. He works as a lecturer and researcher in the Department of Economic Education. His research fields are economic education and management education.

Hengky Pramusinto is a faculty member of the Faculty of Economics, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia. He works as a lecturer and researcher in the Department of Economic Education. His research fields are office administration education and management information system.

Rediana Setiyani is a faculty member of the Faculty of Economics, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia. She works as a lecturer and researcher in the Department of Economic Education. Her research fields are accounting principles and statistics.

Ratieh Widhiastuti is a faculty member of the Faculty of Economics, Universitas Negeri Semarang, Semarang City, Central Java, Indonesia. She works as a lecturer and researcher in the Department of Economic Education. Her research fields are accounting principles and financial accounting.

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Research on Personalized Recommendations for Students' Learning Paths Based on Big Data

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Ziyu Liu, Liye Dong, Changli Wu (✉)
Hebei University of Science and Technology, Shijiazhuang, China
43174609@qq.com

Abstract—With the development of the Internet, the use of hybrid learning is spreading in colleges and universities across the country. The urgent problem now is how to improve the quality of hybrid learning; specifically, how to improve the learning effect of students under an online learning mode. In this paper, we build an online learning path model by exploring the big data of students' online learning processes. The model can be used to find excellent learning paths. Based on students' learning habits, we recommend personalized and excellent learning paths with a high degree of similarity for general students. By comparison, experimental results indicate that our proposed methods not only provide sound recommendations regarding appropriate learning paths with significantly improved learning results in terms of accuracy and efficiency, but our methods also provide support that helps to improve teaching quality, promote personalized learning and target teaching.

Keywords—Big data, learning path, similarity, personalized recommendation

1 Introduction

Today's classroom design and large-scale online courses have fundamentally changed the mode and accessibility of both learning and teaching; they have also significantly affected the academic research into and teaching of higher education. In a traditional face-to-face classroom, the students' dominant position cannot be well reflected. However, only learning online is also not conducive to the students' systematic management and mastery of knowledge. In order to integrate the advantages of the traditional classroom and online learning, and reform the inherent teaching modes and methods, the international education community initially proposed the idea of hybrid learning at the end of the 20th century. Since then, research on hybrid learning has attracted more and more attention. As institutions of higher education began to adopt the hybrid teaching method, more began to learn online. In addition, mechanisms were put in place to record the online and offline learning teaching log data. Faced with massive amounts of data, researchers use different ways to obtain teachers' learning log data. They analyze the learning log data from different perspectives, in order to uncover the best possible learning path. However, different teachers have different teaching habits and styles. With the

increase in the number of personalized teachers, the best learning path (discovered by researchers) is difficult to adapt to each type of student. Therefore, the recommendation of an adaptive personalized excellent learning path has become a research hotspot. These studies will be of great reference value with regard to improving students' learning effect and teachers' personalized teaching methods.

To provide teachers with personalized learning content and an adaptive teaching style, two major problems need to be solved. The first is the mining of both the learning path and the excellent learning path. The second is to find the shortcomings of the general learning path and to recommend the personalized learning path. According to the problems mentioned above, this paper uses process mining technology to mine the excellent learning path. Then, the matrix process similarity principle is used to recommend the best teaching process and resources for each student. It should be noted that the first time "learner" is used, that in this paper, "learner" means student.

2 Related Work

2.1 Learning process optimization

In the era of education informatization 2.0, technologies such as digital teaching resources and telecommunications were developed. These technologies promoted mobile learning based on mobile Internet and smartphones, and gradually became the most recent trend of education development [1]. With hybrid teaching currently in full swing, the study of learning process optimization is now being developed from various aspects.

Yang et al. proposed an important learning method that meets the individual needs of learners and which applies to lifelong learning. The method is fragmentation learning, which can improve and consolidate the knowledge acquired in the learning process [2]. Zhao et al. hold that educational technology is the theory and practice of designing, developing, utilizing, managing and evaluating the learning process and resources. The learning process can be optimized by using changes in educational technology [3]. Xie et al. found a suitable learning path for a group of teachers (rather than a single teacher) in an e-learning environment, through the framework of a profile-based group learning path [4]. Yang Lin et al. proposed a method based on the knowledge concept network topology. The method was created to optimize the learning path. This method uses different networks connected by related concepts to represent different domain knowledge, in order to analyze the concept of the correlation between the massive data in the learning process [5]. Lin et al. used relevant data, such as learning time, playing days and learning chapters, to cluster the learning behavior of different groups by a K-Mean clustering method. By discussing the relationship between learning behavior and learning outcomes, a proposal for learning process optimization was proposed [6]. Zhou et al. used clustering and machine learning techniques to predict their learning path and learning effect. The

study then puts forward suggestions regarding how to optimize the learning process [7].

Existing research into the learning process mainly elaborates the learning process from the macro perspective of the learning environment, learning groups, and learning behavior. These studies also put forward some general suggestions on how to optimize the learning process. However, due to the differences in students' learning habits, learning styles and learning processes, being able to recommend personalized learning paths for different students is particularly important.

2.2 Personalized learning process recommendations

Resnick proposed the concept of personalized recommendations in 1994 [8]. Since then, personalized recommendation technology has become a research hotspot. De-Marcos et al. believed that making a learning resource recommendation is a multi-objective combinatorial optimization problem. Modeling teachers to optimize and combine the content and sequence of appropriate learning resources was declared to be the most critical technology [9]. Liu Min et al. analyzed the teaching style, online teaching preferences, the teacher's knowledge structure, the teacher's online teaching behavior, and the results. The study then made personalized recommendation settings for the content, type, recommendation time and frequency of learning resources [10]. Avi et al. proposed a personalized teaching content algorithm which combines a collaborative filtering algorithm with voting methods [11]. Vanitha et al. presented a collaborative optimization algorithm, combining ant colony optimization and a genetic algorithm to provide learners with a personalized learning path [12]. Huang et al. put forward the framework of a personalized learning resources recommendation system. The system is based on a knowledge map, which provides a technical solution for the establishment of a personalized learning resources recommendation system [13]. In order to meet the needs of different teachers for learning paths, Liu et al. proposed an intelligent learning path recommendation model based on an ant colony algorithm, which could be used for the personalized customization of learning paths in an intelligent learning environment [14].

The personalized research provided a useful reference point for the personalized path recommendation in this paper, mainly from the aspects of learning resources, learning behavior, teaching content, etc. However, few studies examine personalized recommendations from the aspect of a student's learning path. In this paper, we first mine the learning paths of excellent students by using process mining technology. Then, we use the similarity principle of learning paths to recommend excellent learning paths for students with average or poor grades. Finally, we put forward optimization suggestions to improve students' curriculum performance.

3 Learning Path Personalized Recommendation Method

The learning path refers to the route and sequence of learning activities. It is the ordering of the learning activities that the learners need to complete, and this must be

done according to the learning objectives and learning content, under the guidance of certain learning strategies [15]. It is possible that the study of learning paths will not only provide learners with a clear learning route and improve students' learning efficiency, but such study can also serve as the basis upon which managers can evaluate students' learning.

In this paper, the personalized recommendation method of the learning path was mainly studied from three aspects: data preparation, excellent learning path mining and the personalized recommendation of a learning path. Firstly, we collected and organized data during the data preparation phase. Secondly, process mining technology was used to mine the learning logs of excellent students. The excellent learning path models were formed as the basis for the recommendation of the learning path for ordinary students or students with poor grades. Then, the personalized learning path recommendation was proposed by calculating the similarity of the learning paths. Finally, based on the gap between the excellent path and the general path, we suggest ways to optimize the learning path. The specific research route is shown in Fig. 1.

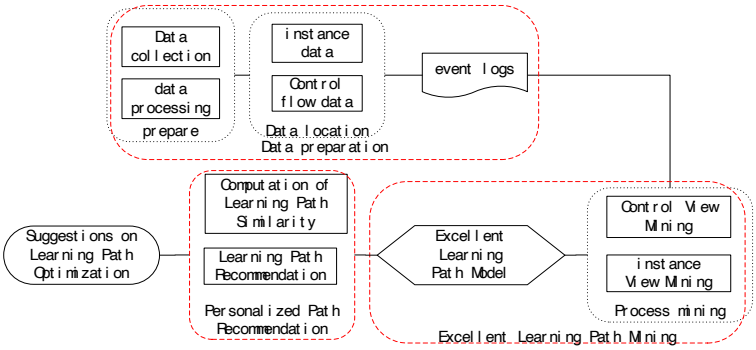

Fig. 1. Steps of personalized learning path recommendation

4 Data Preperation

4.1 Data acquisition

The data in this paper are from the learning website platform of Hebei University of Science and Technology. We took the Electronic Commerce System Analysis and Design course at level 15 and level 16 as an example, in order to analyze the learning path of online students. This is the platform for online learning: the teachers publish online learning tasks in the teacher's backstage system. After class, the students should watch videos or download materials to complete the tasks independently. Teachers need to enter their own system to check and score students' task work. In the student operation interface, there is a separate discussion area, as well as facilities for video learning, data downloading, job viewing, and job submission. In the discussion area, students can publish questions with regard to topics or problems they don't

understand and then wait for responses from their classmates or teachers. In addition, students can directly reply to the published questions in the discussion area, in order to help other students to understand and obtain the corresponding and relevant knowledge. Video learning and data learning can be either viewed online or downloaded. Students can view assignments and submit completed assignments on the job review page.

In the Electronic Commerce System Analysis and Design course, the teacher published seven learning tasks, each of which was graded. For each task, the teacher awarded the students one of five grades, from A-E. After communicating with the administrator, we obtained the learning logs of the two classes. Then, we sorted out the seven learning path logs of the 57 students with a grade A as excellent path mining logs.

4.2 Data procession

The collected data were generally messy and disorderly; it needed to be cleaned and organized. The ID numbers of the data directly obtained from the learning website platform were not continuous, and we needed to organize the learning events by each student. As repetitive events were inevitable in the student learning process, we needed to organize the same event log by time, in order to ensure the reliability of mining. In addition, the Prom (process mining software) needs the data that is the XES structure. Therefore, it was necessary to convert the log from CSV format into XES format (shown below in Fig. 2). This data used the plug-in in the Prom process mining software, which can convert CSV into the required XES structure. The data used the plug-in in the Prom process mining software which can convert CSV into XES structure of the Prom process mining software to change the data format (the plug-in shown in Fig.2).

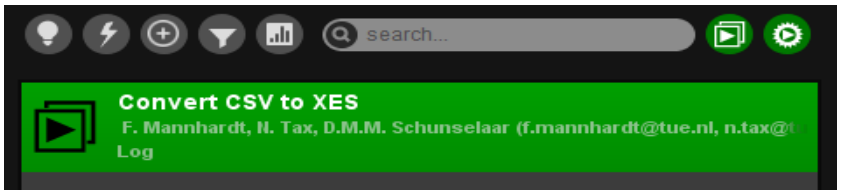

Fig. 2. The Plug-in for changing CSV to XES in Prom

The XES program code is as follows:

```
  <?xml version="1.0" encoding="UTF-8" ?>
  <!-- This file has been generated with the OpenXES
library. It conforms -->
  <!-- to the XML serialization of the XES standard for
log storage and -->
  <!-- management. -->
  <!-- XES standard version: 1.0 -->
```

```
  <!-- OpenXES library version: 1.0RC7 -->
  <!-- OpenXES is available from http://www.openxes.org/
-->
  <log xes.version="1.0" xes.features="nested-attributes"
openxes.version="1.0RC7">
    <extension name="Lifecycle" prefix="lifecycle"
uri="http://www.xes-standard.org/lifecycle.xesext"/>
    <extension name="Time" prefix="time"
uri="http://www.xes-standard.org/time.xesext"/>
    <extension name="Concept" prefix="concept"
uri="http://www.xes-standard.org/concept.xesext"/>
    <classifier name="Event Name" keys="concept:name"/>
    <classifier name="(Event Name AND Lifecycle
transition)" keys="concept:name lifecycle:transition"/>
    <string key="concept:name" value="XES Event Log"/>
    <trace>
      <string key="concept:name" value="commented"/>
      <event>
        <string key="concept:instance" value="0"/>
        <string key="lifecycle:transition" value="start"/>
        <date key="time:timestamp" value="2019-09-
09T10:13:00.000+08:00"/>
        <string
  ......
```


5 Excellent Learning Path Mining

Process mining, also called workflow mining, was initially proposed by R. Agrawal in 1998. Process mining refers to those methods that extract the structured process description from the actual execution set. The purpose of process mining is to extract information from log data, establish a clear process model, and ensure that the process model being built is consistent with the actual process.

The Prom counted students' learning paths after the data were transformed into XES. The Fig. 4 shows the 389 learning paths and 4011 events found in the log summary. After visualizing the learning paths, you can see that there are five frequent learning paths (shown in Fig. 5).

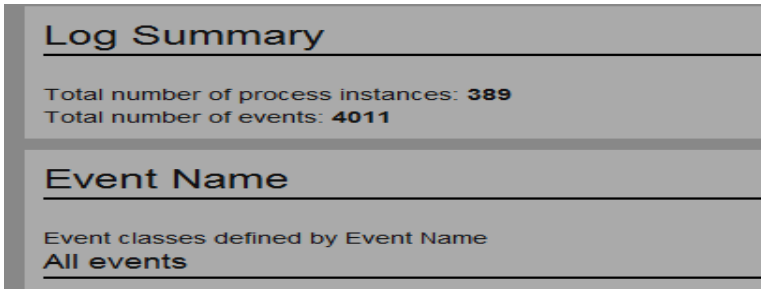

Fig. 3. Screenshot of path statistics

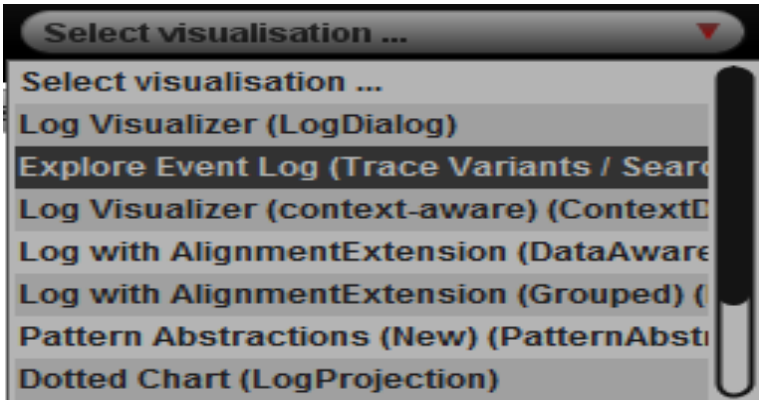

Fig. 4. Screenshot of path visualization

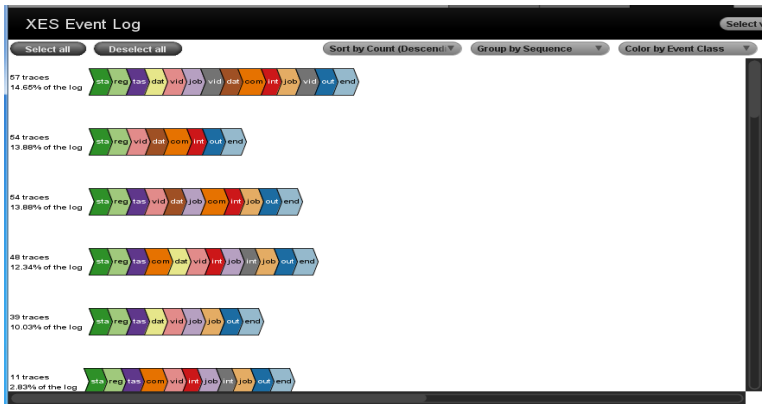

Fig. 5. Visualization of frequent learning paths

By selecting the visual items in Fig. 4, the Prom is able to show the learning paths in Fig. 5. Also, Fig. 5 shows that the first five learning paths account for more than 60% of the 389 total learning paths. We regarded the first five learning paths as frequent excellent learning paths for analysis purposes. We classified the frequent

excellent learning paths into five learning styles: discovery learning, discussive learning, exploratory learning, cooperative learning, and task-based learning.

1. **Discovery learning**: This learning path can be mapped as follows: start→register→taskviewed→datadownloaded→videoviewed→jobviewed→video viewed2→dataviewed→commented→interacted→jobfinished→exit→end. The feature of this learning path is that students will download the relevant data and learn the relevant video data after entering the website. Then, they do their homework according to the learning content. In the task completion process, if there is something that students do not understand, they will first study independently and then discuss the task with each other, in order to finally complete the job.
2. **Exploratory learning**: This learning path can be mapped as follows: start→register→videoviewed→dataviewed→commented→interacted→exit→end. The feature of this learning path is that students do not study for the purpose of finishing the job; rather, they learn and discuss the contents independently. These types of students generally have better consciousness.
3. **Cooperative learning**: This learning path can be mapped as follows: start→register→taskviewed→videoviewed→dataviewed→jobviewed→commente d→interacted→jobfinished→exit→end. The feature of this learning path is that students will first seek cooperation. Then, they will complete the finished task through discussion and cooperation when they don't understand something in the job completion process.
4. **Discussive learning**: This learning path can be mapped as follows: start→register→taskviewed→commented→datadownloaded→videoviewed→com mented2→jobviewed→interacted→jobfinished→exit→end. The feature of this learning path is that the frequency of discussion is obviously higher than the frequency of video learning. As such, students complete the final job through interaction and discussing the problem.
5. **Task-based learning**: This learning path can be mapped as follows: start→register→taskviewed→datadownloaded→videoviewed→jobviewed→jobfin ished→exit→end. The feature of this learning path is that the only reason these students enter the website is to submit the job. They usually don't spend too much time online. On the contrary, they usually perform better in an offline learning environment.

Through the excellent learning paths detailed above, we can clearly and intuitively see the learning path of learners, which are mined using process mining technology as applied to the mining of learning paths. The excellent learning path provides a reference for students with general or poor academic performance. In addition, using process mining technology to mine learning paths may not only provide a clear learning path for learners and improve students' learning efficiency, but this method may also provide a basis for helping managers to evaluate students' learning.

6 Deviation Analysis About General Path and Personalized Recommendations

Student path recommendations should be based on a student's existing learning habits. The above five learning paths are the most frequent of all excellent learning paths, which represent five learning behavior habits, respectively. When recommending learning paths to a general student, we need to discover the characteristics of that general students' learning path, in order to recommend a similar learning path. Based on the above analysis, this paper will use the similarity method of the matrix process to recommend the most excellent learning path.

6.1 Similarity of matrix processes

The difference between two numbers can be obtained by subtraction. The smaller the value is, the closer the two values are. Similarly, two processes can also derive a similarity value by subtracting one from the other. This similarity value can be used to indicate the similarity between two processes [16]. However, the process cannot be subtracted directly, so the existing methods basically measure the similarity of the process by calculating the distance of the graph. In this paper, we calculate the similarity value according to the matrix of the learning process. Specifically, it is assumed that PM and PM', respectively, represent a matrix corresponding to an excellent learning process and a general learning process. The difference matrix (DM) can be obtained by subtracting the corresponding elements of the two matrices. Then, we calculate the absolute values of each element in the DM, and the absolute values are summed to represent the difference between the matrices. The number of rows and columns of a matrix may be unequal. Therefore, if we want to subtract two matrices, we should first normalize the matrices and convert them into matrices with equal numbers of rows and columns. The definition of matrix standardization is as follows:

6-1(Standardization of Matrix): Suppose that NM and NM' represent the standard matrices corresponding to PM and PM', respectively. The construction method of the standard matrix can then be completed in the following steps:

6. The number of rows and columns of the two standard matrices should be equal, and the number of rows and columns is equal to the number of sets of all events.
7. In the standard matrix, the relationship between events is expressed by a unified subscript. The subscript positions of two events in different sequences are identical in the standard matrix.
8. In the standard matrix, the relationship between events is expressed by a unified subscr NM (i, j). Also, NM (i, j)' represent elements of Row i and Column j in NM and NM, and their element values are expressed in the following form (where transition indicates a mapping relationship between two events) :

$$NM(i,j)=\begin{cases}1 & transition\\ 0 & otherwise\end{cases},\quad NM'(i,j)=\begin{cases}1 & transition\\ 0 & otherwise\end{cases}$$

According to the definition, the discovery learning path can transform into a standard matrix, as shown in Fig. 6, and the discussive learning path can convert into a standard matrix, as shown in Fig. 7. The rest of the learning path standard matrix is omitted.

$$\begin{bmatrix}
 & start & reg & task & datd & video & jobv & video2 & datav & com & \text{int} & jobf & video3 & out & end \\
start & & 1 & & & & & & & & & & & & \\
reg & & & 1 & & & & & & & & & & & \\
task & & & & 1 & & & & & & & & & & \\
datd & & & & & 1 & & & & & & & & & \\
video & & & & & & 1 & & & & & & & & \\
jobv & & & & & & & 1 & & & & & & & \\
video2 & & & & & & & & 1 & & & & & & \\
datav & & & & & & & & & 1 & & & & & \\
com & & & & & & & & & & 1 & & & & \\
\text{int} & & & & & & & & & & & 1 & & & \\
jobf & & & & & & & & & & & & 1 & & \\
video3 & & & & & & & & & & & & & 1 & \\
out & & & & & & & & & & & & & & 1 \\
end & & & & & & & & & & & & & &
\end{bmatrix}$$

Fig. 6. Discovery learning standard matrix

$$\begin{bmatrix}
 & start & reg & task & datd & video & jobv & video2 & datav & com & \text{int} & jobf & video3 & out & end \\
start & & 1 & & & & & & & & & & & & \\
reg & & & 1 & & & & & & & & & & & \\
task & & & & & & & & & 1 & & & & & \\
datd & & & & & 1 & & & & & & & & & \\
video & & & & & & & & & & 1 & & & & \\
jobv & & & & & & & & & & 1 & & & & \\
video2 & & & & & & & & & & & & & & \\
datav & & & & & & & & & & & & & & \\
com & & & & 1 & & & & & & & & & & \\
\text{int} & & & & & & 1 & & & & & 1 & & & \\
jobf & & & & & & & & & & & & & 1 & \\
video3 & & & & & & & & & & & & & & \\
out & & & & & & & & & & & & & 1 & \\
end & & & & & & & & & & & & & &
\end{bmatrix}$$

Fig. 7. Discussive learning standard matrix

6.2 Learning process similarity calculation

(Matrix distance similarity MDS): The number of elements of NM(i,j)≠0 and NM'(i,j)≠0 is represented by N0; N1 stands for NM(i,j)≠0, and N2 represents the number of elements of NM'(i,j)≠0. By subtracting the elements corresponding to the positions in the two standard matrices of NM and NM', we will obtain a difference matrix DM=NM-NM'. We take the absolute value for every element in DM and get the absolute value matrix |DM|. The similarity between processes can be calculated by Formula (1) as follows:

$$MDS(PM, PM') = 1 - \frac{\sum_{(i,j)} |DM(i,j)|}{N_1 + N_2 - N_0} \tag{1}$$

The similarity result must be a value between 0 and 1. The following is an analysis of Formula (1) :

The maximum value of MDS(PM, PM') is 1.

When PM and PM' represent the same path, the path matrices of the PM and PM' must be the same, and their standard matrices NM and NM' must be the same. Then :

$$\sum_{(i,j)} |DM(i,j)| = 0 \Rightarrow MDS(PM, PM') = 1 \tag{2}$$

The minimum value of MDS（PM,PM'）is 0.

When PM and PM' represent completely different paths, this means that the transition of events in their event sets are different from each other. Then :

$$\sum_{(i,j)} |DM(i,j)| = N_1 + N_2 - N_0 \Rightarrow MDS(PM, PM') = 0 \tag{3}$$

The general learning path of one of the students is shown in Fig. 8. Then, Fig. 9 shows the DM between the general learning path and the discovery learning path. Finally, Fig. 10 shows the DM between the general learning path and the discussive learning path. After using the above principle to calculate the similarity, we can see that the path of this student is MDS (PM, PM') = 0.35, compared with the discovery learning path. Compared with the discussive learning path, the student's path similarity is MDS (PM, PM') = 0.73. Therefore, it can be seen from the MDS that the discussive learning path is more suitable for this student.

We can find that this student is more suited to the discussive learning path from the differences in learning paths. However, the student lacks elements such as data download, video learning and problem publication in the discussion learning path. From the learning path, you can see that the student only paid attention to the discussion of the problem in the process of learning, but neglected the self-improvement element of learning. The advice for the student is to post questions to the website and discuss the possible answers with classmates after viewing the assignments. However, before solving the problem with other students, the student should first learn to solve the problems that he/she can solve on his/her own. Self-learning methods include video learning and data downloading. In the end, the results of the discussion can be seen in the comments section. Of course, students can also publish the problems they have solved and share resources to achieve self-learning.

$$
\begin{array}{c}
\begin{array}{ccccccccccccccc}
 & start & reg & task & datd & video & jobv & video2 & datav & com & \text{int} & jobf & video3 & out & end
\end{array} \\
\begin{bmatrix}
start & & 1 & & & & & & & & & & & & \\
reg & & & 1 & & & & & & & & & & & \\
task & & & & & & & & & 1 & & & & & \\
datd & & & & & & & & & & & & & & \\
video & & & & & & & & & & & & & & \\
jobv & & & & & & & & & & 1 & & & & \\
video2 & & & & & & & & & & & & & & \\
datav & & & & & & & & & & & & & & \\
com & & & & & & & & & & & & & & \\
\text{int} & & & & & & 1 & & & & & 1 & & & \\
jobf & & & & & & & & & & & & & 1 & \\
video3 & & & & & & & & & & & & & & \\
out & & & & & & & & & & & & & 1 & \\
end & & & & & & & & & & & & & &
\end{bmatrix}
\end{array}
$$

Fig. 8. General learning standard matrix

$$
\begin{array}{c}
\begin{array}{ccccccccccccccc}
 & start & reg & task & datd & video & jobv & video2 & datav & com & \text{int} & jobf & video3 & out & end
\end{array} \\
\begin{bmatrix}
start & & & & & & & & & & & & & & \\
reg & & & & & & & & & & & & & & \\
task & & & & 1 & & & & & -1 & & & & & \\
datd & & & & & 1 & & & & & & & & & \\
video & & & & & & 1 & & & & & & & & \\
jobv & & & & & & & 1 & & & -1 & & & & \\
video2 & & & & & & & & 1 & & & & & & \\
datav & & & & & & & & & 1 & & & & & \\
com & & & & & & -1 & & & & 1 & & & & \\
\text{int} & & & & & & & & & & & & & & \\
jobf & & & & & & & & & & & & & -1 & \\
video3 & & & & & & & & & & & & & & \\
out & & & & & & & & & & & & & & \\
end & & & & & & & & & & & & & &
\end{bmatrix}
\end{array}
$$

Fig. 9. Difference matrix (DM) between general learning and discovery learning

$$
\begin{array}{c}
\begin{array}{ccccccccccccccc}
 & start & reg & task & datd & video & jobv & video2 & datav & com & \text{int} & jobf & video3 & out & end
\end{array} \\
\begin{bmatrix}
start & & & & & & & & & & & & & & \\
reg & & & & & & & & & & & & & & \\
task & & & & & & & & & & & & & & \\
datd & & & & & 1 & & & & & & & & & \\
video & & & & & & & & & & 1 & & & & \\
jobv & & & & & & & & & & & & & & \\
video2 & & & & & & & & & & & & & & \\
datav & & & & & & & & & & & & & & \\
com & & & & 1 & & & & & & & & & & \\
\text{int} & & & & & & & & & & & & & & \\
jobf & & & & & & & & & & & & & & \\
video3 & & & & & & & & & & & & & & \\
out & & & & & & & & & & & & & & \\
end & & & & & & & & & & & & & &
\end{bmatrix}
\end{array}
$$

Fig. 10. Difference matrix (DM) between general learning and discussive learning

In the case of paths that receive fewer recommendations, the similarity of matrix processes method is appropriative to this paper. This method is not only able to calculate the gap between the path of ordinary students and excellent students, but it can also directly see the differences of their learning paths and discover the shortcomings of general students and students with poor performance. Therefore, this method can offer a proposal regarding learning path optimization.

7 The Analysis of Learning Effect

7.1 Analysis of experimental results

Based on the above research methods, this paper conducted an experimental study of the personalized recommendation of learning paths. The study involved 60 students who had average or poor academic performance. Of that group, 30 students used personalized recommendations to learn. We named these students the experimental group. The other 30 students continued to learn in their own way, and they are referred to as the free group. The experimental results are shown in Figs. 11 and 12 (abscissa represents students and ordinate represents scores).

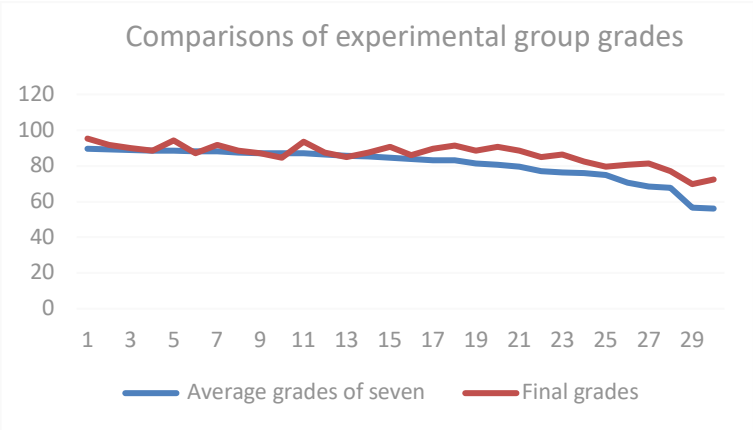

Fig. 11. Results in experimental group

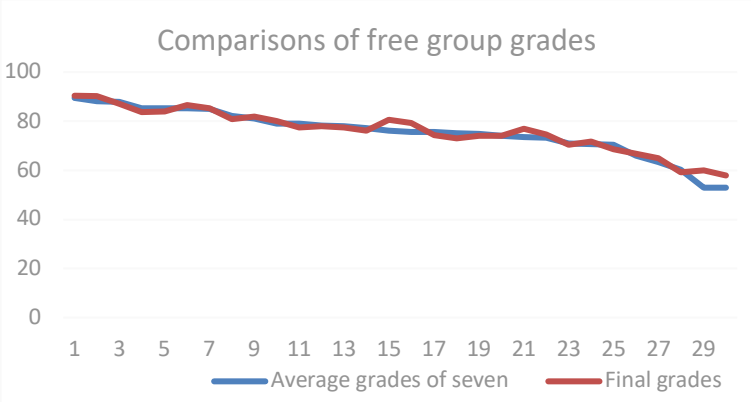

Fig. 12. Results in free group

Table 1. Analysis of experimental results

Items	Learning pattern groups	
	Experimental group	***Free group***
Number of learners	30	30
Number of grade raisers	17（57%）	3（10%）
Number of equals in grades	12（40%）	26（87%）
Number of grade backsliders	1（3%）	1（3%）

From the experimental results shown in Fig. 11 and Fig. 12, the scores of the students in the experimental group can be seen to have significantly improved, while the scores of the students in the free group did not change to any significant degree. In addition, as can be seen from Table 1, the grades of the students in the experimental group improved significantly. Meanwhile, in the free group, the students' grades are not significantly different from their previous grades. The above results show that the use of process mining technology and the path similarity method is very helpful in improving students' learning effect.

7.2 Discussion

Many studies have been done that examine learning paths and personalized learning recommendations. The research results in this paper are consistent with the research results of Lin Qilin [6] et al., which were based on the clustering of student groups. All such studies show that learners' behavior has a great impact on learning effectiveness. In addition to the study of group characteristics, Dwivedi [12] et al. studied learners' learning style and knowledge level by using a variable length genetic algorithm. This study also believes that personalized learning style research and learning resource recommendations are of great help to students trying to improve their academic performance. In general, whether it is the study of group learning path or the study of the recommendation of the learning path of knowledge of a single

student, from the experimental results, both can improve the learning effect of students and the management level of teachers. In addition, the academic performance and learning style of many experimental participants in this paper were different. This was very consistent with the personalized recommendation theory of the different learning styles of Huang Huasheng [13]. This indicates that the recommendation of personalized learning paths is also of great significance to the improvement of students' academic performance. All the above studies can show and support the significance of this study.

8 Conclusion

In this paper, a new personalized learning path recommendation method based on students' learning style is proposed, based on the in-depth mining of online students' learning logs. Firstly, the method applies a process mining technique to mining a students' learning path and obtained an excellent learning path with a general learning path. Secondly, the principle of process similarity is applied, in order to recommend excellent learning paths for students with general or poor grades, based on their individual learning styles.

This study proposes the personalized recommendation of an excellent learning path from the theoretical level. This further lays a theoretical foundation for the subsequent accurate personalized learning path recommendation of products. At the same time, in the field of people-oriented personalized education, teaching students in accordance with their aptitudes under the proposed concept provides a fresh idea in how to improve the learning effect of students and optimize the management of teachers.

The disadvantage of this paper is using the 0-1 matrix. The event occurrence is 1, the event did not occur is 0, and the duration of the event is not taken into account. In addition, the path recommendation of the computer system is not perfect enough, so it can only recommend the path for a single student. Future research will conduct empirical research based on the above theories, so as to iteratively modify the personalized recommendation model of the learning path and form a complete and effective computer recommendation system.

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11 Authors

Ziyu LIU received a B. Eng. degree in Detection Technology and Instrumentation from Hebei Polytechnic University, China, in 1998. She received a Master's degree in Information Management from Hebei University of Science and Technology, China, in 2003. She received a PhD degree in Information Management from Beijing Jiaotong University, China, in 2010. She now works with Hebei University of Science and Technology, Shijiazhuang, China. Her main research areas include knowledge management, ontology and data mining. Email: purpleyuliu@163.com.

Liye DONG received a B. Eng. degree in Engineering Management from Hebei University of Science and Technology, China, in 2017. She is now a Master's degree student at Hebei University of Science and Technology, Shijiazhuang, China. Her main research area is logistics strategy optimization. Email: 1213889850@qq.com

Changli WU received a B. Eng. degree in Management Engineering from Hebei Institute of Mechatronics, China, in 1994. She received a Master's degree in Information Management from Hebei Polytechnic University, China, in 2003. She works with Hebei University of Science and Technology, Shijiazhuang, China since 2003. Her courses include Management, Production Management and others. She has participated in more than 10 provincial, ministerial and bureau level projects and published more than 10 papers. Email: 43174609@qq.com

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Mobile Application Development for Technology Enhanced Learning: An Applied Study on the Students of the College of Mass Communication at Ajman University

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Nidal Al Said
Ajman University, Ajman, UAE
n.alsaid@ajman.ac.ae

Abstract—Educational applications play an important role in modern education. Based on this, the objectives of this study are as follows: analyze a student interview (focus group) that has been conducted among University student of college of Mass Communication at Ajman University; determine the characteristics of educational applications; find out possible advantages and disadvantages of educational applications; formulate, including based on a student interview, criteria for choosing educational applications; divide educational applications into different categories to more fully see the academic possibilities of their use; develop student skills. Based on the objectives, it is decided to divide the study into two parts. The first step is to analyze semi-structured interviews that have been conducted with students. In the second part of the study, a list of educational applications is compiled, indicating their educational categories.

Keywords—Mobile application development; technologies in education; modern education; distance learning; mass communication; student skills development.

1 Introduction

Over the past decade, the use of mobile devices has increased dramatically [1, 2]. According to a recent study, more than a third of American children under two years old have used mobile devices to access media [3]. More and more young children use various mobile devices for communication, learning and games [4]. Thus, many researchers and teachers are increasingly interested in the possibilities of mobile learning and are exploring ways to effectively use mobile devices for teaching children [5, 6]. Due to the simplicity of portability, touch screens, and improvements to user interfaces, researchers expect mobile devices to offer tremendous educational potential, especially for young children in preschools and kindergartens [7].

Mobile technologies (smartphones and tablet computers) can use other technological applications, such as e-books, digital video materials, podcasts, social networks and cloud computing [7]. Studying the educational potential of mobile devices for children is important and increasingly relevant. In 2011, the research team

Common Sense Media conducted a study on the use of the media by children from 0 to 8 years old throughout America. Just two years later, they repeated their study and found a sharp increase in the access of young children to mobile devices and their use. Young children often cannot make individual decisions about when and how they will use mobile devices. Thus, parents, teachers and guardians have the primary responsibility for such an increased use and will continue to play a major role in deciding when, where and how content will be viewed on mobile devices by children [8].

Due to the sharp increase in the use of mobile devices, many have wondered how these devices will affect learning. Currently, five mobile learning opportunities are being identified:

- Encouraging learning anywhere, anytime
- Covering children from low-income families
- Improving social interactions in the 21st century
- Fitting the learning environment
- Providing personalized learning experience [9]

These capabilities are associated with the continuous (transition from device to device and/or context to context) and ubiquitous (increasingly open access anywhere at any time) nature of mobile devices. Mobile devices are increasingly blurring the line between learning activities at school and at home. Thus, a child can learn at any time of the day. For example, children can use the app to learn the alphabet when traveling with their parents in a car, play development games while sitting in a shopping basket, or access facts about the local environment while walking in a local park [10].

While these opportunities are exciting and encouraging, it is also important to consider the challenges associated with integrating mobile learning into children's daily lives [11]. Three categories of mobile learning problems can be defined: social, theoretical, and technological. Social problems with mobile learning for young children arise mainly due to concerns about the time spent in front of the screen. This can hinder the development of self-regulation, social skills, practical skills, communication and interpersonal skills, teamwork and sensorimotor skills [12 13]. The theoretical problem for researchers and developers in the field of mobile learning is as follows. Namely, there is no unique structure or general theory that would guide the development of effective mobile learning environments. In addition, there are some technical problems associated with the use of mobile devices for educational purposes. Designers should create applications that run on a relatively small screen and are user-friendly for both novice digital users (usually children) and digital immigrants. In the case of children, adults most often should be near to eliminate any technical difficulties during learning activities [14].

Today, it is common to perform a large number of tasks using mobile technologies. For example, answering e-mail, reading a book, writing text or communicating with other people through social networks. However, there are still serious problems associated with the integration of such technology in e-learning practices. The term “e-learning” coexists with the concepts of web education, distance learning, online

learning, etc., which are used equally. One of the biggest challenges of mobile learning is ensuring that the tasks match the capabilities of the devices used, especially when considering informal student learning processes [15]. There is no clear separation of formal and non-formal learning. Both forms can be considered complementary, since they coexist in practice, in particular for distance students. Non-formal learning occurs naturally without direct efforts and does not have formal documentation, while formal learning includes organized educational institutions and documentation. Informal learning processes are studied in order to improve formal ones and better correspond to different educational situations of students [16].

There are two approaches to the research, content, and design of language learning through mobile learning. While the latter is related to the constant transition to research, which is related to design. Research in the field of mobile learning that was conducted between 2003 and 2010, was largely focused on the development of mobile learning systems. In a recent literature review with a special emphasis on mobile learning, it was found that many widely cited studies focus on the development of mobile language learning systems and the experimental evaluation of their effectiveness.

The rapid development of mobile technology over the past two decades has created new design contexts and practices. The effective integration of mobile technology into educational practices depends on factors related to people (students and teachers), design (content and technology) and institutions (policies and strategies). This makes their development a difficult task. Although there are many examples of new designs, there is little research on the rationale for developing education procedures [17]. Distinctive features of mobile technologies are flexibility and connectivity. Although technology does not determine development, these characteristics become vital components that must be considered when developing new learning conditions. Effective use to a large extent depends on the specific possibilities of technologies that should fit into the target educational environment, as well as in the contexts of use and educational methods of students [18].

The context of student use is the crucial difference between mobile and non-mobile technologies. Although non-mobile technologies are installed in environments designed for certain types of activities, mobile technologies can be used in almost any environment. Such types of activities for non-mobile technologies include, for example, work-related or educational tasks that involve longer sessions. There are also various types of tasks that technology supports. The learning objectives (formulated by instructors in higher education) today are often associated with the mandatory use of a learning management system. Where the choice of such technological learning objectives depends on the preferences and decisions of teachers, and not on students. These systems are primarily intended for use on desktop computers and laptops and are functionally limited in their ability to access via mobile devices. Students in their daily lives use mobile technologies for independent tasks of various kinds [19]. Thus, it can be concluded that mobile technologies can be widely used in education. In this regard, the objectives of this study are formed:

- Analyze an interview that has been conducted among university students of the college of mass communication ("Graphic Design", "Public relations and advertisement", and "Radio and TV" majors) at Ajman university to highlight the characteristics of educational applications, as well as their possible advantages and disadvantages;
- Formulate, incl. based on the interview, criteria for selecting educational applications;
- Divide educational applications into various categories to more fully see the academic possibilities of their use.
- Develop a mobile application to develop student skills in learning

2 Method

2.1 Research design

Based on the goals, it was decided to divide the study into two parts. The first part included semi-structured interviews with students, in which they were invited to share their opinions on what educational applications should be (see Appendix). Conducting such an interview specifically among students plays an important role since they are the direct recipients of such products. In the second part of the study, a list of education applications is compiled, indicating educational categories. As well as selection criteria for education applications that also will help them to develop their skills.

2.2 Participants

Students from 3 majors ("Graphic Design", "Public relations and advertisement", and "Radio and TV") of college of mass communication at Ajman university took part in an interview. In total, 100 students aged 19 to 21 years were interviewed. The number of men and women was approximately equal. Language used for the interview is Arabic. Students from different Arabic countries took part in the interview (UAE, Jordan, Sudan, Egypt, Syria, Lebanon etc.) Also 2 specialists and representative of the university's IT department; 6 instructors form college of mass communication and 4 instructors from college of "engineering and information technology" at Ajman University were interviewed. 2 interviews were conducted, one concerning the importance of smart phones and their applications and the other the concept of human – computer interaction and the skills they want to gain while using the mobile applications.

2.3 The participant's selection criterion

The decision to conduct an interview specifically among students of higher educational institutions, and not schools, is due to the fact that at this stage they are more well-formed individuals who are ready to evaluate any subjects or phenomena.

In addition, students are more focused on obtaining a specific result in their studies, which may also affect the completeness of their opinion on the qualities of educational applications.

2.4 Research instrument

During the interview, the method of semi-structured interviews was used. This research method is qualitative, that is, it allows one to collect not only statistical data. The use of semi-structured interviews helped to more fully learn the opinion of students. Since in this case they are not limited to answer options and have the opportunity to express their opinion.

Respondents were asked to answer two questions:

- "What, in your opinion, should be an education application?"
- "What, in your opinion, are the pros and cons of education applications?"
- "What skills you want to develop?"

They were told that when answering, they can talk about any characteristics of such applications, whether design or functional component.

2.5 Research issues and restrictions

Only representatives of one age group took part in the interview, which makes it impossible to judge the situation, for example, among school students or working citizens.

2.6 Data analysis

Semi-structured interviews relate to a qualitative research methodology. During the interview, all of the students' answers were recorded and analyzed, thanks to which the most common wordings were highlighted among them. Further, the received responses were structured. For those response categories where percentage allocation was required, the STATISTICA system was used. This software, developed on Microsoft Windows basis, allows one to visualize data during statistical analysis.

3 Results

In summing up the results, it was decided to combine similar answers into general categories. It is also worth noting that when presenting the results, all categories are arranged in random order.

3.1 Functionality

This category includes all answers related to the technical content of the applications. Many respondents noted that one of the most important qualities of an application for them is a variety of functions. For example, an application for learning a language should have lexical, grammatical, and other aspects. According to the respondents, they are more likely to opt for installing a single application with various functions rather than several separate ones, but with the same functionality.

3.2 Intuitiveness

Respondents considered intuitiveness in use as another important criterion for an education application. They noted that the success of working with the application depends, inter alia, on how clear and convenient the interface is. According to many respondents, it should be simple and understandable. This will allow one to more effectively acquire knowledge since in a convenient application there is no need to spend time and resources on understanding its operating principle.

3.3 Progress tracking

The ability to track progress was also important for many respondents. They found it especially useful for those applications that students use for self-education. A progress bar or any other indicator will allow one to see how efficiently the work is being done. In addition, such a function will allow one to track in which aspects or topics difficulties have arisen. Thanks to this, students can understand which topics they should focus more on.

3.4 Relationship with university studies

This item was not very popular; however, a sufficient number of respondents expressed the view that it is necessary to develop an application whose content will be in line with the curriculum. In their opinion, such applications will help diversify the educational process, as well as consolidate the knowledge already gained. For example, a proposal was made to create an application in which, after listening to a lecture, tasks related to it will be opened.

3.5 User-friendly interface

The visual component, according to students, also plays a rather important role. According to them, websites or applications that have a user-friendly interface increase the desire to learn, as well as spend more time on it. The mandatory attributes of a good interface were named:

- Colors (not too bright, not too faded)

- The ability to turn on the night mode function (changing the color and brightness of the screen depending on lighting so that one's eyes do not get tired)
- The ability to adjust the font, etc. Many students found that the availability of images and audio files is necessary.

3.6 Feedback

This item, rather, is directly related to the creation of applications for each university. In this case, the respondents considered feedback necessary with the teacher, which can be carried out directly in the application, and not in person. Suggestions were also made to create a forum inside the education application, where anyone can ask questions to other users. However, such an initiative can have negative consequences, as the respondents will also be students and may answer incorrectly.

3.7 Multilingualism

Extending the language coverage of educational applications plays an important role in disseminating their use. Some respondents noted that they do not always have the opportunity to use an application, since it is not translated into their native language, and the knowledge of other languages does not allow them to complete the work. They noted that it is necessary to use in applications not only English, Arabic and popular European languages but also those that may be less common.

The pros and cons are highlighted based on the features of education using applications. It is necessary to talk about them, since when deciding to apply a similar method in practice, everyone should be able to consider the phenomenon from different angles.

The advantages are as follows:

Interactivity: Using the application on a mobile phone allows one to make the learning process more interactive. Through various means such as animation, color changes, tooltips, etc., the study of a topic becomes more interesting and attractive.

Mobility: Unlike traditional teaching materials, educational applications can be used absolutely everywhere, since almost every modern person has a smartphone with the ability to install them. Especially if applications do not require an Internet connection. This allows one to make the learning process more mobile and learn, for example, while standing in a traffic jam or waiting in line for a doctor’s appointment.

3.8 Variety of approaches

Often, educational applications include various components: pictures (visual), text, various sounds and audio recordings. This allows making the learning process more diverse. In addition, it will allow people with different types of perception to better perceive information. For example, someone better understands by ear, while someone needs text.

Among the minuses there are:

Access problems: Despite the fact that most modern people have smartphones with the ability to install applications, there are a considerable number of those whose technology does not allow this. Thus, some students may be deprived of the opportunity to use educational applications, which puts them in an unequal position with those who have this opportunity.

Health: As it is known, the abuse of gadgets can adversely affect the state of health, no matter what they are used for, for games or for educational purposes. The use of educational applications will inevitably increase the amount of screen time, which can have a negative impact on the health of students.

Learning benefits: App-based learning may not always be effective enough. Especially when it comes to young children, as they often pay more attention to the interactive component, which can adversely affect the learning.

A list of education applications was compiled, in which their didactic opportunities stood out (see Table 1). The purpose of the study is to show how diverse and applicable education applications can be.

Table 1. Didactic features of mobile applications

Type of application	Didactic features	Application examples
Communicative	Organization of autonomous education. Organization of project activities. The implementation of feedback. Self-assessment. Modernization and optimization of control forms.	–Email. –Facebook, –Interview and Feedback Systems: Poll everywhere, SRS etc. – Instant messengers.
Referential	Access to meta information. Creation of mobile exercises for development. Organization of project activities. Creation of problem tasks.	–Reading applications: Kindle, Stanza –Electronic dictionaries, encyclopedias, reference books.
A joint one	Exchange of ideas, resources, materials. Organization of project activities. Creation of problem tasks.	Joint documents: Google Doc –Mental maps –Cloud storage
Documentary	Organization of autonomous education. Creation of an electronic portfolio. Organization of project activities. Self-assessment. Group assessment.	Cloud storage
Multimedia	Organization of autonomous education. Creation of mobile exercises and tasks for development. Visualization of educational material. Organization of project activities.	–Podcasts and video podcasts –Services for creating and demonstrating interactive presentations
Gaming	Learning during the game. Implementation and organization of project activities. Organization of autonomous education.	–Game apps

The selection criteria for educational mobile applications are highlighted, based, inter alia, on an interview among students. For convenience, they are divided into categories with a description (see Table 2).

Table 2. Possible criteria for choosing educational mobile applications

Category	Detailed characteristics
Technical	- Availability on various operating systems. - The need to connect to the Internet (offline or online).
Financial	- Free or paid. - the presence of a demo.
Psychological and pedagogical	-Audio and/or visual information support; -Volume of education information; -The implementation of various forms of interactivity (the presence of a verification system or self-test; the presence of explanations/comments on answers or links to materials); -The availability of test or assignment results for the teacher; -The presence or absence of an authorization system when performing exercises; -The possibility to do tasks several times to consolidate the studied.
User	-Unified interface; -Laconicism of the interface (use of pictograms); -Friendly interface (ease of use); -Adaptability of the interface

Thus, mobile applications can be widely used in education, but it is worth considering some features of their use. When deciding to introduce educational applications in everyday life, it is important to make sure that all students have the opportunity (especially technical) to use them in order to maintain equal educational opportunities for all. In addition, it is necessary to apply certain applications, taking into account the needs of a specific group of students in order to apply this method more effectively. The health aspect should also be taken into account and the screen time should be limited for students.

According to the first interview, the majority of respondents agreed that smartphones play an important role in our lives. They noted that the use of smartphones carries not only entertaining and communicative, but also educational, as well as organizational functions. Among the most important characteristics of mobile applications, respondents noted speed, efficiency and ease of use.

Considering the analysis of the second interview, we can conclude that human computer interaction also plays an important role in the modern world. In order to make it comfortable, it is necessary to take into account various aspects, such as design, application support for different platforms, user-friendliness, etc. Mobile application developers should be aware of changing trends, as well as know different programming languages in order to be able to adapt the application to the operating systems of different smartphones.

From the interview of students, specialists and representative of the university, as well as instructors, we can conclude that when developing a mobile application, many factors must be taken into account. Thus, the skills that will be developed while using the application were highlighted. Knowledge of various programming languages will provide an opportunity to expand the number of systems for applications creating. As noted, the appearance of the application plays an important role for the user. That is why must have design skills. This can also include the creation of photo and video materials, the selection of the right colors, etc. Also, one of the design goals of the

application is to make it easy to use. In addition, students should be involved in at least initial testing. This will allow them to identify possible errors, as well as determine if the application is convenient and useful for other potential users in addition to the student who use the application. Also, knowledge of foreign languages will be a useful skill, as it will allow better control over the content of the application.

4 Discussions

The use of educational applications is a rather important topic in modern conditions, which is why various studies on this topic are being conducted. One of these studies took place in 2015 and was aimed at addressing the problems of integrating mobile applications into distance learning. As in this study, the recipients of the said were students. The study was interpretative and focused on the formal and informal practice of language learning by students. Twenty-five distance learning students were interviewed, who studied foreign languages in Sweden. There were fourteen women and eleven men [20].

In addition, in order to understand how the course developers, choose technology, detailed interviews were conducted with two representatives of the university's IT department. A focus group interview was conducted with three instructors teaching the same topic, from the college of mass communication, and one instructor from each major of the college of mass communication (3 instructors). Then another interview was conducted with 4 instructors from the college of Engineering and Information Technology of Ajman University (total 10 instructors). It is usually suggested that a focus group session should have from 6 to 10 participants; however, the "ideal" group size in the focus group method can vary. There is a study showing successful interview practices in focus groups conducted with only two people [21].

Despite the fact that two people are a small number for the focus group, there is a difference compared to the interview; focus groups use discussion and social interaction, while interviews are by definition more focused on questions and answers. One of the instructors had years of experience in technology-based teaching and initially participated in the development of the course (including the development of official course documentation). Another taught the course for the first time on the Internet and was new to such technology practice [22]. Such an aspect of that study is different from the current study, since the authors of the current study conducted the interview only among students who are recipients of educational applications, and not their producers. This document addressed two main research questions: how do students use technology in their educational processes and why do they use some technologies, but not others. An analysis of practical use of technology shows that students use different technologies in different ways and for different purposes in their formal and informal learning environment [23].

In an informal setting, they prefer to use mobile technology because of its accessibility, flexibility, connectivity and interactivity. They often use it in unstructured, special ways that are in line with their daily practice. Thanks to this use, they can often find time to study in the "gaps" between their planned daily activities,

such as during bus or train rides. However, ongoing discussions about flexibility recognize that there will inevitably be clashes between flexibility and other problems. It is not a case when "more" is "better" [24]. Student practices often rely on previously introduced structures that relate not only to the technologies used, but also to other structures related to their own way of acquaintance, the process of cognition. Such established structures relate to their use of technology in general, which extends to how they use them to learn the language. The structures are also based on their previous learning experiences, thanks to which they developed strategies for learning grammar and vocabulary and for practicing using the new language. Understanding such prescribed structures is important for course developers, as well as for developing software to support student learning practices [25].

Both the nature of the students' interaction with the teaching materials and the strategies they use are volatile and transformative, largely based on their established technology in practice, previous learning experience and their growing knowledge of the new language. The aforementioned structures and practices are based on students' strong preference for self-regulatory individual learning as an effective and often the only accessible form of learning. In contrast, collaborative group activities are considered more difficult to fit into the small- and irregular-time frames available for study. They may be valuable in certain circumstances; for example, group discussions on the Internet are generally seen as helpful in addressing research issues [26].

As for "technology in practice", students use mobile technologies together with their desktop/laptop computers to search for materials not provided by the educational institution that could help in mastering the language:

- Watching TV online
- Read newspapers
- Download various software for vocabulary and structural practice

Using software applications often gives these students the prompt feedback they seek [27]. Thus, the authors can say that this study is somewhat similar to their, since it also examines educational applications in terms of students and their convenience. However, the advantage of the current study is that in it, the interviewed students were able to identify specific pros and cons, as well as characteristics that they would like to see in educational applications and they want to address the skills gained from using such application.

5 Conclusion

Educational applications play a rather important role in modern education, as they allow it to provide greater mobility. Based on the goals, it was decided to divide the study into two parts. The first step was to conduct semi-structured interviews with students, in which they were invited to share their opinions on what educational applications should be to develop their skills when use the application. In the second part of the study, a list of education applications was compiled, indicating their education categories. The selection criteria for education applications were also

highlighted. Students from college of Mass Communication at Ajman University. In total, 100 students aged 19 to 21 years studying in various specialties were interviewed. Also, 2 specialists and representative of the university's IT department; 6 instructors form college of mass communication and 4 instructors from college of "engineering and information technology" at Ajman University were interviewed.

During the study, students named various parameters that they consider important for educational applications. These parameters concerned both the functional component and the design area. Respondents also highlighted the pros and cons of education using applications that were related, inter alia, to health, accessibility and the ability to have equal conditions. Based on students' answers, a list of criteria was compiled in the second part of the study, according to which educational applications should be selected. First of all, when deciding to introduce educational applications in everyday life, it is important to make sure that all students have the opportunity to use them in order to maintain equal educational opportunities for all. In addition, it is necessary to make a choice in favor of those applications that correspond to the needs of a particular group of students. Thus, they will be applied more effectively. The health aspect should also be taken into account and the screen time should be limited for students. Using students and specialists answers we also made a list of the skills that people designing mobile apps must have. Last we addressed the skills the student wants to develop from using such application. Further research can be conducted in schools and colleges, as well as among students in other countries.

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7 Author

Nidal Al Said has PhD degree. He works as Assistant Professor at College of Mass Communication, Ajman University, Ajman, United Arab Emirates.

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The Effect of Learning Motivation, Self-Efficacy, and Blended Learning on Students' Achievement in The Industrial Revolution 4.0

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Ryan Hidayat Rafiola (✉), Punaji Setyosari, Carolina Ligya Radjah, M. Ramli,
State University of Malang, Malang, Indonesia
ryan.hidayat.1701119@students.um.ac.id

Abstract—This study aims to analyze the effect of learning motivation, self-efficacy, and blended learning on students' achievement in the industrial revolution 4.0. This is done to follow the development of the world of education to improve the quality of service, Human Resources and the quality of graduates. The research object was Public High School in Padang, Sampling using Slovin formula. To analyze the research data used Partial Least Square (PLS) Version 3.0. The results showed that (1) Learning Motivation had a positive and significant effect on students' achievement of Public High School in Padang, (2) Self-Efficacy had no significant effect on students' achievement of Public High School in Padang, (3) Blended learning had a positive and significant effect on achievement learning of Public High School in Padang, and (4) Learning Motivation, Self-Efficacy, and Blended Learning together have a significant effect on the Students' Achievement of Public High School in Padang.

Keywords—Learning motivation, self-efficacy, blended learning, students' achievement, industrial revolution 4.0

1 Introduction

Right now, we are facing the fourth industrial revolution known as the Industrial Revolution 4.0. To deal with these changes in innovation, education is also an important thing that is required to experience significant changes to face Industrial Revolution 4.0. Emerging technologies have a profound effect on public education. Only qualified and highly educated people can control this technology [1]. The development and progress of a nation are determined by the level of educational success. Learning activities that are in accordance by the development and changes in educational paradigms are learning activities that can synergize the cognitive, affective, and psychomotor domains simultaneously [2].

The development of computer science and technology as a learning medium has been widely used in every aspect. Teaching with computer media can inspire and motivate students to learn, optimize the classroom environment [3]. Life skills or

innovative skills for living in the era of the industrial revolution 4.0 consist of leadership, collaboration, creativity, digital literacy, effective communication, emotional intelligence, entrepreneurship, global citizens, problem solving and teamwork.

The role of technology supports the teaching and learning process in this digital age because it can help students to become independent learners. This means that students can learn everything and anywhere by clicking on many features or platforms on the internet related to the subjects they are learning. In the teaching and learning process, teachers use many platforms to support their teaching and learning process, the way teachers give assignments, where they focus on developing student skills, and how teachers assess students. Teachers also try to focus on student-centered learning. Thus, students are more active and develop their critical thinking towards learning.

Blended learning is one solution to address the various needs of educational institutions throughout the world. Blended Learning is a combination of traditional classrooms and online learning. This combination provides better learning outcomes [4]. Combining internet technology and face-to-face interaction can improve pedagogy and easier access to information [5]. Blended teaching can facilitate an independent and collaborative learning experience. Blended learning builds a community of inquiry and a free and interactive dialogue platform. The way students speak supports mixed learning [6]. Digital literate students increase the possibility of expanding their learning and conversations outside the classroom [7]. According to [8] the use of cellular technology in education offers new opportunities to integrate face-to-face learning and online learning. The implementation of mobile learning and blended learning is not optimal due to the lack of design of the teaching system, for that mixed learning scenarios are used by combining various forms of learning and integrating various ways to access content using cellular technology.

To support the achievement of educational goals, the Public High School in Padang continues to keep abreast of developments in the world of education to improve the quality of services, Human Resources and the quality of its graduates. In an educational process, a student is said to be successful if he/she can complete the education program on time with good learning outcomes. That achievement or learning outcomes are the realization of potential skills or capacity that a person has. At school, learning outcomes or learning achievements can be seen from students' mastery of the subjects they have taken [9].

The problem that occurs of Public High School in Padang is the decline in student achievement. This can be identified by decreasing the average value of the report cards of Public High School in Padang as follows.

Table 1. The average Report Cards of Public High School in Padang

Academic Year	Semester	Average Value
2015/2016	1	86.5
	2	86.2
2016/2017	1	85.6
	2	85.5
2017/2018	1	85.2
	2	84.2
2018/2019	1	82.5
	2	82.0

To find out these factors, the researchers conducted a Pre-research as an initial description of this study. The initial pre-research was conducted by researchers by interviewing 35 students of Public High School in Padang to find out what are the main factors increased learning achievement. The instrument used in the pre-research is divided into 2 (two) parts, where students are asked to rank 3 (three) factors that can improve learning achievement based on the choices provided. In the second part, students are asked to answer several questions with alternative answers to "yes" and "no" to the factors chosen in the first part. The following are some of the variables that influence learning achievement based on pre-research results.

Table 2. Factors that influence students' achievement in Public High School in Padang

Problem Indicator	Number of People	Percentage (%)
Learning motivation	13	37
Self-efficacy	10	28
Blended learning	9	26
Parental support	2	6
Teacher performance	1	3
Total	35	100

Based on preliminary results, it is known that the factors that predominantly affect learning achievement are learning motivation, self-efficacy, and blended learning. These results become a reference for researchers to test the factors that influence learning achievement significantly.

2 Relevant Literature

2.1 Learning motivation

The motivation is a symptom in the form of effort or strength in a person that causes the impulse to carry out activities to achieve a certain goal [10]. Motivation is everything that drives someone to do something [11]. Learning motivation contains basic components, namely needs, goals, and encouragement [12]. Learning motivation is an impetus that exists in students to function as an effort in achieving their goals or

achievements [13]. Learning motivation as a whole of the driving force that exists between students so that the desire to learn arises [14]. The nature of learning motivation is an internal and external encouragement to students who are learning to make changes in behavior, in general with several indicators or supporting elements [15].

Based on the above opinion, it can be concluded that the motivation have an important role in underlying various actions and behaviors of students who become backgrounds in certain conditions and situations and are carried out to achieve goals.

2.2 Self-efficacy

Self-efficacy is one aspect of self-knowledge which is the most influential in everyday human life because self-efficacy possesses influence the individual in determining the actions to be taken to achieve a goal, including estimates of the challenges.

Self-efficacy determines the amount of effort or tenacity done by someone facing a task or activity [16]. If someone has confidence that he/she will not be able to deal with certain tasks or activities, then he will quickly switch to other tasks or activities and do not want to make a greater effort to complete the task or activity. Self-efficacy is a personal factor that becomes an intermediary or mediator in the interaction between behavioral factors and environmental factors.

Self-efficacy as one of the most influential aspects of knowledge about oneself in everyday human life [17]. This is due to the self-efficacy that has influenced the individual in determining the actions to be taken to achieve the goals including the estimated events to be faced.

2.3 Blended learning

Blended learning is one solution to address the various needs of educational institutions throughout the world. Blended Learning is a combination of traditional classrooms and online learning. This learning provides the benefits of face-to-face learning and electronic learning. The main objective of this research is to assess the effect of blended learning in the teaching process in schools. Blended learning aims to find the right balance between face-to-face and online methods [18]. Blended learning transforms passive students who usually only receive knowledge, which is characteristic of traditional teaching models, into active students who build their knowledge [19][20]. At present, mixed learning abilities are well understood, and their flexibility, ease of access, and the integration of sophisticated multimedia and high technology have been taken into consideration [21]. This combination provides better learning outcomes [4].

Combining internet technology and face-to-face interaction can improve pedagogy and easier access to information [5]. Thus, blended teaching can facilitate an independent and collaborative learning experience. Blended learning builds a community of inquiry and a free and interactive dialogue platform. The students' way to speak supports mixed learning [6]. Digital literate students increase the possibility of expanding their learning and conversations outside the classroom [7]. The use of cellular technology in education offers new opportunities to integrate face-to-face learning and online learning [8]. The implementation of mobile learning and blended learning

is not optimal due to the lack of design of the teaching system, for that mixed learning scenarios are used by combining various forms of learning and integrating various ways to access content using cellular technology. Teachers struggle to develop their teaching competencies in a context where reform and innovation are not the dominant problem. Research on technology-enhanced teacher education programs must discuss how 21st century skills frame training programs and how teachers or educators are prepared to become professional teachers [22].

Improved technology has changed the behavior and attitudes of students, and has changed the way they learn and communicate in and outside the classroom. The widespread use of digital technology has changed education. Therefore technology-based learning is needed. Integrating technology with face-to-face instruction can strengthen interactive and communicative learning environments and provide meaningful learning outcomes [4][23]. Fortunately, blended learning is versatile, so it depends on the instructor's decision when it comes to choosing from a variety of choices, depending on the learning context. Using blended learning can help improve students' academic self-efficacy and students' motivation.

2.4 Students' achievement

Achievement is the result of an activity that can be created, carried out and pleases, obtained by working hard, both individually and in groups. While the definition of learning achievement is a result of the act of making an assessment expressed by numbers or symbols, where all that is about the progress of student learning outcomes during a certain period [24]. That learning achievement is the culmination of learning outcomes that can reflect the results of student learning success towards the stated learning goals. Student learning outcomes can include aspects of cognitive (knowledge), affective (attitude), and psychomotor (behavior). Achievement of learning outcomes can be measured using learning achievement tests.

2.5 Framework

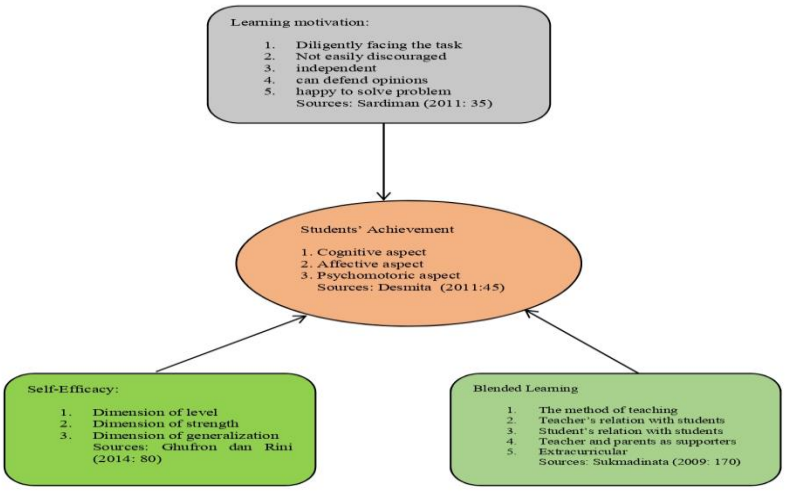

Fig. 1. Research Thinking Framework

2.6 Hypothesis

The initial hypothesis in this study are set as follows: (1) There is an influence of Learning Motivation on students' achievement of Public High School in Padang. (2) There is an effect of Self-Efficacy on students' achievement of Public High School in Padang. (3) There is an influence of Blended Learning on students' achievement of Public High School in Padang. (4) There is an effect of Motivation, Self-Efficacy, and Blended learning simultaneously on the students' achievement of Public High School in Padang.

3 Method

3.1 Research design

This type of research used for this research is to use descriptive-analytic research. Descriptive research methods have the objective to make a systematic, factual, and accurate description, description, or painting of the facts, properties, and relationships between the phenomena investigated [25]. Data obtained is using structured qualitative data, using a Likert scale 1-5, from strongly agree to disagree. In this study examines the effect of learning motivation, self-efficacy, and blended learning for the students' achievement of Public High School in Padang.

3.2 Variable operations

The operational definition is to explain the concept of a variable that can be measured by its measurement parameters.

Table 3. Variable operational definitions

Variable	Definition	Dimension	Indicators	Scale of Measure
Learning motivation (X1)	Internal and external encouragement to students who are learning to make changes in behavior, generally some indicators or elements that support	Diligent; Do not give up; Independent; Able to express opinions; Happy to solve problem	1.Students show perseverance in working on assignments to complete 2. Students never despair when facing learning difficulties 3. Students can study on their own without having to always be supervised by the teacher 4. Students can defend their opinions on a topic by presenting arguments.	Likert
Self-Efficacy (X2)	Knowledge of self or self-knowledge is the most influential in everyday human life	1. Level 2. Strength 3.Generalization	1.Students are confident in their ability to solve difficult problems 2. Students are confident in their competency 3. Students can solve problems based on their understanding of the material	Likert
Blended Learning (X3)	Blended learning combines the best aspects of online learning, structured face-to-face activities, and real-world practices. Online learning system, classroom exercises, and on-the-job experience	1. The method of teaching 2. Teacher relations with students 3. Student relations with students 4. The state of the classroom 5.Extracurricular	1. The teacher's method of teaching helps students understand the lesson 2. The teacher is can be a place for student consultation on his lessons 3. The communication between classmates is very good	Likert
Students' Achievement (X4)	The peak of learning outcomes that can reflect the results of student learning success towards learning goals has been set	1. Cognitive aspects 2. Affective aspect 3. Psychomotor aspects	1. Your students follow all lessons well 2. Students can learn individually or in groups 3. Students show active attitude in class	Likert

3.3 Population and samples

Population is a generalized area (read: leveling) consisting of objects / subjects that have certain qualities and characteristics determined by researchers to be studied and then drawn conclusions [25]. So the population is not only people, but also objects and other natural objects. The population is also not just the number of objects / sub-

jects studied, but includes all the characteristics / properties possessed by the subject or object under study.

The sample is part of the number and characteristics possessed by the population. To determine the sample in the study various sampling techniques was used. The sampling technique is a sampling technique. The sample size cannot be less than 5% of the population. To meet these criteria, sample measurements are calculated using the Slovin formula [25]. The population of Public High School in Padang was representing all levels of education is 120 students. Precision takes 5% to maintain the representativeness of the study sample. Based on the formula above, there were 92 samples taken from Public High School in Padang. The sampling method used is simple random sampling.

3.4 Data analysis

After selecting the sample, making a model, determining the variables used in the study, and making hypothesis, the next step is processing data using Partial Least Square Version 3.0. Evaluation of the PLS model is done by evaluating the outer model and the inner model. The outer model is a measurement model to assess the validity and reliability of the model. Through the algorithm iteration process, the measurement model parameters (convergent validity, discriminant validity, composite reliability, and Cronbach's alpha) are obtained, including the value of R2 as a parameter of the accuracy of the predicted model. While the inner model is a structural model for predicting causality between latent variables. Through the bootstrapping process, t-statistic test parameters are obtained to predict the causality relationship.

4 Result and Discussion

Table 4. Significance Test Result

Influence between Variables	Original sample (O)	T-Statistics (|O/STDEV|)	P Value
Blended learning -> students' achievement	0.351	3.841	0.000
Learning motivation -> Students' achievement	0.256	2.112	0.006
Self-efficacy -> Students' achievement	2.180	0.905	0.366

Based on the above table, the following is an explanation of the results of the research hypothesis test:

Hypothesis 1: Learning Motivation influence on the Learning Achievement of Public High School in Padang. Based on Table 4, it appears that the value of the original sample estimate the Learning Motivation variable against the Students' Achievement variable is positive which is equal to 0.256. Then, it was seen that the t statistic was 2,112 P 1.96 and P Values 0.006 <0.05[26]. So it can be said to have a significant effect. Thus, the H1 Hypothesis in this study was declared acceptable. In conclusion, Learning Motivation has a positive and significant effect on the Students' Achievement of Public High School in Padang.

Hypothesis 2: Self-Efficacy influences Students' Achievement of Public High School in Padang. Based on Table 4, it can be seen that the value of the original sample estimate the Self-efficacy variable on the Students' Achievement variable is positive which equal is 0.218. Then, the t-statistic is 0.905 ≤ 1.96 and P Values is 0.366> 0.05 [26]. So it can be said to have no significant effect. Thus, the H2 Hypothesis in this study was declared rejected. In conclusion, Self-efficacy did not significantly influence on the students' achievement of Public High School in Padang.

Hypothesis 3: Blended Learning influences on the students' achievement of Public High School in Padang. Based on Table 4, it appears that the value of the original sample estimate Blended learning variable on the students' achievement variable is positive which is equal to 0.351. Then, the t-statistic was 3,841 ≥ 1.96 and P Values 0,000 <0.05 [26]. So it can be said to have a significant effect. Thus, the H3 Hypothesis in this study was accepted. In conclusion, Blended learning has a positive and significant effect on the students' achievement of Public High School in Padang.

Hypothesis 4: Learning Motivation, Self-efficacy and Blended Learning together have an influence on Students' Achievement of Public High School in Padang. Based on Table 4, it can be seen that the original sample value estimates the Learning Motivation, Self-efficacy and positive variables which are equal to 0.019 (0.256 * 0.218 * 0.351). Then, the t-statistic is 7.341 (2.112 * 0.905 * 3.841) ≥ 1.96 [26]. So it can be said to have a significant effect. Thus, the H4 Hypothesis in this study was accepted. In conclusion, Learning Motivation, Self-effiacy, and Blended Learning simultaneously have a significant effect on the students' achievement of Public High School in Padang.

5 Conclusion

Although there are indicators that show an emerging need to integrate technology into face-to-face language classes, there are still some limitations that can be the subject of new research. The new generation is equipped with a digital background; thus the mixed learning approach can be very useful because it will improve the quality of learning and increase student access to information.

Integrating technology with face-to-face instruction can stimulate learning and provide a more collaborative learning experience. It is time for higher education to adjust to these changes to pursue increasing demands of both students and the workplace. Student involvement, motivation, and interaction are key factors in achieving a successful learning process. When students can connect what they learn with real-life and personalize it, they become more intrinsically motivated.

Based on the results of the study, here are some conclusions from this study

1. Learning Motivation has a positive and significant effect on students' achievement of Public High School in Padang
2. Self-Efficacy does not significantly influence students' achievement of Public High School in Padang
3. Blended learning has a positive and significant effect on students' achievement of Public High School in Padang

4. Learning Motivation, Self-Efficacy, and Blended Learning together have a significant effect on students' achievement of Public High School in Padang.

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8 Authors

Ryan Hidayat Rafiola is a doctorate students of Universitas Negeri Malang, Malang, Indonesia. He is currently teachingat at the STKIP PGRI Sumatera Barat, Padang, Indonesia. His research interests include Counseling, e-learning, Cognitive Behavior Approach, Educational Psychology, live modeling, Theoretical Model, Cultural Approach in Counseling etc.

Punaji Setyosari is a professor in the post Graduate program of the Department of Education and Technology, Universitas Negeri Malang, Malang, Indonesia. His research interests include research methodologies, evaluation and assessment, instructional media, problem-based learning, and collaborative learning. His scopus ID: 57191276640

Carolina Ligya Radjah is a lecturer in the post Graduate program of the Department of Guidance and Counseling, Universitas Negeri Malang, Malang, Indonesia. Her research interests include Counselng, Self-efficacy Academic, Achievement Mo-

tivation, Elaboration Model, Theoretical Model, Cognitive Behavior Approach, Group Counseling, Cultural Approach in Counseling, Educational Psychology, and etc.

M. Ramli is a lecturer in the post Graduate program of the Department of Guidance and Counseling, Universitas Negeri Malang, Malang, Indonesia. His research interests include Counselng, Cognitive Behavior Approach, Group Counseling, Cultural Approach in Counseling, Evaluation And Supervision Counseling and Guidence, Non-Test Technical Assessment, Educational Psychology, and etc.

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Can a Technology Teach Meditation?

Experiencing the EEG Headband InteraXon Muse as a Meditation Guide

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Caroline Stockman
University of Winchester, Winchester, UK
caroline.stockman@winchester.ac.uk

Abstract—Mobile and wearable technology now offers new avenues for technology-supported meditation practice and learning. Through a qualitative-dominant convergent parallel design, this study explored new empirical findings on the human perception of such technology-guided meditation training. A purposive sample of six participants trialled the device in several sessions during three weeks. Post-use, they commend the device for prompting self-guided learning. They highlight the importance of personalisation and adaptivity in educational technology, befitting Western pedagogical thought. Though these are guiding principles in current technology development, as they are believed to improve learning efficiency, they also prove crucial to user satisfaction and continued use of these technologies of the self.

Keywords—EEG headbands, meditation, technology, qualitative,human-technology relationship

1 Introduction

Electroencephalography, or its materialisation as an electroencephalogram (EEG), is a non-invasive method of monitoring and recording brain activity. Commercial EEG headbands will incorporate wearable technology (typically to placed on or around your head), which has brain sensors, critical points where the hardware needs to be directly on the skin. These sensors will register small electrical fields generated by groups of neurons during brain activity.

This study provides new empirical material on the use of the EEG headbands for meditation training. The commercial availability of this innovative technology is recent, with retail prices of market leader products typically much lower than the leading products in popular consumer technology such as tablets or smartphones.

The InteraXon Muse, or the 'Muse Brain Sensing Headband', provides such EEG technology for meditation. The company developed the headband technology initially for purposes other than meditation, but decided on this route as the best way forward for commercialisation [1]. Since the Muse's entry to the market in 2014, the company

has attracted over $19 million in investments, doubling its revenues every year from its initial $3.5 million in the first few months of release [2].

A structured series of sessions initially guides the user through the functionalities of the device in an incremental way, while the proposed meditation tasks become progressively more complex. One of its unique selling points is the live feedback of the weather soundscapes: in each session, live data on the user's brain activity is exchanged via Bluetooth with an app on that person's phone or tablet. With the data, the app determines if that person is in a meditative state, or not. A distinctive feature is the sound effect of tweeting birds when a calm focus is achieved. If distracted, the user hears rain coming down louder, signalling a need to re-focus. The live feedback throughout the session does allow innovative avenues for self-regulation during learning. After the session, the app generates a graph summarising the fluctuations between a calm, neutral and active mind throughout the session. The app awards 'calm points': one point for every second of 'neutral', three for every second of 'calm' brain states. 'Recoveries' are celebrated too, which is every moment moving from an active mind back to neutral. Further awards can be earned for high calm times, long session lengths, and so on.

There have only been a limited number of studies concerned with the effects of mobile or wearable technology for technology-supported mindfulness or meditation practice (such as [3]), though this is rapidly growing. Though small-scale, this study contributes to the intellectual agenda for human-technology relationship research in that it provides new empirical findings on the human perception of technology-guided meditation training.

This technology materially presents the claim that technology can guide people to learn something as characteristically human as meditation.

1) Can we, as human beings, accept this proposition?
2) Does actual experience with the device alter those pre-use perceptions?

The first question brings us to a core premise of human life (as believing that a technology can teach us something which is human would yield tremendous perceived power to the future teaching potential of technology). The second question investigates if experience with this particular device somehow influences or changes individual preconceptions.

2 Method

2.1 Approach and design

This study opted for a predominantly qualitative approach, with exploration and discovery as guiding principles. Though this is not a phenomenological study, some of the researcher's theoretical biases are inclined that way. The foundation of the approach is a dominant interest in 'understanding the lived experience of other people and the meaning they make of that experience' [4]. For example [5], a qualitative study to explore whether the Sonic Cradle, an interactive sound chamber, can success-

fully encourage users to have (perceived) meditative experiences. For this, they used semi-structured interviews, systematic coding, and descriptive conclusions to capture common subjectivities.

Unlike quantitative approaches, qualitative research often depends on a more interpretive design. This is part of a well-known critique around the subjectivity of qualitative research. Michael Patton [6] suggests using a comprehensive and integrated triangulation model called 'The Rigor Attribute Model', initially developed by [7], to ensure a high quality analytical process. It is a model of assessment along eight dimensions or 'rigor attributes' to determine whether the analysis is 'High-Rigor' (HR) or Low-Rigor (LR).

1. **Hypothesis exploration:** Whether a study has only performed minimal weighting of alternatives (LR) or dynamically reviewed multiple hypotheses and a broadening of explanation beyond the initial framing (HR).

   This study was exploratory and therefore not testing hypotheses as such, but the emergent and iterative nature of qualitative research was an integrated part of the structured analytical steps explained in 2.5 Procedure.
2. **Information search:** whether a study has only included routine or readily available data sources, such as through convenience sampling (LR) or has used purposeful sampling to comprehensively explore inquiry-specific data (HR).

   This study has used purposive sampling specifically relevant to the inquiry.
3. **Information validation:** Whether information was accepted at face value or using poorly tracked original data (LR) or whether a study systematically corroborated and cross-validated information through triangulation and/or sampling (HR).

   This study is information-rich in that it has three different data sets for cross-validation and triangulation, converging during the process of analysis.
4. **Stance analysis:** Whether nothing was done in regards to participant bias (LR) or whether data and participants were contextualised to provide a background to the information they provide (HR).

   This study incorporated contextualisation in its design, as the pre-interviews gathered relevant background information on the participant's relation to technology and meditation more generally, their individual habits and preferences, and attitudes to teaching.
5. **Sensitivity analysis:** An emphasis on face validity and surface-level explanations (LR), or an assessment of the implications which is more strategic and systematic, which includes a consideration for the assumptions, limitations, supporting sources or problematic findings (HR).

   This paper initially discusses the findings at a level close to the data and individual participants, and then moves to the 'bigger-picture' discussion of the implications, limitations, tensions, and more.

6. **Specialist collaboration:** Whether a study has not engaged independent, external expertise or peer review before reporting (LR) or whether it did incorporate such key expertise (HR).

Pre-publication, this study was shared with an international and published expert on technology acceptance, who was invited to comment.

7. **Information synthesis:** Whether the analysis is simply reported in a sequential form with little or no synthesis or integration (LR) or whether an analysis has 'dug deeper' in line with interpretive design, and presented integrated information with a thorough consideration for diverse interpretations, noting both consistencies in the data as well as tension points (HR).

This discussion of the findings follows a pattern which weaves participants together through an integrated narrative, with specific attention to their individual similarities and differences in experience and interpretation.

8. **Explanation critique:** Whether little or no use was made by other analysts (LR) or whether different perspectives were put to use, help explain, distinguish a chain of reasoning, or examine findings (HR).

This study was of a sufficiently small scale to be executed by one person rather than a research team, but references to other relevant research and literature are included throughout to examine and explain findings. The final draft of this article was also shared with participants prior to publication.

In regards to Information Validation above, [8] recommend 'convergent parallel design' as a term to describe where different data is collected in the same space of research, and in a relatively brief time. The 'convergence' refers to the merging of the separate results of analysis into one interpretation and conclusion. Other established authors use related terminology in their typologies, such as a 'parallel mixed design' [9], a 'qualitative dominant' study [10], considering the combination of data and weight of analysis, or a 'partially mixed concurrent dominant status design' [11].

2.2 Pilot

A pilot study with six participants preceded the execution of research and findings presented in this paper, as a best practice technique for rigour in empirical research. The pilot was near-identical to the final project, apart from two main changes. Firstly, participant sessions were video recorded in the pilot which did not yield any discussion-worthy data, so this was omitted in the final project. Secondly, participants initially used the device in a controlled experiment setting, whereas in the final project, participants were allowed to take the device to a setting that was comfortable and familiar to them (like their home). Some participants in the pilot recommended this to allow full immersion in the use of the device. This did lend greater authenticity to the experience of the device for personal use, which some of the session forms (see 2.4 Data) evidenced.

2.3 Sample

In this case, the study purposefully recruited young adults (aged 21 or 22) who had undertaken several years of formal higher education to become teachers, as this adds an explicit framework to their perception of the Muse as a meditation guide. They are within the product's customer market, though they have never used the device before, or even heard about it. They are open to meditative practice, though have no or zero previous experience with any form of meditating training, technology-aided or otherwise. Participants self-reported to be part of a healthy population (i.e. no diagnoses of mental ill health issues). Both this and the previous factor have been identified as important to mindfulness research [12]. Participants were recruited by an independent project assistant, who did not conduct any of the interviews, as guidance on qualitative research [13] has pointed out the unrecorded researcher-participant interactions prior to formal data collection can actually impact on the findings.

Purposive/purposeful sampling focuses on depth of information generated by specific cases, and for that reason, it is typically small: usually 30 or less [14]. In a meta-review on this topic [15] analysed the 11 most-cited phenomenological studies in education & health sciences, which had sample sizes ranging from 8 to 31. Other guidance [16] has stated between 5 and 20. The number of interviews, rather than participants, has been used as an indicative measure as well. The sample here consists of 6 participants, preceded by a pilot study with 6 unrelated individuals. Each did 2 interviews, totalling 12 interviews represented in this paper, with additional data as further outlined below. For phenomenological studies, 5 to 25 interviews has been suggested as sufficient [17]. It must be noted, however, that while these numbers are offered as a general rule of thumb, there is often little empirical or theoretical argument as to the 'why' of these numbers. Given the available resources and study objectives, the size of the participant group and amount of data collected in this project are appropriate and at its full capacity. In line with Patton's pragmatic suggestions, [18] also argues the sample size depends on 'the quality of data, the scope of the study, the nature of the topic, the amount of useful information obtained from each participant, the number of interviews per participant, the use of shadowed data, and the qualitative method and study design used.' Repeat engagement with participants, as is the case here, is also presumed to mean a smaller amount of total participants is needed [19]. Again, the current project proposal can demonstrate to be on the small side but sufficient for all of the above indicators.

2.4 Data

Each participant was given the choice between completing two or four sessions with the headband. A 'session' is a guided meditation exercise using the headband for a minimum of ten minutes, up to thirty minutes. Only two participants chose to stop after the second session, whereas all others completed four sessions. This generated three data sets: interviews (12 in total of 20 to 30 minute duration), pre- and post-session forms (40 in total), and app data reports (20 in total). The interviews form the

primary data set, with the forms and app data providing supplementary data to support or contrast findings from the interview analysis.

1. **Interviews -** Before their first session, participants would be invited to a 30-minute pre-use interview (as further outlined in '2.5 Procedure'). After their last session, another interview would take place to actively reflect with the participant on the whole experience, consider pre-use views, and co-interpret patterns of change where they occurred. These interviews lasted 20 to 25 minutes on average. They were semi-structured, with appropriate techniques of listening, prompting, and establishing rapport deployed.
2. **Session forms** - Before and after each session, participants would complete a self-reflection form with four open-ended questions. This helps contextualise whether their immediate post-use reflection aligns with the retrospective interpretation given in the post-interview, and enrich the other data sets with session-specifics.
3. **App data** - With each use, the app generates a report for the user which allows them to see the overview of the session: how many moments of distraction, how many 'birds', etc. It is displayed in a graph and recorded. This forms a minimal set of quantitative data used in this project to juxtapose with the participant's narrated experience in the post-interview, and post-session forms. (App data may for example show tensions in what actually happened with the participant's recollection of the experience.)

2.5 Procedure

Participants were aware that they would be using a technology for meditation in this project, though they did not see or know about the device before its first use. They were told about the expectations for their participation in the study, at which point they were asked to provide their informed consent in writing (or decline further participation, which none of them did). The data gathering tools used in this study are common and ethical, while EEG headbands are in themselves non-invasive devices. Participants had the right to opt out throughout the research. Internal ethical approval was obtained in full before the start of research.

A semi-structured interview proceeded based on a core set of questions. All participants were asked all of these questions, though they occurred in an order natural to the conversation, and were enriched with follow-up questions as appropriate to the responses given. Patton's guidance [20] on questioning was followed closely. They would then take the device with the login details as provided, download the app on a personal device, and proceed with using the headband for 2 or 4 sessions. They could self-determine the place and time for the session. On average, participants did a session every 4 to 6 days. Everyone completed within 21 days. Each participant completed a self-reflection form before and after each session, collected by an independent research assistant. The participant then returned after the last session for the post-interview with the lead investigator, which proceeded in a manner identical to the pre-interview.

In terms of the analytical procedure, the following steps were observed:

1) Transcribe pre-interviews one-by-one

   During each transcription: active note-taking on emerging insights and analysis

2) Resting the data
3) Re-read pre-interview, with note-taking on emerging insights and analysis
4) Compare these notes with the ones made during the initial transcription
5) Transcribe post-interview, as in step 1
6) Thematic coding in NVivo using the Five-Level QDA Method [21]
7) Juxtaposition of Findings with the Supplementary Data Sets
   a) Session forms – read and analysed per session across the participants
   b) App data – accessed and analysed per participant across sessions
8) Integrated Report of Analysis
9) Member and Expert Check

Step 1 (and 5) was a manual transcription of the interviews into a written format. Transcribing is not just transferring audio to written symbols, it is already an active making sense of the data. Embracing this analytical view, transcription was parallel to note-taking in separate documents attached to the transcription files. The notes represent interpretations of certain sections, highlight what seemed to stand out as key data, and pick on specific points of interest to revisit later. The pre-interviews were first transcribed, and then individually reread before transcribing that participant's post-interview. So the analysis during the post-interview transcript was similar to the pre-interview transcript (i.e. active note-taking, interpretation and analysis) but additionally took into account the pre-interview data and preliminary insights drawn from there.

In **step two**, a few weeks were allowed in between transcription of the pre- and post-interview data. This 'resting' of data analysis helps to regain a fresh perspective, and upon resuming the analysis, see if the same sections stand out as important, the same emerging insight present themselves upon revisiting the data. It enhances validity of findings not to rush a particular interpretation, but to repeat the analysis and compare notes with the initial round, as one potential way to mediate initial assumptions or interpretations. This can only be done if sufficient time has been allowed for the 'resting' phase, unless multiple researchers are involved.

Then, in step six, the transcripts were further analysed with NVivo using the Five-Level QDA Method (Qualitative Data Analysis) [21], which is an iterative procedure. Initial codes emerged from step 1 to 5, while further codes were developed during step 6 and 7. Most codes were emergent allowing for inductive analysis, though not all. The act of coding requires revisiting the particularities of each interview, while building towards thematisation. For this, Seidman's guidelines on making and analysing thematic connections were followed [22]. Themes do not necessarily constitute unanimity of experience, but can capture variability. The thematic organisation allows for a structured discussion of findings, as presented in the next section. That composition should again be recognised as an act of interpretation in qualitative research in itself [23]. Insights were then juxtaposed to the self-reflection forms and the app data, per individual participant, in step seven. The report presented here has presented those integrated findings, highlighting in particular where contrasting material occurred.

Though member checking is not without its critique, the paper was shared with the participants pre-publication and they were invited to comment or input further on the analysis and presentation of results. All participant identifiers were anonymised by assigning unrelated names (by a random name generator).

3 Findings

3.1 Pre-Use: Attitudes to technology and meditation

The participants' attitudes to technology in general were very diverse. Lucy states she 'wouldn't be able to live without it' (Intv 1/a/09:41), and Jenny confesses to be 'addicted' to her phone: 'it pretty much runs my life' (Intv 2/a/16:52). She feels comfortable with this high level of reliance. In contrast, Martha feels technology is necessary but altogether undesireable: 'weirdly I hate technology but I always go for the easy option' (Intv 5/a/10:36).

Though none of the participants had much direct experience with meditative practices, they had some indirect sense of what it might entail. Grinning, Lucy defines it as 'kind of uh way of destressing um you see it a lot on TV shows which are very like 21st century kind of um [1 second pause] don't want to say the word hippie but almost like very open-minded and things like that' (Intv 1/a/01:07). Another participant, Alex, actually describes her family background as 'kind of like a hippie family' (Intv 6/a/02:39), in a light-hearted manner. However, she has never connected the idea of meditation with technology before. In general, she feels technology is useful but says 'I can cope without it' (Intv 6/a/14:27). Debra expresses a similar feeling, in that she perceives technology as useful, as long as people don't become over-reliant, and maintain a healthy balance – in contrast to Jenny as stated above. To Debra, meditation is about 'calming your brain' and 'controlling your thinking' (Intv 4/a/05:46). She has used the Headspace app and this has been her only experience of meditative learning, and she experienced it as positive but didn't continue beyond its free content. The Headspace app is also Jack's only experience of meditative learning, but he says: 'I had a go and then got bored, so I stopped' (Intv 3/a/1:57). This is also very similar to Martha's experience with the app. All participants do believe meditation is a skill that can be learned with good guidance, though individual views differ as to whether it would be personally suited to them.

3.2 Pre-Use: Attitudes to learning meditation with the muse

According to the participants, teachers are equipped with a host of special skills and characteristics, measured by high standards and expectations. Teachers need to be inclusive (Intv 1/a, Intv 4/a) as well as approachable, kind and caring (Intv 6/a), emotionally intelligent and responsive (Intv 2/a), encouraging (Intv 3/a), creative, engaging, enthusiastic and passionate (Intv 4/a), apt at building relationships (Intv 1/a, Intv 4/a) with a student- or child-centred approach (Intv 1/a, Intv 4/a . These pedagogical beliefs are in keep with modern, Western educational thought – which is unsurprising

given their educational background. While none of the participants had used the Muse before, they were also hardly aware of the device and its functionalities. They struggled to picture what it might be like. They did have some ideas of a narrating voice (Intv 1/a, Intv 2/a) as well some sort of glasses showing certain images (Intv 1/a/08:04). Something simple: 'it needs to be like button, go' (Intv 6/a/10:34) as well as discrete, not 'like some sort of alien headset […] like you can shove it under a pillow so you don't look insane' (Intv 6/a/11:09).

They mostly expressed positive expectations towards the potential of the technology, which they have not used before and know little about, to teach meditation. Their pre-use beliefs on whether a technology could teach meditation range from a confident 'I don't see why not' (Intv 2/a/07:21) to a more cautious 'just doesn't seem like a match made in heaven really' (Intv 5/a/04:13).

R can you still learn the same way

P yeah

R as you would from a human being?

P I'm sure you can. I think I mean maybe the world is leading in that way where you're so much more technology-focused that that might be the future, you're learning from technology.

R yeah

P If you don't know any different, that we're learning meditation from technology, if we didn't have if we'd never been taught meditation through an actual person it wouldn't make any difference, we probably wouldn't know what we're what we would have been getting different if it was a person

(Intv 1/a/16:42-17:11. R: Researcher, P: Participant Lucy)

3.3 Post-Use: Attitudes to learning meditation with the Muse

Post-use, participants express much more nuanced views. All participants do express a post-use interpretation that the device is expensive and sophisticated (despite being factually cheaper than their smartphones). However, due to frustrations outlined in 3.6 below, not all would pay its actual price for continued use.

Martha was arguably the greatest sceptic pre-use, and post-use does conclude that 'human-led meditation instruction is a bit more natural' (Intv 5/b/after 7:45). She somewhat dismissively describes her experience as 'a little bit like virtual reality' (09:34) and adds that it was 'a bit um creepy' (10:52) in feeling that the device was reading brain activity. Of all participants, she spent the least amount of time with the device, completing in only 4 days. By contrast, Jack completed his 4 sessions over 20 days, longer than anyone else, and concludes 'I liked the technology actually a lot more than I thought I would' (Intv 3/b/05:12). On their pre-session forms before the first session (which is their first encounter with the device), Jack and Martha interestingly express sentiments different to what one could expect from the final result. Jack writes that he is 'slightly apprehensive, [it] looks a bit scary' (P3-S1a) and Martha writes 'Looks like something out of Tron. I am almost excited to put it on.' (P5-S1a)

Lucy, who was very optimistic pre-use, did experience the use of the headband as positive and follows Jack closely by completing her 4 sessions in 19 days, though scoring significantly less 'Muse points' than him (3052, vs 4350), indicating Jack achieved longer 'states of calm' according to the device. Lucy states she trusted the device, and feels there were clear moments of learning, including a changed perception of meditation. She experienced her sessions largely as positive, and relates this to a growing comfort in the human-technology relationship. After her fourth session, she writes: 'I have learnt to trust the technology and let myself be taken over by it in the session', and feels this affects her learning in a good way (P1-4b). In her view, the technology made meditation 'more relatable and accessible' (Intv 1/b/05:03). But she says, 'I'm not sure the technology was actually teaching me to meditate or was more facilitating my teaching of myself' (Intv 1/b/15:10). She goes on to explain the technology is useful to 'kickstart' a process of self-reflection as a learner.

Jack feels the same: 'it's not necessarily explicitly teaching you how to meditate but it's helping you realise by yourself how to meditate' (Intv 3/b/04:40). Despite Alex's frustrations, she expresses a similar sense that the technology is useful to prompt greater self-awareness: 'I think it made me more aware of what I was like how distracted I can get it made me aware of different things I wasn't aware of before about myself' (Intv 6/b/12:25), and a bit later: 'I wouldn't say it taught me how to meditate but it taught me how it made me reflect like made me more self-aware' (about 15:00). Jenny says the same: 'I guess in a different way it actually teaches you to self-evaluate yourself? And to self-assess and to say actually no, I'm not at that stage, I need to go back and that in itself is quite powerful because make sure you're in touch with your own body and what you're feeling for yourself' (Intv 2/b/09:50). In a sense, the participants are actively validating the device's educational potential through finding a fitting place for it in their taught pedagogical framework.

3.4 Post-use: Human vs Technology

For Jack, the post-session data was a highlight of his experience (Intv 3/b). To him, that functionality was a key reason to continue meditation with the device. 'I think the yeah the feedback that this can give would be better than a human teacher can give' (Intv 3/b/25:02). This is in sharp contrast with his pre-use claim that no technology could ever be better than human teaching (Intv 3/a/17:45).

Both Jenny and Debra started with a positive predisposition towards the idea of learning to meditate with technology, but both conclude, in Debra's words: 'I didn't feel like it was teaching me anything' (Intv 4/b/02:24), and later on explains: 'I felt more stressed than before I had done them because I just listened to heavy rain [laughs] for the whole session um which actually doesn't make you feel very good about yourself because you're like 'oh I'm not very good at this' (Intv 4/b/08:15). However, Debra scored most 'Muse points' of all participants (4853, just over 500 more than the runner-up, Jack), and most 'birds' (204, which is 75 more than Jack). So according to the app's data, and in contrast with her personal view, she did better than everyone else. Her first two sessions were in that sense significantly more suc-

cessful than the final two, however, which may influence her retrospective evaluation overall in the post-interview.

While Jenny and Debra share some of their views, Jenny is still open to meditation practice with technology, but Debra expresses a clear preference for human teaching, which she aligns closely to a polar nature/technology discourse:

P I I don't think that technology is as useful as a person [chuckles] um but like I said the headspace app I've found that was useful

R hm-mh

P but that was a recording of a person

R hm-mh

P who was doing a meditation lesson with you

R hm-mh

P so actually that's still kind of human in a sense

R yeah

P because it's just a recording and you're you're taking part in the lesson but from home or um but

R but you have different feelings about this technology right?

P hm-mh I just found it the woman was like a robot [chuckles] and every session she was pretty much telling me the same instructions

R yeah

P um

R like a robot

P like a robot it wasn't any different each week um yeah and it just felt more kind of tech-y you know with the data and the graphs and all the different pages on the app

R yeah

P um having to wear a band round your head

R yeah

P it just didn't it wasn't as natural and [1 second pause] like meditation is meant to be natural, you can go outside if you want, it's meant to be about connecting and with yourself and the world

R and did you feel like this distanced you more rather than

P yeah it didn't connect you you just you sat in a your room and you put a metal band round your head [chuckles] and you listen to rain

R yeah

P but it wasn't natural rain was it it was a it was a [1 second pause] fake recording of rain [chuckles]

R yeah

P um it just didn't feel it didn't feel natural at all or human I would say it felt very tech-y

(Intv 4/b/13:39-15:23. R: Researcher, P: Participant Debra)

Similarly, Alex still feels the 'divide' between technology and meditation which she articulated pre-use. Her post-session forms consistently express her sense of difference between her personal (non-technology) preference and the use of the device.

She experienced the electronics as highly distracting and annoying (including the headband itself, the phone, the female narrator, the birds, and the rain). If anything, she says, the perception of that division has grown stronger: 'I thought it I was wondering whether it would like turn me to 'the other side' [grins] see if I would but clearly not' (Intv 6/b/11:49). However, the rejection isn't absolute. Several participants feel that rejecting the device for themselves doesn't mean rejecting the teaching potential entirely: 'I think it I think it definitely has potential to teach others like I know what I know but I think there's people I know that would benefit from it' (Intv 6/b/19:02). Equally, Debra praises the Headspace app as a technology for meditation practice (Intv 4/b).

Despite her personal frustration with it, Jenny concludes 'I do think that it would be able to teach you' (Intv 2/b/25:21) and continues: 'it is the right teacher with the right learner and that is actually sometimes what happens even with humans because someone may not click with a human and that actually tells you it will teach them better than the human will so'. She feels that 'the optimum would probably be a combination of both um [4 second pause] I don't [sighs] I don't know they're just so different' (25:00). But even Martha, who swiftly rejected the device for herself, concedes: 'I think for someone if someone had never meditated before I think it would teach them well' (Intv 5/b/03:29).

3.5 Post-Use: Moments of learning

Moments of learning occur in the form of self-reflection and self-understanding. After her first session, Lucy writes: 'I'm not sure I've learnt how to meditate because clearly I couldn't do it but I learnt about myself instead!' (P1-S1b) and though a different insight, Jack writes after his first session that he is 'Better at sitting still and being calm than I thought!' (P3-S1b). This is pertinent because he emphasised in the pre-interview that 'sitting still' was difficult for him, and he associated this closely with meditation practice. He saw meditation as 'chilling out by yourself and clearing your head' (Intv 3/a/14:55) and after using the device, he states (without prompting) 'one of the things that this has taught me is maybe like meditating is absolutely a lot more to it than sitting still which is a preconception I had' (Intv 3/b/1:44), explaining further that 'it's very much an active process which I hadn't really considered it to be' (03:20).

Jenny, Martha and Debra, who did not enjoy their experience overall (despite objective successes shown in the app data), also do not feel they have developed their pre-use understanding of meditation. But Alex does express a learning process of that nature: 'I think I realised meditation is different to that everyone I was like in my head that wasn't meditation to just stay calm and focus on your breath and that's it. To me it would be reflecting on something I think yeah like reflecting on one point and just kind of like or like something like patience or something and just kind of like having kind of like small thoughts about it but I wouldn't consider meditation in my eyes to be complete silence not thinking about anything and just being like because I think I get so distracted which I've learned' (Intv 6/b/05:48-06:22). Later on, she adds that she feels that the device was 'trying to teach me meditation just kind of like monk-

style just like silent and nothing and just kind of like sitting there doing nothing really' (Intv 6/b/14:03), which conflicts with her personal definition of meditation – and is the opposite of Jack's insights.

Despite her positive predisposition to technology, Jenny's experience with the device was highly frustrating, in her words: 'I literally just wanted to throw it across the room' (Intv 2/b/15:15), even though the app data shows relative success in achieving calm states in comparison to other participant results. She reattributes this to herself: 'potentially like my fault not technology's fault I would say like there's a good chance it is more my fault' (Intv 2/b/8:59). This expresses an interesting human-technology relationship, with the device being 'excused' for having to deal with flawed human users.

3.6 Post-use: Frustrations

Feelings of frustration across participants were directly related to three things: 1) The rain 2)A mismatch between self-assessment and the soundscapes 3) A lack of personal adaptivity

This often went hand in hand with favouring human teaching above technology. Lucy for example states: 'it would be better with a human teacher cause then, they'd see that I wasn't there or that I was stressing or my shoulders were tense or something they can see the physical signs and then they can talk me through more strategies whereas the technology was very neutral so it just said "keep breathing" and I was getting more angry' (Intv 1/a/06:17). In his interview, Jack echoed exactly the same sentiment (Intv 3/b). Near the end of the interview, Lucy explains again that a human teacher would allow for personal feedback and co-constructive reflection and action on the results of learning, which is exactly what Debra and Jenny also express as the educational void. On her second post-session form, Jenny writes: 'I don't feel like I am learning to medtitate because I still don't have a technique that works – it keeps telling me the same thing' and also 'When its getting hard and I am struggling to focus it does nothing to support me except rain harder which annoys me!! I don't look forward to using it.' (P2-S2b). Her app data does however indicate a 20% improvement in calm state from the first to the second session.

Debra got many birds in her first two sessions (90 and 107), but a lot of rain in the final two sessions, indicating distraction. The app data directly relates to her experience. She characterises her third session, for example, as 'bad. I didn't get any birds. :-(' (P4-S3b). After the final session, when she got only 7 birds, she writes 'meditation should be quiet.' (P4-S4b). She also retrospectively concludes: 'I don't feel I have learnt anything new from using the headband' (P4-S4b) even though on the first two post-session forms, when she got many birds, she does express learning. For example, after the second session, she wrote: 'Happy because I have improved' (P4-S2b). Retrospectively, she does not feel that the data accurately represents her performance and that this made her distrust the device (Intv 4/b). Jenny and Alex express the same 'mismatch' sentiments on their post-session forms.

While Jack likes the technology more than he thought he would, and states he would continue using it, he did find it equally distracting and annoying when the

soundscapes did not match his self-assessment: 'like when I was getting distracted it showed me that I was distracted but there were times whenever I thought I felt that I was calm, I felt that I was focused, and I wasn't hearing birds' (Intv 3/b/19:15). The same is true for Jenny and Martha. Nobody enjoyed the rain (though that is the function's intent), but for some participants like Jenny, it did cause a spiral ending in rejecting the device (Intv 2/b/3:15).

4 Discussion

4.1 Overall observations

The participants had never used the device itself, but were open to the idea that it could teach meditation; ranging from very acceptant 'why not' attitudes, to more cautious willingness to try. They were of course aware that the project entailed the use of a technology for meditation, so they could have been influenced by that context in itself. Experienced meditators could perhaps feel differently, with a developed sense of what meditation entails.

As trainee teachers near-graduation, however, they do have very explicit and high expectations of good teaching. They name qualities such as empathy, creativity, kindness and care, enthusiasm and passion, as key to good teaching. Post-use, they didn't report experiencing these as traits of the device, which is perhaps unsurprising. At the post-use stage, the technology's potential was commended as a 'catalyst' for learning, prompting self-assessment and self-reflection as valid tools for learning meditation. So a re-categorisation occurred of the device using their existing framework of pedagogical knowledge. In some cases, the device's functionality of feedback was considered better than human teaching. However, any sense of automated, robotic, or unresponsive human-technology interaction was a highly negative experience.

They did note strong feelings of frustration and distrust where the device's feedback did not match their inner self-assessment. Objectively recorded experiences with the Muse were less significant than subjective experiences and predispositions to technology in this sense. Of course, a human-led learning context could yield the same experience, for example when a student receives a test score which he or she doesn't feel reflects their true learning. There is a sense of unfairness to the experience, with a resulting disengagement with the context of learning. Teacher adaptivity was also brought forward as key to sustained learning, in that a teacher can pause to explain why something is happening, or give personalised tips, or moments of encouragement if it's getting difficult, or discuss individual progress and tailor subsequent activities. They were disposed towards believing this adaptivity and personalisation is a normal technological possibility, and disappointed to encounter a one-size-fits-all model instead. Much current research and development in technology for education is building towards greater adaptivity and personalisation as it demonstrates higher learner gain. But aside from educational impact or effectiveness, these functionalities may be more important than anticipated to meet human expectations.

Participants state their moments of learning as, firstly, a developed understanding of what meditation is, and secondly, a greater understanding of their own habits and preferences. The latter underlines its potential as a self-reflection tool, for meditative practice or otherwise. The former is perhaps unsurprising, as the participants started with very little prior knowledge of meditation, other than assumptions or indirect information, and therefore whatever they experienced next would be an enrichment to the little direct knowledge they had pre-use. As a meditation guide, it would appear the device did teach its users something about meditation after all.

4.2 Limitations

Though the interview is a common and accepted data gathering tool in qualitative research, it is underpinned by the idea of 'the modernist subject' in Western thought [24]. We can never fully understand the Other, though phenomenology accepts that language and stories are pretty much as close as we can get to understanding the Other's experiences, if we listen carefully and diligently. Reporting qualitative research findings has been likened to story-telling [25], which of course adds its own layer of meaning. Though an academic necessity, such as in writing this paper, it creates a further distancing from a more direct relation to the Other. Yet Seidman encourages researchers to be affirmative in their analysis: 'you have mentally lived with and wrestled with the data' [26]. Ethics in research is not only about data protection and confidentiality, but the integrity of the researcher in faithfully presenting findings with respect to the participant's voice. The mechanisms of participative inquiry in the design of this study hopefully have enabled that further.

The participants in this study were from a Western, white background, and approach meditation as a secular, stress-reducing technique. Though this helps sample coherence, the field of research pertaining to this topic of study certainly requires more culturally and racially diverse participants, as for example found in [27]. Otherwise the sample in this study is of course small, but the rich data set did yield an interesting, diverse analysis. Larger samples could potentially afford a view on trends.

5 Conclusion

Before use, participants accepted the proposition that there was a technology which could teach them to meditate, with varying levels of enthusiasm and scepticism. After using the device, it was commended as a catalyst for self-guided meditation learning, prompting self-reflection through the meditation exercises provided. However, this study emphasises the importance of personalisation and adaptivity in educational technology, as the experience of an automated, unresponsive human-technology exchange is highly negative, and dramatically reduces the likelihood of continued use – especially for learning. Arguably this matches modern Western pedagogical thought for human-to-human education, but the human-technology relationship is held to those same principles. Active 'human versus technology' comparisons mediated the

perception of the device before, during, and after use. Expectations of technical possibility are normalising a technology's personal responsiveness as the new standard.

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7 Author

Dr Caroline Stockman, BA MA PGCE PhD, is a Senior Fellow of the Higher Education Academy, experienced researcher and Senior Lecturer in the Department of Education Studies and Liberal Arts, Faculty of Education, University of Winchester, Winchester, United Kingdom.

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Design, Construction and Evaluation of a Web Application for the Teaching-Learning Process on Financial Mathematics

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Ricardo-Adán Salas-Rueda
Universidad Nacional Autónoma de México, Ciudad de México, México
ricardo.salas@icat.unam.mx

Abstract—This quantitative research aims to analyze the impact of the Web Application for the Teaching-Learning process on Simple Discount (WATLSD) through data science and machine learning (linear regression). The sample is composed of 42 students of the careers in Administration and Marketing who attended the Financial Mathematics course during the 2018 school year. The ADDIE model allows organizing the construction of the WATLSD through the stages of Analysis, Design, Development, Implementation and Evaluation. The results of machine learning indicate that the use of the WATLSD during the learning process positively influences the motivation, active role and development of mathematical skills. Likewise, data science establishes 3 predictive models on the use of the WATLSD in the educational field. Finally, advances in technology such as the WATLSD allow the creation of new virtual spaces for learning and teaching.

Keywords—Educational technology, Teaching, Learning, ICT, Data science, Machine learning

1 Introduction

Today, technology is changing the way of assimilating knowledge and developing the skills of students [1], [2]. In the 21st century, Internet is modifying the organization of school activities and educational practices [3], [4]. For example, web applications facilitate the personalization of learning through the consultation of information at any time and place [5].

The educational environment is changing because teachers are incorporating digital tools, web platforms and applications in school activities [6], [7]. Even educational institutions seek to create new virtual spaces to increase the motivation of students during the teaching-learning process [8], [9].

According to [10], Information and Communication Technologies (ICT) are essential to organize the school activities in the 21st century. In fact, technology is transforming the way of managing the information and content of the courses [10], [11].

Teachers have the possibility of building new spaces for learning and teaching through technology [12], [13]. In fact, technological skills of students facilitate the incorporation of ICT into and out of the classroom [14], [15].

This quantitative research analyzes the use of the WATLSD in the teaching-learning process on financial mathematics (Simple Discount) through data science and machine learning.

The research questions are:

- What is the impact of the WATLSD in the teaching-learning process on the Simple Discount (development of mathematical skills, active role and motivation of the students)?
- What are the predictive models of the use of the WATLSD in the teaching-learning process?

2 ICT in the Educational Field

Technological advances such as web platforms and applications positively influence the teaching-learning process about music [16], mathematics [17], reading comprehension [18], engineering [19] and English language [20].

One of the challenges of teachers in the 21st century is to develop the skills of students [21]. Various authors (e.g., [10], [16]) mention that the use of technology in school activities allows the development of skills.

For example, Moodle facilitates the creation of new virtual spaces that allow developing skills on music issues [16]. Similarly, web applications allow the development of grammatical skills in the course on Language Teaching [10]. Even the incorporation of web applications in the field of statistics favors the development of mathematical skills and active role of the students [5].

2.1 Construction of educational web applications

Various authors (e.g., [5], [18], [20], [22]) have built web applications in order to improve the teaching-learning process and develop the skills of students. For example, [20] designed and built a web application to facilitate the understanding of the alphabet and pronunciation of letters in the English language.

The benefits related to the incorporation of web applications in school activities are the consultation of the contents from any place and time [5]. Also, the use of web applications allows the customization of the educational process because students control the pace of learning ([10], [18], [22]). Even students have the advantage of using various technological tools such as educational platforms and web applications from smartphones, tablets and laptops ([20], [23], [24]).

For example, [22] created a web application to facilitate the assimilation of knowledge about reading and writing at the basic educational level. Similarly, [17] built the MaGrid application with the purpose of facilitating the teaching-learning process and developing mathematical skills at the basic educational level.

[18] developed the Quráni application to facilitate reading comprehension considering the user profile with hearing problems. Even [5] built a web application to facilitate the development of mathematical skills in the field of statistics.

Web applications allow transforming the educational context because students have access to information at any time and place ([22], [18]). In fact, mobile devices facilitate the use of web applications during the teaching-learning process ([25], [26]).

3 Methodology

The objective of this quantitative research aims to analyze the impact of the WATLSD in the teaching-learning process on financial mathematics (Simple Discount) through data science and machine learning.

3.1 Participants

The sample is composed of 42 students (20 men and 22 women) of Administration (n=16, 38.10%) and Marketing (n=26, 61.90%) who studied Financial Mathematics course at a university in Mexico City during the 2018 school year.

The machine learning allows finding the linear regressions with 60% (n = 25 students), 70% (n = 29 students) and 80% (n = 33 students) of training section to evaluate the research hypotheses.

In addition, 40% (n = 17 students), 30% (n = 13 students) and 20% (n = 9 students) of the evaluation section allows identifying the accuracy of linear regressions on the impact of the WATLSD in the teaching-learning process.

3.2 Procedure

The procedure of this quantitative research began with the use of the ADDIE model to analyze the characteristics and needs of the students (See Table 1).

Table 1. Use of the ADDIE model

No.	Stage	Aspect	Description
1	Analysis	Course	Financial Mathematics
		Unit	The Interest unit contains the topic on Simple Discount
		Objective	The student will understand the calculation of the Simple Discount
		Students	The students attended the third semester of careers in Administration and Marketing during the 2018 school year
		Problem	The students of Administration and Marketing have difficulty to assimilate the knowledge on the Simple Discount
		ICT	Design and construction of the WATLSD to facilitate the learning process through simulation of data
2	Design	General objective	The student will understand and use the formulas on the Simple Discount in the practical context
		Particular objectives	The student will understand the concepts of Nominal principal, Accumulated amount and Simple Discount

			The student will use the formulas on the Accumulated amount, Simple Discount and Effective principal
			The student will relate the theoretical concepts on Simple Discount to the practical context
		Use of technology	The WATLSD presents the contents on the use of the Simple Discount during the request for a bank loan
3	Development	Technology Incorporation	The WATLSD requests information about a bank credit to start the simulation of data
			The WATLSD presents the procedure to calculate the Accumulated amount of a bank credit
			The WATLSD presents the procedure to calculate the Simple Discount of a bank credit
			The WATLSD presents the procedure to calculate the Effective principal of a bank credit
4	Implementation	Technology implementation	The students of the Financial Mathematics course use the WATLSD during the 2018 school year
5	Evaluation	Measurement instrument	The questionnaire consists of 7 closed questions (See Table 2)

The WATLSD was built through HTML and the PHP programming language. The students of the Financial Mathematics course used this web application through the following address: http://sistemasusables.com/mf/descuento/inicio.html

The WATLSD requests information about a bank credit to start the simulation of data (See Fig. 1).

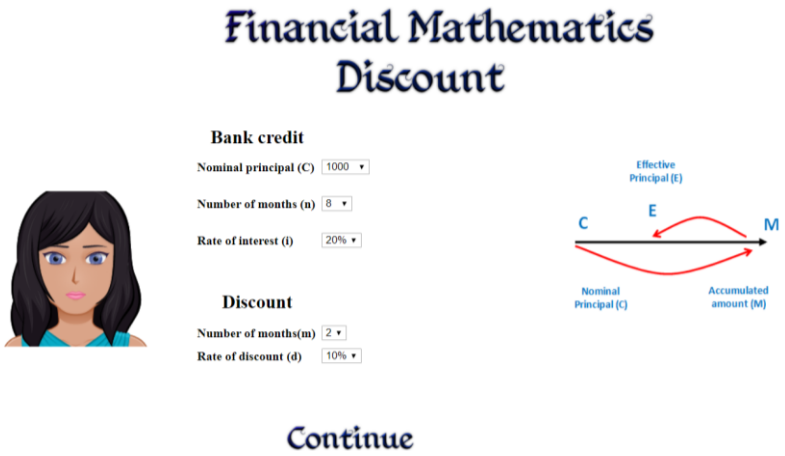

Fig. 1. Request for information in the WATLSD

The WATLSD presents the calculation of the Accumulated amount (See Fig. 2).

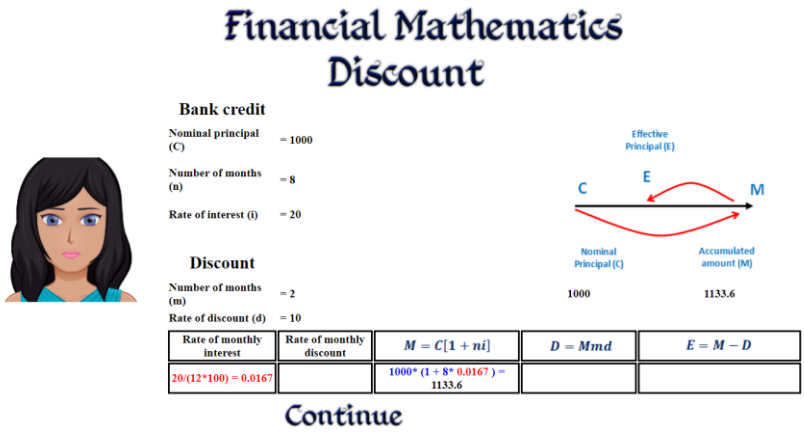

Fig. 2. Calculation of the Accumulated amount in the WATLSD

Fig. 3 shows the calculation of the Simple Discount in the WATLSD.

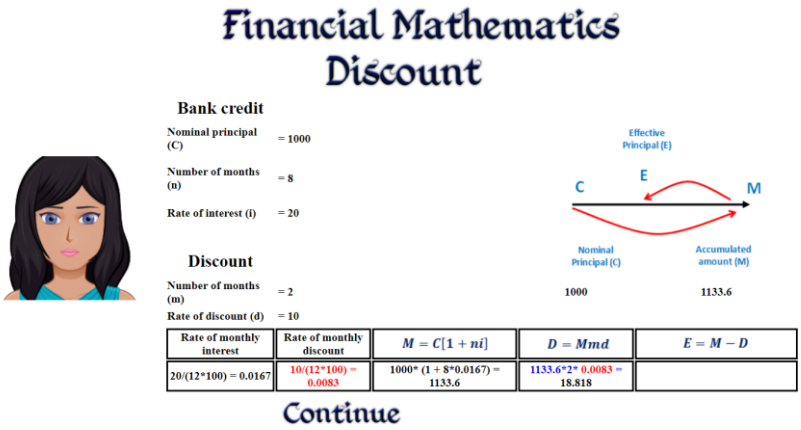

Fig. 3. Calculation of the Simple Discount in the WATLSD

The WATLSD presents the calculation of the Effective principal (See Fig. 4).

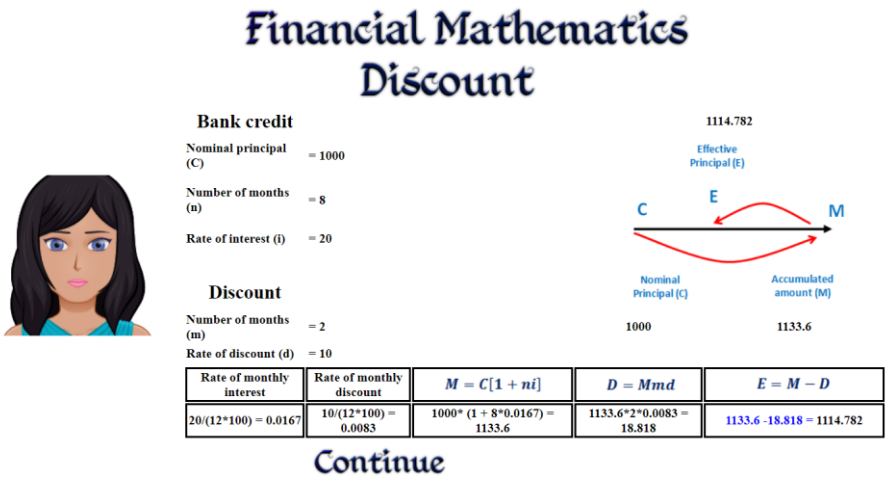

Fig. 4. Calculation of the Effective principal in the WATLSD

Fig. 5 shows the model of technological acceptance on the use of the WATLSD during the teaching-learning process.

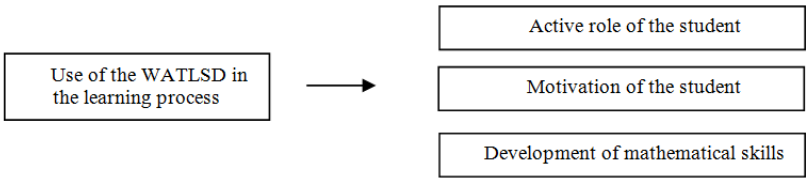

Fig. 5. Technological acceptance model on the use of the WATLSD

The research hypotheses are:

- Hypothesis 1 (H1): The use of the WATLSD during the learning process positively influences the active role of the student
- Hypothesis 2 (H2): The use of the WATLSD during the learning process positively influences the motivation of the student
- Hypothesis 3 (H3): The use of the WATLSD during the learning process positively influences the development of mathematical skills

On the other hand, data science allows the identification of the following predictive models on the use of the WATLSD in the educational process:

- Predictive model 1 on the WATLSD and active role of the student
- Predictive model 2 on the WATLSD and motivation of the student
- Predictive model 3 on the WATLSD and development of mathematical skills

3.3 Data analysis

The Rapidminer tool allows performing the calculation of the machine learning (linear regression) to evaluate the research hypotheses and build the predictive models on the use of the WATLSD during the educational process of Simple Discount.

Machine learning divides the sample into two groups, that is, the training section (60%, 70% and 80%) allows obtaining the linear regression and the evaluation section (40%, 30% and 20%) allows knowing the accuracy of linear regression (See Fig. 6).

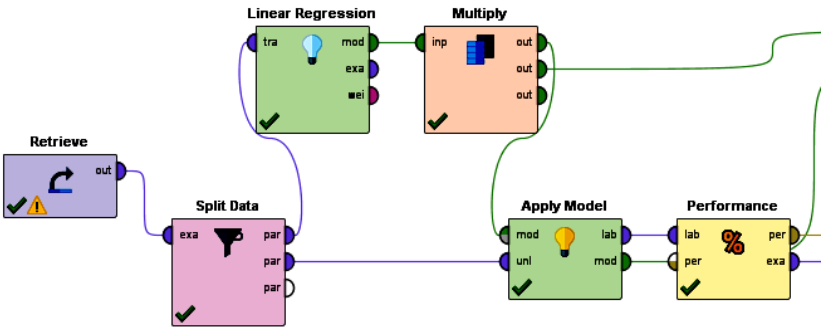

Fig. 6. Calculation of machine learning in the Rapidminer tool

The decision tree technique allows building the predictive models through the Rapidminer tool (See Fig. 7).

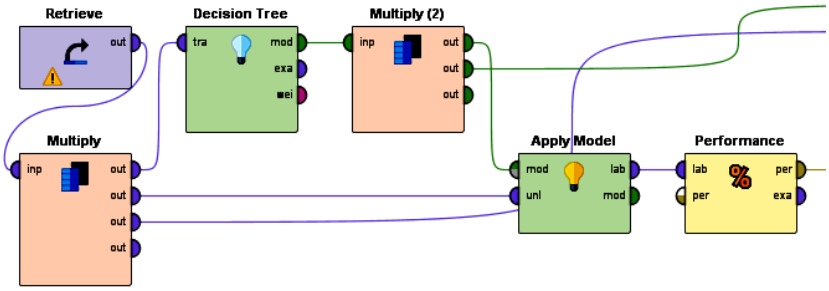

Fig. 7. Construction of predictive models in the Rapidminer tool

Finally, the SPSS software allows validating the measurement instrument by means of the Load Factor, Cronbach's Alpha, Average Variance Extracted (AVE) and Composite Reliability (CR).

3.4 Data collection

The measurement instrument (questionnaire) has 7 closed questions related to the use of the WATLSD in the Financial Mathematics course during the 2018 school year (See Table 2).

Table 2. Questionnaire

No.	Variable	Dimension	Question	Answer	n	%
1	Profile of the student	Sex	1. Indicate your sex			
				Man	20	47.62%
				Woman	22	52.38%
		Career	2. Indicate your career			
				Administration	16	38.10%
				Marketing	26	61.90%
		Age	3. Indicate your age			
				19 years	30	71.43%
				20 years	7	16.67%
				21 years	4	9.52%
				22 years	0	0.00%
				23 years	1	2.38%
2	WATLSD	Learning process	4. The WATLSD improves the learning process on financial mathematics			
				Too much (1)	25	59.52%
				Much (2)	17	40.48%
				Little (3)	0	0.00%
				Too little (4)	0	0.00%
		Active role	5. The WATLSD improves the active role of the student			
				Too much (1)	36	85.71%
				Much (2)	6	14.29%
				Little (3)	0	0.00%
				Too little (4)	0	0.00%
		Motivation	6. The WATLSD improves the motivation of the student			
				Too much (1)	26	61.90%
				Much (2)	15	35.71%
				Little (3)	1	2.38%
				Too little (4)	0	0.00%
		Development of mathematical skills	7. The WATLSD improves the development of mathematical skills			
				Too much (1)	24	57.14%
				Much (2)	17	40.48%
				Little (3)	1	2.38%
				Too little (4)	0	0.00%

The Load Factor (> 0.50), Cronbach's Alpha (> 0.70) and Composite Reliability (> 0.70) values guarantee the reliability of the questionnaire [27]. Table 3 shows that the values on the Load Factor exceed 0.650, that is, Learning Process (0.860), Active Role (0.735), Motivation (0.757) and Development of Mathematical Skills (0.654). Also, the values of Cronbach's Alpha (0.731) and Composite Reliability (0.840) are greater than 0.70.

Table 3. Validation of the questionnaire

No.	Variable	Dimension	Load Factor	Cronbach's Alpha	Average Variance Extracted	Composite Reliability
1	WATLSD	Learning process	0.860	0.731	0.570	0.840
		Active role	0.735			
		Motivation	0.757			
		Development of Mathematical Skills	0.654			

4 Results

The WATLSD improves too much (n=25, 59.52%) and much (n=17, 40.48%) the learning process about financial mathematics. Likewise, the results of machine learning with 60%, 70% and 80% of training indicate that the use of the WATLSD during the learning process positively influences the active role, motivation and development of mathematical skills (See Table 4).

Table 4. Results of machine learning

No.	Hypothesis	Training	Linear regression	Conclusion	Square error
1	H1: WATLSD → active role of the student	60%	y = 0.428x + 0.571	Accepted: 0.428	0.365
		70%	y = 0.444x + 0.555	Accepted: 0.444	0.372
		80%	y = 0.363x + 0.636	Accepted: 0.363	0.409
2	H2: WATLSD → motivation of the student	60%	y = 0.833x + 0.333	Accepted: 0.833	0.433
		70%	y = 0.849x + 0.300	Accepted: 0.849	0.489
		80%	y = 0.778x + 0.351	Accepted: 0.778	0.464
3	H3: WATLSD → development of mathematical skills	60%	y = 0.436x + 0.841	Accepted: 0.436	0.456
		70%	y = 0.527x + 0.722	Accepted: 0.527	0.509
		80%	y = 0.422x + 0.881	Accepted: 0.422	0.439

4.1 Active role of the student

The WATLSD improves too much (n=36, 85.71%) and much (n=6, 14.29%) the active role of the student (See Table 2). Likewise, the results of machine learning with 60% (0.428), 70% (0.444) and 80% (0.363) indicate that hypothesis 1 is accepted (See Table 4). Therefore, the use of the WATLSD during the learning process positively influences the active role of the student.

Fig. 8 shows the predictive model 1 on the use of the WATLSD in the educational context. For example, if the student thinks that the WATLSD improves much the learning process on financial mathematics, has an age ≤ 19.5 years and is a man then the WATLSD improves much the active role of the student.

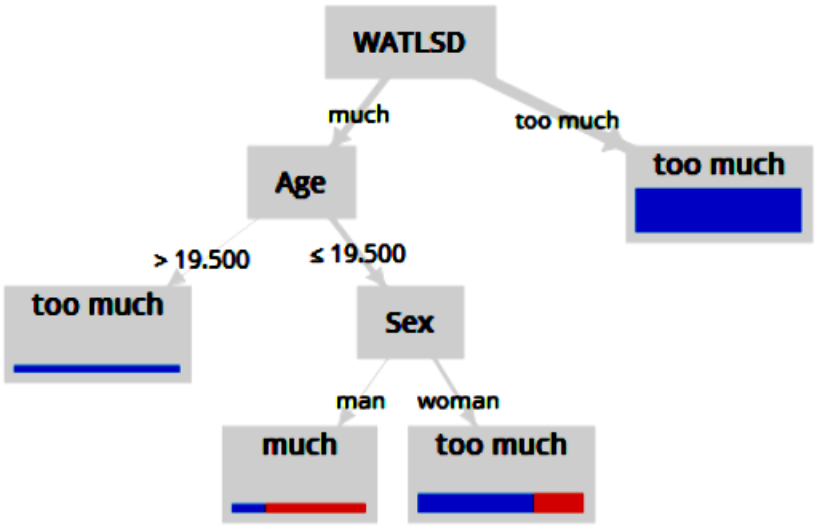

Fig. 8. Predictive model 1 on the use of the WATLSD

Predictive model 1 on the use of the WATLSD in the educational context has 4 conditions and has an accuracy of 90.48%. For example, if the student thinks that the WATLSD improves much the learning process on financial mathematics, has an age ≤ 19.5 years and is a woman then the WATLSD improves too much the active role of the student.

4.2 Motivation of the student

The WATLSD improves too much (n=26, 61.90%), much (n=15, 35.71%) and little (n=1, 2.38%) the motivation of the student (See Table 2). Likewise, the results of machine learning with 60% (0.833), 70% (0.849) and 80% (0.778) indicate that hypothesis 2 is accepted (See Table 4). Therefore, the use of the WATLSD during the learning process positively influences the motivation of the student.

Fig. 9 shows the predictive model 2 on the use of the WATLSD in the educational context. For example, if the student thinks that the WATLSD improves much the learning process on financial mathematics and has an age > 19.5 years then the WATLSD improves much the motivation of the student.

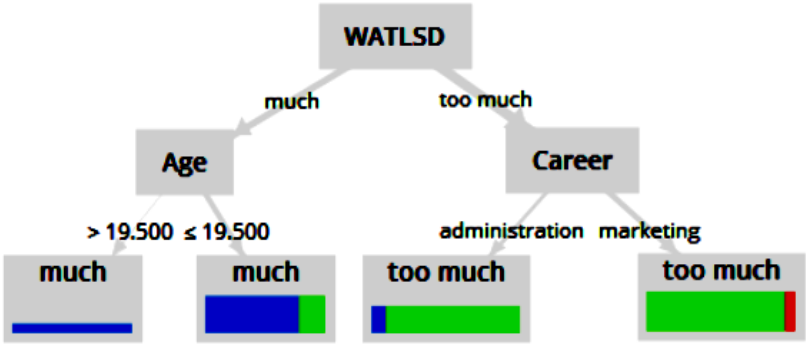

Fig. 9. Predictive model 2 on the use of the WATLSD

Predictive model 2 on the use of the WATLSD in the educational context has 4 conditions and has an accuracy of 88.10%. For example, if the student thinks that the WATLSD improves too much the learning process on financial mathematics and takes the career of Administration then the WATLSD improves too much the motivation of the student.

4.3 Development of mathematical skills

The WATLSD improves too much (n=24, 57.14%), much (n=17, 40.48%) and little (n=1, 2.38%) the development of mathematical skills (See Table 2). Likewise, the results of machine learning with 60% (0.436), 70% (0.527) and 80% (0.422) indicate that hypothesis 3 is accepted (See Table 4). Therefore, the use of the WATLSD during the learning process positively influences the development of mathematical skills.

Fig. 10 shows the predictive model 3 on the use of the WATLSD in the educational context. For example, if the student thinks that the WATLSD improves much the learning process on financial mathematics and has an age ≤ 19.5 years then the WATLSD improves much the development of mathematical skills.

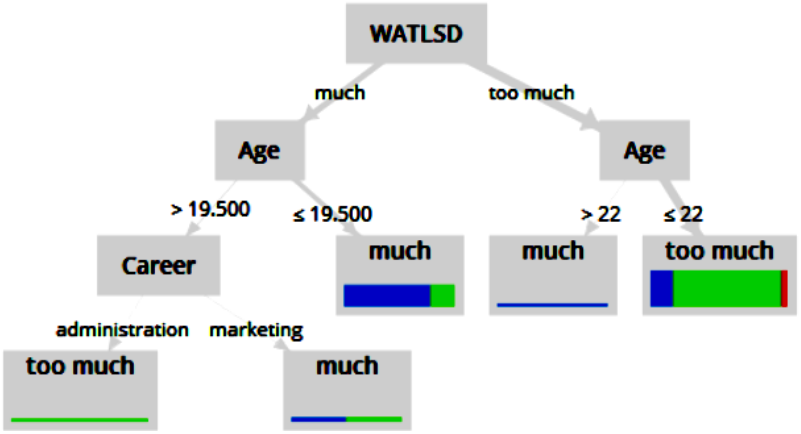

Fig. 10. Predictive model 3 on the use of the WATLSD

Predictive model 3 on the use of the WATLSD in the educational context has 5 conditions and has an accuracy of 78.57%. For example, if the student thinks that the WATLSD improves too much the learning process on financial mathematics and has an age ≤ 22 years then the WATLSD improves too much the development of mathematical skills.

5 Discussion

Today, technology is changing the organization and implementation of school activities [13]. For example, the incorporation of web applications and digital tools in the teaching-learning process facilitates the assimilation of knowledge and development of skills.

5.1 Active role of the student

Most of the students in the Financial Mathematics course think that the WATLSD improves too much (n = 36, 85.71%) the active role of the student. Even the results of hypothesis 1 on machine learning with 60%, 70% and 80 training are greater than 0.360. Therefore, the use of the WATLSD during the learning process positively influences the active role of the student.

Also, data science identifies 4 predictive conditions on the use of the WATLSD and active role of the student, which are distributed in the Too much (n=2) and Much (n=2) categories.

5.2 Motivation of the student

Most of the students in the Financial Mathematics course think that the WATLSD improves too much (n=26, 61.90%) the motivation of the student. Even the results of

hypothesis 2 on machine learning with 60%, 70% and 80 training are higher than 0.770. Therefore, the use of the WATLSD during the learning process positively influences the motivation of the student.

Also, data science identifies 4 predictive conditions on the use of the WATLSD and motivation of the student, which are distributed in the Too much (n=2) and Much (n=2) categories.

5.3 Development of mathematical skills

Most of the students in the Financial Mathematics course think that the WATLSD improves too much (n=24, 57.14%) the development of mathematical skills. Even the results of hypothesis 3 on machine learning with 60%, 70% and 80 training are greater than 0.420. Therefore, the use of the WATLSD during the learning process positively influences the development of mathematical skills.

Data science identifies 5 predictive conditions on the use of the WATLSD and development of mathematical skills, which are distributed in the Too much (n=2) and Much (n=5) categories.

The WATLSD facilitates the teaching-learning process on the Simple Discount in the Financial Mathematics course through the detailed presentation of the mathematical calculations. In fact, the motivation of the student is the factor that has the greatest positive relationship with the use of the WATLSD during the learning process. On the other hand, the active role of the student is the factor that has the least positive relationship with the use of the WATLSD during the learning process.

The predictive models 1 (90.48%), 2 (88.10%) and 3 (78.57%) on the use of the WATLSD during the learning process have an accuracy greater than 78.50%. Finally, this research shares the ideas of various authors (e.g., [1], [12]) on the fundamental role of technology in the educational field. In particular, the WATLSD allows innovating school activities in the Financial Mathematics course.

6 Conclusion

Universities are transforming the teaching-learning process through the construction of new educational virtual spaces. In particular, the WATLSD is a web application that facilitates the educational process on Simple Discount through the simulation of data.

The results of machine learning indicate that the use of the WATLSD during the learning process improves the active role, motivation and development of mathematical skills. Likewise, data science identifies the predictive conditions on the use of the WATLSD in the Financial Mathematics course.

The limitations of this quantitative research are related to the contents of the WATLSD on Simple Discount. Therefore, future research may analyze the impact of technological tools during the teaching-learning process on Simple Interest, Compound Interest, Amortizations and Annuities.

This quantitative research recommends the design and construction of educational web applications in order to improve teaching-learning conditions. For example, the WATLSD allows the students of the Financial Mathematics course to consult the contents at any time and place.

The implications of this study are the benefits of using technological tools in school activities. In particular, the WATLSD presents the mathematical procedure to facilitate the assimilation of knowledge about the Simple Discount. In conclusion, teachers can create new educational experiences through the construction and use of web applications.

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8 Author

Ricardo-Adán Salas-Rueda is a full-time researcher in the Instituto de Ciencias Aplicadas y Tecnología, Universidad Nacional Autónoma de México. PhD in New Technologies Design. Member of the National System of Researchers in Mexico (CONACYT) level I (2019-2021) and candidate (2016-2018). Research lines: Data Science and Educational Technology. ORCID: https://orcid.org/0000-0002-4188-4610

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Point Estimation with Markers for Effective Mobile Auditory Graphs

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Zico Pratama Putra (✉), Deni Setiawan
Queen Mary University of London, London, United Kingdom
z.putra@qmul.ac.uk

Bagus Priambodo
Universitas Mercu Buana, Jakarta, Indonesia

Mila Desi Anasanti
Imperial College London, London, United Kingdom

Abstract—While researchers have performed numerous studies to understand the human interpretation of visual graphs in reading, comprehending and interpreting displayed data; visually impaired (VI) students still face many challenges that prevent them from fully benefiting from these graphs in class. In this study, we conducted a test with 20 students to track the work described in studies in an expanded scenario. As we have tried to answer the question as to whether adding multi-reference mapping of sonification to auditory graphs could improve the of point estimation accuracy in non-visual condition. We also emphasize the efficiency of the performance of multi-reference graphs to make them as efficient as mapping using single pitch. Our proposed study improved performance of multi-reference task completion time by having fewer reference note. The results help provide empirical evidence that the multi-reference mode provides more accurate results than the single-pitch mode and confirms that adding contexts to auditory graphs could be used for better comprehension.

Keywords—Auditory graph, collaborative work, ubiquitous and mobile devices

1 Introduction

The implementation of auditory displays, which deals with the use of non-speech sound to display information, has been engaged in many complex work environments, ranging from computer applications, medical workstations, aircraft cockpits, and control centres of atomic reactors. A specific type of auditory displays is sonification, which is a technique used to typically mapping data sets to acoustic parameters to represent the data audibly. It usually represents information in non-speech audio [1]. It can help users to analyse the trend of data and its distribution by hearing the sound as a representation of the rendered acoustic data [2]. Data sonification benefits from

the fact that it can be perceived more broadly and clearly than speech that is precise and requires more focus [3].

Many studies have been proposed to improve science, technology, engineering and mathematics (STEM) education for VI students using sounds in learning [4]; visually impaired (VI) users still face many challenges that prevent them from fully benefiting from graphs. Consequently, it affects their understanding of data visualisation, and in turn reduces their role in collaborative tasks with their sighted peers in both educational and working environments. Although, the auditory graphs have been proposed for these VI users, most studies of auditory graphs have only been carried out on a non-portable device like personal computer (PC) which does not offer specific modality input like haptic interaction.

In this study, we are interested in exploring further support of non-visual point estimation tasks using another form of sonification by integrating multiple tones as references to represent a note as previously conducted by Metatla et al [5]. Their study showed that using multiple references could improve the accuracy of point estimation tasks in auditory graphs.

2 Background

2.1 Auditory graph implementation on mobile devices

Research related to the auditory display on a mobile device has been evolving in recent years due to the extensive use of mobile communication [6]–[9]. Researchers have exploited the use of accessibility features such as screen readers and voice commands for communication purposes such as to create, record, send and receive emails; use of maps for navigation; and modify a document [8], [10], [11]. An earlier study has developed a system on a tablet PC, called exPLoring graphs at UMB (PLUMB), which was designed to support people with visual impairments to understand graph by using auditory cues [12]. To date, the closest work to our study has been developed by researchers from Monash University, GraCALC, as an approach for implementing numerical and statistical graphics to VI [13]. The system presents a graphic from a mathematical function as a line graph which then displayed on a web-based service. Putra et.al. have designed mobile auditory graph (MAG) to support collaborative task for VI users to enable them to create and edit graph collaboratively [14].

2.2 Auditory graph design

The design of auditory graphs focuses on the question of mapping the dimensions of sound to the displayed data. The main mapping issue includes whether pitches should be increased or decreased in response to changes in the associated data. Auditory graphs can be considered a class of sonified displays which uses sound to display quantitative information. This means that any changes in quantitative data are mapped to changes in one or more dimensions of sound. Auditory graph as part of auditory display framework may solve the audio clutter arises from an attempt to listen to

many numeric values in speech. Imagine the difficulty of trying to remember 10 or more data values spoken out loud. Non-speech sounds facilitate the traceability of auditory graphs by simply following a continuous sound trend whose pitch changes according to the values in the data set.

As in the visual graphs, the auditory graph characteristics need to be set up properly so that the listener can understand the meaning of data. While, the properties of the visual graphs (i.e., spatial area, colour, trend, and size) are regularly changed, the audio properties in sonification, such as pitch, pan, rate, volume, and timbre may be modified. These properties describe some mappings to the sound attributes such as loudness (identifies with the sound's amplitude), pitch (a feature that relates to the frequency of sound) and timbre (a characteristic of a sound that identifies it from the various reference of a similar pitch and volume) [15].

Walker et.al. [16] explored these questions by comparing data-to-display mappings, polarities and scaling functions to correlate data values with the associated sound parameters for both sighted and VI people. They discovered that in some circumstances, VI listeners might prefer opposite polarities to sighted listener perceptions. They found that for a specific mapping, for example, mapping coin size to pitch, VI people tended to have an opposite mapping compared to sighted people.

Brown et al. [17] explored further the question of mapping sound and formulated guidelines for the design of auditory graphs based on research into the sonification of line graphs and guidelines for sonifying graphs with two or three series of data. Earlier research suggests that adding context cues such as checkmarks and labels to graphs offers advantages for non-visual interaction [18], [19]. Recognizing the point's position in space plays an integral role in reading and/or building graphically based representations [20].

Metatla [5] study developed a simple user interface for the users to predict a point by providing a vertical slider that can be moved along the Y-axis with the two modes: single point display and multi-reference display. The users can estimate the point when positioning it at a desired location on an axis [5].

In the single point display or pitch-only display, by mapping the pitch of a sine wave to the Y coordinate of the point with a positive polarity, users predict each point's position on an axis, i.e. increasing the pitch upwards for each point and decreasing the pitch downwards for each point. Using the same positive polarity as the pitch-only display, the position of a point in the multi-reference display can be predicted relative to an origin with multi-reference of tones. This can be done by determining both the pitch difference on that point in comparison with the subsequent points and the length of the sum of the successive notes separating it from the origin. Thus, a greater distance provides a longer sequence of tones. An ascending set of tones will be produced for points located below the origin, and a descending set of tones for those above the origin [5].

Metatla et.al found that there was a major disadvantage of using the multi-reference mode as it takes more time as compared to the use of usual pitch only graphs [5]. Based on their study, we would like to test whether using less multi-references will lead it to be more efficient as users can retain less information to remember the data, yet still improve the accuracy of point estimation.

Therefore, our study investigates whether employing multiple tones can assist point estimation tasks for perceiving a better perception and interpretation in auditory graphs, yet still as efficient as those using pitch only graphs. In order to confirm this assumption, 20 sighted participants took part in the study in March 2019.

In our MAG app., we developed an algorithm to only works for positive Y values with ascending from 0 up to a maximum value (YMax) for multi-reference. The idea is to play notes in multiples of 10ths of the maximum Y value leading up to the value of the point the user is trying to estimate (YEstimate). This approach is used in order to reduce the number of reference tones presented while still giving the user enough information to make a fairly accurate estimate of the point of interest. The reason for this is that researchers [5] found that if a lot of reference tones were played, people lost track of them and they became less useful.

3 Experiment

We developed an experiment to study the influence of sonification on the accurate estimation of point positions by adding reference markers. Our research centered on providing information that could help estimate the point position in relation to its proximity to an initial point.

3.1 Apparatus

The MAG interface has been developed based on a 9.7-inch screen Samsung Galaxy Tab S2 with the Android 7 operating system. We designed a mobile graph application with multimodal input by allowing gesture interaction to support the task of rendering the auditory graph (see Figure 1). Swipe interaction was implemented to help the users to locate the points on the X-Y coordinates.

Pitch-only mapping: We sonified the position of a point on an axis in the first design by plotting the pitch of piano and coin tone to the Y coordinate of the point according to a positive polarity. The tone's pitch changes in accordance with the point's movements on the axis; the value with the lowest frequency was mapped into coin sound and piano for higher frequency and was increased linearly to attain the maximum value of 100 in 1638 Hz frequencies in midi note G#6.

Multi-references mapping: In the second design, we applied the same pitch mapping used in the first prototype. But instead of hearing only one pitch, there are sequential reference tones with different pitches that correspond to all points before the current position and the original reference. This version only works for positive Y values. We think of the Y values going from 0 up to a maximum value (YMax). The idea then is to play notes leading up to the value of the point the user is trying to estimate (YEstimate). Whether YEstimate > YMax * 0.5, we only start playing them from the point YMax * 0.5, so the user will never have more than 4 notes played before the value of YEstimate is played.

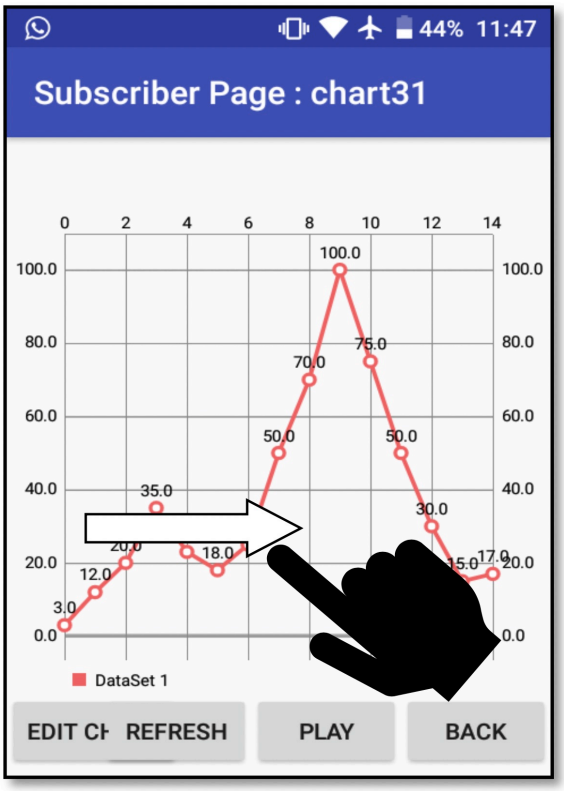

Fig. 1. Illustration of user's hand interacting with the MAG interface by tapping and/or swiping from the left part of the graph to the right.

In order to generate a sequence of tones, our reference tones had a duration of 200 milliseconds and were superimposed with a delay of 200 milliseconds. The point's position can be estimated in relation to an origin by comparing the difference in pitch at that point with the next points and the total length of the successive notes separating it from the origin. A longer distance yields a longer succession of tones. It will be important to use a different instrument when playing fractions of YEstimate > YMax * 0.5 compared to the instrument used to play YEstimate < YMax * 0.5, as we clearly want to be able to distinguish between the two.

In our MAG app., whether YEstimate is higher than half of YMax (>0.5*YMax) or below half of YMax (<0.5*YMax), the system only begins playing the reference in ascending order. For the point above half of YMax, the system plays the reference from the point above half of YMax with a piano sound, while for the point below half of YMax, the reference from the point above zero is played with coin sound. Thus, the user will never have more than 5 notes played including the value of YEstimate. For example, when the user reaches number 86 with YMax number is 100, he/she hears the sequence of tones composed of all the pitches of points 60, 70, 80 and 86 as the

YEstimate. When the user reaches number 46, he/she hears the sequence of tones composed of all the pitches of points 10, 20, 30, 40 and 46 as the YEstimate.

The sounds were generated by mapping the Y-coordinates of graphs into the pitches. In this study, the Y-axes were ranged from 0 to 100 which one value as one increment as shown in Figure 1.

3.2 Experimental design

Participants: A total of 20 sighted participants volunteered to take part in study 1 (16 men and 4 women) between 18 and 39 years old, and another 20 sighted participants in study 2 (11 men and 9 women) between 18 and 39 years old. They were a mixture of university staff (both academic and non-academic), undergraduate and postgraduate students from Queen Mary University of London. They were randomly assigned to two groups of ten in a within-subject experimental design.

Procedure: Participants were given an overview of the experiment on arrival as the aim of this study. They presented with the explanation related to how long the study will be performed and the instruction of the interface on how to assess the auditory graphs in our MAG app.

After that, they were asked to complete the first questionnaire about their demographic details and musical education (in relation to the musical instrument). Fourteen participants assessed their musical education as "playing no musical instrument" or beginner, the rest of them stated that they are playing at least one musical instrument. The participants had no experience with non-visual interaction.

The participants were then randomly assigned to one of the two groups. Each of them was asked to estimate two different graphs (graph A and graph B) with one of the two modes (pitch-only or multi-reference mode). They were paired to use different mode for each of the graphs so that it will diminish the learning effect using two modes with the same graph. For example, user 1 was asked to estimate the graph A with the pitch-only mode and the graph B with the multi-reference mode, while user 2 was asked to use the opposite mode using the multi-reference mode for the graph A and the pitch-only mode for the graph B.

Participants were trained on the respective displays and could spend as much time as they want to familiarize themselves with the interfaces before starting the experiments. Specifically, the participants were familiarized with the various sonification mappings used and asked to spend sufficient time until they felt comfortable with both the mappings used.

The training usually lasted 10 minutes per each sample graph with pitch-only or with multiple-reference markers. The training graphs was in a visual state, which was first displayed as a linear graph with notes from 10 to 100 in multiples of 10, i.e. 10, 20, 30, and so forth. The participants were then presented in the second graph in the form of randomly arranged notes, however, still have a maximum value of 100. The purpose of this second graph was not only to reinforce their memories of the range of pitch sounds, but also to familiarize them to the display of other values between tens, such as 18, 23, 75, etc. The participants were asked to lay their fingers on the left-hand side of the MAG app interface that showed the graph, then were asked to slide

their finger until the end of the right-hand side. When their finger touched a certain point, they heard a tone of the Y-value in accordance to the real value they had seen on the graph.

After the training, the testing task usually lasted from 4 to 6 minutes per condition in the non-visual state. In this setting, participants could see the graph area, however the line graph is hidden. The users had to rely on the sonifications to estimate the position of the points as they swiped their finger to the target positions. They were asked to perform 10-point estimation trials per mode, i.e. either pitch-only or multi-reference mode. Initially, participants began to tap the MAG app from the left part of the graph for the first trial and swiped slightly to the right direction for the next trial and so forth. They were asked to state their estimated numbers every time they hear a pitch to be noted by the observer. They were not given any feedback about the real Y-value after the test.

3.3 Research question

The main research questions of the experiment were:

1. Will users produce lower point estimation errors when using multi-reference sonification mapping relative to pitch-only sonification mapping?
2. Will it still be slower performing point estimation tasks when using the multi-references sonification mapping with fewer references no more than five tones as compared to the pitch-only mapping?

4 Results

4.1 Study 1

Evaluation of point estimation error with one sample audio: To evaluate how well users can perform point estimation task, we observed the RMSE between the estimated (predicted) values to the true values, apart from the different categories of graphs and different presentation modes. This is an exploratory study, with the intention of examining how well sighted participants perform point estimation tasks using the first version of the MAG app prototype.

The results were then calculated across all subjects by calculating the RMSE between the estimate values with the true values; one for the pitch only and the other for the multi-reference mode. This separation of using 2 modes was implemented as we were interested to know whether there is a relationship between the performance of point estimation tasks and the mode used to perform the tasks. To confirm whether the difference between the two modes is statistically significant, we performed a student t-test comparing the means of the RMSE obtained between the two modes. Our null hypothesis is that the RMSE mean of the pitch-only mode is equal to the mean of the multi-reference mode. A one-tailed test was used to test if the RMSE mean of pitch-only mode is significantly greater than those of the multi-reference mode.

The t-test resulting in an insignificant different of the RMSE means which implies that the two modes are not significantly different (t = -1.59, p = 0.121).

The experiment was failed to prove that the multi-reference mode provides more accurate results than the pitch-only mode.

Completion time: The completion time of point estimation tasks was calculated across all subjects; one for the pitch only and the other for the multi-reference mode. The t-test resulting in a significant difference in the completion time means which implies that the two modes are significantly different in regard to the time completion used (t = 2.6719, p = 0.01134). In term of completion time, the experiment was also failed to prove that the multi-reference mode performance could have same level to the pitch-only mode. Based in this result, we consider implementing two sample audio sources, having coin for point below half of YMax and the rest with piano sound as describe previously, as follows:

4.2 Study 2

Evaluation of point estimation error with two sample audios: The results of point estimation tasks using piano and coin sample audio calculated across all subjects by calculating the RMSE between the estimated values with the true values; one for the pitch only and the other for the multi-reference mode. This separation of using 2 modes was implemented as we were interested to know whether there is a relationship between the performance of point estimation tasks and the mode used to perform the tasks. After calculating the RMSE, the values were plotted into four boxplots to visualise the distribution of the error for each method and each type of graph.

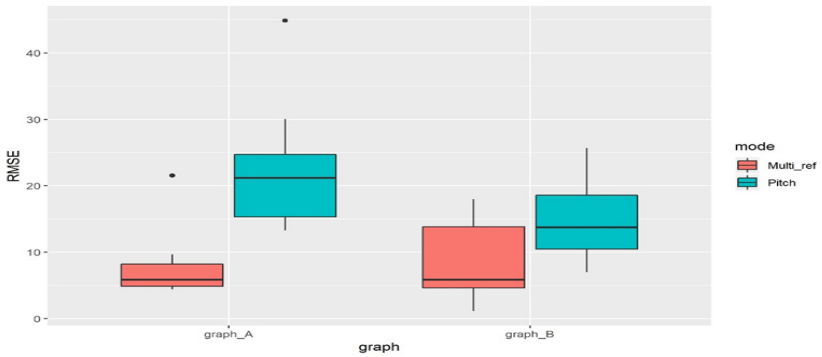

Fig. 2. Comparison of four boxplots, representing the distributions of RMSE obtained from the multi-reference mode and the pitch only in graph A and graph B as dis-played on the X-axis. The Y-axis shows the RMSE values between each error from 0 to 30. The legend denotes the task in the multi-reference and the pitch only mode.

We then combined the RMSE results from graph A and graph B as both graphs were assigned with random values and patterns, thus can be treated as if they are in one graph. The boxplot of these combined graphs consistently shows that using multi-

reference mapping improved the performance represented by its lower RMSE values as shown in Figure 2.

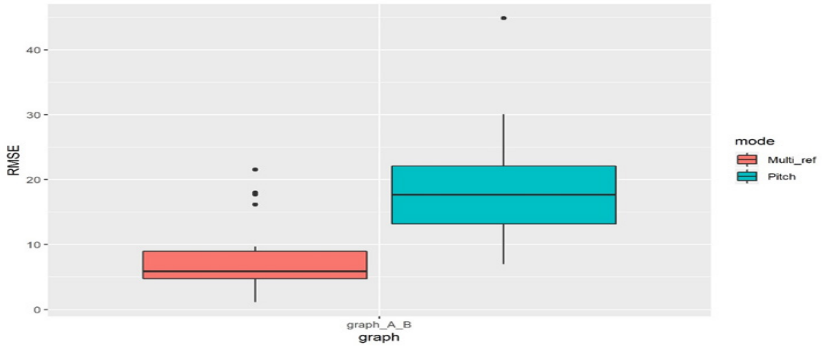

Fig. 3. Comparison of the boxplot of RMSE values calculated from graph A and graph B combined using the multi-reference and the pitch only mode.

To confirm whether the difference between the two modes is statistically significant, we performed a student t-test comparing the means of the RMSE obtained between the two modes. Our null hypothesis is that the RMSE mean of the pitch-only mode is equal to the mean of the multi-reference mode. A one-tailed test was used to test if the RMSE mean of pitch-only mode is significantly greater than those of the multi-reference mode.

The t-test resulting in an insignificant different of the RMSE means which implies that the two modes are not significantly different ($t = -4.59$, $p = 0.00006.172$). The aim was achieved through this study; the experiment's results generally show that the multi-reference mode provides more accurate results than the pitch-only mode.

Completion time: The completion time of point estimation tasks was calculated across all subjects; one for the pitch only and the other for the multi-reference mode. After calculating the completion time, the values were plotted into four box plots to visualise the distribution of the completion time for each method and each graph. The time is presented on Y-axis in milliseconds.

As seen from the boxplots in Figure 4, in general, the time used to complete the tasks using multi-reference mode shows less performances with those using pitch only mode in term of their median and quantiles with the distribution may slightly different. In graph A and B, the multi-reference mode has a wider distribution than the pitch-only mode.

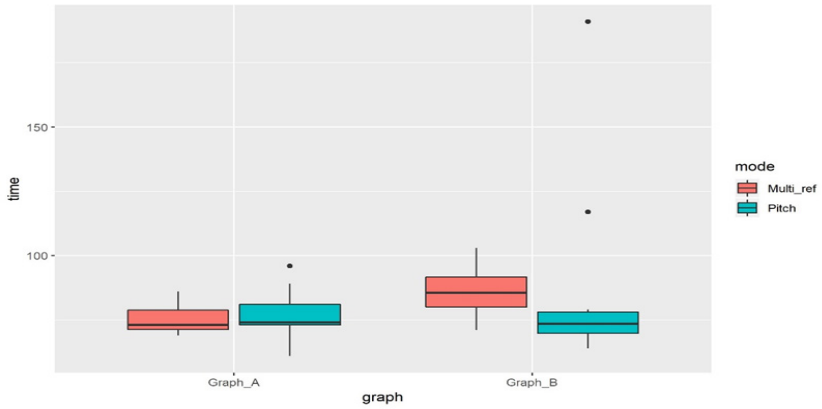

Fig. 4. Comparison of four boxplots representing the completion time from the multi-reference and the pitch only mode in graph A and graph B as displayed on the X-axis. The Y-axis shows the time in milliseconds (ms) from 0 to 200 ms. The legend denotes the task in the multi-reference (orange colour) and the pitch only (teal colour) mode.

Our null hypothesis is that the completion time of the pitch-only mode is equal to the mean of the multi-reference mode. A one-tailed test was used to test if the completion time mean of the pitch-only mode is significantly greater or smaller than those of the multi-reference mode.

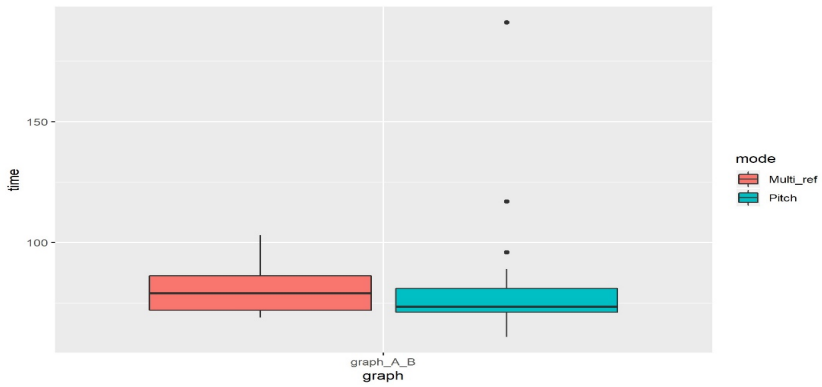

Fig. 5. Two boxplots depicting the completion time (in milliseconds) obtained to complete point estimation tasks using the multi-reference and the pitch only mode from the combined graph A and graph B.

When the completion time results from graph A and graph B were combined, the boxplot on Figure 5 consistently shows that completion time is not significantly different ($p > 0.05$), but the multi-reference has a wider distribution.

The t-test did not result in a significant difference of the completion time means which implies that the two modes are not significantly different in regards of the time completion used ($t = -0.299$, $p = 0.76$).

5 Discussion

5.1 Analysis of the accuracy to estimate point-estimation tasks

The exploratory study 1 was failed to prove that the multi-reference mode provides more accurate results than the pitch-only mode (t = -1.59, p = 0.121). The participants seemed to have difficulty differentiating markers before and after 50% of YMax while using only one sound sample (piano sound). They need additional references to separate the two parts of this pitch, so study 2 is needed under the same conditions as study 1, but include additional sample sound (coin sound) and split them for any number before and after 50% of YMax. In general, the results showed that the multi-reference mode generated more accurate results when the participants were asked to estimate for graph A and B. The t-test resulting a significant difference of the RMSE means which implies that the two modes are significantly different (Mpitch-only = 18, Mmulti-reference = 6) (t = -4.59, p = 6.172 x 105). The first research question of this study has been answered for this population that the users produce higher point estimation errors when using the pitch-only sonification mapping compared to the multi-references sonification mappings.

5.2 Analysis of the completion time to finish the tasks

Concerning the duration of the trial, the users' opinions were divided between those who considered the pitch only mode to be faster and those who against it. In general, most participants considered the multi-reference was a faster for point estimation trial rather that pitch only. Their feedbacks were opposing the literature that it requires longer time for the multi-reference task completion. However, the pitch only mode could be the most demanding attention because they have no context information to help the point estimation process. Tough, most participants believed that the trial estimation time to complete the tasks was shorter in the multi-reference mode.

Most participants found it was really difficult to follow the note-by-note presentation in the pitch only mode. Although a few users felt that the completion time used to conduct the test on multi-reference graphs were longer than the one used pitch-only graphs, however, on average there was no significant difference in the duration of the test time between the two modes as shown in Figure 5. The conclusion seems to be different from Metatlas' [5] conclusion as they found that there was a compromise between speed and accuracy for multi-reference sonification. This tradeoff is actually could be anticipated by limiting the number of references. We successfully proved this claim in our experiment by creating the number of the references to a maximum of 5, separating the sound reference to under 50% and above 50% of YMax, and shortening the sound delay between the references. With this, participants will have a shorter time to maps the tones to the value and also the application will have a shorter time to present the graphs in tones as compared with the point presented in the work of Metatla et al. Therefore, research question 2 of this study has been answered, there was no significant difference between the task completion times between pitch-only

and multi-reference modes. In conclusion, most of the participants responded that multi-references were faster in the estimation trial, although the statistical test calculating the completion time between the two modes confirmed that the difference was not significant ($t = -0.299$, $p = 0.76$).

6 Conclusion

In general, the results of the experiment show that the multi-reference mode generated more accurate results compare to the pitch-only mode. The evaluation confirms that adding context to auditory graphs such as tick marks could enhances the perception of auditory graphs.

Furthermore, while a few participants considered that the point-only is faster but less accurate, most of the participants responded that the multi-reference mappings were faster in the point estimation trial. About 80% of them also considered that the multi-reference mode was also easier for estimation as the single note may require each user to remember the wider band of pitch sounds.

Compare to Metatla's work, we showed the improved performance on point estimation tasks containing fewer reference tones which results in less reduction in speed of performance of the point estimation tasks. We also successfully managed the approach to be scalable, in the sense that there will never be more than a fixed number of tones played no matter what the numbers are on the Y-axis.

Although the outcomes of this study have been successful, several areas require further investigation since there are several differences from Metatla's study: the fact Oussama used negative numbers and the polarity of the pitch change. Therefore, we plan to conduct further study more like Oussama condition but preserving the key aspect of our approach. The other condition could be similar to Metatla's, but not use negative notes, and it should use the same instruments and graphs as we did for the study 2. Since we have split the sample sound to coin and piano sound in the latest study, the coin sound should be replaced with piano notes throughout the whole display in future study.

7 Acknowledgement

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9 Authors

Zico Pratama Putra and **Deni Setiawan** both work for School of Electronic Engineering and Computer Science, Queen Mary University of London, London, in United Kingdom

Bagus Priambodo works for Faculty of Computer Science, Universitas Mercu Buana, Jakarta, in Indonesia. Email: bagus.priambodo@mercubuana.ac.id

Mila Desi Anasanti works for Section of Genomics of Common Disease, Department of Medicine, Imperial College London, London, in United Kingdom

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Project-Based Learning Approach for Teaching Mobile Application Development Using Visualization Technology

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Zhanat Nurbekova
L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan

Vadim Grinshkun
Moscow City University, Moscow, Russian Federation

Gaukhar Aimicheva (✉), Bakyt Nurbekov
L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan
aimicheva@mail.ru

Kalima Tuenbaeva
Al-Farabi Kazakh National University, Almaty, Kazakhstan

Abstract—This article is devoted to the experience of applying the Blended Project-Based Learning Approach Using Visualization Technology in teaching mobile application development for IT-students. This technology is based on a project-based method, pair programming, teamwork and using of digital educational resources as a visual learning content. The authors describe the impact of the used teaching methods and digital educational resources on the student's cognitive skills during the mobile application development in the workshop where the students gained hands-on experience on mobile application development through «active doing» method, interactive tasks and creating different types of mobile application projects. The workshop's curriculum is developed in terms of the scaffolding. So, the students improve the skills develop projects starting from simple «Hi, Kazakhstan!» to a complete software with the functions of search and update from the Internet. The well-designed project topics on development mobile application arise the interest and provide the high motivation of the learners.

The impact of Blended Project-Based Learning Approach is evaluated through the questionnaire, testing and evaluation of mobile application projects developed by students. The effectiveness of such an approach for teaching mobile application development is confirmed by the empirical data.

Keywords—Mobile application development, project-based learning approach, digital educational resources, cognitive skills, pair programming, interactive tasks

1 Introduction

Mobile computing is one of the rapidly developing areas of computing. Mobile applications are successfully used as part of innovative educational technologies to enhance learning in various disciplines [1], [2] and the demand for competent mobile application developers globally is high [3]. But the issue of teaching mobile application development is relevant to this day [4-13], [15], [18], [19], [21-33].

After the ACM computing curricula was published in 2013, where many of the courses covered the topic of mobile computing, the mobile application development course began to be implemented by many universities. A feature of the mobile application development course is in the interdisciplinary correlations between traditional areas of computer science such as software development, human-computer interaction, web programming, data security, and network interaction. In view of this feature the earlier works considered the issues of integrating the mobile application development course into the «Computer Science» curricula [4], [9], [11], [12]. So teaching mobile application development can be implemented:

- As a separate topic in the introductory programming courses
- In the basic courses, such as «Algorithms and data structures», «Database systems», «Operating systems»
- In the elective courses «Software Development», «Human - computer interaction» at senior courses
- As the projects on courses connected with the network programming, the distributed computing systems on senior courses
- As capstone project and a final year project

According to [14], [15], [17], [23-25] the content of mobile application development courses are based on the basic concepts of mobile software such as: 1) user interface design and usability; 2) device cooperation, 3) hardware issues; 4) data handling; 5) application interaction; 6) programming issues.

As research and MOOC-courses analysis has shown the main goals of teaching mobile application development, which can be formed as: 1) learning the computer science principles in terms of mobile computing; 2) the computational, logical, design thinking skills development; 3) the mobile application user interface design skills development; 4) development the skills of mobile application analysis, design, implementation and testing [4-13], [15], [18-19], [21-27], [29-30].

The issues of the teaching mobile application development with the emphasis to cognitive difficulties of understanding, remembering, applying, analyzing and creating during mobile application programming are not adequately investigated [22], [24], [28], [30], [32-33].

The scientific research about applying the set of approaches to teaching mobile application development for iOS is considered in the work [22] and provides the evidence that the students haven't been encouraged with the problem-based approach to learn course content. Students wish to know a problem-solving algorithm, as it is, and do not wish to know how to obtain such an algorithm. It is evident that the

students are only able to understand, to remember and to apply the gained knowledge. At the same time, the authors note that students have the cognitive difficulties of acquisition the topics as «Optionals», «Closures» and «Properties», where the analysis and creating skills are required. To increase the achievement, especially on complex topics, the authors improved the learning content by decomposing the main learning goal into sub goals that are revealed during the 1-2 minute learning video modules. Thus, the authors have been able to increase the students' attention concentration and achieve complex topics, which require analysis and creating skills, to 80%.

As it is known, to acquire the mobile application development better it is necessary to focus on the development of skills which are implied in the knowledge and application of object-oriented programming concepts (abstraction, encapsulation, inheritance, polymorphism) and design patterns in mobile application development [24], [30], [32]. And the most students' cognitive difficulties on programming mobile applications arise in this field [24]. For this reason the authors suggest an innovative teaching methodology using hands-on mobile programming techniques, specific projects and the «active doing» method for teaching cross-platform two-dimensional mobile game development. The «active doing» method provides students to gain hands-on experience by implementing the theoretical knowledge on mobile application development in practice.

In [30], the authors teach to apply the object-oriented programming skills in practice for mobile game development. The authors suggest the training modules on mobile game development which includes the hands-on projects and guidelines for teaching the computer science students in junior courses. The hands-on projects demonstrate how to develop mobile games, thereby motivate students to learn the content and the object-oriented programming fundamental principles.

Interactive tasks to train programming in real time [33] are being used to teach the skills and concepts of the mobile application programming course as The Mobile Computing with App Inventor - CS Principles» on edX platform. The platform provides an assessment the task performance and in case of errors, teaches to write a code correctly. In response to such interactive tasks, the students are acquired skills for the understanding, remembering, applying and analyzing on mobile application development.

In teaching mobile application development, it is necessary to consider that students acquire programing skills better programming in a pair or in a team through collaborative learning [34], [35]. Besides, there are empirical data which have been proved that IT-students prefer the visual and kinesthetic learning style [36]. Many researches have been experimentally proved the effectiveness of a project-based approach to teach mobile application development for developing the design thinking and such soft-skills as critical thinking, problem solving, teamwork and communication skills [24], [29], [30], [40].

The conducted overview of researches lead to make a conclusion about the necessity of applying the project-based learning approach, pair programming, using interactive tasks in real time, watching video instructions, and using «active doing» method for better development of cognitive skills on mobile application development.

The following research questions will be addressed in this study: «To what cognitive skills are the discussed above learning methods impacted?», «To what extent the mentioned above methods impact to the learning efficiency and to the students' motivation learn a mobile development course?», «How does applying visualization technology enhance learning process?».

The considered methods were implemented during a workshop on the mobile application development using the digital educational resources (DER) as a visualization technology. The research results and applied methods are discussed below in the relevant sections.

2 Materials and Methods

The first and second year students of the specialties like «Computer science», «Software and computer engineering», «Information systems» took part in the workshop which was held within two weeks with the volume of 60 hours. During the workshop 89 students acquired skills on the mobile application development for iOS on the integrated development environment Xcode using the object-oriented programming language Swift. Such a programming language combines the principles of object-oriented and functional approaches of programming. The core concepts are «object» and «class», while the main logical methods used in the mobile application development are abstraction, analysis, synthesis, induction, deduction, generalization and classification. Correct implementation of the logical methods provide the developing a clear hierarchy of classes, data structure and mobile application logic that affects the mobile application efficiency.

During the workshop, the teaching process was based on visual and kinesthetic learning style, implemented by using the DER and project-based method. The visualized educational content of the workshop was presented by DER covered all fifteen course topics.

The structure of each DER includes the following units:

1) The theoretical unit is a multimedia and animation unit which represents learning content on mobile application development as a diagrams, tables, charts, images, animation, video and audio fragments.
2) The training unit represented by interactive tasks-simulators, which allows students to increase their mental activity in mobile application development, reinforce skills, and create a «success feedback» in students's minds and increase their motivation to further study of the course content through the training function (see Figure 1).
3) The control unit is represented by test tasks with a single or multiple choices with the correct answers. After testing is complete, the test results have been shown at the screen. The students can get to know the correct answers and compare them with their own answers. This part of work allows to make the self-analysis and promotes self-development of the student's personality.

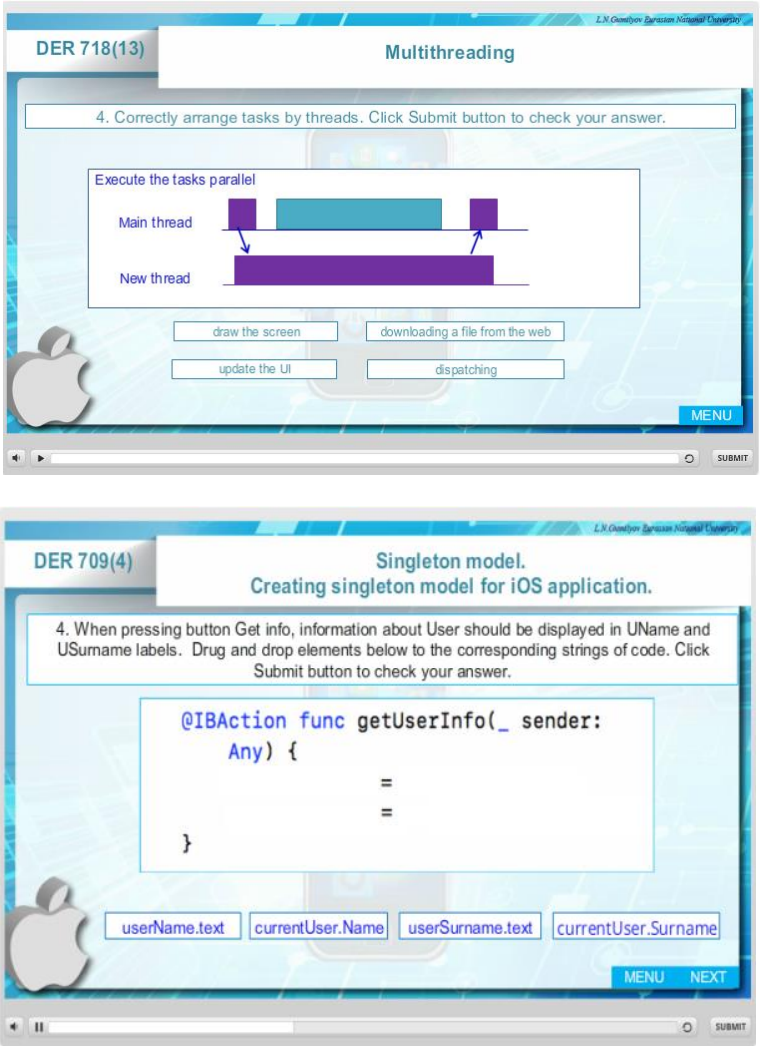

Fig. 1. Examples of the interactive tasks

DER are developed in accordance with the spiral approach [37-39] which proposes scaffolding and repeating content at increasingly complex levels. In addition, each DER includes the video-clips demonstrating mobile application development step-by-step from simple «Hi, Kazakhstan!» to a complete software with functions of search and update from the Internet.

The lesson structure is not a linear, but of a spiral structure. It means that the challenge set at the beginning of the lesson requires to be returned to it repeatedly during the lesson. That moment, students were suggested to perform the following types of learning activities:

1. Learn the course content with the DER;
2. Perform the interactive tasks;
3. Perform the lab sessions based on pair programming;
4. Control assessment.

At the end of the lesson, the students had time for a team work on the educational project.

To ensure the effective teaching of the mobile application development we should assess the impact of the used teaching methods and techniques on the cognitive skills development, according to Bloom's taxonomy. Table 1 presents data about the assessment of the DER impact on the cognitive skills classified according to Bloom's taxonomy and students' achievement through mobile application development.

Table 1. The impact of the DER on the cognitive skills, classified according to Bloom's taxonomy and developing through mobile application development

№	The unit of the DER	The cognitive skills
1	The multimedia and animation unit	remember, understand
2	The training unit with the interactive tasks-simulators	remember, understand, apply, analyze
3	The control unit	remember, understand, analyze, evaluate
4	The video-clips demonstrating mobile application development	remember, understand, apply, analyze

As it is showed in the table, DER provides the asquisition only as a part of the cognitive skills, mostly «remember», «understand» and «apply». To ensure the asquision of other most important cognitive skills of analysis, evaluation and creating, students were offered other learning activities using the methods discussed in the introductory part of the article (see Table 2).

Table 2. The impact of teaching methods on the cognitive skills during the mobile application development

№	The teaching methods	The cognitive skills
1	Performing the lab sessions based on pair programming	remember, understand, apply, analyze and evaluate
2	The «active doing» method for work on the self-study and educational projects.	remember, understand, apply, analyze, evaluate and create
3	Team work on educational projects for the development of mobile applications.	remember, understand, apply, analyze, evaluate and create

To assess the impact of used approach on the students' cognitive skills development the survey, control testing, evaluation of interactive tasks, individual work, criterial assessment of educational projects for mobile applications were applied.

The course curriculum is offered to the students the next topics of mobile application projects to perform them during hands-on and self-study work:

№	Hands-on projects for lab sessions	Projects for self-study work
1	«Hi, Kazakhstan!», «Weather forecast».	Student Portfolio.
2	Calculator.	Game «777».
3	«Guide of the Kazakhstan's City».	«7 Wonders of the World».
4	«The major tourist attractions of Astana with positioning on the map».	«Map of sports complexes in Astana».
5	«Work with a student database using Json».	«Astana business-directory».
6	«Threading».	«Currency Converter».
7	«App for students testing assessment».	Game App «Who Wants to Be a Millionaire?».

The instructional video, interactive tasks-simulators, hands-on and the self-study projects encourage students to acquire the cognitive skills required at all stages of mobile application development: analyzing and formalization of a problem, designing the app architecture and logic, codding, testing, debugging and evaluating of the mobile application. In addition, students gain experience in using logical methods for mobile application development (abstraction, analysis and synthesis, induction and deduction, generalization and classification) to designing a hierarchy of classes and objects, defining protocols and other class properties, using blocks to optimize code, access to remote database and process threading in order to save mobile device resources and to develop an optimized mobile application.

3 Results and Discussion

As experiment showed that using the DER as visualization technology for explaining educational material allows teachers to save the time. Instead of 50 minutes duration of the lecture within the traditional approach, using the DER reduces the actual time to 10-12 minutes. The possibility to perform an interactive task repeatedly provides consolidation of knowledge and developing hands-on skills on topics such as designing of an architecture, using components, defining outlets, class properties, coding, thereby developing necessary cognitive skills. In addition, the DER can be implemented both in LMS and interactive platforms, for example, Google Classroom, for implementing personalized learning technology [41], [42].

One of the benefits of using the DER is to increase the motivation of students in comparison with the traditional teaching. The survey has been examined the students motivation to study the mobile application development course using the DER. 94.4% of students have found the mobile application development course interesting and the using DER for learning the course content efficient. Due to the post-intervention survey of students aimed to evaluate DER, it was revealed that the most useful block of DER is the video-clips of the hands-on mobile application development and the possibility of self-study complex topics (see Figure 2).

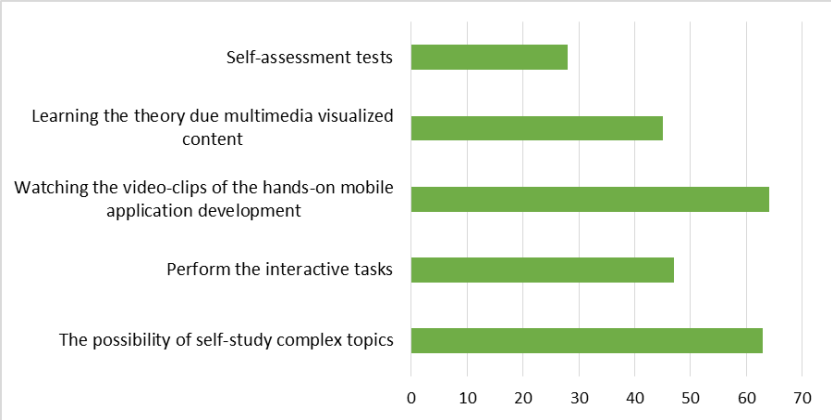

Fig. 2. The post-intervention survey of students aimed to evaluation DER

Figure 3 shows the project types and degree of their completeness by students. According to the survey results (see figure 3), the tasks for self-study work on mobile application development turned out to be the most difficult for implementation. It is obvious that students have not sufficient skills on «analysis» and «creating» for the mobile application development. During the classes students in collaboration with the teacher analyzed the mistakes in projects performance within self-study work, which has been positively impacted on the team projects performance at the level of 92%.

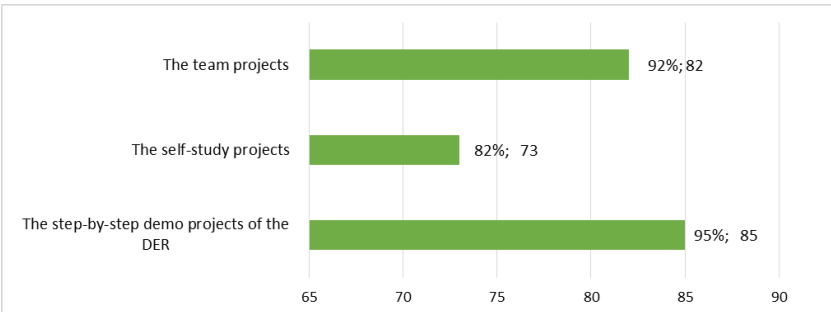

Fig. 3. The project types and degree of their completeness

At a result of the workshop students developed team projects on different topics such as Directory of universities of Kazakhstan, Recipe mobile-book, Kazakh-English dictionary, Math interactive simulator for preschool age children, Logic puzzle game, etc. The developed mobile application projects had been evaluated by three levels (low, sufficient and high) using the criterial assessment. Due to the criterial assessment system the qualitative data were collected which allowed to appraise the following knowledge and skills of students to develop mobile applications:

- The skill to formalize the requirements and define the data structure of the mobile application;

- The skill to identify the abstract levels within the Model-View-Controller model, the classes and objects;
- The skill to determine the mobile application states and the sequence of segues between mobile application views;
- The knowledge and skill to determine the optimal data structure and data access methods;
- The knowledge and skill to use components;
- The skill to code class algorithms using patterns, closures and other programming language mechanisms;
- The skill to debug the application code;
- The skill to evaluate the mobile application conformity to initial specification requirements.

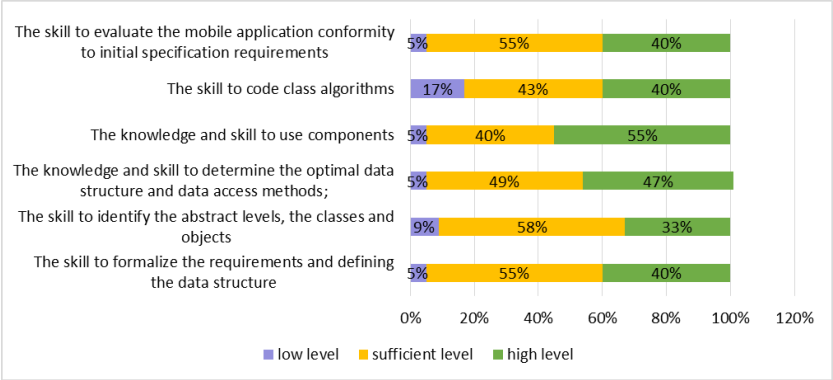

Fig. 4. The results of assessment of the students' knowledge and skills to develop mobile applications

The results of evaluating students' projects represented on the histogram (see figure 4) show that some students have a low level of knowledge and skills in: «Formalizing the requirements and defining of the data structure of the mobile application», «Identification of the abstract levels, classes and objects», «Coding of class algorithms using patterns, closures and other programming language opportunities». This is due to the fact that to acquire these topics it is necessary to require cognitive skills of «analysis», «creating», «using of logical methods for mobile application development». And another reason why the students have such a low level of knowledge on the mentioned above topics may be an insufficient level of object-oriented programming knowledge which is a basic for mobile application development. The above assumption is proved by results of the preliminary survey that the most of students (90%) learned the Pascal programming language as a basic one (see figure 5) and in the second half-year, students learned one of the object-oriented languages such as C ++ (73%), Java (47%), Python (26%).

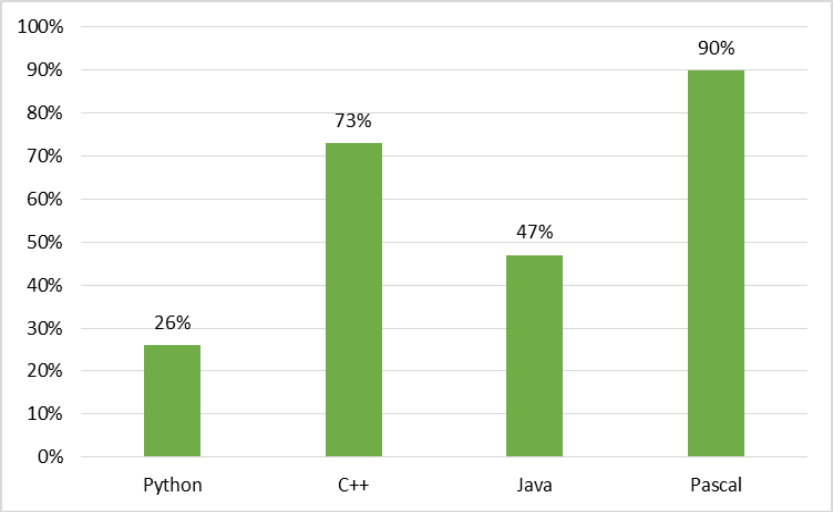

Fig. 5. The results of the survey on the programming languages knowledge

4 Conclusion

Thus, this research allowed to investigate the effectiveness of an blended approach based on project-based learning, pair and team programming, using DER for provide interaction and visualizing of learning content and implementation «active doing» during hands-on session as well as analysis of students' cognitive skills through the criterial assessment of developed projects. Furthermore, this work could provide a framework for an instructional design of a methodological system on teaching mobile application development aimed to feasible choice of the appropriate learning techniques and approaches.

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6 Authors

Zhanat Nurbekova, Doctor of Pedagogy, Full Professor, Director of the Institute of digitalization of L.N. Gumilyov Eurasian National University, Satpayev str 2, 140000, Nur-Sultan, Kazakhstan, zhanat_n@mail.ru

Vadim Grinshkun, Doctor of Pedagogy, Full Professor, Head of Digital Education Department of Institute of Digital Education in Moscow City University, Moscow, Russian Federation, vadim@grinshkun.ru

Gaukhar Aimicheva, Senior Lecturer, Department of Computer science and Information Security, L.N. Gumilyov Eurasian National University, Satpayev str 2, 140000, Nur-Sultan, Kazakhstan, aimicheva@mail.ru

Bakyt Nurbekov, Doctor of Pedagogy, Full Professor, Department of Higher Mathematics, L.N. Gumilyov Eurasian National University, Satpayev str 2, 140000, Nur-Sultan, Kazakhstan, b_zh_nur@mail.ru

Kalima Tuenbaeva, PhD in pedagogy, Library Director, Al-Farabi Kazakh National University, 71/27 al-Farabi Ave., 050000, Almaty, Kazakhstan, kalima_t@mail.ru

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Improving Accuracy in Imitating and Reading Aloud via Speech Visualization Technology

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Xiaobin Liu (✉), Diying Wu, Yiwen Ye, Manfei Xu, Jianli Jiao
South China Normal University, Guangzhou, China
liuxiaobin@m.scnu.edu.cn

Wenheng Lin
Nansha Dongchong Middle School, Guangzhou, China

Abstract—This article reports on a teaching experiment that uses speech visualization technology to facilitate EFL (English as a foreign language) learners' ability of imitating and reading aloud (IRA). Traditional practice of "listen and repeat" used in pronunciation and intonation training often only hazily illustrates some salient speech features, such as pitch and intensity, etc., making it difficult for learners to accurately differentiate the features of pronunciation and capture the subtlety of intonation of the target language. As speech visualization transforms aural information into visual graphics and illustrates it in a clearer way, it can highlight the most important phonetic features of utterances. Such technology was used in a three-month teaching experiment carried out in a senior middle school in southern China for the purpose of reducing learners' phonetic errors and enabling them to perceive sense groups appropriately. The results indicated that this approach was effective in increasing accuracy in pronunciation while did not have a significant effect on the fluency and rhythm in speech.

Keywords—Speech Visualization Technology, English pronunciation, speech

1 Introduction

There has been a long-reached consensus that in language learning, reading aloud (RA) is closely related to listening, reading, and writing in EFL teaching, and that it has always been regarded as a basic and effective method for EFL learners to improve their speech accuracy. Madsen [1] points out that RA can test students' pronunciation, intonation, mastery of English phonetic rules, fluency, and grammatical competence. Halliday [2] mentions that oral reading helps learners deal with difficult texts with high information density. Remarkably, in the context of silent reading, "even skilled readers have a little voice running through their heads the whole time" [3]. Warner, Crolla, Goodwyn, Hyder and Richards [4] insist that "reading aloud is apparently an indispensable part of teaching". It can be concluded that what learners can learn from RA includes not only some certain language items, but also the whole system of the

target language [5]. Based on this idea, it is of high importance to strengthen learners' oral reading training and improve their abilities in pronunciation, intonation and other relevant aspects during daily teaching.

EFL teaching has emphasized that learners should be exposed to an abundance of English recordings of native speakers and receive a wide variety of corresponding imitating and reading aloud training. Imitating and reading aloud (IRA) which is a further version of RA focuses on learners' perception of the speech input and their speech imitation experience. They are supposed to manage to produce speeches as exactly as the original audio texts [6]. IRA remains one of the main approaches to train Chinese learners' English pronunciation. Normally, given a text and the related audio or video material, learners are required to imitate the speech, rehearse it several times and finally read it out. Through imitating and uttering aloud some sections or paragraphs of a text, or some short passages, learners can be encouraged to pay more attention to their pronunciation and intonation accuracy, and the process of their language acquisition (namely, chunking) can be also promoted [7]. In this way, learners' language becomes increasingly accurate and close to the original sound version. Eventually, learners are able to use the target language flexibly [8]. Therefore, the method of IRA is highly recommended to language teachers in their teaching of speech.

However, the traditional practice of "listen and repeat", which is still commonly found in language classes currently, tends to allow learners to aurally sense the pitch, intensity, and other salient speech features hazily, making it difficult for them to accurately perceive the varied pronunciation and intonation features of their target language. It fails to provide learners with more detailed and accurate guidance. Besides, the traditional method also indicates that students are in need of high-quality English teachers who often serve as language role models for students to follow. Such teachers are not only limited in number but also would encounter great difficulty in conducting speech training to large size classes having at least 40 students. To solve these problems, speech visualization technology supported by multimodal discourse theory may provide an alternative way.

2 Multimodality and Speech Visualization

Inspired by Maybury's [9] and Hill's [10] definition of modality in human-computer interaction in the field of computer science, researchers use modality to refer to the way in which humans interact with the external environment (such as humans, machines, animals, etc.) utilizing their senses (such as seeing, hearing, touching, etc.) [11]. Various modalities can be found in newspapers, magazines, advertisements, posters, storybooks, textbooks, encyclopedias, instructions, computer interfaces and even in people's daily communication with each other [12]. For example, while people are talking, they are vividly using body language, including facial expressions and gestures, indicating that people actually are applying some modalities in daily communication. [13].

Since the emergence of multimodality, its concept has been studied and further investigated in a great number of disciplines such as social semiotics, conversation or discourse analysis, interface design, human-computer interaction, visual design, mathematics, hypermedia, media studies, new literacy studies and so on [14, 15]. Some of the important issues in multimodal discourse research include as follows: Is there a "stronger" or a "weaker" modality in a multimodal discourse? Do they complement each other? Can one of the modalities strengthen or weaken the information provided by the other modalities? [12] Some scholars believe that the more modalities presented, the more information and learning experience people can obtain [16]. Therefore, multimodal discourse theory advocates that teachers can properly use images and sounds integrated with texts and other interactive ways to stimulate learners' multiple senses in language learning.

Speech visualization is one of the technical realizations of multimodal discourse theory. Technically illuminated by the traditional oscilloscope, speech visualization technology presents the acoustic information in the form of electronic graphics, images, text, data, charts, etc. Simply speaking, it converts auditory information into visual symbols. From the perspective of multimodality, this technology adds visual modality to the interaction originally limited to auditory modality in the process of human-computer interaction. In recent years, tools and systems of speech visualization have sprung up with the development of information technology. Overall, speech visualization can be divided into the following categories: (1) speech edition; (2) speech analysis; (3) speech recognition; and (4) visual speech for instance, audio editing tools, such as Cool Edit as well as specialized phonetic software such as Praat, are widely used in various relevant industries.

There are at least three advantages of speech visualization in language teaching. To begin with, employed in the design of teaching activities, speech visualization achieves dynamic presentation of visual interfaces (such as speech waveform, fundamental frequency, energy, etc.) and relevant speech data analysis, thereby closely integrating the planning and final implementation of teaching activities to improve the efficiency of teaching and learning [17]. Secondly, speech visualization allows teachers to use visual symbols to express abstract aural information, which enables learners to understand the phonetic features of the target language in a more visual and accurate way and provides effective guarantee for oral training. Thirdly, as most EFL classes in China are of large size, the visual form of learning can help learners practice and correct their pronunciation independently without teachers at their sides, relieving teachers' pressure of correcting every inaccurate response.

Up to now, a great number of scholars have studied the effect of visual tools on speech teaching. Among them, Hincks [18] mentions that teachers have been using signal analysis software to visualize speech for decades to support teaching and help learners perceive and produce target sounds of a second language. Levis and Pickering [19] and Chapelle [20] believe that the application of visualization technology (such as the use of WASP and Praat) is an important progress in intonation teaching. Godwin-Jones [21] points out that speech analysis and language learning software (for example, Visio-Pitch of KayPentax) are helpful for the accuracy of pronunciation in language learning. Gorjian, Hayati and Pourkhoni [22]

and Boersma and Weenik [23] explore the effectiveness of Praat in phonetics learning and helping learners master English prosodic features. By employing Praat, Brett [24] provides feedback on vowel and diphthong learning while Wilson [25] and Dixon [26] study the teaching of segmental sounds and suprasegmental features. Wallace and Lima [27] present the role of visual techniques such as the role of Audicity and Praat in pronunciation teaching. Martin [28] introduces WinPitch LTL II whose functions mainly include an automated visual comparison between learners' imitation and the model recordings, and the automated feedback of correcting learners' pronunciation on segmental and suprasegmental levels. Tamandani [29] uses Praat to study the stress and intonation teaching for undergraduate students of AMU. Chun [30] describes the role of Speech Analyser in speech teaching. Fox [31] investigates Speech Analyser and Praat in his related research of online phonetics course teaching. Levin [32] studies the practicability of Cool Edit in speech teaching. Derman, Bardakçı and Öztürk [33] use Praat and Cool Edit to assist the investigation of Arabic learners' reading speech in terms of stress and pause when they learn Turkish as a second language. Sariman and Çetin [34] use Cool Edit when studying the influence of computer-aided instruction on the skill of word stressing in teaching Turkish as a foreign language. Zoghbor [35] conducts research on how to teach multi-dialect L2 learners to produce oral English using Cool Edit.

In China, plenty of researchers have made use of various speech visualization tools to carry out speech teaching research. Sun [36] and Zhuang and Bu [17] use Praat to investigate college English majors' accuracy problems in pronunciation. Zhou and Zhang [37] undertake research on oral English fluency using Cool Edit, while Xie [38] focuses on increasing learners' ability of sound recognition and sensitivity to the differences between English and Chinese sounds by making use of Speech Analyser. However, the application and research of speech visualization tools for English IRA training have not been much explored yet.

3 Two Common Problems of IRA

According to David Nunan [39], accuracy and fluency are two important dimensions of oral ability. These two dimensions have then become two major reference designators for evaluating learners' speaking ability and quality. In order to reveal the current situation of English speech teaching, some researchers in China made use of the RA recording samples of 125 college level English learners from China for detailed analysis. By looking statistically at their various errors in RA, researchers found there were two main types of errors, namely, phonetic errors (43 per cent) and errors affecting oral fluency (31 per cent) [40]. From the perspective of error analysis, this study proves that accuracy and fluency are two major indicators and the most common problems with regard to EFL learners' spoken English ability.

The subjects in the research above are learners at an advanced stage of EFL learning. Do Chinese K-12 EFL learners also encounter similar problems? Since 2011, Guangdong Province in China has added Computer-based English Listening and Speaking Test (CELST) to the College Entrance Examination. CELST consists of

three tasks: Reading Aloud, Role Play, and Retelling. Reading Aloud task mainly requires candidates to firstly watch a one-minute video clip and imitate the pronunciation and intonation along its playing. Candidates can have a short rehearsal reading the subtitles of the video clip for about one minute. Then they listen to the speaker once again and have to read along with the subtitles provided. The testees should finally read the subtitles. Candidates are required to keep their pronunciation, intonation and speech speed as consistent as possible with what they hear from the clip. Such a task is referred as IRA in this paper. To inquire into high school graduates' English pronunciation and intonation, a random sampling of IRA recordings from 200 testees participating in the 2011 CELST was conducted and the types of their errors were described and classified. 1,682 errors in total were found by the authors and the specific distribution of errors is shown as follows (Table 1), while the definitions [40, 41] and examples of these errors are shown in Tables 2, 3 and 4.

Table 1. Error statistics of IRA task in CELST

Error types		Amount	Ratio (%)
Phonetic errors	Mispronunciation	442	26.3
	Addition	54	3.2
	Reduction	62	3.7
	Stress	136	8.1
	Subtotal	694	41.3
Fluency errors	Error on sense group	392	23.3
	Repetition	256	15.2
	Invalid mending	61	3.6
	Filling	20	1.2
	Towing	20	1.2
	Subtotal	749	44.5
Word deletion		113	6.7
Word addition		31	1.8
Intonation errors		95	5.6
Grand Total		1,682	100

Table 2. Definitions and examples of phonetic errors in IRA task in 2011 CELST

Error types		Examples	
		Original version	Incorrect sample(s)
Phonetic errors	Mispronunciation: Incorrect or inaccurate pronunciation, e.g. pronouncing a word into another one which shares a similar sound.	(1) For the South Pacific, this is a critical time. (2) So it may not stay healthy much longer.	(1) From the South Pacific, this is a critical time. (2) So it might not stay healthy much longer.
	Addition: Adding a segment or segments to the end of a word.	(1) We depend on it. (2) The South Pacific Ocean is on the surface of it still a healthy ocean.	(1) We depends on it. (2) The Southern Pacific Ocean is on the surface of it still a healthy ocean.
	Swallowing: Swallowing part of the sound of a word when uttering.	It's changing in ways that, if left unchecked, could develop into a global crisis.	It's chan(g)ing in ways that, if left unchecked, could develop into a global crisis.
	Stress:	Over 60% of the world's	Over 60% of the world's fish

	Misplacing the correct stress position of a word and stressing the wrong syllables.	fish catch comes from the Pacific [pəˈsɪfɪk].	catch come from the Pacific [ˈpəsɪfɪk].

Table 3. Definitions and examples of fluency errors in IRA task in 2011 CELST

Error types		**Examples**	
		Original version	Incorrect sample(s)
Fluency errors	Error on sense group: Inappropriate pause (e.g. a sense group is split by wrong pausing) or lack of pause (e.g. speaking in a non-stop way).	The South Pacific is on the surface of it still a healthy ocean.	The South Pacific is on the surface of it still a / healthy ocean.
	Repetition: Uttering a word again.	But like all oceans, it has little or no protection.	But like all oceans, it has little or no protection, protection.
	Invalid mending: Pronouncing a word or a segment as a correction or an addition.	But like all oceans, it has little or no protection.	But like all oceans, it has little or no protection, tation. But like all oceans, it has little or no protection, person.
	Filling: Using some meaningless sounds in between two words, such as eh, hm, ah, uh, er, en, etc.	The South Pacific is on the surface of it still a healthy ocean.	The South Pacific is on the surface of uh, uh, a healthy ocean.
	Towing: Drawling part of the sound of a word.	We depend on it.	We depeeend on it.

Table 4. Definitions and examples of other errors in IRA task in 2011 CELST

Error types	**Examples**	
	Original version	Incorrect sample(s)
Word deletion: Missing or skipping some words in the text.	And protecting the fish will ensure a healthy ocean for all the marine life of the Pacific.	And protecting the fish will ensure a healthy ocean for all the marine life (of the Pacific).
Word addition: Adding a new word to the text.	The South Pacific is on the surface of it still a healthy ocean.	The South Pacific is on the surface of a it still a healthy ocean.
Intonation errors: Pronouncing within inaccurate or incorrect tones, e.g. wrong rising or falling tone, or no tones.	So it may↗ not stay↘ healthy much longer↗.	So it may → not stay → healthy much longer →.

Table 1 shows that the learners' IRA errors are primarily made up of phonetic errors (41 per cent) and fluency errors (45 per cent). Such findings are basically consistent with Gao's study [40] quoted above. The present study adopts large random sampling and carries out corpus-based rigorous analyses (i.e., testees' recordings in the 2011 CELST were made into a recording corpus). The validity of the results is therefore guaranteed.

The analysis of the error types found in 2011 CELST indicates that the errors are also closely related to the learners' inability to grasp the phonetic features of the

materials they imitated. For example, they had difficulty pronuncing the vowel sounds which are related to the shape and size of speakers' oral cavity (such as coronal high vowel). Correct pronunciation of these types are difficult for learners to attain. In addition, the fluency errors are usually caused by learners' confusion about the sense groups, i.e., different components in a sentence which are divided according to meaning and structure, of the utterances. Learners' perception of sense groups directly determines whether they can pause appropriately when performing an IRA task. If learners can perceive the sense groups visually in such a task and receive sufficient uttering training, their accuracy of perceiving sense groups can therefore be improved.

4 The Experiment

4.1 Research questions

In view of the mentioned common errors made by Chinese EFL learners in IRA and in light of multimodal discourse theory, this study attempts to explore how speech visualization technology in teaching can help to reduce learners' phonetic errors and fluency errors in speaking. There are two specific questions to be answered: (1) Whether speech visualization in teaching can effectively reduce learners' phonetic errors? (2) Whether speech visualization in teaching can help learners perceive sense groups correctly so that they can improve their oral fluency?

4.2 Subjects

This study targeted two parallel classes of similar English level (according to their scores in the Senior High School Entrance Examination) as the research subjects. They were Grade-One students in a senior high school in Panyu District, Guangzhou, China. They were taught by the same English teacher who was also responsible for the grading throughout the experiment. There were 40 students respectively in these two classes, one serving as the experimental class and the other as the control class.

4.3 Instruments

The instruments used in this study mainly include: (1) Cool Edit Pro 2.0 (CE) which was used to present the recording waveform of the materials and produce teaching courseware for classroom teaching and students' self-learning; (2) language laboratory in which students conducted self-directed IRA training and Pronunciation Power 2 (PP2) with which they have their utterances recorded and converted into waveforms for comparisons with the standard recording waveforms; (3) SPSS (version 18.0) with which the authors analyzed the experimental data; and (4) two test items of equivalence for pre-test and post-test respectively.

4.4 Process

This experiment lasted for three months. The following is a detailed introduction of this experiment.

Pre-test: In order to confirm that the experimental class and the control class were at the same level of IRA before the experiment, a pre-test for the two classes was conducted. Participants read the same material out in the same language laboratory, which was recorded as data resources. Then the English teacher graded the recordings according to the scoring criteria (Table 5) of IRA task in CELST (with a full score of 20).

Table 5. The scoring criteria of IRA task in CELST

Rank	Pronunciation and Intonation		Speed and Content	
	Score	***Standard***	***Score***	***Standard***
A	8-12	(1) Fluent and accurate pronunciation (2) Correct and natural intonation (3) Fluent and coherent utterance	6-8	(1) Reading aloud at the originally suggested speed (2) Complete the whole content (no more than three words skipped)
B	4-7	(1) Roughly correct pronunciation (2) Roughly correct intonation (3) Roughly fluent utterance	3-5	(1) Reading aloud roughly at the originally suggested speed (2) Several words skipped
C	0-3	(1) Most morphemes are mispronounced (2) Incorrect and not natural intonation (3) Broken utterance	0-2	(1) Not reading aloud at the originally suggested speed (2) Skipping a whole sentence or more than 10 words

To better analyse statistically, the authors converted all the scores into the scale of zero to ten points. A scoring sample is shown in Table 6.

Table 6. A scoring sample of IRA in 2011 CELST

Scene	Original text	An IRA sample of Candidate A	Scoring
1	The South Pacific is on the surface of it still a healthy ocean.	A south *pacifical* is on the face of it *see* a helpful oc…/	Total score: 7 (Level B) Pronunciation and Intonation: 4 This sample presents many mispronounced words (e.g.'critical' is sounded as 'correctical'), mainly flat intonation, and roughly fluent utterance. Speed and Content: 3
2	We depend on it.	We depend on it./	
3	Over 60% of the world's fish catch comes from the Pacific.	Over 60% of the world's fish catch come from the Pacific[ˈpəsɪfɪk]./	
4	But like all oceans, it has little or no protection,	But like all ocean it's/ little of no protection,/	
5	so it may not stay healthy much longer.	so it may not say healthy/*not* longer./	
6	For the South Pacific, this is a critical time.	From the South of Pacific[ˈpəsɪfɪk],/ this is a *correctical* time./	
7	It's changing in ways that, if left unchecked, could develop into a global crisis.	It's changing in way that, if left *much*, /could *delop* into a *go by colicy*./	
8	Some of its residents have been through crisis before.	Some of its *resaident* have *be flau colicy* before./	

9	And protecting the fish will ensure a healthy ocean for all the marine life of the Pacific.	And protect the *fit* will inside a health ocean of/ the many life of the *pastical*./	This candidate can basically follow the original speed, but misses some words (e.g 'ocean' is voiced as 'oc'.).
10	It will require international commitment and co-operation.	It will require *intonation* commitment and cooperation.	

* The words of mispronunciation are italic.
* The words of swallowing are underlined.
* The words of wrong stress are boldfaced.
* The pauses are marked with "/".

To test whether the difference of the converted scores (with a full score of ten) in IRA task between the two classes was significant, SPSS 18.0 was used to conduct an independent sample T-test on the data. The results are shown in Table 7.

Table 7. The independent-samples t-test results of pre-test

	Experimental class (*N=40*)		**Control class (*N=40*)**		**t**	**p (2-tailed)**
	M	***SD***	***M***	***SD***		
Pre-test	6.235	1.742	6.168	1.830	-0.064	.148

*Significance: $p < 0.05$

It can be concluded from Table 7 that there is no significant difference in the mean score of IRA performance between the two classes before the experiment ($t<1$, $p>0.05$), so it can be determined that the two classes were at the same initial levels.

Experiment materials: The preparation before the experiment included making ten units of learners' textbooks into speech coursewares. The key task was to conduct and offer the visual analysis of every text recording using the CE waveform, aiming at deepening learners' perceiving and understanding of the suprasegmental features (e.g. pronunciation, intonation, sense groups, and so on) through intuitively demonstrating audio, images, and text together during the class. At the same time, learners practiced reading aloud and strengthened their oral competence through IRA training. Fig.1 is the screenshot sample of the courseware using CE waveform to visualize the recording "I say to myself: Aren't they lucky?" from English Book 4, Unit1, Women of achieve.

Fig. 1. Annotation of words and sound intensity data added to CE waveform of text recording (The underlined are stressed syllables. The size of the letters indicates the strength of the voice.)

Practical teaching: According to the experimental plan, the teacher had started the experimental teaching since the second week of the new term in February 2012. The practical teaching was mainly divided into two parts: classroom teaching and after-class self-directed learning. Firstly, the teacher demonstrated the experimental courseware in the experimental class and assigned the students to do self practice at home and review it by themselves. Secondly, the students of the experimental class also needed to keep on IRA training in the language laboratory after class. The training applied CE and PP2 to visualize the recordings for IRA practice and to compare such self-made visualization with the template waveform of the recordings. Examples are shown in Fig.2 and Fig.3.

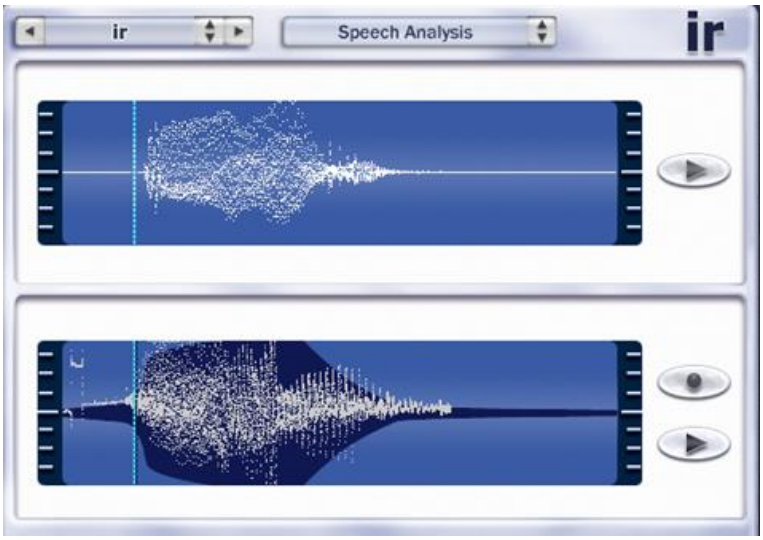

Fig.2. Learners used PP2 to make visualized comparison between the recordings

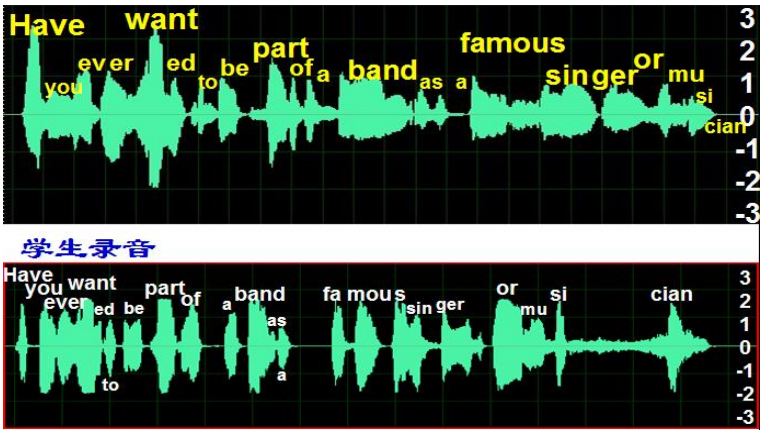

Fig.3. Learners used CE to make visualized comparison between the recordings (The upper one is the original recording. The lower one is the learners' imitation recording.)

Meanwhile, the control class did not adopt speech visualization approach and received training by means of merely repeating after the teacher in class and imitating the official recording materials after class. Each time a unit was finished, the teacher checked the students' IRA results through recordings and rated them based on three degrees (grade A, B, C, as illustrated in Table 5). At the same time, the teacher gave suggestions to the students for helping them solve their problems found from the recordings. Students were encouraged to discuss their learning strategies individually with the teacher.

After a twelve-week instruction, post-tests on both classes were carried out. The test content simulated the IRA task in CELST. Besides, the difficulty, speed, and duration of recording, and scoring criteria were all set to be equivalent to the requirements of the CELST. According to the research questions of this study, the key points of the test consisted of phonetic accuracy and speaking fluency. The evaluation of phonetic accuracy was mainly based on to what extent these subjects imitated the content, pronunciation and intonation of the text, while the assessment of speaking fluency was based on whether the subjects' imitation speed was appropriate and whether their division of sense groups was accurate. When the test was completed, the recordings of both classes were graded by the teacher and the relevant data collected.

Data collection: The 40 subjects in each of the two classes participated in the listening and speaking test by the end of the teaching experiment. Some recording samples were discarded due to failure of recording or poor quality in sound volume. 32 valid test samples of each class in the post-test were respectively collected.

Data analysis: This study compares the recording data of the experimental class and the control class in three aspects: content and accuracy in pronunciation, fluency and rhythm in speech, and the overall effect. Since the participants were students from two classes, the author used the independent sample T-test to compare the average value of each item of the two classes to test the significance of difference. The following is the analysis of the results.

Content and accuracy in pronunciation: As shown in Table 8, the mean score of the experimental class is higher than that of the control class in content and accurate pronunciation (4.59>4.22), and the difference is significant (p=0.027<0.05), which indicates that IRA assisted by visualization is conducive to train learners' accuracy.

Table 8. The independent-samples on content and accuracy in pronunciation of post-test

	Experimental class (*N=32*)		**Control class (*N=32*)**		**t**	**p (2-tailed)**
	M	***SD***	***M***	***SD***		
Post-test	4.59	.615	4.22	.706	2.265	.027

*Significance: p< 0.05

Fluency and rhythm in speech: Table 9 shows that in terms of fluency and rhythm (i.e., sense group), there is no significant difference in the mean score between the two groups (t=0.497<1, p=0.621>0.05), which reveals that the visualization method has not been proved to have a positive effect on learners' English speech fluency.

Table 9. The independent-samples on fluency and rhythm in speech of post-test

	Experimental class (*N=32*)		**Control class (*N=32*)**		**t**	**p (2-tailed)**
	M	***SD***	***M***	***SD***		
Post-test	3.72	.457	3.66	.545	.497	.621

*Significance: p< 0.05

Overall effect: Noted from Table 10, the mean score of the experimental group is higher than that of the other group (8.31>7.88) in the listening and speaking post-test, and the difference is significant (p=0.045<0.05). It represents that over all, the method of speech visualization adopted in this study can promote IRA training.

Table 10. The independent-samples on overall effect of post-test

	Experimental class (*N=32*)		**Control class (*N=32*)**		**t**	**p (2-tailed)**
	M	SD	M	SD		
Post-test	8.31	.896	7.88	1.271	1.052	.045

*Significance: p< 0.05

5 Reflections

This study found that speech visualization technology can significantly help learners improve accuracy in their English speech. However, it has less satisfactory results in training learners' fluency and rhythm in speech. Four aspects are considered when reflecting on the experiment process and the analysis of the data obtained. Firstly, the time to implement the experiment is not sufficient enough. Improvement of fluency and rhythm requires long-term training, especially the perception and

division of sense groups which require continuously longer time exposure to a larger amount of language input. Secondly, the participants usually need time to read the content on the screen before imitating and reading out the text, thus their voice cannot be synchronized with the content on the screen, which is consistent with most learners' behavior. Thirdly, learners are accustomed to listening to the recording first and then imitating in the way they were daily trained to do. As a result, they might have difficulty keeping up with the speed of the recordings. Lastly, the visual analysis and presentation of speech may increase the amount of information loaded in learners' IRA process, thereby objectively reducing learners' fluency.

By pinning down the aspects which account for a lack of improvement in terms of learners' speech fluency and sense group awareness, feasible ways to solve these problems can be obtained. The following two points are thus proposed.

5.1 Shadowing

As this study focuses on learners' independent use of speech visualization technology, not much guidance to IRA was given to learners during the experiment. Besides, learners' existing imitation habit makes it difficult for them to keep up with the switching speed of the screen text when their oral reading responses were recorded. In other words, learners are in need of scientific methods which may help them improve their oral fluency. According to the influence of speech visualization on speaking fluency and due to the fragmentary feature (for example, sentence by sentence) of speech visualization materials, a combination of shadowing method and speech visualization materials is highly recommended. Shadowing refers to the act or task of listening in which the learners track the speech they hear and repeat it as exactly as possible [39, 42]. When listening to a chapter of language learning recording, learners do not take notes but only follow and read with the speaker on the recording synchronously, trying their best to imitate the speakers' pronunciation, intonation and tongue [43]. This method helps learners practice both pronunciation and intonation and exercise their vocal organs in a steady way, and develops their habits of following the model recording sentence by sentence carefully and raise their awareness of identifying and corresponding with the original text. Shadowing is considered to bring about an obvious promoting effect on early-staged non-English-major learners. The visual materials in this experiment are presented sentence by sentence. Therefore, the combination of the visual materials and the shadowing method can improve learners' accuracy more effectively, and increase their fluency and ability to perceive sense groups efficiently.

5.2 Aural modality assisted with visual modality

Speech visualization is an implementation form of multimodal discourse theory. One of the basic premises of multimodal discourse theory is that the increase of modalities can bring more information and learning experience to learners at the same time. In this experiment, visual modality was added to the traditional single aural modal training. Learners were exposed to multimodalities which brought them more

information and experience. However, it also causes overload of information to learners in the process of IRA, which objectively making fluency more difficult to achieve. This problem occurred because of the neglect of interaction and differentiation among modalities during the designing of visual materials. Besides, the aim of this experiment, which targets at improving learners' accuracy, is also neglected to some extent. In fact, the "listen and repeat" mode is still the most significant activity in this experiment, which indicates that the aural modality should still be dominant while visualization process only performs as a subsidiary means. Therefore, more attention should be paid to the amount of information input when the designed materials are expected to reduce learners' burden of visual information load which may significantly affect learners' fluency in speaking. Some detailed information such as intensity data can be presented in the correction materials after learners' IRA practice. The results also show that in multimodal teaching, modalities strengthen or complement each other. A more flexible way should be further explored in dealing with the complex relationships among various modalities.

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8 Authors

Xiaobin Liu is an associate professor of School of Foreign Studies, South China Normal University. His research interests include educational technology & EFL teacher development, computer assisted language learning.

Diying Wu is a master student of School of Foreign Studies, South China Normal University.

Yiwen Ye is a master student of School of Foreign Studies, South China Normal University.

Manfei Xu is an associate professor of School of Foreign Studies, South China Normal University. Her research interests include corpus application in language teaching and teacher education. She is also a corresponding author of this paper.

Jianli Jiao is a professor of School of Information Technology in Education, South China Normal University.

Wenheng Lin is an English teacher of Guangzhou Nansha Dongchong Middle School.

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Exploring MOOC User Behaviors Beyond Platforms

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Dilrukshi Gamage (✉), Indika Perera, Shantha Fernando
University of Moratuwa, Moratuwa, Sri Lanka
dilrukshi.gamage.lk@ieee.org

Abstract—MOOC user behavior is generally studied using the data collected within platform interactions in the learning system or via outside social media platforms. It is important to understand the root causes of anomalies in MOOCs, such as the 80% attrition, less interactions within platforms and what causing the reflected behaviors beyond platforms. We study MOOC student behaviors outside the platform using ethnographic methods, mainly focusing on diary study and interviews. Two groups, 11 extreme users who have completed many MOOCs and 10 who never completed MOOC have been used to collected data. The log sheets data and interviews were analyzed using Epistemic Network Analysis (ENA) method to explore if there is a significance between these 2 groups and other qualitative comparisons to explore behavioral patterns. Our results indicated 4 behavioral patterns with insights into significant level of learner's habits between extreme and novice users' behaviors leading to completion or dropping. This reflect the design gaps of MOOC platforms and based on the behavioral patterns, we provide recommendations to meet the learners needs.

Keywords—MOOC, User behaviors, diary study, epistemic network analytics

1 Introduction

Massive Open Online Courses (MOOCs) are a phenomenal education technology consist of short videos, peer graded or self-graded assignments and forum to interact. Despite being advantages, MOOCs face challenges, such as the high drop-out rate which has been constant between 80 − 90% from the total enrollments [30]. Researchers argue number of completions may not be ideal metrics for measuring success but other factors such as percentages from those who watch all the content, take quizzes/assignment and engage in the MOOC [18]. Such MOOC behaviors being measured in many platforms to understand and improve learner experience and retention. Especially many MOOC data traces learners' clicks, views, assignment submissions and forum entries investigate various aspects of MOOC learning, such as the effect of lecture video types on learner engagement [20], the introduction of gamification [11], the impact of instructor involvement [37] and the significance of peer learning [12].

Apart from the data generated within the MOOC platform itself, few data-driven research works go beyond. Such as exploring the learners' traces on the wider Web, in particular the Social Web, to gain understanding of learner behavior in a distributed learning ecosystem. Billions of users are active on the larger Social Web platforms such as Twitter and existing research has shown that detailed user profiles can be built from those traces, covering dimensions such as age [27], interests [2], personality [3], location [21] and occupation [31]. However, data within MOOCs and social platforms may provide certain behavior without knowing causes triggering to the interactions or the reason causing the behaviors. Such as, some users may never log into continue assignments and platform logs only provide evidence that the did not log, but would not support "why". However, by tracing the learner experience within the time and context leads to understand the root causes of certain behaviors and anomalies. Participate in pre-course surveys or learner interactions in system offer only a snapshot-based perspective as learners drop out or retention, but little is known about the user experience that leads up to take part and learning in MOOC and how it should be best supported. It is extremely important to bring learning analytic to the data gathered beyond the platforms. We aim to examine and understand the journey of the MOOC participant which may lead to retain or drop off. Thereby uncover gaps in the user experience and then take actions to optimize the experience. We aimed to get insights from situations like "where" or the "context" of the learner who take part in the MOOC, what emotions or state of mind at various learning tasks during the course, what life responsibilities they have, how they manage the daily responsibilities and what support and motivation they get could significantly influence to the drop off or retain in a MOOC. At the same time, we particularly interested to understand if there is a behavioral difference between those who conveniently complete MOOCs and those who struggle to finish.

It is crucial to understand that MOOC student behavior in a learning platform or on the Social Web cannot provide us with a source of diverse, fine-grained and longitudinal learner traces which let us to be empathetic about contextual understanding of user behaviors and experiences over time. Our main objective is to understand the learners: i) Learning habits of extreme and novice users ii) MOOC usage scenarios such as primary tasks they perform in a course. iii) Changes in learning behavior.

In the course over the time with their perception and resonate the changes and examine the gaps by understanding the learners journey towards taking the MOOC. We aimed to provide design insights to close the gaps in the MOOC learning experience. To do this, we gathered our data using ethnographic methods specifically following diary study. Large amount of longitudinal data was collected from 21 participants over a period of 1 year. Participants were gathered using snow ball method, where we first searched web and also inquired from personal networks for participants who have at least finished 10 MOOCs. We called them extreme users of MOOCs, then found relevant referrals to who they might know with similar capacity. First author of this research is an extreme MOOC user and belongs to many MOOC communities who actively gathered network to provide data. Considering the ethical compliance's and to educate the participants about expectations and to complete the process of our data collection, selected 21 participants were explained via a short induction meeting. In

this, we clearly stated that they can opt out of this commitment. It is mainly because, in a diary study user are request to provide many data as much as possible voluntarily which takes extra effort and consumes huge amount of time commitment and may include privacy data.

We used quantitative ethnography method Epistemic Network Analysis (ENA) to analyze the large amount of qualitative data gathered through the diary study while observing the patterns of MOOC behaviors under the lenses of extreme MOOC users and non-extreme MOOC users to understand if there is a significance in the behavioral patterns in experiencing MOOC. As key findings, extreme users change their daily habits to cater to MOOCing yet sometimes face challenges to complete tasks due to platform design gaps.

Extensive mobile usage and MOOCs pedagogical limitations to be supportive in continuing the course using the mobile was well visible in results. Non extreme users face mainly motivational issues. While they perform tasks, keeping their level of interest is key factor in the journey. In the next sections, we illustrate in details of background of previous research, methods of this research. Next, detail analysis with discussion followed by conclusions and finally, the future directions which need to change in design to cater inclusive design to learner habits and lifestyle of 21st century is depicted.

2 Related Work

2.1 Learner behavior and motivations

Learner behavior, motivation and engagement patterns are important factors in understanding the success of MOOCs. In order to understand this, researchers have been using many qualitative, quantitative or mixed methods. Reviewing the literature, we found research base on analyzing the MOOC platform data [8, 39] or other social platform data [9] pre-post course survey [25], interviewing the participants [38], matching the system data to participant survey data [32] as common methods to understand behaviors, motivation and engagement of MOOC participants. Some research argued need of mix methods to understand the deep reason to engage in MOOCs or keep the motivations. They conducted survey questionnaire followed up by interviews [24].

Results in many of those research reveals a snapshot of the problems in the usage. For example, based on the analysis of Coursera platform data patterns of engagement and disengagement in three MOOCs, [25] has found 4 categories of user behaviors:1) Completing, the learners completed the majority of assessments. 2) Auditing, learners watched most of the videos but completed assessments infrequently. 3) Disengaging, learners completed assessments at the start of the course, then reduced their engagement. 4) Sampling, learners explored some course videos

They suggest interventions should be targeted these categories of users to increase the engagement. Similarly, [14] has analyzed leaner engagement from 4 MOOCs in

Futurelearn platform data set stating that learning is a social activity which engagement patterns will be different in Futurelearn than Cousera, since it is based Social Constructivist pedagogy. In such a platforms learner found to be collectively learn by discussing and engaging. Replicating the same method in [25] and found only 'Completing' and 'Sampling' clusters, but not 'Disengaging' and 'Auditing'. However, our argument lays on the fact that these patterns have been identified based on the engagement in the platform yet learner background, their context information, reasons for any changes between clusters were uncovered. Identifying the reasons on what triggers anyone to transit from one state to another will bring important insights in controlling these transitions.

Many survey data reveals that motivation and engagement in a course is based on the perceived factors such as Extrinsic factors (relevance to study and lifestyle interest) and Intrinsic factors (improve themselves) [24]. This will be based on the questionnaire design but will not provide significant insight to the actual behavior within the context over the time. Detail analyses of learner behaviors using in-depth qualitative study recommended to uncover the reasons which affects course completion rate [23]. Research in this tandem followed focus groups which students describe their experience taking a course of what they like and dislike and qualitative method with interviewing the learner has been commonly practiced. However, interviewing the learner over a period of time has not been commonly practiced due to nature of heavy time and resources requirement. Yet, key qualitative method "Grounded theory" has been used to understand user's perception towards a success of a MOOC [17], which found 10 dimension that MOOC need improvement based on the data collection through observations on forum postings, social media postings, formal and informal interviews [16]. However, these qualitative results does not support clear evidence of learner behaviors change over time based on the task and what are their experiences towards particular tasks. Therefore, we used diary study yet more effective systematically design version incorporated with media which participants were requested to take pictures of their context in ease of recalling the memories of the experience. This integration has proven to be significant in producing more accurate and insightful than user just repeating what they experience during the follow up interview [6].

2.2 User experience with diary study

Studying user behavior in the CHI, CSCW and LAK communities lately created a buzz namely User Experience (UX). As such method, Diary Study has been widely used method and accepted to understand user behaviors with temporal contexts. Research to password usage in daily life [22], use of paper in everyday students life [28] and studies of understanding mobile internet use [10] has extensively used Dairy studies. In these studies, most commonly used observations, questionnaires in collecting data. Further, qualitative methods from HCI involve talking directly with users, such as semi-structured interviews, focus groups and open interviews, as well as procedures such as user observation, analysis of video recordings and diaries used [4]. Yet the diary study is used less common due to the time it takes, high commitment needs from the participants and also the time it takes in analyzing complex data. Nev-

ertheless, in this research we used Diary study and immediate follow-up interviews as the method to collect data. Our objective was to collect longitudinal data capturing contextual understanding of MOOC user behaviors and experiences over time. It mostly helps us to gain insights of learner habits, usage scenarios and related motivational levels and changing behaviors which can be very difficult in a lab setting to gather. Thus, Diary studies are useful for understanding long-term behaviors, yet time-consuming and may be expensive. According to [36], although diary study may be expensive and time consuming, it results the most effective than usability test and interviewing. To improve the effect of diary study, [6], investigate the use of media in capturing context affects the diary study method. They suggested modifications to traditional diary techniques that enable annotation and review of captured media incorporation as a variation on the diary study more appropriate for researchers using digital capture media. In other words, taking a picture and describing the event in follow up interviews were found be more effective than keeping a log data.

2.3 Quantitative ethnography by ENA

Epistemic Network Analysis (ENA) method has been widely used in Learning Analytics (LA) communities lately. Specifically the recent analysis of meta research on understanding to increasing the Impact of Learning Analytics used ENA in to explore the relationships between the dimensions Focus, Purpose, Scale, Data, and Settings extracted from LAK conferences and JLA used this method in quantifying the relationship with the use of binary occurrence of codes with in the corpus [13], [26]. In order to make sense in the deluge of information in the digital age, using this kind of new science of Quantitative Ethnography make potential to bring boundaries between qualitative data, In this case we used to understand the difference between novice and extreme users behaviors using qualitative data but processed by quantifying according to ENA. This dissolves the boundaries between quantitative and qualitative research and give researchers tools for studying the human side of big data [34]. Although our intention in this research is to analyze log files and interviews generated in diary study using ENA, method itself is widely applicable with well-defined process. Explaining the process is beyond our research and page limits, therefore, we recommend readers to be familiar with the process in a worked example by Shaffer who brought the concept to the LA community [33].

3 Methodology

3.1 Diary study

We used Diary study with in-situ as the main method of understanding the MOOC participants learning habits, primary tasks they perform in a course, time and context they perform these tasks, attitudes and motivations in performing those tasks, changes in learning behaviors in the course over the time with their perception. By identifying those, we resonate the changes and examine the gaps by understanding the learners'

journey towards taking the MOOC. We incorporated media where participants were requested to support any audio, video or image of the context to recall the memory. At the same time, we structured our diary study in to a 5-step process where we invest in time to make frequent engaging weekly meetings with 1-2 participants at a time with post study meeting in the end. This involvement helps to keep interest high and reminds participants of the importance of the diary entry in data collection. We introduced a calibrated Logging sheet to facilitate in-situ logging method which cover the 24 hours with the data which we are interest in analyzing. It included easy way for the user to fill the activities, log the moods and context and specifically we crafted to highlight the MOOC activities which we are interest in examining.

3.2 Participants

Since we were intending to understand the behaviors of MOOC users, our recruitment needed to narrow on the aspect whether the target participants have taken MOOCs and willing to take a course during this study. At the same time, we constrained to seek extreme users (those who have completed at least 10 MOOCs) and novice to MOOCs (those who has not completed a single course) intending to find if there are behavioral changes between two groups. Sample collected using snowball method where one user find similar users in their network [5]. Having been in the field of MOOCs for a few years, we first used our own network to find extreme users. We also used search engines to find extreme users and found many who completed considerable number of MOOCs keeps internet records in blogs and social media and often keep best practices advises. Then, we found non-extreme users, the type commonly found and easily accessible through posting in forums of usual MOOCs. We used our enrolled Coursera and edX courses forum to spread the word and also used twitter. Based on our criteria 21 participants were finally selected to study. Table 1 explains the demography of the participants.

Table 1. Participants demography of the study with the coun-try they live, the course platforms they have taken courses and willing to take during the study with the user type of Extreme (EX) or Novice (NC). Among these 9 are females and 12 are Males while 6 participants with 8-5 job, 8 with Freelance and 7 with flexible jobs

Participaints	Country	Course Platforms	User type
P1	USA	Coursera, edX, OpenSAP	EX
P2	USA	Coursera, edX	EX
P3	Germany	Coursera, edX	EX
P4	India	Coursera, edX	EX
P5	Sri Lanka	Cousera, edX	EX
P6	India	Coursera, edX	EX
P7	India	Coursera, edX	EX
P8	USA	Coursera, edX	EX
P9	India	Coursera, edX	EX
P10	USA	Coursera, edX	EX
P11	Australia	Coursera, edX	NC

P12	Russia	Coursera, edX	NC
P13	Sri Lanka	Coursera, edX, Udacity	NC
P14	Sri Lanka	Coursera, edX	NC
P15	Sri Lanka	Coursera, edX	NC
P16	Finland	Coursera, edX, EMMA	NC
P17	Sri Lanka	Coursera, edX	NC
P18	USA	Coursera, edX, Udacity	NC
P19	USA	Coursera, edX	NC
P20	Germany	Coursera, edX	NC
P21	South Africa	Coursera, edX	NC

3.3 Procedure

Conducting a diary study is time consuming and expensive, yet we planned our study, using resources and time effectively. We structured the diary study process to 5 steps.

During **Step 1**, planed the entire diary study holistically as in timeline, what need to be done and how. Based on literature [7, 19] and our own experience, we identified key tasks that we focus in changing behaviors in MOOCs such as watching video, taking quiz, completing assignments, take part in the forum, and online meetings. Next, we created a logging sheet to maximize the effectiveness of data collection which covered 24 hours of activities, the context of the activity and level of motivation or feeling at the context. At this step, a sample participant was searched, got confirmation agreements for follow up meeting times, payment methods, expectations, payment terms and guided the communication channels. This was a paramount step for us as participants were spread over the globe with different time zones, different expectations and accepting methods. For example, few participants faced issues such as amazon gift cards values were not found useful, issues with bank accounts, unavailability of payment method PayPal. For each participant, we agreed to compensate accordingly. At the same time, we created a comprehensive orientation plan in useful web guide to explain our intentions and to be clear up front on what is expected and how we expect it linking all the contact channels, communication updates and follow up chart.

In **Step 2**, scheduled orientation calls with the confirmed participants in a common Google hangout based on their availability gathered in step 1. We ended up having to organize 4 of the meeting due to time zones and availability of users. During orientation, each participant was given a time to meet us every week individually. This is a one- to-one follow up interview at every end of week of the course they are taking part during the study. During the orientation call, we demonstrated how to use the log sheet and how to incorporate media to provide us rich data, how to reach us and how to upload their daily log sheets.

During **Step 3**, each participant is taking part in a course of their interest MOOC platform. In this case, participants randomly took courses from OpenSAP, Coursera, futurelearn and edX with similar instructional design, 4-5 weeks courses in Humanity, Energy and Entrepreneurship. They are meeting us individually every end week of the course schedule. Normally, a MOOC schedule their activities per week and we meet

the participant in end of the weekly cycle. This process is highly depending on the course schedules; therefore, it took nearly 300 days to completed 21 participants as we fully focused only 1-2 participants at a time. This helped us to get to know more of the participant, give more attention and collect rich data set while keeping them motivated to continue the study until we reach our expectation. The participants took courses between 2017 January to 2017 Oct.

Step 4, was somewhat similar to step 2 as we gathered all the participants who provided the log sheets to reflect their insights as a group. For example, those who took part in a course during May-June 2017 were gathered in July for closing-up meeting to provide us more information of how the overall course experience felt and the course expectations in the respective MOOC platforms they followed.

In **Step 5**, which is the final stage, we made sure all the participants were compensated and cleaned the data for the purpose of analyzing. At the end of this step, we were able to structure, code and summarize the finding to be able to build ENA diagrams and journey maps while preparing context summaries.

Once we collected all the log sheets and transcribed the interviews on each participant, we coded these qualitative details based on previous literature indications of MOOCs behaviors, many participants are either conducting a cognitive task (where their activities based on cognitive behaviors or individual thinks) or social task (based on collective ideas and conversations) [29]. Based on those and convergent by the data, we define 7 codes: 1) Cognitive behaviors of watching video(C.watch Video), 2) Cognitive type of Taking Quizzes(C.Quizzes),3) Cognitive Course Assignments (C. Assignment), 4) Cognitive behavior of Forum usage (C.Forum) Forum Activity, 5) Cognitive type of Meeting and online discussions (C.Discussions) 6) Social Behavior of Forum usage (S.Forum), and 7) Social type of online meeting and discussions (S.Discussions).

ENA was conducted to identify if there are behavioral similarities between extreme users and novice users. The ENA tool [1] was used where its algorithm uses a moving window to construct a network model for each line in the data, showing how codes in the current line are connected to codes that occur within the recent temporal context [15], defined as 1 lines (each line plus the previous lines) within a given conversation. The resulting networks are aggregated for all lines for each unit of analysis in the model. In this model, we aggregated networks using a binary summation in which the networks for a given line reflect the presence or absence of the co-occurrence of each pair of codes. The ENA model included the 7 codes as mentioned and we defined conversations as all lines of data associated with a single value of Participant type where experience or a novice subset by Participant number, C.Watching.video, C.Quizzes, C.Assignment, C.Forum, S.Forum, C.Meeting Discussion, and S.Meeting Discussion. The ENA model normalized the networks for all units of analysis before they were subjected to a dimensional reduction, which accounts for the fact that different units of analysis may have different amounts of coded lines in the data. For the dimensional reduction, we used a singular value decomposition, which produces orthogonal dimensions that maximize the variance explained by each dimension. (See Shaffer et al.,[35] for a more detailed explanation of the mathematics).

In addition, to understand the behavior patterns, logging sheets were analyzed and graphed based on 3 key attributes as: 1) Context (the situation of the participant). 2) Logging time 3) The key tasks performed in the MOOC.

4 Results and Discussion

Our study generated 665 logging sheet entries including context information and motivation levels during the task performed in courses they took part. This is 31.6 sheet entries per person which reflected 89% success compared to overall expected entries per person. Text entries during the interviews were coded using 2 researchers with an inter-rater reliability Cohen Kappa's 0.87.

ENA networks were visualized using network graphs where nodes correspond to the codes, and edges reflect the relative frequency of co-occurrence, or connection, between two codes. Our model had co-registration correlations of 0.96 (Pearson) and 0.96 (Spearman) for the first dimension and co-registration correlations of 0.99 (Pearson) and 0.99 (Spearman) for the second. These measures indicate that there is a strong goodness of fit between the visualization and the original model which intended to see the difference of MOOC behaviors.

At the same time, we plotted behavioral graph based on the 3 attributes which reflect the patterns of behaviors in the usage of MOOCs. Next sections will derive the outcome of the ENA graph which indicate the differences in MOOC extreme vs non extreme users and also type of behavioral patterns.

4.1 MOOC user habits and usage of extreme and novice

Habits are the behavioral patterns visible during time, which will be directly correlating with time of the day and frequency of tasks. Such as "What time of day do users engage in MOOCs? Context of this engagement and weight of the engagement in terms of number of hours spent". Usage can be explained as key tasks perform at the time of engagement where we defined as 7 codes. To test for differences of these behaviors between experienced extreme used and novice, we applied a Mann-Whitney test to the location of points in the projected ENA space for units in Novice and Extreme experienced MOOC participants. The results along the X axis (MR1), a Mann-Whitney test showed that Extreme experienced participants (Mdn=0.52, N=10) was statistically significantly different at the alpha=0.05 level from Novice (Mdn=-0.36, N=11 U=9.50, p=0.00, r=0.83).

Other than these main tasks, occasional log sheet entries with programming, reading books and articles were found. During our follow up interviews, we clarified that those tasks were relating to course assignments. As a key finding, we present that MOOC usage heavily weighted on watching videos (52%). Assignments (25%), quizzes (11%) and least in the forum's (9%) activity and rarely on the online synchronous meetings discussions relating to MOOC (3%). Fig. 1 reflect the specific Extreme experienced participants, Novice participants and compression of 2 groups.

Connection between watching video and use of forum was the highest yet Novice had a weight of 3.21 and Extreme 3.15. Using social type forum and Videos, Novice weighted as 2.53 and Extreme 2.99. In watching video and doing assignments, Novice was 1.78 and Extreme is at 2.46, video and quizzes, Novice was 1.73 while Extreme weighted at 2.00. The graph containing the difference (bottom of Fig 1) indicate the key tasks conducted by extreme users. The results of this behavior in other words proves the previous course survey conducted in OpenHPI platform inquiring perceived helpful features in MOOC which describe 63.7% of students highly satisfied with videos [19]. This indicates that Extreme users are more often complete assignments and quizzes whereas Novice more tend to watch the videos in MOOCs but comparatively less engage in other activities.

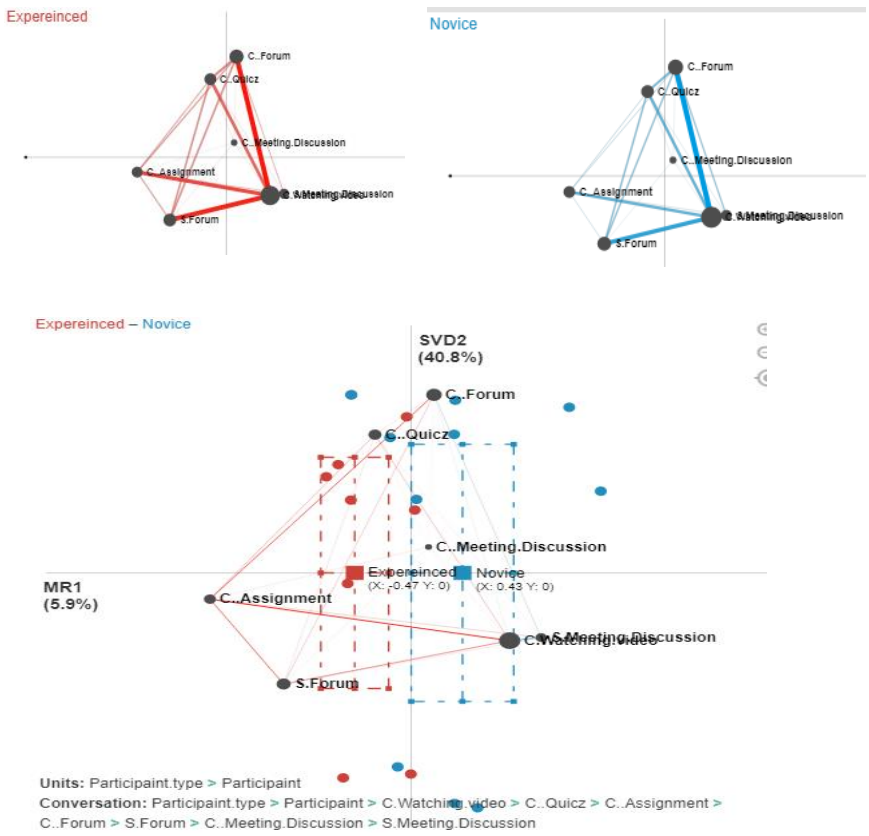

Fig. 1. ENA graphs on Extreme (Red), Novice (Blue) and in the bottom the compression on both groups which indicate the significant lines in red

However, we also scrutinized and map the participants time of the logging, devices they use and context environment at the time of logging. As a key finding, we were

able to classify 4 behavioral patterns based on the user styles. It is presented in the Fig. 2 where based on context, usage task and time of logging its categories into 4 patterns. The green is the use of Mobile device and orange is use of Notebook or PC device to use MOOCs while each pattern has following patterns:

Pattern 1: Active in early morning, logging accessed via a desktop or notebook, used to attempt or complete assignments, reading materials. These are mostly the tasks need high cognitional and both hands in typing, designing, writing, accessing data in own repositories or other.

Pattern 2: Active in mid-morning to afternoon, access via Mobile /portable devices and some with desktops. Mainly consumed content while commuting or unsettled seating environments, such as on the move which hands and legs will be occupied for short roams and activities. This time particularly used to watch / listen videos or short quizzes.

Pattern 3: Active in evening, majority access via Mobile or portable devices, commute in traffic conditions or distance, Major task is watching or listing to the MOOC content video.

Pattern 4: Active in the night to late night, access via Desktop or Notebook, some forum activity, assignment related activities combined with retrospection of overall tasks are commonly practiced.

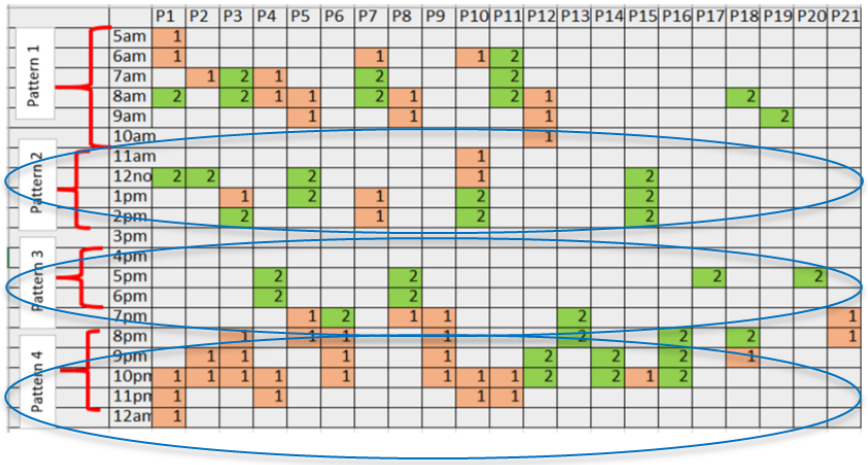

Fig. 2. Behavior based on context, logging time and MOOC tasks of the users identified 4 significant patterns

4.2 Implications of the behavioral patterns

During the study, we not only focused the behavioral patterns, but also the knowhow of the occurrence of these patterns. Majority of video consumption was occurring at the time of users are mostly on the move or in situations such as when they are spent on waiting for something, travelling to daily work or a usual free time

but not enough time to spend related to chores of day. Video consumption mostly incorporated mobiles and other portable devices to access the content. This implies that Short videos commonly practiced in MOOCs and need only short time stamp that can continue any time and context. Participants well adjust MOOC primary task of watching videos in their daily rituals.

We observed that extreme MOOC users have daily rituals cooperating with primary tasks of MOOCs, such as the participant has habits of watching or listening to video while traveling to work, exercise or any other leisure activity. But non extreme users mainly reflect the pattern of "lookers" who mostly spend only on watching video's yet time investment of other activities were limited. Their daily lifestyle carried somewhat unpredictable rituals. We found that P11, P13, P17, P19 and P21 occupied in daily jobs with dramatic changes of workloads such as children's school work, office new project assignments and sudden business travels. They lose track of the MOOCs by missing deadlines where most of MOOCs follow strict deadlines in completing courses. Majority (72%) of the participants indicated the use of MOOCs as a supplement to the knowledge enhancement and less view it as a compulsory livelihood enhancement certificate for work or lifestyle. Participants perceived source of knowledge is the video content in the MOOCs. They explained that, completion of MOOCs has no direct impact, however, if they miss their time of work due to MOOC tasks, it is high likely to meet a direct (negative) impact. Therefore, the least effort's and best outcome perceived as acquiring knowledge by watching video as it is structured more instructive similar to typical university course with easy to follow than self-discovering learners.

Although we observed high video consumption, we found less forum activities (9%) or online or on-site meetings relating to MOOCs (3%). Forum is the main feature of being social and interact with other students in a MOOC. Scrutinizing in to more data in participants social behavior, surprisingly, our results (log entry details) reflected that they are socially active in their physical world which reflected significant social activities such as initiating and having team meeting, friends gathering or even other social activities online such as social media interactions with friends yet none of those characters reflect in their MOOC activity profile. We specifically followed up if they have a log entry with using social media and if it has anything to do with a MOOC friend or group. In other words, we never found log entrees attempting set up a team for study on MOOCs or not even if any participant initiates discussions about the MOOC they follow with immediate family, friends or gusts in the physical world. We were unable to find any significant evidence to MOOC social interactions. However, the log entries with forum, we found that email notifications triggered most of the forum activities to take part and encouraging to interact with each other. Only 2 extreme MOOC participants joined meetings which the course has facilitated. We identified that those participants keep their calendar entries reserved and tracked the timing of the meeting well in advance. Log entry P1.3.2 (participant 1's 3rd week day 2 log entry), P3.1.2, P19.1.3 revealed that forum participation rather an activity they do as a result of the course instructions to introduce themselves. When a user use forum, we made sure to ask if they were requesting some help, socially moving with getting to know each other or any other specific related things in discussion. We

found that none of the social interactions with conversations in ``getting and doing things together`` were occurred as collective artifacts or building community with sense of belonging. 79% of the forum task were relating to requesting help in technical matters or assignment related matters.

During the task relating to quizzes, participants were able to quickly finish with less cognitive load and just clicking interactions. This interaction is well supported in Mobile by many MOOC providers. We believe, many MOOC platforms provide quiz facility with in the video itself which users must interact to move further. Most occasions, quizzes are light weight reflections from the directly supporting pedagogical concept mastery base learning. In order to complete quizzes, many users use the continues time of watching video at any context. In other words, as a habit, many users attempt quizzes during the time of watching videos.

Assignments and other related things were highly depended on the participants availability of the time to sit in a relax mode of environment. Overall, only 7% of time used for Assignments. Mostly accessed in the early morning or in the night where users need comfortable typing gestures and comfortable seating positions. Requirement of special context and interactions such as heavy typing, designing or building needed for assignments. Interaction designs beyond typical gestures are needed to build an inclusive user culture.

4.3 MOOC user motivations, changes of behaviors and perception

We examined the participants activities, level of motivation over the period of time from start of the course date to end. Some of the data points in the log entries were confusing to understand as why it was less or high motivating, yet during follow-up interviews we were elaborated comprehensively.

We identified that many users are experiencing significant motivational decrements over time. Experience gaps were well visible towards later stages of the journey of the course. Most commonly, being isolated without a cohort which feels less sense of belonging, they lose interest to continue. Although we observe self-regulated skill in extreme users, they demonstrated experience difficulties in managing time with the daily rituals or unexpected events occurring in the daily life. One other major finding was that user experience difficulties in compatibility of the devices, such as the content is not mobile friendly or the interactions need in MOOC is not usable on a mobile device. Many tasks of the MOOCs required typing actions which mobiles does not provide optimal interface and it is less supportive in providing a better user experience.

At the same time, we found that learners missing deadlines due to loose track of the course, no support from any other learner and sudden changes to daily life rituals affected lot in the motivations and how they experience the course. Once recovering from time disturbances, participants face missing deadlines which has nothing to do with the course quality or learner skills, but merely the learner capacity will ultimately log in system as failures. Therefore, it is vital to understand the experience gaps of MOOC participants to design user centered interventions. Overall, we reveal 2 cate-

gories of experience gaps in the journey of MOOC. These are system gaps and learner gaps.

System gaps: In the MOOC usage, we identified users are shifting devices base on the context. Such as while travelling, users much depend on the mobile, yet only few MOOCs provide the ability to fully function in mobile. Options to access light weight audio files with minimum user interactions were expected at time in this context.

Learner gaps: Participants ability to self- regulate the time consumption effectively and ability to be versatile in any context was much expected.

4.4 Laminations and recommendations

Diary studies usually contain rich data, yet it has the limitation of analyzing biases. At the same time, during this study, we requested participants to take part in a course of their choice in any platform. Although most of the courses in MOOC platforms follow similar structure, changes in course pedagogy and platform features may have affected the leaner experience and behavioral patterns. We revealed that MOOC users may encounter difference learning experience and belong to different behavioral patterns. At the same time, they experience system gaps and learner gaps during the journey of MOOCs. Based on that, our recommendations are 2 folds, Platform recommendations and pedagogical recommendations based on habits and experience gaps.

Micro/Pico completion modes: Pedagogical: Participants required to be able to complete at Micro or Pico learning stages than expectation of completing the weekly cycles such as 4-5 weeks in normal MOOCs. Learning need to be identified as objects which can be combined in creating modules where students will be able to accumulate based on time demands and volatile time availability of each learner. This will benefit learners who demonstrated each behavioral pattern. Currently, if student complete the course work early in the week, it does not impact to the overall completion. However, if students could finish modules and return at next stage to continue, complete and if it is measured by how many modules were completed oppose to requirement spending all 4-5 weeks, will demonstrate the effective use of volatile time of the participants. Therefore, we recommend success as not the competition rates at the end of the course but Micro / Pico levels over the time.

Device independence on tasks: Platform: Many MOOC participants use different devices based on the task, such as portable devices for watching videos. Much rarely participants use Mobile devices to contribute to forum or assignment submissions. The space is wide open for designers to understand on-the-go users and implement interactions catering to the needs. Such as, while unable to use the typing, how might the user complete other tasks? Is typing required using fingers? Such temporal considerations have been device driven, not work driven. In contrast, less research has been undertaken in understanding of temporal factors of the social and organizational environment that shape work. We recommend to explore user centered contextual driven interaction techniques for MOOCs to incorporate in Primary tasks,

5 Conclusion

We claimed that MOOC users behavioral habits have been analyzed using surveys, system analytic with in the MOOC platform and some in out side the platform using social media. User behaviors in the systems will provide limited knowledge of learner behavioral changes over the time. Mainly it does not capture learner motivations, context of the learner and learner experience at the time of the tasks. To identify learner behaviors with context over time, we used user experience method diary study. We strategically design the diary study into 5 step process and conducted the study using 21 MOOC participants spending 4-5 weeks with each participant. With the use of effective strategies such as in-situ logging, designed logging sheet, defined and useful communication and compensation mechanism we completed the study analysing log data and interviews using ENA methods. Identifying MOOOC habits, usage and behavioral changes over time beyond the system or social media, Our results indicated 4 behavioral patterns depending on time, context and device. At the same time gaps in the experience was found as system and learner gaps while extreme user behaviors significant to novice users of MOOC. Based on the findings, we provide 2 recommendations. Although it is not the only possibility to enhance user experience, we anticipate more studies over the time to understand more users and promote user centered design for MOOC users.

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7 Authors

Dilrukshi Gamage is member of the Institute of Electrical and Electronic Engineers (IEEE) association and serve in the executive council since 2017. She is a final year PhD student at the Department of Computer Science and Engineering in University of Moratuwa, Sri Lanka.

Her research area is pedagogical development using technology and Human Computer Interactions. She has been reviewer for top tier journals (Computers and Educations) and published and reviewed in many conferences (TALE, ECUCON, ICALT, CHI, CSCW).

Indika Perera is a senior lecturer at the University of Moratuwa, Sri Lanka. He holds a PhD (St Andrews, UK) MBS (Colombo), MSc (Moratuwa), PGDBM (Colombo) and B.Sc. Eng. (Hons) (Moratuwa). His research interests include research topics of software architecture, software engineering; technology enhanced learning, UX and immersive environments. He is a Fellow of HEA(UK), MIET, SMIEEE and a Chartered Engineer registered at EC (UK) and IE(SL).

Shantha Fernando is a Senior Lecturer at the Department of Computer Science and Engineering, University of Moratuwa, Sri Lanka. He served as the Director, Centre for IT Services, University of Moratuwa. and the Director, Engineering Research Unit, University of Moratuwa. He is one of the founders and the Chief Advisor of TechCERT, affiliated to LK-Domain Registry.

His PhD was obtained from the Delft University of Technology, The Netherlands in 2010. His expertise are in Computer and Information Security, Information Systems, and e-Learning.

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A Sports Teaching Mode Based on Social Networking Service Teaching Resources

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Xuelin Yang (✉), Xiaojun Jiang, Li Rong
Taizhou Polytechnic College, Taizhou, China
33923367@qq.com

Zhe Xu
Hebei North University, Hebei, China

Abstract—As today's ideal in regard to health globally goes deep, sports courses receive more and more attention. However, high-quality teaching resource scarcity exists in current PE teaching, thus affecting the teaching effect. In this study, a teaching mode based on Social Networking Service (SNS) teaching resources was designed. Firstly, SNS-based PE teaching network learning community was designed, and self-organized construction of teaching resources was achieved in the learning community, including network courseware, teaching knowledge points, common problems, cases and media materials, etc. Thus, the network teaching mode oriented to self-organization of teaching resources. To test the teaching effect of this new teaching mode, Tai Ji course was used for teaching practice. A kind of virtual software for Tai Ji teaching was used, and virtual 3D technology and multi-functional operating interface were applied to create a brand-new Tai Ji learning mode. The results show that the average score of the students who took the new Tai Ji course teaching mode is much higher than that of students with regular teaching, and the proportion of high score students is also higher, indicating that the teaching mode proposed in this study can significantly improve the teaching effect of Tai Ji course, and also provide a beneficial thought for constructing a new teaching mode for other courses.

Keywords—SNS' network teaching; teaching mode; Tai Ji course

1 Introduction

As the education system pays more and more attention to teenagers' comprehensive quality, PE course also plays an increasingly important role in the whole course structure. In the higher education system, PE course has become an important part of liberal education and undertakes the role of strengthening students' physique and comprehensive quality. College PE course design is based on relevant courses of PE major, including course content, teaching mode and teacher resource, etc. [1]. As an important constituent part of Chinese traditional martial arts, Tai Ji owns very strong national features and the function of strengthening one's body.

Carrying out Tai Ji course in colleges can not just let students gain richer methods to do physical exercise, but also promote students' sense of national pride and carry forward Chinese traditional culture. Hence, an increasing number of colleges start to set up the teaching resources about Tai Ji, and good teaching feedback has been obtained [2]. However, current college Tai Ji teaching resources also have certain problems which generate some negative impacts on effective implementation of Tai Ji education. On the one hand, present Tai Ji teaching courses excessive emphasize external teaching and ignore connotation teaching. As a result, many students only learn to imitate the movements of Tai Ji, but fail to grasp the real charm of Tai Ji. Tai Ji is a Chinese traditional martial art combining the internal and the external, and has high requirements for learners' psychological state and comprehension ability. However, the class hours of college PE teaching are few. Thus, many teachers do not teach theoretical knowledge in teaching, and only teach movements. On the other hand, many colleges lack the teachers with high level, which to certain degree hinders the effective implementation of Tai Ji teaching [3]. As a traditional martial art, Tai Ji is mainly inherited by handing down from the older generations of the family and master- apprentice teaching. Although the movements of Tai Ji have been basically made public, it is hard to really grasp the entire systematical knowledge effectively. Consequently, many students only learn superficial knowledge of Tai Ji, but fail to effectively comprehend its connotation.

SNS refers to Social Networking Service, and its core is sharing, interaction and cooperation among people [4]. Benefiting from the rapid development of internet and intelligent platform, the coverage and influence of SNS improve rapidly. In such case, the teaching method of SNS network teaching resource also has arouses extensive attention and research of education workers. The introduction of SNS into the teaching mainly owns two advantages. On the one hand, with SNS network, the in-depth communication and exchange can be conducted between students, between students and teachers, and between teachers, which can play a positive role for students to grasp the connotation of the knowledge learned and for teachers to improve their professional ability [6]. On the other hand, SNS can make high-quality teaching resources shared and transmitted via network. Via SNS network, students can acquire rich high-quality learning resources. Meanwhile, these resources can be updated rapidly to effectively make up for the insufficient learning resources [6]. Seeing from the two points, the teaching method of SNS network teaching resource can actively solve the problems existing in current Tai Ji course. Thus, this study investigated the practice and application of SNS network teaching resource method, in the hope of improving the problems and shortcomings in current course.

2 State of the Art

SNS stress the connection of individual-centered social relations. People can share their dynamics and communicate in the form of rich media. Currently, student-centered teaching has become one of important trends of college course reform. Hence, teaching framework construction based on SNS has aroused the attention of

many education workers. Lim [7] conducted SNS teaching research by taking South Korean students as the qualitative case study object according to the feature that international students are difficult to adapt to American new life and new culture, including instant message, blog, chatting website and emails of the students. The results show that the use of SNS in different ways contributes to the subjects' emotional health and academic purpose. Hori et al. [8] combined SNS online learning system with open resources of open educational resources (OER) higher education and developed a flexible learning environment based on electronic textbooks. It was found that the learning environment is more beneficial to enhancing students' learning interest. Moreno et al. [9] combined SNS with Facebook and created the learning page and learning team related to open education. The results show that such learning institution can more easily attract students and enhance the learning effect. Zheng et al. [10] applied SNS in the construction of teaching resource sharing platform and let students and teachers jointly participate in the teaching resource construction and management, thus expanding the resource richness. Chen [11] developed a theme-based learning design framework based on SNS network. It could be used in the teaching process of many courses focusing on practice, and presented a good application effect on promoting students; problem solving ability and operation ability.

Teacher's teaching ability has a significant effect on course teaching effect. Evaluating teacher's teaching ability in a scientific and rational way plays an important role in promoting teacher resource and teaching effect. At present, teacher's teaching ability evaluation gradually develops to overall reflection of teaching-related abilities, and emphasizes the marching with talent training objective. For example, Huang [12] considered teaching ability assessment of college teachers should be linked to major training objective and course teaching objective, and the specific evaluation indexes and methods were designed from 6 basic elements: knowledge, design, expression, implementation, attitude and effect. Zhao et al. [13] combined actual situations of college PE teaching, and applied Delphi method to dynamically boost and construct teaching ability evaluation index system of college PE teachers containing four indexes (knowledge learning ability, teaching practice ability, teaching research ability and information technology application ability) to truly and accurately embody teacher's teaching ability.

Current defects in college PE teaching are mainly reflected in teacher resource. The insufficient teacher resource leads to the lack of high-quality teaching resources. Meanwhile, the teaching contents fail to really touch subject connotation and essence. For the shortcomings in PE teaching, this paper explored the application mode and practice of SNS network teaching resource method in PE teaching. The innovation points of this study are mainly reflected in two aspects. Firstly, SNS network teaching resource method was applied in Tai Ji course teaching, and the proposed teaching design mode can effectively assisting in solving two main problems existing in current Tai Ji course teaching. Secondly, teacher's professional ability and level have significant influence on effective implementation of Tai Ji course teaching. The deficiency in this aspect is also one of main problems. Teacher ability assessment

method was proposed on the basis of data mining, and assessment method has positive promotion effect in improving teacher level of Tai Ji course.

3 Interactive Teaching Mode Based on Educational Games

3.1 SNS network

With the rapid development of internet, network teaching has become a widely-used teaching mode. Especially in the higher education field, it has gained the theoretical research application achievement. Compared with traditional mode, the significant changes have happened to the teaching mode of network teaching system. The relations of each entity are shown in Fig.1. In the network teaching system, network teaching resource is dependent on network teaching environment. Teachers and students release and acquire teaching resources by network learning environment, and they can communicate with each other. The network teaching system has the open characteristic. Teachers can release and update teaching resources anytime, and push them to students in real time. Students can broke through the space-time restriction of traditional teaching mode, conveniently acquire learning resources, independently arrange and allocate learning time.

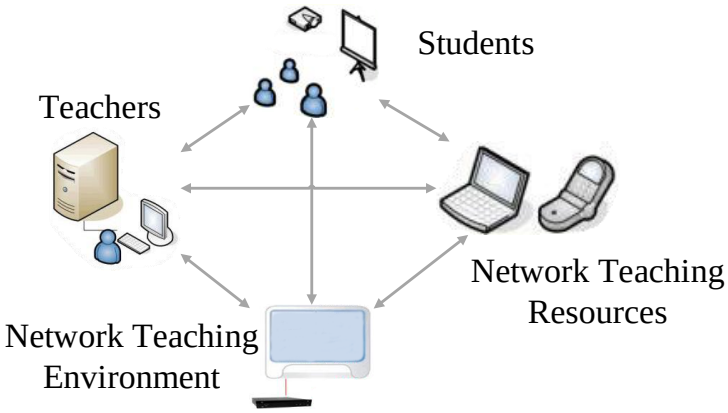

Fig. 1. Network relationship of network teaching system

The full name of SNS is Social Networking Service, and its core is to advocate sharing, interaction and cooperation among people. With SNS platform, people can share and display their personalized contents anytime and anywhere, and can break the time-space limit to interact and cooperate with others, thus creating rich valuable information [12]. Due to this characteristic of SNS, it can be used to construct a learning environment of resource sharing, cooperation and communication for teachers and students. In SNS environment, information spreading mode changes significant, and information acquisition efficiency also improves greatly. As shown in Fig.2 and Fig.3, users passively receive information or gain information sources

through the search engine. SNS-based information transmission mechanism focuses on active push. The system can actively push the valuable information to users according to their interests, which can have a positive role in promoting information acquisition efficiency.

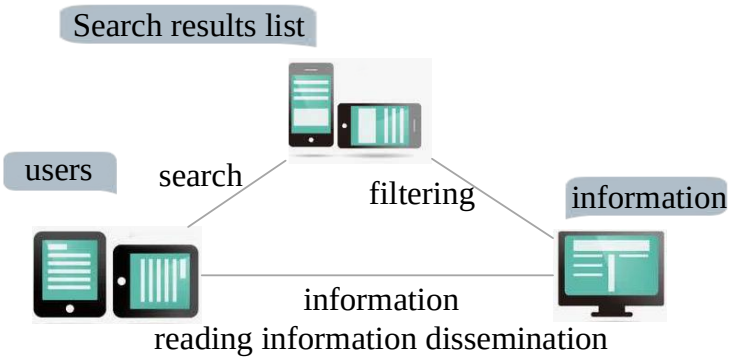

Fig. 2. Traditional information transmission mechanism

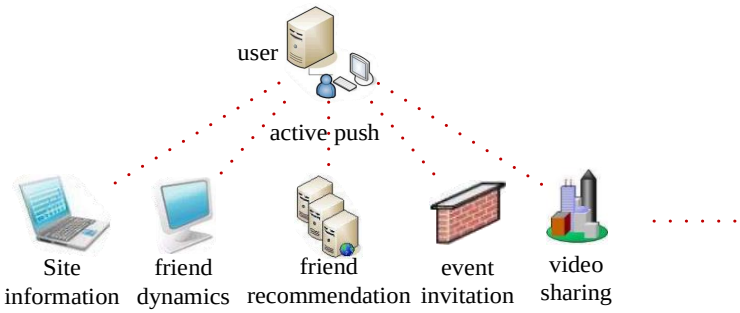

Fig. 3. SNS-based information transmission mechanism

3.2 Construction method of SNS network teaching resource

In the self-organization construction model, network teaching environment can form stable teaching resources and environment after the operation for some time, without the need of external intervention or only with the minimum supervision. This study aims to design a SNS-based self-organization construction model of network teaching resources. The teachers and students are both system users and learning resource contributors. The SNS-based self-organization construction model of network teaching resources is shown in Fig.4. In this model, students' communication with teachers and other students and learning resources collected by students will be deemed as the original data of teaching resource and recorded by the system. Teacher's asking and answering will also be used as the important supplement of teaching resources. Through the self-organization construction model of teaching

resources, a lot of teaching resources come from the experience of students and teachers, and own high value in terms of resource practicability. Students can utilize these resources to improve knowledge mastery depth, and teachers can keep improving their teaching ability.

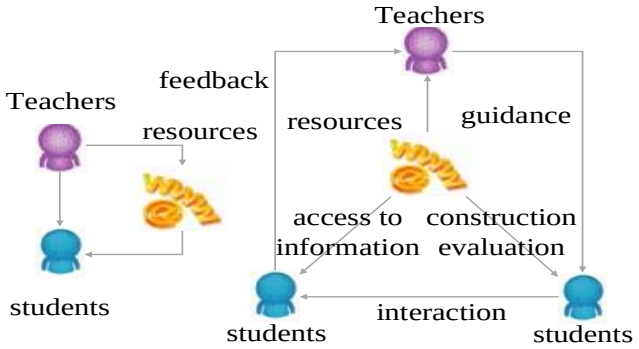

Fig. 4. Self-organization construction model of network teaching resources

3.3 Network teaching mode oriented to teaching resource self-organization

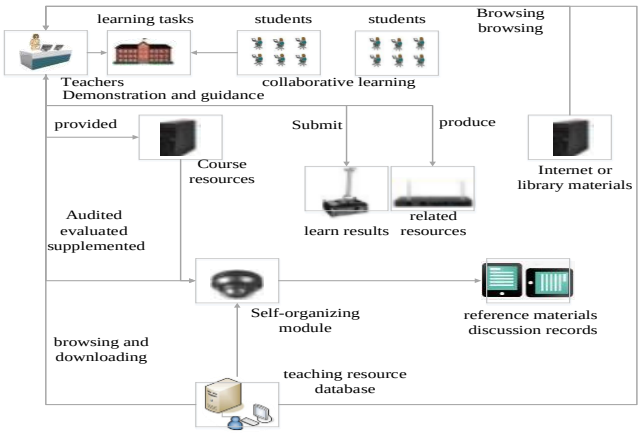

Fig. 5. Network teaching mode oriented to teaching resource self-organization

In SNS-based network teaching, the communication between teachers and students generates original resources. However, these resources cannot be directly used in teaching, and need planning and standardization. In the meantime, after teaching resources form, the continuous interaction and feedback between teachers and students will continuously optimize and improve these resources, thus achieving teaching resource self-organization. The network teaching mode oriented to teaching resource self-organization is shown in Fig.5. The whole process is composed of two parts. The major function of the first part is to achieve the interaction process among

teachers, students and learning resources. The main function of the second part is to realize resource self-organization process. The cooperation and activity between teachers and students generate original resources. However, these resources cannot be directly stored in the database as the teaching resources. After standardization and normative treatment of these teaching resources by the self-organization module, they can be used as the teaching resources. All proposed teaching resources are stored in the teaching resource library.

3.4 Design mode of "SNS network teaching resource library" based on PE major

SNS network teaching resource library is the core of network teaching mode. Storing, updating and optimizing teaching resources need to be achieved by depending on the resource library. According to the SNS-based network teaching mode oriented to teaching resource self-organization, this study designed the system architecture of teaching resource library which is composed of four sub-systems, as shown in Fig.6. Network teaching subsystem realizes teaching and learning functions. Under network support, teaching and learning processes can break through time-space limit and be conducted anytime and anywhere. In resource releasing and browsing subsystem, both teachers and students can become the subject of teaching resources, including actively submitting resources, mutual communication and writing. Resource library management subsystem standardizes and normalizes the original resources contributed by teachers and students to form valuable teaching resources. Resource storage subsystem is used to store all kinds of teaching resources, including network courseware, teaching knowledge points, common problems, cases and media materials.

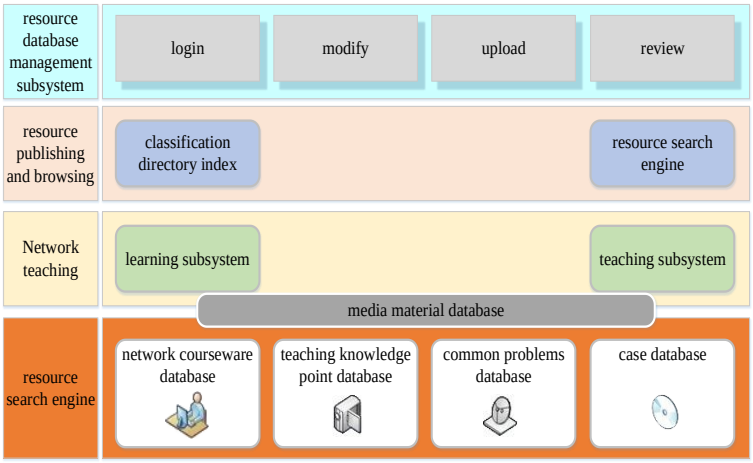

Fig. 6. System architecture of network teaching resource library

In addition, the network teaching resource library also provides user operating interface for teachers and students. Every user has the sole username and identify. After logging in the resource library, the system will load different function modules according to user identify. The function design of user operating interface is shown in Fig.7, which consists of learning interface, online releasing and backend management modules.

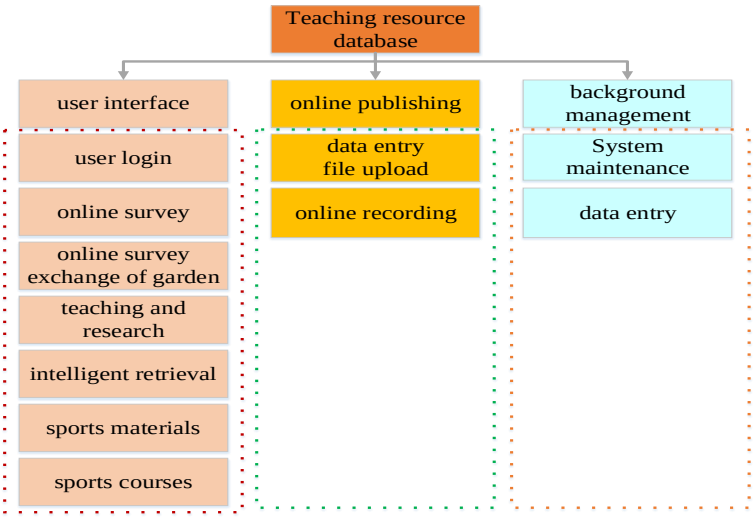

Fig. 7. Function design of user operating interface of network teaching resource library

3.5 Teacher ability evaluation of SNS network teaching resource

In the SNS-based network teaching method, learning resources own strong self-organization characteristic. Compared with traditional artificial construction method, the self-organization method does not need manual intervention, and can carry out objective resource library construction under the unified framework. This characteristic can bring the positive influence on real and accurate evaluation of teacher's teaching ability, and can avoid the drawback of manual evacuation, that is the teacher's teaching ability cannot be reliably and truly reflected. In order to achieve this characteristic, a teacher ability evaluation framework based on data mining was constructed in this study, which comprises 6 steps.

1. **Preprocessing of evaluation index database**

Since the data types in the evaluation index database are very numerous and the manifestation modes differ, normative processing is required before data mining. Anonymous coding principle is followed in data preprocessing, and the characteristic variable is discretized according to the pre-established principle. The teacher evaluation data after preprocessing can be expressed with the vector:

$$U_i = [u_{i1}, u_{i2}, u_{i3}, ..., u_{ik},] \tag{1}$$

2. Rough set reduction of teaching data

To reduce the calculation amount in data mining process, the teaching evaluation data can be reduced by the decision attribute under the precondition of no loss of key information. If the following three conditions are met, the dataset D can be expressed with the reduction set D1 about decision attribute set E, without causing the decision distortion:

$$D_1 \subseteq D, D_1 \neq \varnothing$$

$$Z_{I_{ND}(D_1)}(I_{ND}(E)) = Z_{I_{ND}(D)}(I_{ND}(E))$$

No $D_2 \subseteq D_1$, Makes $Z_{I_{ND}(D_2)}(I_{ND}(E)) = Z_{I_{ND}(D_1)}(I_{ND}(E))$

3. **Association rules mining for teaching data**
After the reduction of the rough set, data mining problem becomes a mining problem of data association rules, i.e. solving the association rules of D=>E in R={S,B,H,f}.

Input: transaction database D, minimum support threshold min_support;
Output: frequent itemset L in D;

4. Teaching data mining

In teaching data mining, decision table R, minimum support ε and minimum confidence level λ need to be input, and association rules mining is implanted.

5. **Principal component analysis of teaching ability**
The purpose of principal component analysis is to determine the weight of each decision index in association rules mining. It utilizes statistical analysis method to process discrete information. Principal component analysis of teaching ability involves 3 steps:

Normalize the data
Judge index correlation and calculate the weight
Gain the composition of principal components an describe them

6. **Evaluation result analysis**
The integration of evaluation results is conducted according to Formula (2). The teachers with higher scores have the stronger teaching ability.

$$X_i = \sum_{j=1}^{q} Q_j \cdot P_{ij} \tag{2}$$

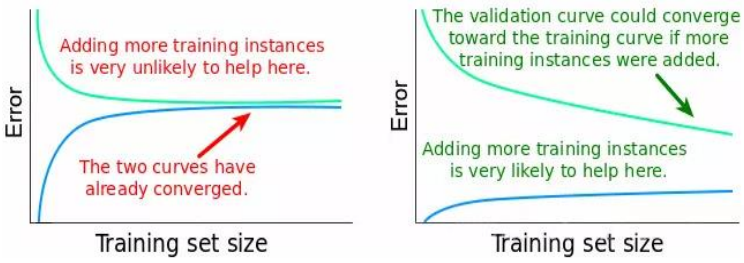

Fig. 8. Effect contrast algorithm diagram of two data mining algorithms

It can be seen from the left diagram of Fig.8, when the sample number of the training set increases to a value, the error of verification set basically remains unchanged, indicating that increasing more training data points cannot always bring the better model. It is better to try to construct more complicated model algorithm, instead of increasing the size of training set. The right diagram in Fig.8 demonstrates that increasing more training samples will lower model error and improve model performance.

4 Teaching Example and Effect

4.1 Teaching example

In this study, the teaching design mode based on SNS network teaching was applied in the teaching practice of Tai Ji course in the sophomore year. In the process of teaching practice, two demands were mainly considered in the design of teaching platform: constructing a convenient cooperation and communication platform for students and teachers, and providing self-organization environment of learning resources. In combination of teaching practice of Tai Ji course in the sophomore year, this study designed teaching resource management and optimization mode, thus effectively solving the problem that there is lack of high-quality Tai Ji teaching resources. Meanwhile, teachers can keep improving their teaching ability through this platform. The teaching resource management and optimization mode of Tai Ji course in the sophomore year is shown in Fig.9. The resource management and optimization basically achieve self-organization treatment.

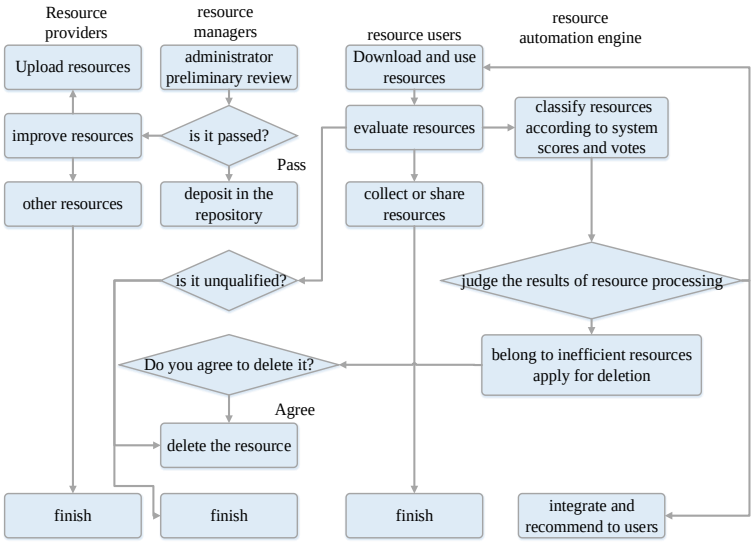

Fig. 9. Teaching resource management and optimization mode of Tai Ji course in the sophomore year

The general framework of Tai Ji course teaching system based on SNS network teaching is shown in Fig.10. The system is composed of three levels: presentation layer, business logic layer and data access layer. Each layer depends on the services provided by the next layer, and offers the packaged services to the last layer. Teachers and students interact with the system through the user interface provided by the presentation layer.

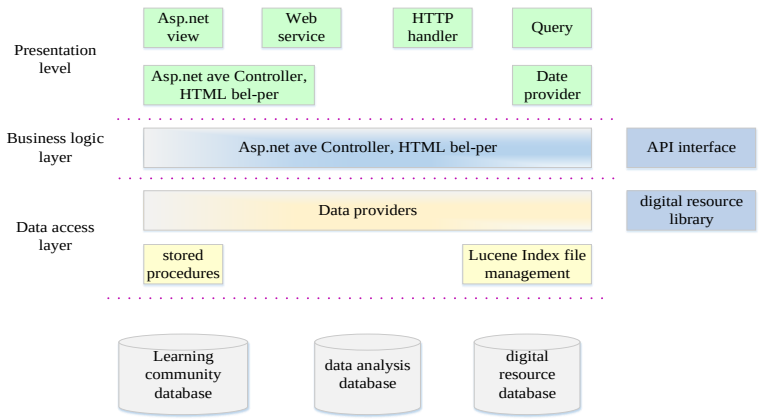

Fig. 10. General framework of Tai Ji course teaching system based on SNS network teaching

In this study, a kind of virtual software of Tai Ji teaching was used, called "TaijiZen Yun Shou". "Tai Ji Chan Yun Shou" is a teaching App which is researched

and developed by TaijiZen International Culture Development Co., Ltd. Its iOS version displays 3D learning mode of TaijiZen Yun Shou through the form of 3D animation. The users can rotate the learning interface 360° to view different angles of different movements. The application presentation is shown in Fig.12 and Fig.13. The software can apply virtual 3D technology and multi-functional operating interface to create a brand-new Tai Ji learning mode in the teaching process, and is built in English and Chinese learning commands. Its advantage is that students can view the movement, skill and routine of TaijiZen Yun Shou from various angles. Fig.13 shows the application of SNS multimedia teaching by PE Teachers.

Fig. 11. Screenshot I of official version application of TaijiZen Yun Shou in SNS

Fig. 12. Screenshot II of official version application of TaijiZen Yun Shou in SNS

Fig. 13. Presentation of PE multimedia teaching application

4.2 Teaching effect

In order to test the teaching effect of SNS-based network teaching resource method, Tai Ji course in the sophomore year was taken for example for teaching practice. In the teaching practice, two horizontal classes were selected: control class (50 students) and experimental class (50 students). The traditional teaching mode was used for the control class, while SNS-based network teaching resource method was applied for the experimental class. After the completion of the teaching, the questionnaire was prepared to test the teaching effect of the two classes, and the distribution of test results is shown in Table 1. It can be seen from Table 1 that, the average score of experimental class is 90, higher than the control class (84). In addition, the proportion of high scores (above 80) in the experimental class is also higher than that of control class, indicating that SNS-based network teaching resource method significantly improves students' scores in Tai Ji course.

Table 1. Teaching effect test results of both classes

Score interval	Experimental class		Control class	
	No.	***Proportion***	***No.***	***Proportion***
<60	1	2%	2	4%
60-70	6	12%	8	16%
70-80	14	28%	20	40%
80-90	24	48%	19	38%
90-100	5	10%	1	2%
Average scores	83.41		75.72	

5 Conclusion

To solve the problem that there is lack of high-quality teaching resources in current PE teaching, a teaching mode based on SNS network teaching resource was designed in this study. The self-organization construction of teaching resources was achieved from building the PE teaching network learning community based on SNS to network courseware, teaching knowledge points, common problems, cases and media materials, etc. Meanwhile, for scientific and accurate evaluation of teachers' teaching ability, this study also proposed the teacher ability evaluation system applicable to SNS network teaching based on data mining method. Finally, the teaching design mode based on SNS network teaching was applied in teaching design and implementation of college Tai Ji course, and a kind of virtual software for Tai Ji teaching was also applied. Virtual 3D technology and multi-functional operating interface was used to create a brand-new Tai Ji learning mode in the teaching process. The results show that the average score of students for whom the new Tai Ji course teaching mode proposed in this study was used is higher than that of students receiving traditional teaching method, and the proportion of high scores is also higher. The teaching test effect demonstrates that this method can significantly promote students' scores. But, the teaching effect of the new teaching mode in this study still needs to be tested so as to promote and use it in more courses.

6 Acknowledgement

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8 Authors

Xuelin Yang is an associate professor in the Taizhou Polytechnic College, Taizhou, China (33923367@qq.com).

Xiaojun Jiang is an associate professor in the Taizhou Polytechnic College, Taizhou, China (33923367@qq.com).

Li Rong is a Researcher in the Taizhou Polytechnic College, Taizhou, China (33923367@qq.com).

Zhe Xu (Correspondence Author) is a Lecturer in the College of Information Science and Engineering, Hebei North University, China (124243157@qq.com).

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Exploring Student Academic Performance Using Data Mining Tools

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Ranjit Paul
North Lakhimpur College, Lakhimpur, India

Silvia Gaftandzhieva (✉)
University of Plovdiv "Paisii Hilendarski", Plovdiv, Bulgaria
sissiy88@uni-plovdiv.bg

Samina Kausar
Shanghai University, Shanghai, China
University of Kotli Azad Jammu and Kashmir, Kotli Azad Kashmir, Pakistan

Sadiq Hussain,
Dibrugarh University, Dibrugarh, India

Rositsa Doneva
University of Plovdiv "Paisii Hilendarski", Plovdiv, Bulgaria

A.K. Baruah
Dibrugarh University, Dibrugarh, India

Abstract—Most of the educational institutes nowadays benefited from the hidden knowledge extracted from the datasets of their students, instructors and educational settings. The education system has gone through a paradigm shift from traditional system to smart learning environments and from teacher-centric system to context-aware any time anywhere student-centric approach. In this changing scenario, we have undertaken a study to investigate the results, grades and patterns of the students of North Lakhimpur College. The paper aims to evaluate the quality of learning on the basis of 19249 grades received from 758 students in 511 courses, included in the curriculum of 3 study programmes.

Keywords—Datasets, quality evaluation, data mining, student academic performance, educational data mining

1 Introduction

Educational Data Mining (EDM) is an emerging discipline, concerned with the application of data mining, statistical methods and machine learning for exploring the distinctive and increasingly large-scale data produced from educational organizations to better understand students and educational settings. EDM techniques can be applied

to can get useful information which will help the educationalists to design or amend the formation of the courses. EDM is useful in many different areas including categorizing at-risk students, priority learning needs for diverse cluster of students, increasing graduation rates, efficaciously evaluating institutional performance, optimize curriculum renewal and maximize the use of campus resources [1]. By extracting (mining) valuable information from educational data that may have an effect on students' performance, we can achieve the highest level of quality in higher education system. Major goals of EDM are:

1. Planning and Scheduling of courses as per student characteristics
2. Constructing Courseware
3. Predicting Student's Performance
4. Recommendations for Students
5. Detecting Student Behaviour
6. Providing Feedback for Supporting Instructors [2]

Student's academic performance depends on diverse factors like psychological, personal, demographics, educational background, academic advancement and other environment variables. These variables are often related in complicated nonlinear way and the interrelationships among these variables participated in complex and multi-faceted academic performance is not clearly understood [3].

During the recent years, the extraction and analysis of data generated during the learning process has become increasingly important. Many education institutions worldwide have already used Learning Analytics to improve the quality of learning [4], student success and retention [5, 6, 7], and immediate feedback [8].

The paper aims to evaluate the quality of learning in North Lakhimpur College on the basis of 19249 grades received from 758 students in 511 courses, included in the curriculum of 3 study programmes.

2 Literature Review

There are various scientific literatures to dig out the hidden patterns from the sea of data of the students from different educational organizations. The extracted knowledge may be utilized by the authorities of the institutes, academicians and educators for the betterment of the students and enhance the performance the learners and obviate the dropout of the students. There are an assortment of machine learning tools and data mining techniques employed to discover such knowledge.

Learning Analytics combines approaches, methods and results from different scientific fields such as intelligent data analysis and business intelligence, predictive modelling, etc.

Krpan and Stankov [9] applied data mining technique for grouping students with similar characteristics for e-learning systems.

Nagy et al. [10] in their research "Student Advisory Framework" utilizes classification and clustering technique to build an intelligent system. This intelligent system can be used to decrease the high rate of academic failure among the students by

providing consultations to first year university student to pursue a certain education track. They have proved this by a real case study in Cairo Higher Institute for Engineering, Computer Science and Management on the dataset collected from 2000−2012.

Ariouat et. al. [11] used two step based approach to improve educational process mining. In the first step they create clusters based on employability indicators and in the second step they obtained clusters using the AXOR algorithm. They have tested their result using ProM Framework and found that their model optimizes both performance/stability and comprehensibility/size simultaneously.

Ahuja et. al. [12] compared various clustering and classification algorithms by applying on the same dataset. They have highlighted different design challenges like goal and functionality, precision, and overheads when the data set is extremely large. They have also discussed graph-based clustering, centroid-based clustering, and various supervised classification algorithms that can be applied to Educational Data mining.

Hussain et. al. [13] tried to find out the association rule on the dataset that contained 666 instances with 11 attribute. They used data mining tools like Orange, Weka and R. Studio to study and compare various clustering and classification methods. It is believed that neural network performs well on big dataset but the authors found that neural network was the best classifier on the above dataset with 90.84% accuracy. The authors also found that PAM and K-means clustering performs better than hierarchical clustering.

Educational data mining techniques can make a difference to an educational institution by discriminating the academically weak and at-risk students. The final grades of a student can be predicted using internal assessment marks. Hussain et al. [14] collected the internal assessment marks and final grades of three different colleges from Assam, India to devise a model for such prediction using deep learning methodologies. The sequential neural deep learning model with Adam optimization outperformed the Adaboost and Artificial Immune Recognition System v2.0 classifiers. The statistical parameters proved it efficacy.

3 Dataset Description

The Dataset was collected for the students of who took admission in three different programmes namely BA, BSc and BCA from the North Lakhimpur College of Assam, India. It contains 19249 grades received from 758 students in 511 courses. A student has to earn 120 credits during six semesters to complete these three programmes. There are 25% marks for Internal Assessment and 75% Marks for End-Semester Examination in each course during every semester in UG Programme.

Table 1. The 10-point gradingsystem

Grade	Marking Percentage	Grade Point
A+	>= 95	10
A	>= 85	9
B+	>= 75	8
B	>= 65	7
C+	>= 55	6
C	>= 45	5
D	>= 40	4
F	< 40	0

4 Data Visualization

We had utilized data mining tools to visualize the data. The following figure (Fig. 1) depicts the Multidimensional scaling (MDS) of the BSc course for 'F' grade students. The frequencies of 'F' grade with occurrences among 25-30 are depicted in yellow color and larger sizes while the 0-5 in blue color and smaller size in the diagram.

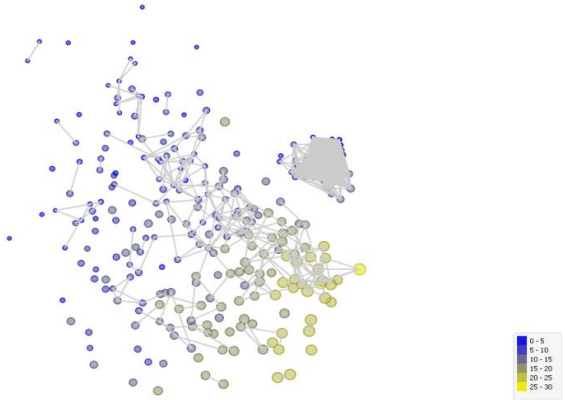

Fig. 1. MDS of the BSc course for 'F' grade students.

The Fig. 2 is the Sieve Diagram of two grades for the BCA course. It compares Grade A+ frequencies with the Grade F frequencies in a two-way contingency table for that course.

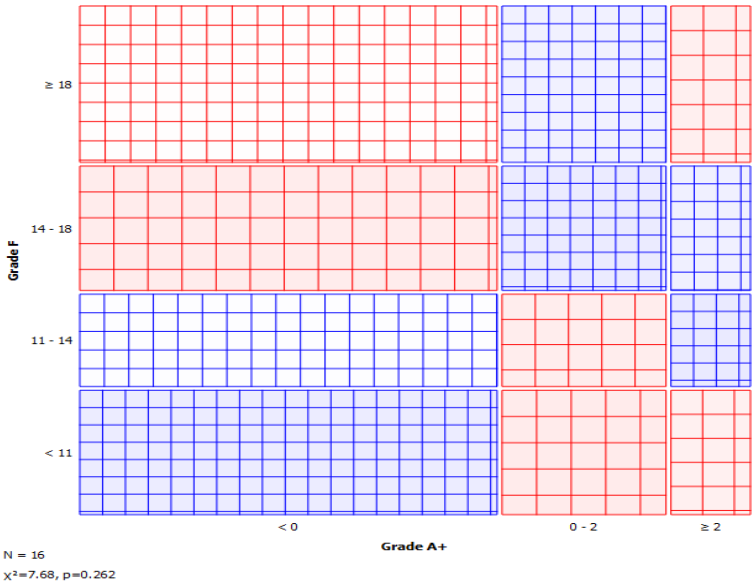

Fig. 2. Sieve Diagram of the BCA Programme

Fig. 3 is the Mosaic Diagram of four grades viz. A+, A, B, B+ for the BA Programme. In the diagram it compared graphically grades A+, A, B, B+ with each other.

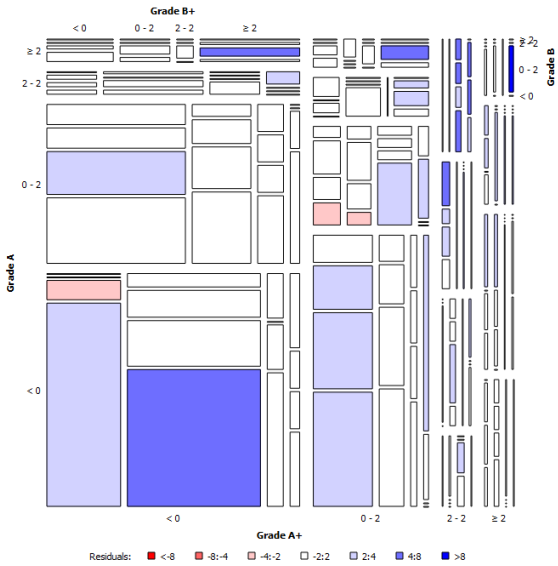

Fig. 3. Mosaic Diagram of the BA Programme for 4 grades

5 Experiments and Results

The quality of the training in North Lakhimpur College, Assam, India (Autonomous) evaluated on the basis of grades received from the students in different courses. The quality of education is evaluated by two aspects - the feedback of teachers to students during the training and students' success in subjects.

5.1 Feedback during training

The feedback of the teachers to the students during the training in each course is evaluated on the basis of an investigation of the relation between the intermediate and final grades of the students. For this purpose, statistical methods for t-test have been applied. The following null hypothesis was set for each course in which the intermediate assessment has been conducted (391 courses):

H0: Any differences in intermediate and final grades are due to chance.

To accept or reject the null hypothesis, the values required for the t-test are calculated. According to this statistical method, the null hypothesis can be rejected when the calculated t-value>t-table value. The calculated t-value is greater than the t-table value at an alpha level of .05 for grades obtained in 93% of BA courses, 58% of BCA courses, and 78% of BSc courses. In all of these courses, the difference in intermediate and final grades is not due to chance. This difference is due to the measures taken by teachers to improve student success and timely feedback of teachers. Fig. 4 represents the difference between the calculated t-values and table-values for each subject.

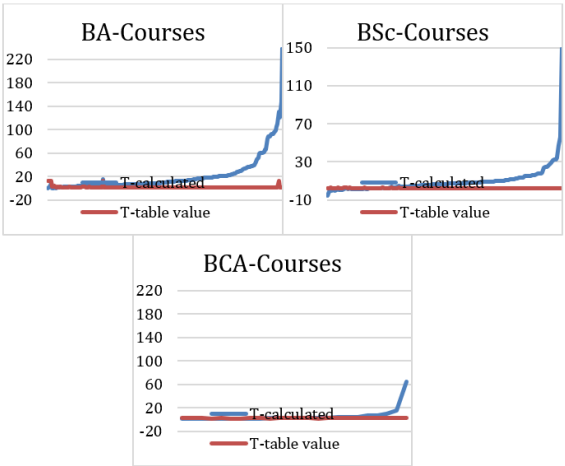

Fig. 4. Difference between table-values and calculated t-values

Table 2 represents only the values for the first three courses from each study programme, for which the difference in values is the largest.

Table 2. Calculated t-valuesandtable-values

Programme	Course	Calculated t-value	Table t-value
BCA	CT-2-BCA-603	9.313186813	2.262157163
BCA	CT-4-BCA-501	15.51724138	2.262157163
BCA	CT-3-BCA-402	64.60580913	2.262157163
BA	YT-4-ASM-201	120.5543439	1.966049679
BA	YT-4-ASM-101	147.4014468	1.965882662
BA	YT-4-ENG-101	238.3096643	1.965179935
BSc	ET-3-CHE-401	47.51901	1.981372
BSc	ST-2-CSC-201	55.48712	1.969385
BSc	YT-4-ENG-101	149.3545	1.968565

Table 3 presents the differences between students' intermediate and final grades in points for each study programme. Most students in all programmes increased their final grade with 10-20 points, and the lowest number of grades were increased by 50-60 points. The timely intervention of teachers did not help to increase 228 grades of students in BA programme, 20 grades of students in BCA programme and 115 grades of students in BSc programme.

Table 3. Differenceof intermediate and final grades in points

Programme	<0	0-10	10-20	20-30	30-40	40-50	50-60
BA	228	599	3798	3682	2037	420	13
BCA	20	41	141	66	22	2	0
BSc	115	428	1865	1727	1127	490	26

For each course, the differences between the intermediate and final grades of each student were examined. Table 4 presents the data for the course CT-4-BCA-103 PROGRAMMING AND PROBLEM SOLVING studied in the BCA program. During the intermediate assessment, all 16 students received low grades. The data from the table show that 8 students failed to complete the course successfully, although 6 of them significantly increased the number of points obtained in the final assessment, on the basis of which the final grade was calculated. The other 8 students have completed the course successfully, as 4 of them are increased their grades with two units (from F to C) and 4 with one unit (from F to D).

Table 4. Grades ofstudents in CT-4-BCA-103 course

Student	1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17
Intermediate Grade	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Final Grade	C	C	F	D	C	F	F	F	D	F	D	C	D	F	F	F

5.2 Student performance

The quality of courses in the three study programmes was evaluated on the basis of student performance.

The number of A +, A, B +, B, C +, C <D and F grades are calculated for each course. The analysis aims to check if there are courses in which most students have received high grades and courses in which most students have received poor grades. Table 5 presents a summary of the courses in the BCA program.

Table 5. Numberof grades in BCA courses

Course	A+	A	B+	B	C+	C	D	F
CT-3-BCA-101	0	0	0	0	1	4	1	10
CT-3-BCA-102	0	0	0	0	0	0	0	16
CT-4-BCA-103	0	0	0	0	0	4	4	8
CT-3-BCA-104	0	0	0	0	0	0	0	16
CT-3-BCA-105	0	0	0	0	0	1	2	13
CP-4-BCA-106	5	4	7	0	0	0	0	0
CT-4-BCA-201	0	0	0	0	0	0	0	13
CT-4-BCA-202	0	0	0	0	0	2	0	11
CT-4-BCA-203	0	0	0	0	0	4	3	6
CT-4-BCA-204	0	0	0	0	0	0	1	12
CP-4-BCA-205	0	1	5	7	0	0	0	0
CT-3-BCA-301	0	0	0	0	0	1	1	10
CT-4-BCA-302	0	0	0	0	0	1	1	10
CT-3-BCA-303	0	0	0	0	0	1	2	9
CT-4-BCA-304	0	0	0	0	0	0	0	12
CT-2-BCA-305	0	0	0	0	0	3	3	6
CP-4-BCA-306	0	2	9	0	1	0	0	0
CT-3-BCA-401	0	0	0	0	0	1	2	7
YT-0-EVS-401	0	0	0	1	5	4	0	0
CT-3-BCA-402	0	0	0	0	0	0	0	10
CT-4-BCA-403	0	0	0	0	2	2	4	2
CT-3-BCA-404	0	0	0	0	1	3	1	5
CT-3-BCA-405	0	0	0	0	0	0	0	10
CP-4-BCA-406	0	4	2	4	0	0	0	0
CT-4-BCA-501	0	0	0	0	0	0	0	10
CT-4-BCA-502	0	0	0	0	0	2	2	6
CT-4-BCA-503	0	0	0	0	0	1	0	9
CR-8-BCA-504	0	1	2	5	2	0	0	0
CT-4-BCA-601	0	0	0	0	0	0	2	8
CT-2-BCA-603	0	0	0	0	0	4	4	2
CR-14-BCA-604	3	1	4	2	0	0	0	0

The analysis shows that there are courses in which students have only low grades - CT-3-BCA-102, CT-3-BCA-104, CT-4-BCA-201, CT-4-BCA-304, CT-3-BCA-402, CT-3-BCA-405, CT-4-BCA-501. The results obtained give us a reason to claim that the quality of training in these courses is low and measures for its improvement should be taken. There are courses in which few students have passed the course with C +, C and D grades, some of which have been successfully completed by only one student - CT-4-BCA-204 (grade D), CT-4- BCA-503 (grade C). There are also a large number of courses in which over 50% of the students have received low grades, and

thegrades of passed students are C +, C and D - CT-3-BCA-101, CT-4-BCA-103, CT-4-BCA-202, CT-3-BCA-301, CT-4-BCA-302, CT-3-BCA-303, CT-2-BCA-305, CT-3-BCA-401, CT-3- BCA-404, CT-4-BCA-502, CT-4-BCA-601. These results can be interpreted as a sign ofthe poor quality of teaching in these courses and the need to study the reasons for the poor results and to take measures to improve the students' performance. The results achieved in the other courses included in the study programme are significantly better, such as these in courses CP-4-BCA-106, CP-4-BCA-205, CP-4-BCA-306, CP-4-BCA -406, CR-14-BCA-604 in which all students received high grades- A +, A, B + and B. Fig. 5 presents the percent of A+, A, B+, B, C+, C, D and F grades in each course in the study programme BCA.

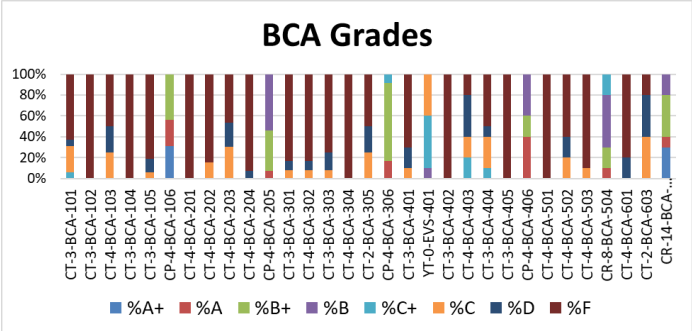

Fig. 5. Grades in BCA study programme

No one student has successfully completed the YT-4-ENG-101, YT-4-ENG-201, ET-3-STS-101, ET-5-ANT-201 courses, which are 1.41% of all courses included in the syllabus of BA study programme. More than 80% of students did not successfully complete the training in the other 10 courses (3.52% of all courses). These results indicate that it is necessary for teachers to look for the reasons for the poor results and to take measures to improve the quality of training and students' performance. The number of poor grades obtained is below 10%in 110 courses (38.73% of all courses), which is a sign of high performance of the students in these courses. Fig.6 presents the percent of A+, A, B+, B, C+, C, D and F grades in each course in the study programme BA.

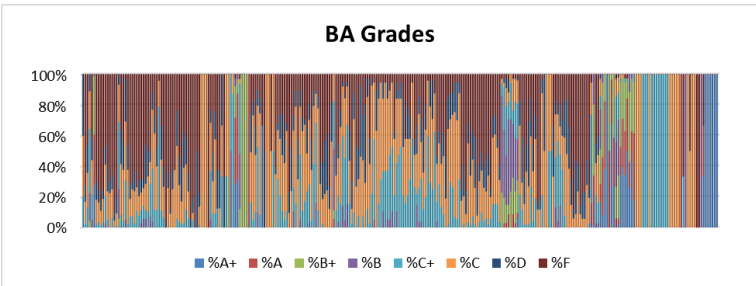

Fig. 6. Grades in BA study programme

The results of the analyses show that students enrolled in BSc study programme have the highest performance. All students received F grade and did not complete only one course CT-3-ELE-301 (0.36% of all courses). More than 80% of the students did not successfully complete the training in the other 17 courses (6.25% of all courses). These results indicate that it is necessary for teachers to look for the reasons for the poor results and to take measures to improve the quality of training and students' performance. The number of F grades is below 10% in 125 courses (45.96% of all courses), which is a sign of high student achievement in these courses. Fig. 7 presents the percent of A+, A, B+, B, C+, C, D and F grades in each course in the study programme BSc.

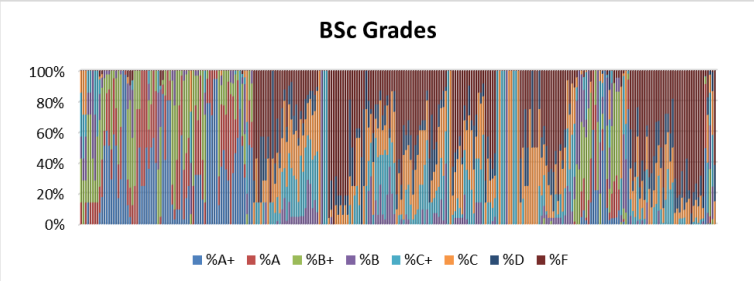

Fig. 7. Grades in BSc study programme

An in-depth analysis has been made to evaluate the quality of the courses according to the students' results. It aims to determine whether students have low grades only in certain courses or in all courses. Table 6 presents the number of grades A +, A, B +, B, C +, C, D and F received from each student in the courses included in the curriculum of the BCA programme. For example, student 001 has 13 low grades (F), 18 grades in the interval from A + to D, 2 of which are A + and 1 A. This indicates that the quality of teaching in courses in which the student has F grades is probably not on a level.

Table 6. Numberof grades ofeachstudent in BCA programme

Student	A+	A	B+	B	C+	C	D	F
001	2	1	3	0	3	7	2	13
002	0	1	3	2	1	3	1	20
003	0	0	1	1	0	0	0	9
004	0	0	1	1	1	0	1	13
005	0	2	2	2	1	6	5	13
006	0	1	0	0	0	0	0	5
007	2	2	2	1	2	5	3	14
008	1	0	1	1	0	0	0	14
009	0	1	2	3	0	3	4	18
010	1	1	1	2	1	3	4	18
011	0	0	4	1	1	1	1	23
013	1	0	2	3	1	4	4	16

Student	A+	A	B+	B	C+	C	D	F
014	1	3	1	1	0	4	3	18
015	0	1	4	1	1	2	5	17
016	0	0	1	0	0	0	0	5
017	0	0	1	0	0	0	0	5

Fig.8 presents the percent of A+, A, B+, B, C+, C, D and F grades for each student.

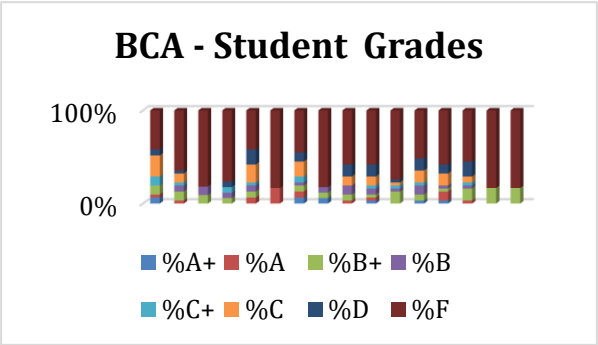

Fig. 8. Percent of grades of each student in BCA programme

Table 7 presents the number of grades only for those students who have received high percentA + and A grades. The results of the analysis show that the quality of education in some courses is likely to be poor. For example, a student who has received 33% high grades has not completed 13% of the courses. This indicates that there is a high probability of the quality of teaching in these courses is not on high level and that poor grades are not entirely due to the unpreparedness of the student.

Table 7. Percentof grades ofeachstudent in BA programme

Student	A+	A	B+	B	C+	C	D	F
017	28%	3%	3%	9%	41%	16%	0%	0%
023	20%	13%	0%	0%	17%	30%	7%	13%
036	31%	0%	6%	16%	31%	13%	3%	0%
054	31%	3%	3%	6%	28%	22%	6%	0%
056	22%	3%	9%	3%	31%	28%	0%	3%
062	23%	3%	6%	0%	10%	39%	6%	13%
115	23%	7%	3%	3%	3%	7%	7%	47%
235	25%	6%	0%	6%	6%	44%	3%	9%
285	25%	6%	6%	0%	0%	25%	9%	28%
348	18%	9%	12%	3%	6%	6%	6%	41%
478	30%	7%	0%	0%	10%	27%	10%	17%

Data for all students can be seen in Fig.9, which presents the percent of A+, A, B+, B, C+, C, D and F grades for each student.

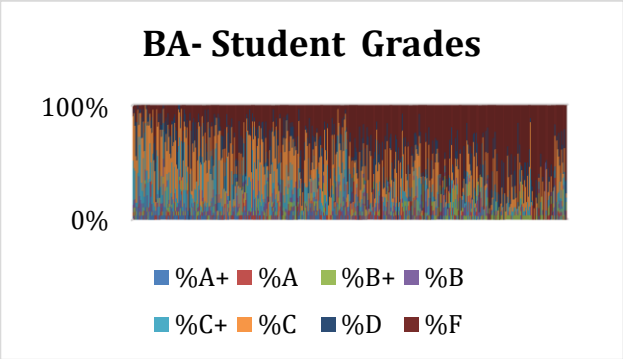

Fig. 9. Percent of grades of each student in BA programme

Table 8 presents the number of grades only for those students who have a high percent of high marks - A + and A. The results of the analysis show that the quality of teaching in some courses is likely to be poor. For example, a student who has 56% excellent grades (A+ and A) has not completed 22% of the courses. This indicates that there is a high probability the quality of teaching in these courses is not good and poor grades are not due to the lack of preparedness of the student in a full degree. On the other hand, some strong students do not have F grades in any of the courses (see Table 8 and Fig. 10), which requires further analysis of the causes of the case described.

Table 8. Numberof grades ofeachstudent in BSc programme

Student	%A+	%A	%B+	%B	%C+	%C	%D	%F
007	11%	37%	11%	26%	33%	33%	7%	0%
013	44%	0%	4%	37%	26%	19%	0%	0%
049	44%	15%	4%	22%	48%	19%	11%	4%
051	52%	4%	19%	52%	26%	11%	4%	0%
058	52%	4%	11%	52%	22%	22%	7%	0%
100	33%	4%	7%	4%	4%	19%	15%	48%
109	26%	7%	0%	7%	26%	26%	7%	33%
118	41%	15%	7%	19%	30%	30%	7%	22%
119	22%	11%	19%	11%	33%	33%	7%	33%
136	30%	0%	7%	7%	4%	26%	11%	48%
172	26%	11%	0%	22%	33%	26%	4%	37%
192	33%	0%	11%	0%	19%	33%	4%	33%
283	22%	11%	33%	11%	7%	15%	22%	52%
319	0%	4%	15%	11%	7%	7%	7%	81%
330	22%	19%	26%	7%	4%	19%	15%	59%

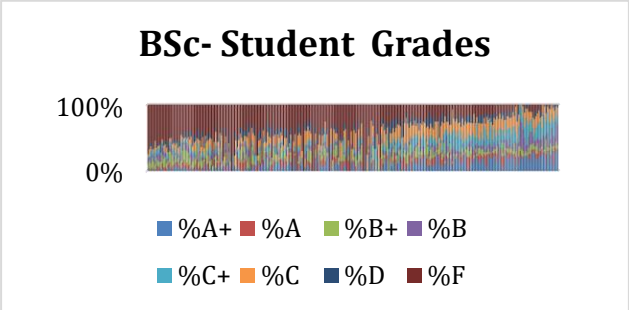

Fig. 10. Percent of grades of each student in BSc programme

Hierarchical Clustering was performed on the three different Programmes datasets, viz. BA, BSc and BCA. The following figure depicts the dendrogram for the BCA course only. From the figure, it is clear that grading occurrences 9, 10, 12 form the highest clustering. Silhouette score of the clusters proves it efficiency.

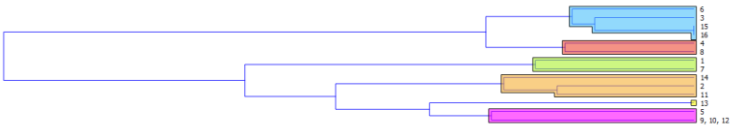

Fig. 11. Dendrogram of the BCA Programme

6 Conclusion

The quality of the training in North Lakhimpur College, Assam, India (Autonomous) was evaluated on the basis of 19249 grades received from 758 students in 511 courses, included in the curriculum of three study programmes. The results from the evaluation of feedback of the teachers to the students during the training show that the final grades in 93% of BA courses, 58% of BCA courses, and 78% of BSc courses had been improved after measures taken by teachers to improve student success and their timely feedback. There are courses in which all students have low grades or few students have passed the course with C +, C and D grades. These results can be interpreted as a sign of the poor quality of teaching in these courses and the need to study the reasons for the poor results and to take measures to improve the students' performance. An in-depth analysis which aims to determine whether students have low grades only in certain courses or in all courses.

During the next study year, all analyses will be conducted again. The results will be compared with the current results. The result of the comparison will show if the taken measures are gave results and the quality of courses has been improved.

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8 Authors

Ranjit Paul is working as an Assistant Professor in the Department of Computer Science, North Lakhimpur College (Autonomous). He is a research scholar in the Centre for Computer

Science and Applications, Dibrugarh University. His area of interest is Educational Data Mining.

Silvia Gaftandzhieva is an Assistant Professor at the University of Plovdiv "Paisii Hilendarski", Faculty of Mathematics and Informatics. Dr. Gaftandzhieva gained her Ph.D. at February, 2017. She has taken part in more than 10 national and international projects. Dr. Gaftandzhieva is an author of 40 scientific publications in the field of quality assurance (of HE, e-Learning, Projects, etc.), Learning Analytics, e-Learning, m-Learning, etc. with over 100 citations.

Samina Kausar is currently working as a researcher and also a PhD. scholar at School of Computer Engineering and Science, Shanghai University, China. She received the M.S. degree in computer science from the International Islamic University Islamabad, Pakistan. She is also working as Assistant Professor at University of Kotli, Azad Jammu and Kashmir, Pakistan. Her research interests are in the fields of big data, bioinformatics, computer networks, cloud computing, data mining, E-learning, and machine learning.

Dr. Sadiq Hussain is System Administrator at Dibrugarh University, Assam, India. He received his PhD. degree from Dibrugarh University, India. His research interest includes data mining and machine learning. He is associated with Computerization Examination System and Online Examination Management System of Dibrugarh University.

Rositsa Doneva is a Professor at the University of Plovdiv "Paisii Hilendarski", Faculty of Physics and Engineering Technologies. Dr. Doneva gained her Ph.D. at October, 1995. She has led/taken part in more than 50 national and international projects. Prof. Doneva is the author of over 120 scientific publications and 40 textbooks and learning materials with over 300 citations.

Dr. A. K. Baruah is a Professor in the Department of Mathematics, Dibrugarh University. Already six scholars have received Ph. D. degree under his supervision. He has 49 Publications in different refereed Journals of National/International repute and 05 Publications in Proceedings of International Conferences.

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A Personalized English Teaching Design Based on Multimedia Computer Technology

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Yan Zhao
Yantai Nanshan University, Yantai, China
ttftpy@163.com

Abstract—In the Internet age, the proliferation of multimedia computer technology (MCT) brings unprecedented opportunities to English teaching in colleges. This paper firstly carries out a questionnaire survey on the current status of personalized teaching of college English, and summed up the main problems with the current teaching mode. On this basis, the authors developed an MCT-based personalized English teaching design, with the aid of information technology (IT) and online teaching platform. To verify its effect, the proposed design was tested through contrastive experiment. The results show that the MCT-based personalized English teaching design could improve the interests and performance of English learning, and cultivate a good learning habit. In summary, this paper explores the personalized teaching of college English from both theoretical and practical angles, laying a good basis for high-quality English teaching and personalized development of students.

Keywords—Multimedia computer technology (MCT), online platform, personalized English teaching design, teaching effect

1 Introduction

Under the trend of globalization, English, an important universal language, becomes an essential skill to international talents. However, there are many problems with the teaching of English as a second language, such as the poor teaching effect and the weak ability to practice the language. Educators around the world are striving to find the right teaching strategy to solve these problems.

With differences in personality and learning ability, college students vary greatly in the demand and acceptance of English learning. English teachers must teach students according their aptitude and demand, i.e. implement the strategy of personalized teaching [1]. To realize personalized teaching, college English teachers should recognize the individual differences and defects of students in English learning ability, treat students as equals, and fully tap their potential.

The idea of personalized teaching can be traced back to ancient times. Some educators advocated the thoughts of teaching students according to their aptitude and providing education for all people without discrimination [2]. In modern times, the first attempts to adapt teaching techniques to individual differences were made be-

tween the 1960s and 1970s, creating individualized teaching system and instructions [3].

In the Internet age, the proliferation of multimedia computer technology (MCT) has changed how we live and learn, and brought new opportunities to personalized English teaching in colleges. The space for personalized teaching and learning has widened, thanks to computer technology and the Internet. Audiovisual, computerized, and programmed teachings are all personalized teaching modes based on computer technology [4].

The recent studies [5] mainly deal with the following aspects of personalized teaching: concept, connotation, features, means, modes and implementation methods. Some scholars explored personalized teaching from the angle of computer and information technology, including the design and implementation of personalized teaching systems, the analysis of student data on online learning platforms, and the recommendation of suitable learning resources [6].

In 2007, the Department of Higher Learning, Chinese Ministry of Education released the College English Teaching Requirements [7], calling for the transition to personalized English teaching in colleges. Since then, many Chinese researchers have tried to personalize the teaching of college English.

Some researchers [8] developed new personalized teaching modes for college English from the perspectives of teachers and students. One of these modes is thematic teaching, a strategy of quality education. Thematic teaching integrates English with the knowledge of other disciplines, and provides students with real communication environment outside the campus. This method can effectively enhance the learning efficiency. However, it is very difficult to implement and popularize this approach, unless stakeholders refresh their philosophy on development.

Some researchers [9] promoted personalized teaching and learning of English with modern education techniques like the MCT and the Internet technology (IT), marking the main trend of English teaching. This strategy replaces backboard writing with multimedia courseware, gathers rich language materials through online teaching, and creates a real linguistic environment. Nonetheless, the online teaching may be too complex to control, if the strategy is not meticulously designed [10].

Drawing on the relevant literature, this paper surveys the current status of college English teaching, and sums up the problems with the current teaching mode. On this basis, the authors developed an MCT-based personalized English teaching design, with the aid of IT and online teaching platform. Finally, the proposed design was verified through contrastive experiment.

2 Questionnaire Survey

This paper carries out a questionnaire survey to understand the current situation of personalized English teaching in colleges. The questionnaire was designed in reference to Aharony's research [11]. The survey targets non-English majors randomly selected from a college in Hangzhou, eastern China's Zhejiang province. All of them

are freshmen, sophomores or juniors. A total of 500 questionnaires were issued, and 494 (98.8%) valid responses were obtained.

2.1 Current situation of English learning

The statistics on the respondents' preference for English are plotted as Fig. 1. It can be seen that most only a few students hold a negative view of English. The favorable view of English is attributable to the international status of the language. The mastery of such a widely spoken language benefits future learning and work. Most college students aim to acquire necessary knowledge and skills through English learning. In other words, their motives of English learning are very utilitarian, which should be mitigated under teacher guidance.

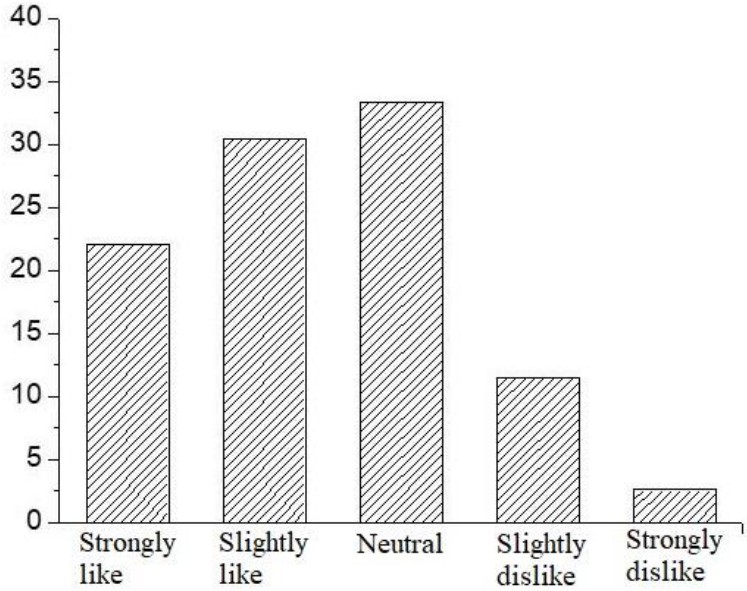

Fig. 1. Respondents' preference for English

2.2 Current situation of English teaching

The teaching method and effect directly affect the learning interest [12]. Fig. 2 presents how frequent the MCT is used by college English teachers. It can be seen that 70% of teachers often use the MCT to teach English, and only 1.05% have never utilized the technology in English teaching. Further investigation shows that 90% of college English teachers have used electronic whiteboard, more than that for any other multimedia tool.

Fig. 3 displays the survey results on teacher-student interaction. It can be seen that most teachers do not actively interact with students in the teaching process. Only 32.3% of teachers maintain active interaction with students. Meanwhile, 18.9% think

little of teacher-student interaction, and 2.3% have never interacted with students. Our survey also reveals that most students do not communicate with teachers or classmates, even if they face some problems.

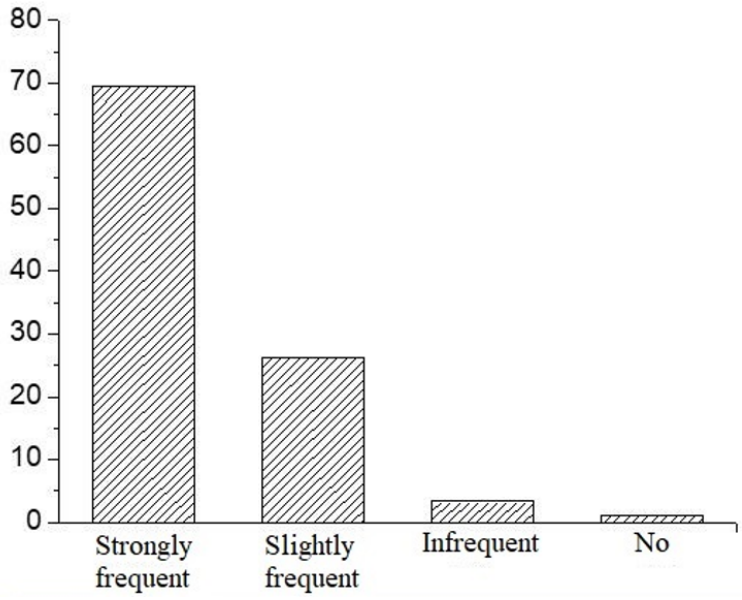

Fig. 2. Frequency of MCT utilization among college English teachers

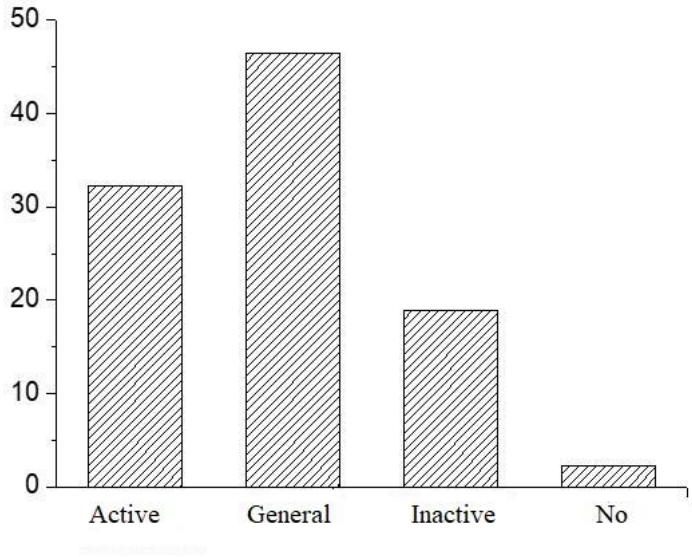

Fig. 3. Teacher-student interaction

2.3 Current status of personalized English teaching

Fig. 4 shows the survey results on personalized teaching of college English. It can be seen that only 4.97% and 29.82% of college English teachers are strongly or slightly concerned about the learning styles, respectively. Thus, most teachers have not paid enough attention to learning style. Besides, multimedia and online resources have not been sufficiently utilized by college English teachers, most of whom still teach based on textbooks. Furthermore, many teachers now implement personalized English teaching, using the traditional method of group instruction, and most students (75%) agree that personalized teaching helps them learn English.

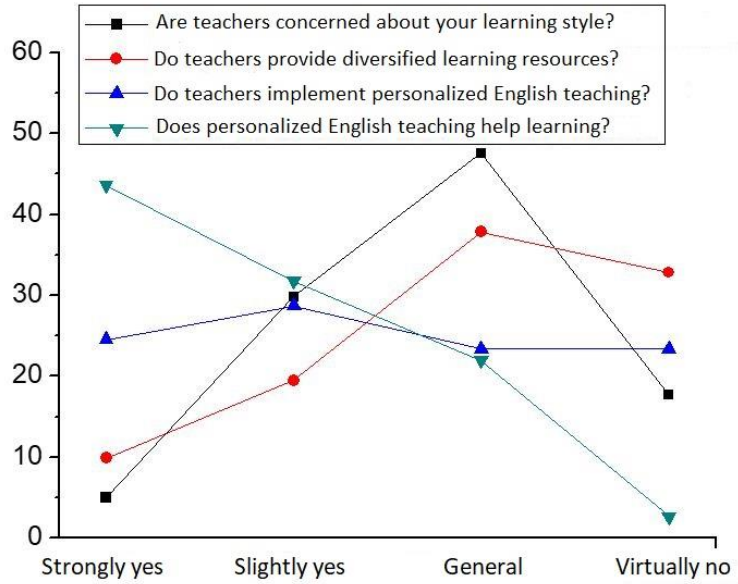

Fig. 4. The current status of personalized English teaching in colleges

Through the survey, the following problems were found in the current teaching mode of college English:

1) Despite the generally favorable views of English, most students have utilitarian motives for English learning. Their cognition and attitude of English learning should be corrected under teacher guidance.
2) Most teachers know how to MCT in English teaching, but have rarely utilized tools other than the electronic whiteboard. The students are only provided with a limited amount of learning resources. The teacher-student interaction should be further improved.
3) English teachers have not paid enough attention to learning styles in the teaching process, failing to implement highly individualized teaching methods and means.

3 MCT-Based Personalized English Teaching Design

3.1 Development and implementation

Based on the survey results, this paper develops and implements an MCT-based personalized English teaching design from five aspects, namely, teaching preparation, pre-class personalized preview, in-class personalized Q&A, post-class personalized review, and personalized data analysis & feedback, with the aid of the IT and online teaching platform. The design aims to stimulate the learning interests and teaching efficiency of English.

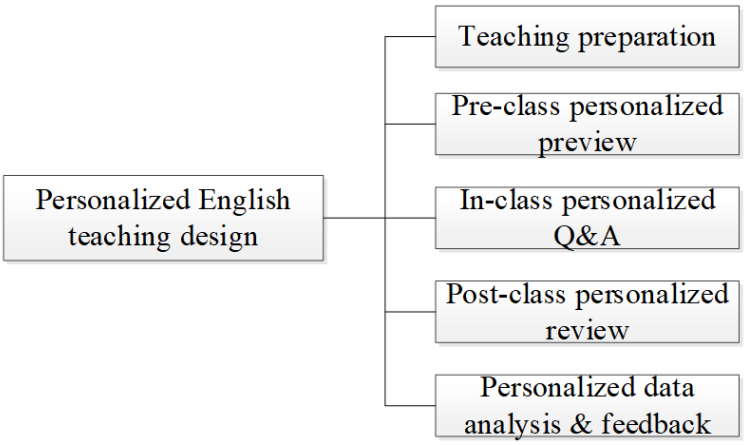

Fig. 5. MCT-Based personalized English teaching design

Teaching preparation: During teaching preparation [13], the teachers need to set out the teaching goals, select suitable teaching and evaluation methods, and design and develop teaching resources, according to the requirements of the syllabus and the actual situation of the students.

Here, two Grade 2 classes are selected from a college, and respectively taken as the experimental class and the control class. The two classes both have 53 students. The MCT-based personalized English teaching design and the traditional English teaching design were implemented in the experimental class and the control class, respectively. As shown in Fig. 6, the students in the control class had better English proficiency than those in the experimental class before the experiment.

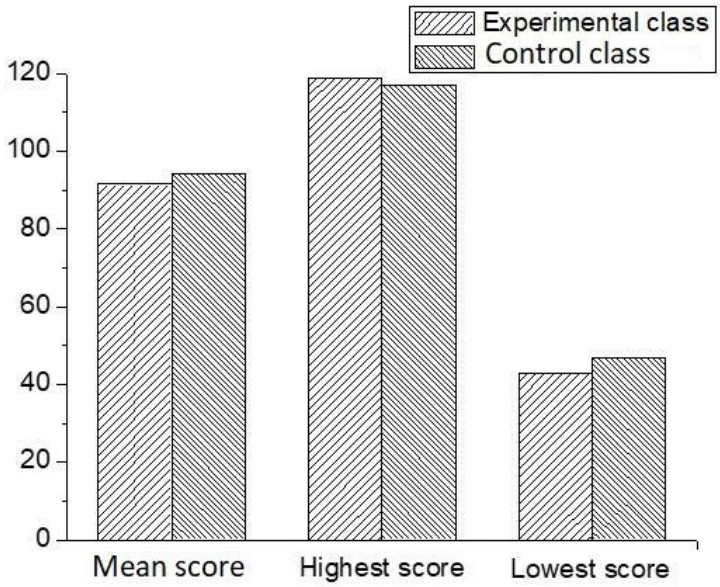

Fig. 6. Comparison of English proficiency before the experiment

Considering the learning situation and teaching contents, the teacher of the experimental class taught English by such methods as stratified teaching and inquiry-based teaching. With the aid of the MCT, the teacher prepared the teaching contents into audiovisual materials, e.g. slides and micro-lectures, and published them to students on online teaching platform, creating a new learning environment with students as the center. Fig. 7 shows a slide prepared by the teacher.

Fig. 7. A slide for personalized English teaching

Pre-class personalized preview

Teacher: The purpose of pre-class preview is to change aimless learning into learning with questions [14]. Considering the learning situation and features of each student, the teacher provided a variety of preview materials, and prepared/uploaded different sets of test questions for preview and review, which can be selected flexibly by students. In addition, the teacher tutored the students and answered their questions via the online platform, and monitored the learning activities on the platform, including the selection of preview materials, the completion of preview tasks, and the communication between students.

Students: After logging on the online platform, the students chose the most suitable material for preview, and answered the preview test questions. The platform rated their answers and provided the suggested answers, showing the students their preview effect. Then, the students marked their mistakes and doubts, and discussed them online with classmates and teachers.

In-class personalized Q&A: Through the online platform, the teacher learned about the preview effect and mistakes of students. During the class, he/she explained the common mistakes in class, and answered the uncommon ones via one-on-one tutoring. Of course, the Q&A process could also be implemented in the form of group teaching.

Post-class personalized review

Stratified and individualized learning: The teacher classified the students into three levels (A, B and C) based on the following factors: the skills of listening, speaking, reading, and writing, English test scores, and the attitude, ability and method of learning [15]. For students on each level, the teacher prepared a set of post-class review questions and exercises, and offered targeted tutoring.

Similarly, the performance of students was not evaluated solely based on the total score, but also considering the progress [16]. Take level C students for example. These students have a poor foundation and low interest in English, and were encouraged to stimulate their interest and confidence in English learning.

Personalized interest cultivation: The teacher tried to discover the interest of each student and guided him/her to integrate the interest into English learning, aiming to arouse his/her enthusiasm of English learning. There is no fixed pattern for the integration, as long as the learning contents are related to the knowledge to be learned. For instance, the students interested in writing were asked to write on a given topic in English. Other tools to integrate interest in English learning include cosplay and mind mapping.

Personalized data analysis and feedback: Any student activity on the online platform, whether it is learning, testing or communication, produces data. To facilitate personalized teaching, this paper adopts content analysis and social network analysis [17] to analyze the personalized data generated by each student, and feeds back them to the teacher. Such data include learning contents, learning time, test scores and communication data. Then, the teacher could make timely adjustment to the teaching method and contents, in the light of the learning situation. Meanwhile, each student could learn about his/her situation of English learning, and adjust his/her learning

method in a timely manner. Fig. 8 lists the post-class exercise scores of students on different levels in the experimental class.

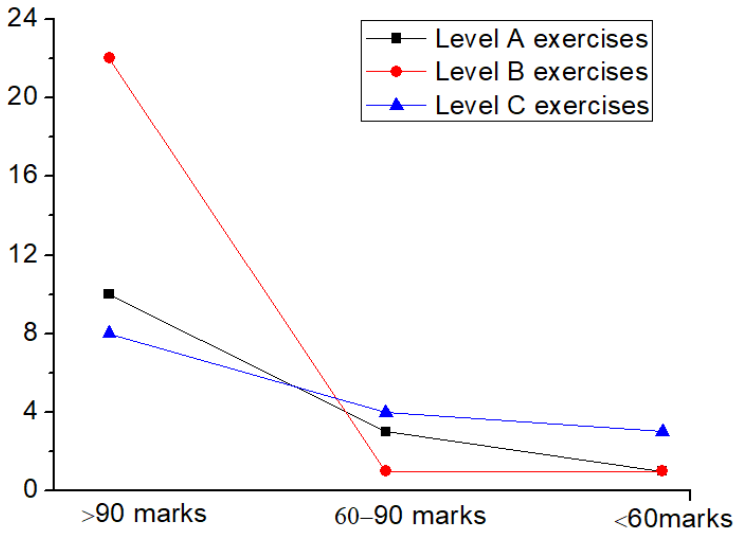

Fig. 8. The post-class exercise scores of students on different levels in the experimental class

3.2 Effect analysis

Test scores: Table 1 compares the independent samples t-test results on the midterm and final test scores of experimental and control classes. It can be seen that the students in the experimental class had the higher scores in both tests. The score difference was not significant in the midterm test (p=0.587>0.05), but very significant in the final test (p=0.048>0.05). The comparison shows that the MCT-based personalized English teaching design helps to improve the English performance.

Table 1. Comparison of the independent samples t-test results on the midterm and final test scores of experimental and control classes

Item	Experimental class (M±SD)	Comparison class (M±SD)	T	p
Midterm test score	92.433±18.643	90.432±18.786	0.532	0.587
Final test score	96.134±19.654	92.239±19.853	0.473	0.048

Learning attitude: The teaching effect is directly related to learning efficiency and attitude [18]. Fig. 9 records the changes of experimental class in the learning attitude before and after the experiment. Obviously, the learning attitude of the students was greatly improved through the experiment. This means the MCT-based personalized English teaching design can arouse the learning interest in English.

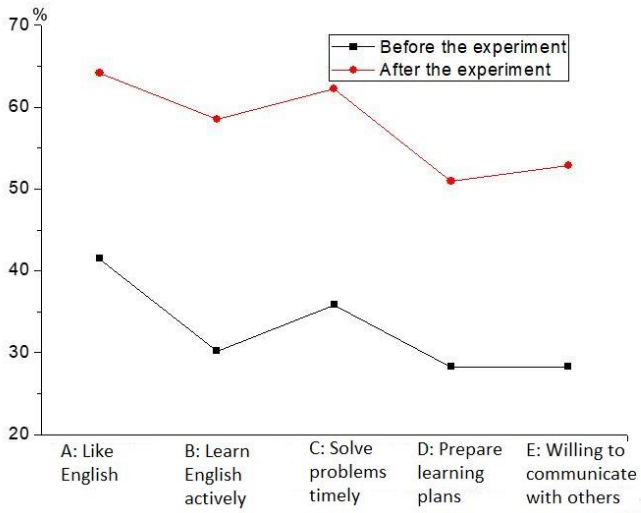

Fig. 9. The changes of experimental class in the learning attitude before and after the experiment

Learning strategy: Fig. 10 compares the learning strategies of the experimental class before and after the experiment. An obvious change in the learning strategy of English was observed, after implementing the MCT-based personalized English teaching design. Through the experiments, the students became willing to preview before class and complete homework, formulated a knowledge framework after learning, selected pertinent learning resources, learned from the experience of classmates, and communicated frequently with teachers.

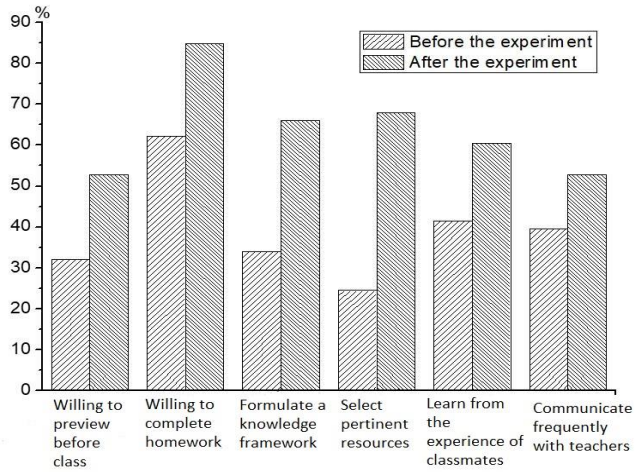

Fig. 10. Comparison of the learning strategies of the experimental class before and after the experiment

Satisfaction: Fig. 11 presents the survey results on how satisfied the experimental class is with the MCT-based personalized English teaching design. It can be seen that the majority (98.8%) of students were slightly or highly satisfied with the design. The few dissatisfied students should be given special care in future, because their dissatisfaction arises from the lack of interest or poor computer literacy.

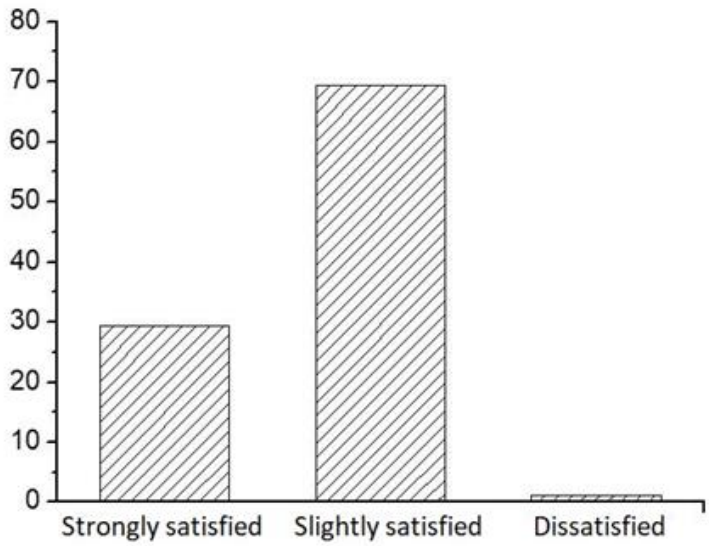

Fig. 11. Satisfaction with personalized English teaching design

4 Conclusion

1. In the Internet age, the proliferation of the MCT brings new opportunities to personalized English teaching in colleges. This paper mainly develops an MCT-based personalized English teaching design. The main conclusions are as follows:
2. According to the questionnaire survey on the current status of college English teaching, the major problems in the current teaching mode of college English include: some students have incorrect cognition and attitude of English learning, the teachers mostly rely on only one MCT tool (electronic whiteboard), the teaching resources are not diversified, the teaching process is not sufficiently individualized, and teachers and students rarely communicate with each other.
3. Based on the survey results, the authors developed and implemented the MCT-based personalized English teaching design from five aspects: teaching preparation, pre-class personalized preview, in-class personalized Q&A, post-class personalized review, and personalized data analysis & feedback.
4. Through contrastive experiment, the MCT-based personalized English teaching design was proved to have the following functions: improving the interests and performance of English learning, and cultivating a good learning habit.

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6 Author

Yan Zhao was born on 9th, December,1984 in Jinan City, Shandong Province, China. She received B.A. degree of English from China University of Petroleum in 2007 and M.A. degree in English Language and Literature from China University of Petroleum in 2009. She started her teaching career in August, 2009 in Yantai Nanshan University. Since 2009, she has authored 6 papers in English teaching, literature and linguistics and participated in a project.

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Correlation between Self-Efficacy and English Performance

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Yinchun Chen
Shanghai Jianqiao University, Shanghai, China
chenyc@gench.edu.cn

Abstract—Self-efficacy may affect our behaviours, thoughts and emotions. The students with strong self-efficiency tend to have good autonomous learning ability. However, there is little report on the correlation between self-efficacy and English performance. To make up for the gap, this paper explores the influence of self-efficacy on English performance based on the theories on self-efficacy. Specifically, a questionnaire survey was carried out among male and female students in three grades, covering all aspects of English learning (e.g. listening, speaking, reading and writing). The collected data were analysed statistically on the SPSS. The results show that self-efficacy influences the selection of environment and behaviour; the students with strong self-efficacy can flexibly use various cognitive and learning methods, and achieve excellent self-management and regulation; the students with good English performance have high self-efficacy scores, revealing a positive correlation between self-efficacy and English performance. The research findings lay a theoretical basis for improving English performance based on self-efficacy.

Keywords—English performance, self-efficacy, behavioural efficacy, ability efficacy

1 Introduction

It is a difficult task to learn English as a foreign language. The learning methods for the mother tongue are often not applicable to English. Neither is rote memorization a suitable way for English learning. The students may have invested lots of time, energy and effort, but failing achieve a desired English performance [1-2].

The difficulty in English learning, coupled with the growing importance of the language, poses a tremendous pressure on students. As a result, many of them have gradually lost interest and confidence in English learning. Thus, negative emotions continue to accumulate over the time [3].

In the learning process, the students with high self-efficacy have relatively few negative emotions [4]. Self-efficacy is a set of beliefs that individuals hold about their motivation, cognitive ability and action capacity to achieve goals. These beliefs greatly influence the effect of English learning, because the English performance of a student hinges on his/her mood and attitude in learning [5].

In English learning, the self-efficacy of a student is manifested as the belief in his/her own ability to learn English. As mentioned before, students with high self-efficacy tend to be optimistic and willing to learn, despite the setbacks and challenge-es in the learning process. On the contrary, students with low self-efficacy are not confident, and fearful of difficulties in learning [6].

By improving self-efficacy, it is possible to regulate the behaviours, habits and attitudes of English learners, and enhance English performance continuously in a comprehensive manner [7]. One of the key aspects of self-efficacy is psychological self-regulation, which promotes the effect of cognitive strategies in English learning [8].

Studies have shown that self-efficacy is composed of an individual's attitudes, abilities, and cognitive resources. These components may vary with genders, ages, education levels, and regions [9]. Based on self-efficacy theory, this paper probes deep into the impacts of self-efficacy on the English performance of second language learners, and explores the relationship between self-efficacy and the English performance.

2 The Relationship between Self-efficacy and Learning Ability

2.1 Theoretical basis of self-efficacy

Self-efficacy is a form of thinking. It plays an important role in the individuals' judgment of their own abilities and self-regulation process [10]. The self-efficacy in learning reflects the individual's judgment of ability and belief in academic aspects, which is affected by personal learning ability, teachers or parents' expectations and emotions etc. It's also the learner's judgment of their ability to complete learning tasks and the confidence of achieving a goal [11]. Fig 1 shows the ternary interaction causality diagram. A ternary interaction is formed between the individual's subjective factors (e.g., cognition, emotion, and thinking), the environment, and the behaviour. Fig 2 shows the hierarchy of individual needs. The hierarchy of human needs is divided into five levels from low to high, which are physiological needs, security needs, belonging and love needs, respect needs, and self-actualization needs; the first three needs can be regarded as real needs, and the last two are high-level needs, that is, growth needs. The low-level needs must be met before high-level needs [12]. Under the influence of self-efficacy, the behaviour subjects adjust their ability, thinking mode, and behaviour intensity. Throughout this entire process, the action mechanism of self-efficacy is achieved by thinking, selection, motivation, and physical and mental reactions of the subjects [13].

The theoretical levels of self-efficacy are divided into the hierarchy of needs, achievement motivation, self-efficacy, achievement goals, self-determination and self-worth [14]. In the learning process, the satisfaction degree of individual psychological needs will determine the energy and nature of learning motivation. Self-efficacy complements English learning motivation and attitude from a new perspective [15].

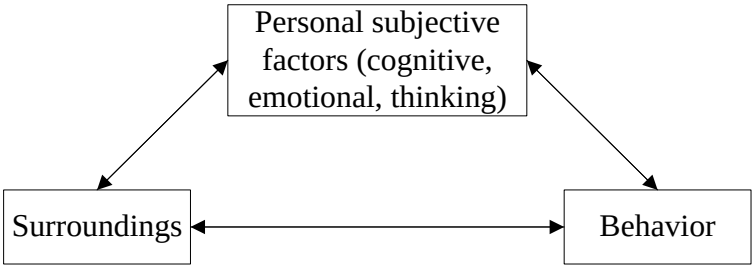

Fig. 1. Ternary interactive causality diagram

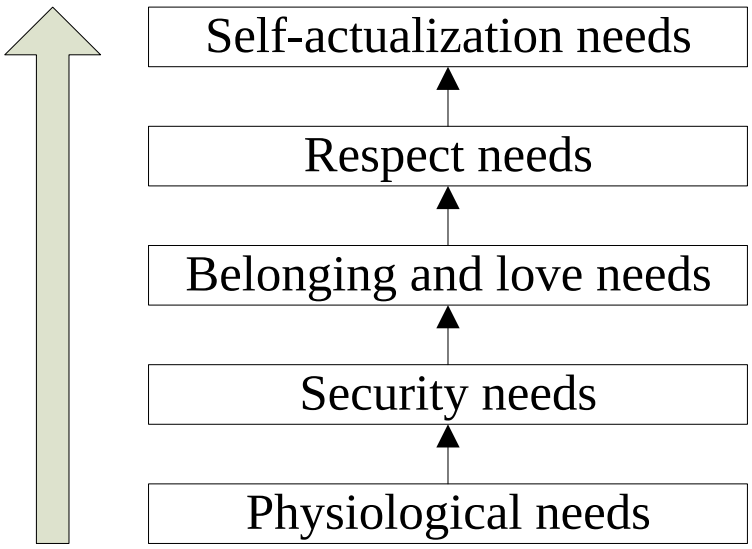

Fig. 2. Hierarchy of individual needs

2.2 The relationship between students' self-efficacy and academic performance

Some researchers have explored the relationship between self-efficacy and English reading ability, finding that through the proper use of their relationship in the training, the students can improve their level of self-efficacy, the use of reading strategies and English reading performance [16]. Fig 3 shows the self-efficacy mechanism, including selection process, cognitive process, incentive process, and emotional process. Self-efficacy affects the selection of environment and behaviour; beliefs of self-efficacy affect cognitive processes in a variety of ways; self-efficacy plays a major role through the thinking process accompanied by motivation factors or processes. There is a certain relationship between students' English autonomous learning, academic performance and self-efficacy. Some studies have found that there is a significant correlation between student autonomy, learning strategies, learning motivation, and self-regulation and English learning self-efficacy [17, 18]. Under normal circumstances, students with

high self-efficacy can flexibly use a variety of cognitive strategies, learning strategies, and self-management and regulation.

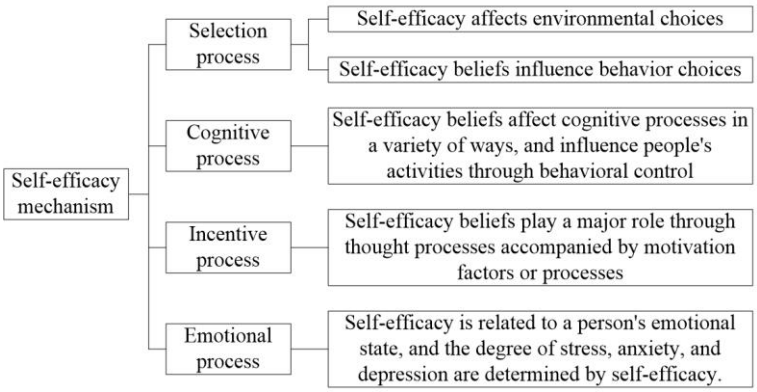

Fig. 3. Self-efficacy mechanism

3 Research Subjects and Methods

At present, research on the impact of self-efficacy on English learning is a very hot topic, but the overall research is not deep enough. Also, there have been few researches on the relationship between self-efficacy and English performance. In this paper, the questionnaire surveys and practical statistical analysis methods were adopted to deeply explore the high school students' English learning autonomy, self-efficacy score and the relationship between English performance and self-efficacy. Learning autonomy was scored on a 100-point scale and self-efficacy was scored on a 5-point scale. Table 1 lists the basic information of the test subjects selected from high school students in a middle school in Xiaogan, Hubei province. A total of more than 240 questionnaires were issued, and 216 were valid questionnaires were recovered, including 120 boys and 96 girls in three grades.

Table 1. Basic information of subjects

Type	Category	Quantity	Percentage/%
Sex	Male	120	55.56%
	Female	96	44.44%
Class	Senior grade one	66	30.56%
	Senior grade two	87	40.28%
	Senior grade three	63	29.17%
Academic record	Excellent	49	22.69%
	Medium	125	57.87%
	Difference	42	19.44%

The selected measurement tool was the questionnaire of English self-efficacy, covering English listening, speaking, reading and writing. The survey was conducted with

the cooperation of the teacher in the class as a unit, while the participants knew nothing about the purpose of the survey file, in order to ensure the authenticity and reliability of the questionnaire. Data analysis was performed using SPSS software.

4 Research Results and Analysis

4.1 Analysis for English learning autonomy of high school students

The English learning is the process of actively forming a cognitive structure through the recognition of English forms. Autonomy can be regarded as a sense of self-efficacy in the cognitive process, which affects students' learning motivation, behaviour and performance. Students' acceptance of English knowledge can only be accomplished by their own construction. Learners actively synthesize, reorganize, and transform existing knowledge, to obtain new information, things, or achieve personal significance. The self-efficacy is improved when the learners are constantly acquiring language input that is higher than their current language ability. Only when students are exposed to language information that is higher than their current language level will they have autonomy.

The autonomy of English learning includes English learner autonomy, English learning goal setting, English learning motivation, English learning strategies and English learning evaluation. Fig 4 shows the English learning autonomy scores of senior high school students. It can be clearly seen that students scored the highest in English learning goal setting, followed by English learning motivation and English learner autonomy. Fig 5 shows the gender-based English learning autonomy scores of high school students, indicating that there is a difference in male and female students' English learning autonomy scores; except for the English learning motivation, male students scored higher than female students in other aspects. Fig 6 shows the English learning autonomy scores of high school students based on English performance. It can be clearly seen that students with excellent performance scored significantly higher in English learning autonomy, and the scores from various aspects of English learning autonomy showed significant differences in English performance.

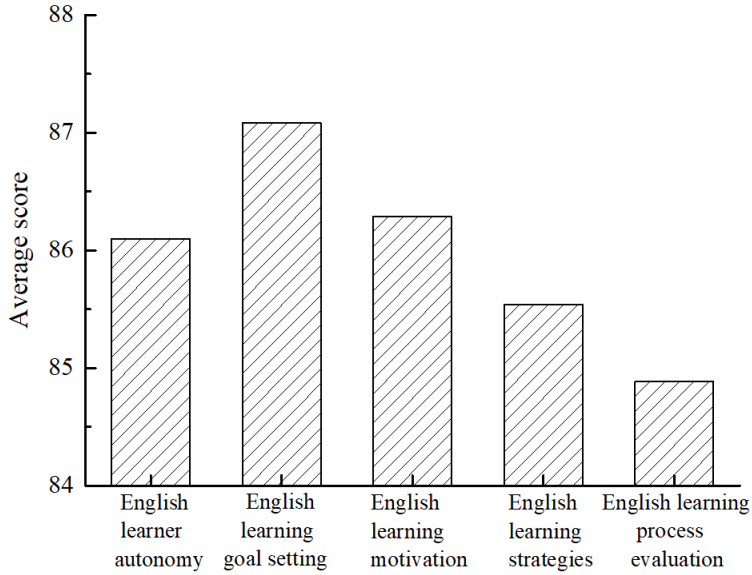

Fig. 4. English learning autonomy score of senior high school students

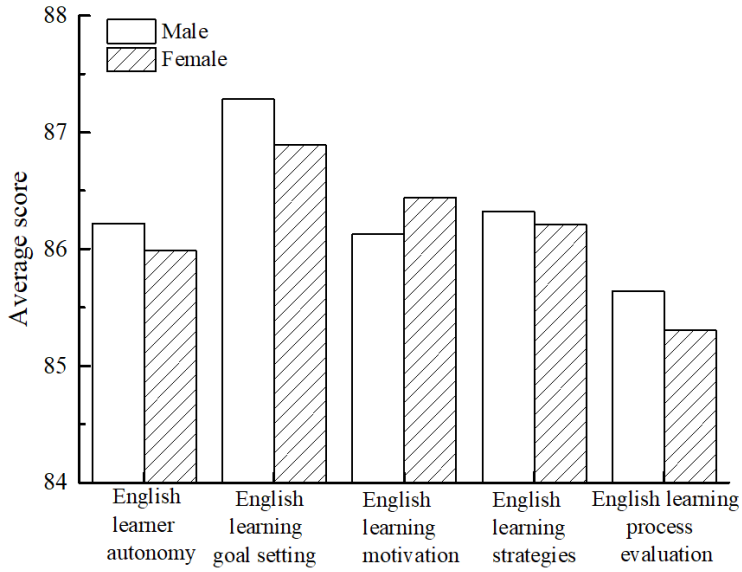

Fig. 5. Gender based assessment of English learning autonomy of senior high school students

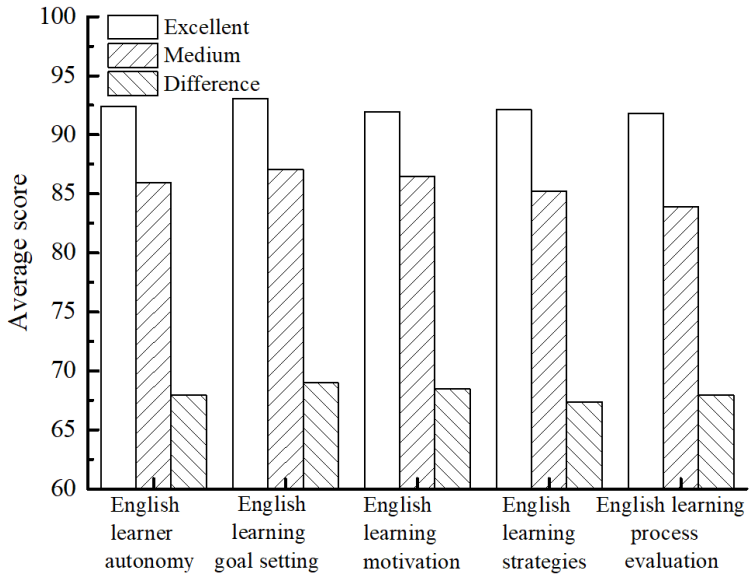

Fig. 6. English learning autonomy score of senior high school students based on learning achievement

4.2 Discussion on the relationship between self-efficacy and English performance

Students with low self-efficacy tend to be pessimistic about learning autonomy and learning motivation. English learning efficacy includes three aspects: self-efficacy, behavioural efficacy, and ability efficacy. Fig 7 shows the overall level of English self-efficacy; the self-efficacy scored higher than the behavioural efficacy, and the behavioural efficacy scored higher than the ability efficacy. However, the average score of the overall English learning efficacy did not show a significant difference, while there was a significance difference in the maximum values (the maximum score of the ability efficacy was significantly smaller than the other two), which indicates a significant difference in the efficacy among different students. Fig 8 shows the self-efficacy scores of English learning based on gender differences. It can be clearly seen that male students' self-efficacy and behavioural efficacy were higher than females, while female students' English-learning ability efficacy was higher than males, but there is no significant difference in terms of gender factor. Fig 9 shows the English learning self-efficacy score based on English performance. It can be clearly seen that students with good English performance scored higher in self-efficacy, and there are significant differences in self-efficacy scores in terms of English performance factor. In this paper, students' English learning performance values and self-efficacy scores were subjected to regression standardized residual analysis. The regression relationship between self-efficacy and English performance is shown in Fig 10. It can be clearly seen that there is a significantly positive correlation between the two.

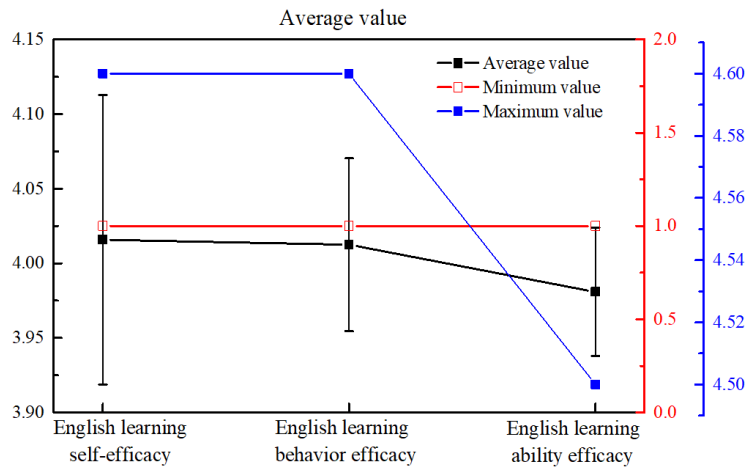

Fig. 7. Overall level of English Self-efficacy

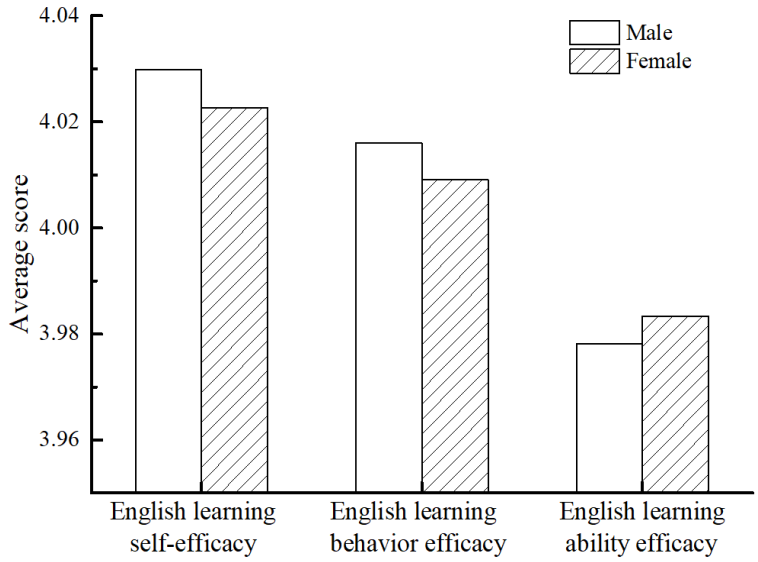

Fig. 8. English learning self-efficacy score based on gender differences

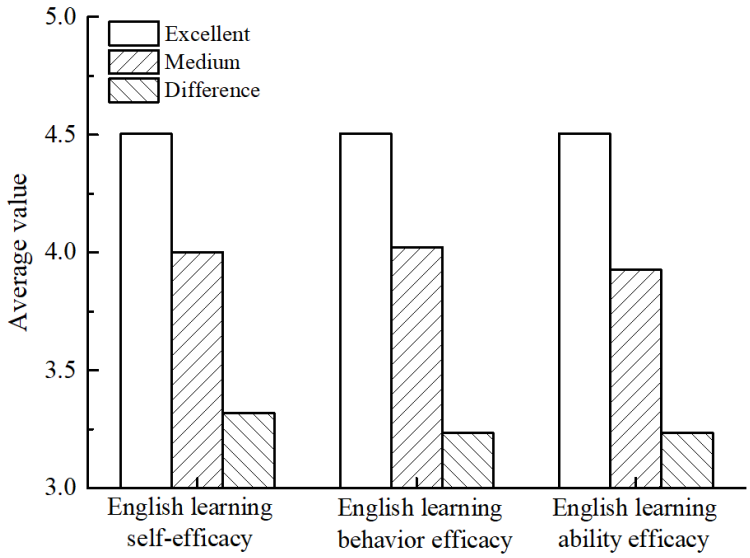

Fig. 9. English learning self-efficacy score based on learning performance

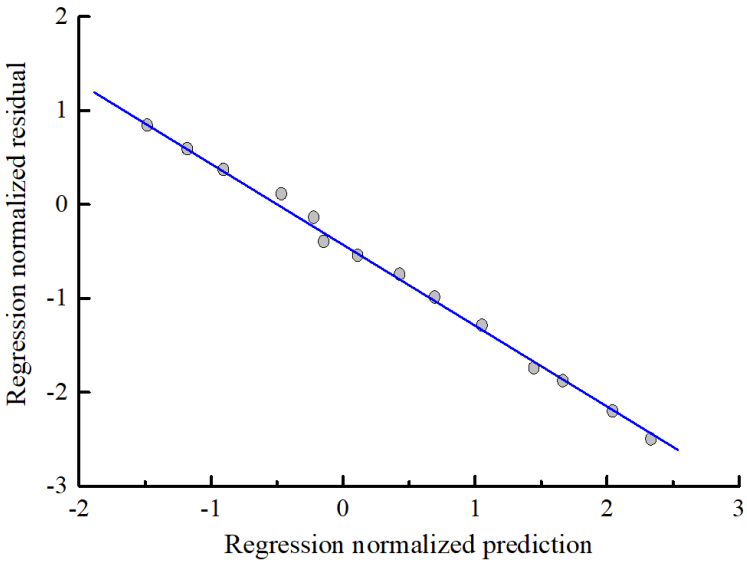

Fig. 10. The regression relationship between self-efficacy and English performance

4.3 Strategies for enhancing self-efficacy and English performance

The survey shows clearly that the improvement of self-efficacy is conductive to promoting students' English learning performance. Fig 11 shows strategies for enhancing self-efficacy and improving English performance. Specifically, students should be

encouraged to set reasonable learning goals and strengthen their sense of achievement in achieving the goals. Furthermore, students should properly treat the learning results and make reasonable attribution, and strengthen English learning strategy training to improve their learning ability. Also, it's necessary to use learning models to motivate students' learning, realize the active use of teachers' persuasion and encouragement by giving play to students' motivation of "self-evaluation", and focus on the relationship between students' psychological state and academic emotions.

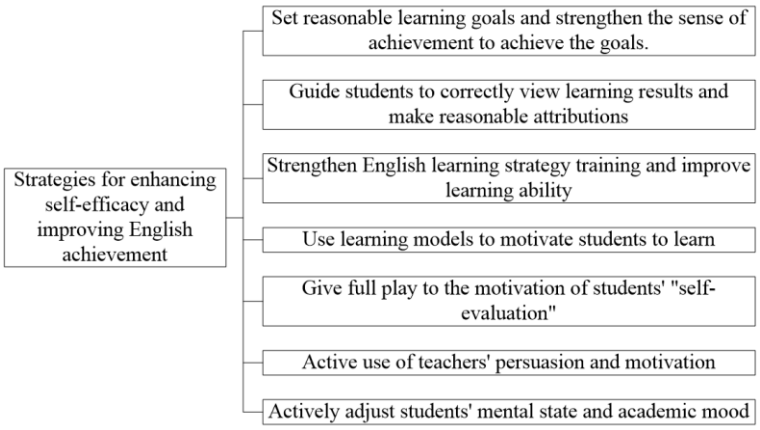

Fig. 11. Strategies for enhancing self-efficacy and improving English performance

5 Conclusion

Based on the theory of self-efficacy, this paper explores the impact of self-efficacy on English performance, and deeply studies the internal relationship between the two. The specific conclusions are as follows:

1) Self-efficacy mechanisms include selection processes, cognitive processes, incentive processes, and emotional processes. Self-efficacy affects environmental choices and behaviour choices. Self-efficacy beliefs affect cognitive processes in various ways, and play a major role through the thinking process accompanied by motivational factors or processes.
2) English learning autonomy includes English learner autonomy, English learning goal setting, English learning motivation, English learning strategies, and English learning evaluation. Students with excellent performance scored significantly higher in English learning autonomy, and the scores in all aspects of English learning autonomy showed significant differences in English performance.
3) The sense of efficacy in English learning includes three aspects: self-efficacy, behavioural efficacy, and ability efficacy. Students with good English scored higher in terms of self-efficacy scores, and there is a significantly positive correlation between self-efficacy and English performance.

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7 Author

Yinchun Chen was born on 4th, April, 1980 in Huanggang City, Hubei Province, China. She received B.A. degree of English from Yanshan University in 2003 and M.A degree in English Language and Literature from Yanshan University in 2008. She started her teaching career in July, 2003 in Yanshan University. Since 2003, she has authored more than 10 papers in English teaching, literature and translation. She has participated in compiling several textbooks and CET4 tutorials, authored a book *Innovative Development and Research of English-Chinese Translation in Cross-cultural Context*, participated in a state project and hosted a municipal research project.

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Toward an Adaptive Educational Hypermedia System (AEHS-JS) based on the Overlay Modeling and Felder and Silverman's Learning Styles Model for Job Seekers

https://doi.org/10.3991/ijet.v15i08.10574

Aymane Qodad (✉), Abdelilah Benyoussef, Abdallah El Kenz
Mohammed V University, Faculty of Sciences, Rabat, Morocco
Aymane2006@gmail.com

Mourad El Yadari
Moulay Ismail University, Meknes, Morocco

Abstract—In this paper we introduce a new design of an adaptive educational hypermedia system for job seekers, this proposal is based, for the part of learning objectives, on a job model which allows adapting the content and the path of education to the intended jobs, and, for the learner model construction, on a specific use of the learning styles of Felder and Silverman.

First, we present existing literature to give a general review on adaptive educational hypermedia systems, in that way; we have reported the related items to different notions in the adaptive educational Systems area as the differentiated pedagogy, the learning objects, and the learner profile. Then we argued our choice of the components of our model and we detailed the new ones.

As designed, the model can produce a suitable learning path for the user to match the job characteristics and the learning style of the person in order to help the user owning the job sought. With the possibility of linking the required competencies to the education skills, we aim to map business tasks to learning activities.

Based on this approach, we designed an Adaptive Educational Hypermedia System named AEHS-JS that will help to improve the efficiency and pragmatism of job search activities.

In plus of the social impact of this work as it help job seekers to complete their profiles and get the career they are looking for, this work will allow companies to find the candidates that match the job criteria sought.

Keywords—Adaptive educational hypermedia systems; learning object, learning styles, learning path, Overlay Modeling, differentiated instruction, Job model, Employability.

1 Introduction

Online learning is increasingly used in universities and schools; in this fast-growing world, most e-learning systems do not yet make the business requirements as

their priority. To meet this need Research has shifted to adaptive learning, which represents a domain of research in education in continuous development.

Traditional learning systems treats all users the same way, they deliver them the same content. When it comes to different people this way to do has shown its limits in terms of efficiency and effectiveness. The slogan “all things to all people” do not work.

There are several forms of adaptation, namely: adaptation based on user modeling, or those that use learning objectives to provide the learner with an education that fit with his profile [1]. So-called personalized Educational Hypermedia Systems are systems that use a methodology based on the objectives, preferences and knowledge of each, while adapting to their necessities [2]. In this way, a student in an adaptive educational model will be attribute a content that suit to his expertise on the theme.

Making personalized learning a big step towards improving online learning outcomes, but it is not enough because it does not take into account the needs of organizations and the learner's requirements. The purpose of learning is the knowledge of a learner who will contribute to the success of the learning process.

By working on this area, we are looking to suggest a new model that meets the business requirements to the learner part. The main goal is to set up an educational framework built on the work prerequisites and the user; this system will allow you to connect to the market.

We will begin the second section with a listing of related works. Then we will introduce the uses cases and the screenplay of the learning activity, thereafter in section four we will go through our model of Adaptive Educational Hypermedia System, we will zoom on the job model. To finish we will discuss the results, the conclusions, and draw some perspectives.

2 Literature Review

2.1 The adaptive learning systems

Recently, several studies have been interested in adaaptive learning systems that provide the suitable material in the appropriate way to the student by analyzing its profile (Figure 1), these methodologies may be classified into 3 categories:

The preferences category is related to models that define the education experience based on the learner preferences as the personality style. In this sense, we find the works of DeCoux [3], Maseleno [4], PRITCHARD [5], Savage [6] and TRUONG & Huong [7].

These models uses and analyze the student behavior [8-9], observes it comportment [11-27], gives the user an online or mobile survey [12], [28], [14] and let him precise his choices and individual characters [15-16].

In our paper [10] we introduced a model based on the Felder and Silverman’s learner styles to define the learner model and give the student a learning experience that meet the job needs.

The second class, which is based in the user background and his knowledge, is considered as the most important feature for Adaptive Educational Hypermedia System [17].

This aspect can be represented in many ways. The first one is a rated System where we measure the degree of the learner knowledge in a domain by a rate (Exp.: a value between 0 and 5) or a grade (Exp: High, normal, lower,), this method is simple to implement but it remains insufficient for some innovative and adaptive techniques.

Besides this model, Overlay illustrate the learner data [18], this model allocates a numerical number, 0 or 1, to every portion, showing the learner knowledge or not of an object.

The last category focus on the learner aims to select the suitable education experience for every single user.

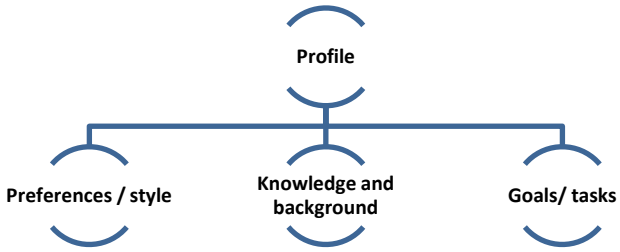


Fig. 1. The learner dimensions

Today, the challenge is not to bring people the knowledge and help them to fully learn it, the principal aim of education systems is to help learners to get the knowledge they need to get into the enterprise and and being able to satisfy the job requirement.

All of these systems make the learner model at the center of their models to establish the user learning experience, this make possible to adjust the path of education to the learner but does not allow thinking through the requirement of the business or the work opportunity we are targeting.

2.2 The learning style model of silver man

Several models in the literature have treated The Learning Style ([3] DeCoux [3], Maseleno [4], Pritchard [5] and Savage [6]).

In our case, we used the learning styles of Felder and Silverman and adapt it to our new model in order to have a system that bring the whole adaptation power. Indeed, we are leaning towards this choice for its easiness and its weight in the education researches [7] The model of Felder & Silverman Learning Style is a questionary of 44-item that identifies the learner's learning style. In order to spare the heaviness of the survey in an education system intended to be accessible online, we have restricted the list of questions to 20 relevant ones that represent the main questions [23]

2.3 The differentiation in pedagogy

In her research, Carol Ann explained the importance of differentiation in pedagogy, she based her conclusions on the fact that we cannot treat at a groupp of students in the sameway. The objective is to engage the learner in a challenging learning activities that enhance the the learning experience and build a system that take the student to higher level of compliance, This can be done over four ways: through content, the style of learning, product/process, and the background [32]., [24] , in this work we focused on differencing the learning style and content , at the end, the result and environment are already known in an adaptive learning system.

The content: Adopting a strategy of differentiation at the content level consists on defining the learning objects list and organizing them in a number of ranks of knowledge and intellectual performance starting from lower-level intellectual expertise to higher-level. In our model we chosen the Taxonomy of Bloom (a grouping of 6 ranks comportment of intellectual starting by bottom-level intellectual abilities to higher-level). [25]

Therefore, we can build six different forms from one learning object; those new LO versions will be attributed to the student according to his score. By way of illustration, a student who has no experience in a domain will be given LOs with an inferior degree: memorizing and understanding, and a different one with some experience will receive learning objects for a higher level as applying and analyzing.

Learning styles: Every student has its favorite learning style, an important way of differencing is based on the provided support of education: it can be visual, auditory or written. Our choice in the model we want to apply is based on The Felder and Silverman's Learning Styles Model (see section III)

3 Research Methodology

In order to validate our model and reach our goals we based our research methodology on following instruments:

- Interviews with the human resources responsible for the job offers: this part of work will allow us to compare the results of different applicants and evaluate the value added of the learning experience on the process of selecting and recruiting candidates. It will bring us the result of each candidate and allow us to calculate the success rate. As the positions opened were only two in numbers, this part will bring us more information about each candidate independently of his results.
- A survey for the job seeker who have benefited from the learning experience, to collect quantitative data and their feedback. The survey is made up of 3 parts, the first one contain general instructions, the second specify the personal information (Gender, Age, years of experience…etc.) , the third part is the body of the questionnaire where we gather candidate's opinion on the experience and the level of usefulness of the skills acquired by questions like : “ what was the content that help you the most in the interview?“ or a collect of opinion like : “The following items describe statements about the learning experience, please indicate your degree of

agreement or disagreement about them: 1- The skills learned in the training helped me to convince the recruiter about my profile, 2-…etc.” with 6 choices (Strongly disagree, Disagree, Disagree somewhat, Agre somewhat, Agree, and Strongly Agree)

The participants were chosen from a list of 89 resumes received by the human resources responsible for the job offer. This task was done using a matching engine [35] to select resumes that match the most to the job need. The objective is to keep only the profiles that do not represent a big difference with the need.

In this study, we have limited our scope to a single job offer "Banking Business Analyst", the same process can be applied iteratively to a list of job offers.

A group of 23 candidates was selected to take the interviews with the job offer responsible. From this group, we have contacted some candidates to benefit from the learning experience based on our designed model.

In order to compare the result of the experience to a reference, we divided our group of 23 preselected candidate into two subgroups, the first one with 13 candidate to take the learning experience and the second with 10 candidates who will follow the normal interview process without any training experience.

In our study, the learning experience consists of the following main steps:

- Step I: The Job seeker authenticate in the system and fill in his account profile (individual data, competencies, CV...)
- Step II: The Job seeker response to a survey that determine his learner style
- Step III: He select the job he is looking for from the opened positions. (the model works for different job offers, but in this case we will focus on one job offer)
- Step IV: The system build a learning path that take into consideration both the job selected and the Job Seeker analyzed profile.

This learning path will lets the Job Seeker expand the competencies and befitted as the perfect applicant for the associated job.

Regarding the inductive part of our research, we established a new model of an adaptive learning system (cf. next section for more detail) that will be applied to the selected candidates.

4 An Adaptation System For Job Seekers

4.1 Business and uses cases

Before presenting the adaptation system architecture, we will start with a learning scenario, which represent the theoretical basis for the design of our system architecture; this scenario may take into consideration the job model, which is the principal component of our SHEA.

A job seeker who logs on to the system for the first time must complete a registration form including his resume and answer a survey that help us to determine his learning style and competencies.

Thereafter, the job seeker selects one or more job offers that interest him / her, at this step our model is completed by the learning goals of the candidate, which is an important information for our system.

The learning experience is done through the pursuit of the learning path generated. Accordingly, it is possible to clearly distinguish three essential phases in the process of learning for a job:

- Registration form including the upload of resume
- Survey to determine the learning style
- The choice of a list of interesting job by the job seeker
- The system build content and learning path (matching the learner profile, the job wanted and the learning elements)

4.2 The adaptation model

The ALS (Adaptive Learning System) we designed is built with the following models:

- The Job Model
- The Domain model
- The Learner Model
- The Instruction Model
- and The Adaption Model (Fig. 2).

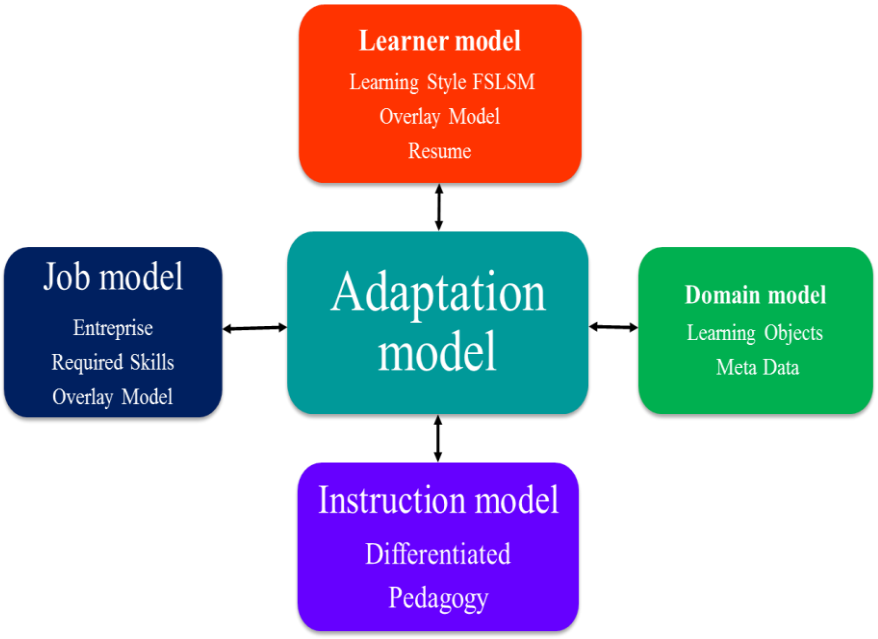


Fig. 2. Adaptation Model

This global model is detailed by it components as below:

The Domain Model: This model is made of a universe of LOs (learning objects) based on the SCORM Principles, a various forms of an identical LOs and the metadata content as established by [21]

Fig. 3. Figure 1: Learning objects

As described by Robert BECK [28], the LO is "a collection of content items, practice items, and assessment items that are combined based on a single learning objective", in our case the learning objective is the job skills need.

We choose the learning objects for our domain model to prevent the "reinventing the wheel", it's a way to save time by reusing and sharing content to focus on specialized tasks and learning objects.

Our choice of SCORM standard will make the object reused in any learning management system or browser and easily manageable. In this standard, the learning object must comply with the Metadata of Learning objects LOM IEEE. The figure 1 in [34] describe the UML Class Diagram of IEEE LOM Metadata Standard.

In order to give an example of our learning objects, first we must specify our educational problem, in our case it is related to job we are looking for. Secondly, we will define the metadata to make our LO searchable in several search engines. Finally, we have to specify the requirement needed to be able to pursue the related LO.

Once the Learning Object's defined, our system have to choose between all indexed LOs in our Domain Model to propose to the learner the most suitable LO to his profile. Therefor we must build our Learner model that represent the profile of the learner.

The Learner Model: The learner model is set to define the Job seeker description, the learner model, as Brusilovsky [20] presented it, take 2 proportions, the major concern the data, and the other is based on the style of learner.

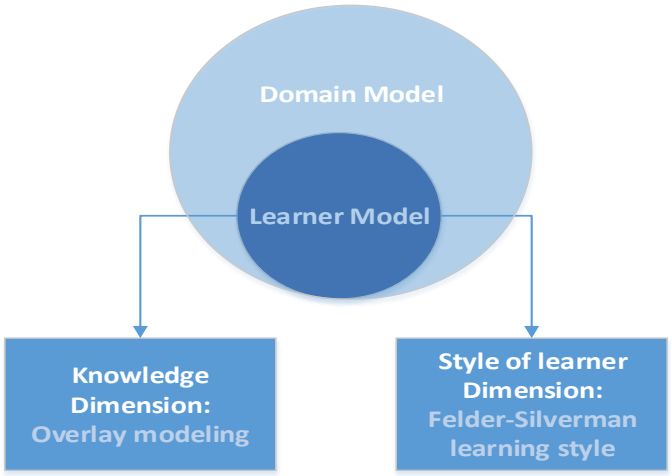


Fig. 4. Learner Model

In terms of data line, we used the model of overlay for the ease of setup and for the reason that it is a model that use a numerical value to qualify the degree of knowledge of an item. The principal notion of overlay modeling consist on considering the learner model a subgroup of domain model, and for all items in the model of learner (related to every item in the domain model) has a particular rate that quantify the learner's knowledge of this item. This rate is named the mastery of the item.

For each learner we define the level of mastery for a unit of course. It's can progress with the experience of learning and be evaluated based on the quizzes established. As shown in the table below: learners who obtain a result percentage less than 50 are classed as "Novice" and the level of mastery M=1. The other class M=2 is intermediate with percentage between 50 and 70. The advanced one M=3 is reserved for learners who obtain a percentage greater than 70. Only learners with a mastery of M=3 degree can move to next level of topic.

The information about the learner model is warehoused in the database and will be used by the adaptation model to generate the learning path adequate to the learner.

Table 1. Learner level

Level	Score	Mastery
Novice	M(X) < 50	M=1
Intermediate	50 < M(X) < 70	M=2
Advanced	70 < M(X)	M=3

The learner relational schema can be present as follow:

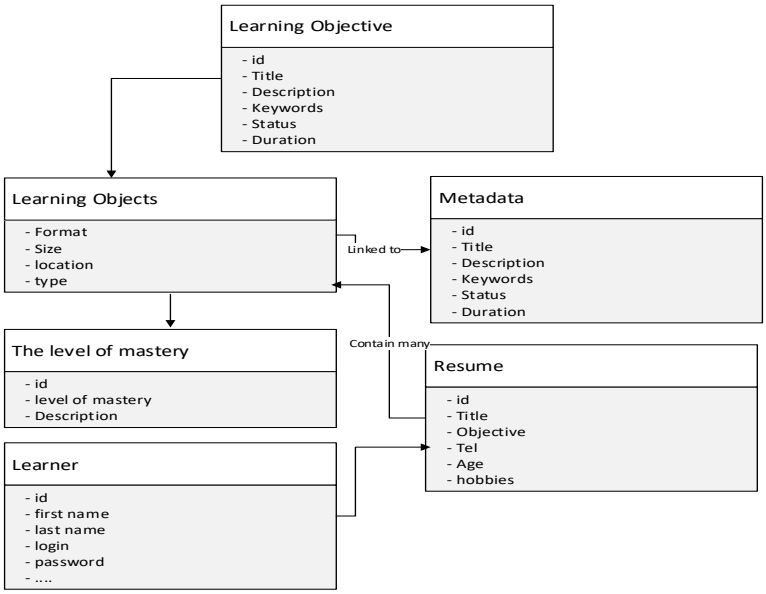


Fig. 5. Relationnel Schema for Learner

In practice, the proficiency of knowledge will be evaluated regarding the CV analysis of the student.

Fig. 6. Learner model components

For the learning style level, as we chosen the FSLS (Felder-Silverman learning style) model [22] (cf. sect. III) our relational model will contain the below classes,

where the feeding of the learning style class linked to a learned is done by a resume data treatment and the result of the Felder and Silverman's Learning Styles test.

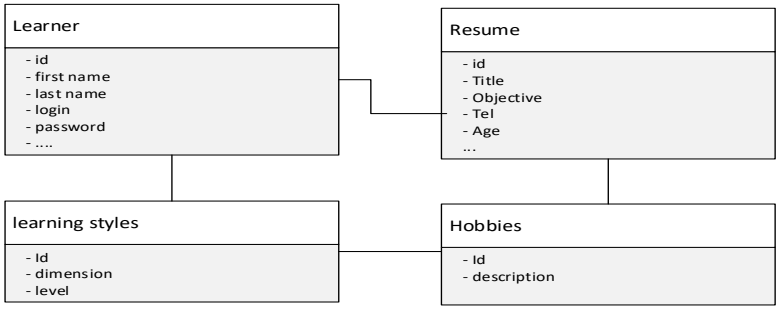


Fig. 7. Learning styles tables

Job Model: In this part we will define the job needs based on the list of skills and requirements that the person looking for this job must satisfy to get the job done.

This model organize and describe the business needs (in terms of jobs and offers). It connects between the components of business need (The Enterprise characteristics, the offer description, the looked-for profile, the wanted competencies, a competencies assessment…)

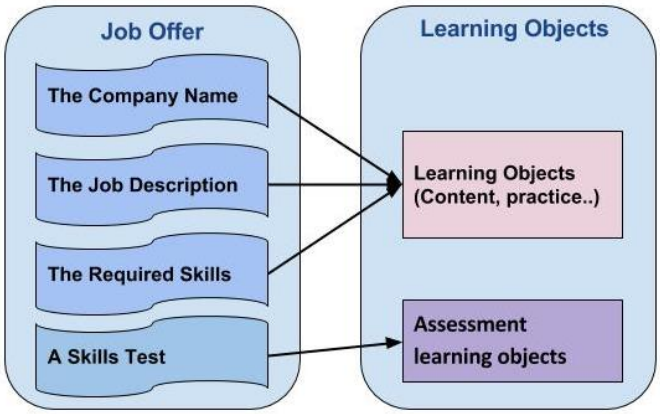


Fig. 8. The job model

The principal dimension of the job model concern the “required skills”; in this context, we have chosen the model named “overlay” to implement this component. It afford representing the information for learners in every subject in a adaptable approach.

The Overlay modeling is used to organize the knowledge by dividing the domain model into different concepts and subjects, this approach allow educational AHS.

The advantage of using an identical system to characterize the knowledge notion in job and learner models will help for the correspondence processing in the adaptation model. In the same way established in learner model, we use the overlay model to characterize the required skills by a Job offer. At the level of the job model we define for every unit of course the level of mastery needed. It's can be liked to a job description to categorize a group of job offers (cf. table 2 below).

The information about the Job model is stored in the database and will be used by the adaptation model to generate the learning path adequate to the job wanted.

Table 2. unit mastery required

Unit of course	Job description	Mastery required
Unit 1	Project Manager	M=3
Unit 2	Software engineer	M=1
Unit 3	English Professor	M=2

The job offer relational schema can be present as follow:

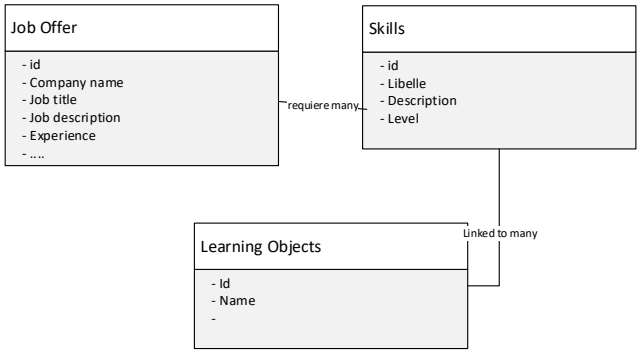


Fig. 9. Job Offer relationnel Schema

Instructional model: The model of instruction define the education strategy adopted to allocate the LOs existing and organized in the model of domain. In this global model we chosen the differentiated pedagogy for the possibilities its offer in terms of adjusting of the instruction at the different levels as the content, the process or the learning materiel (Cf. Sect. IV)

Adaptation model: The adaptation model represent our engine that to define the list of LOs based on the analyze of learner profile (Mastery, LS) and the details of the chosen employement (necessary competencies...) , the main work consist on assigning LOs that tie with the required skill by the business (job offer) and the learner characteristic. (Cf. Fig. 2).

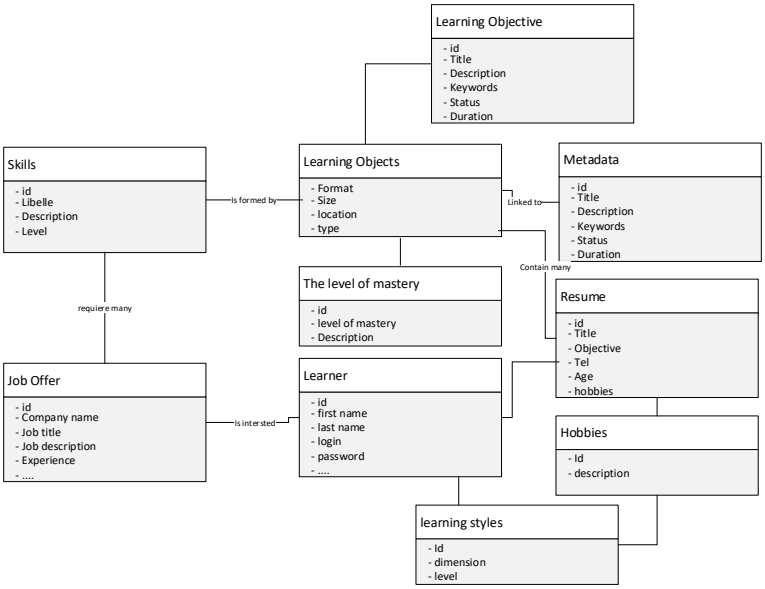


Fig. 10. The Adapatation relationnel schema

In order to determine the list of learning objects and to define the learning path for the learner, we eliminate the LOs list assimilated by the candidate from the required by the job offer. As the LOs are designed into the same model (domain model) this subtraction can be modeled in its standard form under the following mathematical formula:

$$\sum_{k=0}^{n} Final(LOs) = \sum_{k=0}^{n} Required(LOs) - \sum_{k=0}^{n} Acquired(LOs)$$

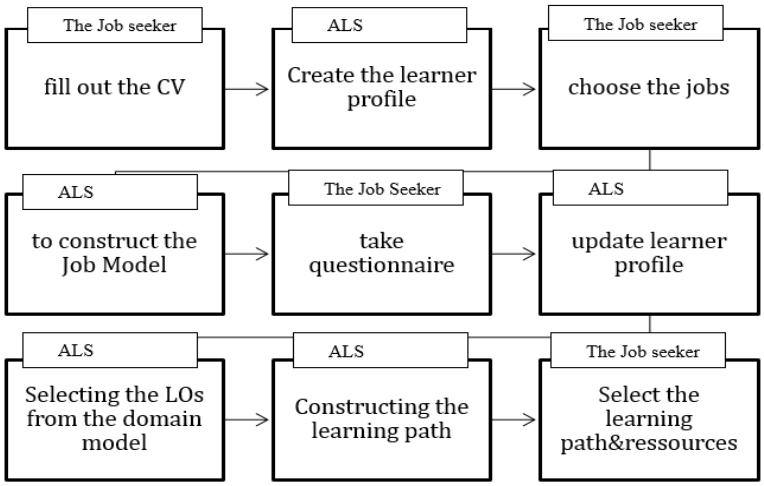
Where,

LOs: The Learning Objects list. This list must contains the metadata related to LS of the candidate.

Final (LOs): The final list that will be used in the learning experience.

Required (LOs): The LOs list necessary in the job offer

Acquired (LOs): The Learning objects list already learned by the Student (in our case: the job seeker).



Algorithms principal steps:

```
BEGIN
Step 1: Filling the learner data from CV and skills
tests: M (X) = ∑MLi where i=competency acquiered by the
learner and MLi = level of mastery of the competency
Skills M(X) = ∑Skills/mastery level =∑MLi
Step 2: take survey to define the learning style
Learning style LS(X) = LSi
Step 3: filling the job model data based on the job de-
scription chosen
Job description = ∑MLj where j = competency required by
the job
Step 4: generating the LP(learning path) established on
the model of job and selecting the learning objects from
the domain model
Initiate the unit number u =1
Initiate content level l = 1
Initiate learner level = MLi (based on the model of
learner)
Step 5: take the learning experience (courses and as-
sessments of unit u)
Present the unit u
If the skill test related to the unit u M(Xu) > MLu
go to next unit u=u+1
Else present unit u with level = l+1
Go to step 5
Step 6: update the learner model
```

```
  Step 7: Evaluate if the learner model skills ∑MLi in-
clude the job model skills required ∑MLj
    ∑MLi ⊂ ∑MLj : present the CV of the job seeker to the
company
  Else : Go to step 4
  END
```

5 Results

Survey Results: To validate our model of learning designed for job seekers, we explored the results of the survey taken by the candidates.

Regarding the impact of the training on the interview process, we received the response detailed in the table 3

Table 3. The usefulness of the skills acquired in training in interviews

The skills learned in the training helped you to convince the recruiter about your profile?	
Strongly disagree	7%
Disagree	13%
Disagree somewhat	5%
Agree somewhat	7%
Agree	40%
Strongly agree	28%

Furthermore, 69% of candidates who agreed or strongly agreed on the usefulness of skills learned in the training have a number of years of experience less than 4 years.

The table 4 shows the results related to most useful skill acquired for the interview process.

Table 4. The usefulness of the skills acquired in training in interviews

The most useful Skill learned by the job seeker for the interview	
Banking functional	43%
Project management fundamentals	28%
Business Analyst CCBA	17%
Communication	8%
Others	4%

It was found that candidates who qualified themselves as adapted to the position were more satisfied about the experience and had less difficulty reported in the interview process.

The result shows us that more than 70% of candidates were in favor of repeating the experience or recommending the learning to other people.

Interviews Results: Through the 23 candidates preselected for the job interview process, two candidates were admitted to the position; both of them had completed the learning experience.

Furthermore, the interview results shows that appreciations of eight candidates qualified them to be accepted if there were more opened positions. Six of these candidates were in the list who completed the learning experience.

The 13 candidates who passed the learning experience were better rated in all major required skills except "communication" where the rest was slightly better appreciated; these candidates demonstrated greater enthusiasm for the position than others were.

The job offers responsible mentioned that some candidates declared that they had followed a training for the interview and he appreciated this.

Table 5. Interviewers' statements revealed some remarkable feedbacks on candidates (table 5).

Candidate	Statement on the candidate
M, B	He is certified in project management, he has good communication skills but it is clear that he is not motivated by the position.
G. L	He has demonstrated knowledge of the field, he is certainly not an expert but he will be able to satisfy the job needs
M. A	The candidate M.A is very motivated for the position, he has some communication difficulties, he has a lot of potential and masters project management and business analysis approach
Y. B	The profile is interesting, he can support us in the training of new recruits, but he shows that he has never practiced project management in operating conditions; it will take him a little time to master the project approach.

Generally, results shows that the interviewers were more interested by the profiles who did the training. In deed, they qualified them like more "interesting", "fitting to the job", "motivated", and "initiated in the domain".

6 Discussions

The main goal of this work was to set up a system that help job seekers to boost their chances to get the position they are looking for.

Based on the results, the adaptive learning system designed for the job seekers, improved the employability related to the job offer in question by 56%, indeed, The effectiveness of the system was also confirmed by the candidates feedbacks who reported the utility of the education content as it helped them to gain greater profile and showcase their competencies.

These findings confirm the works of Ng and Feldman, [36] and Krueger & Rouse [37], on how positively education is influencing core task performance and employability.

Seeing that the majority of candidates who were satisfied by the experience are junior is interesting, this can be explained by the fact that this category of candidates is still in touch with education, and regarding their experience, they are the ones who needs the most such as learning experience.

It is normal that the impact of the system was more visible on some skills than others, indeed, some skills like communication and relationship management needs more

time and practice to see significant results, the system shows more efficiency on knowledge skills like functional banking or management. This finding shows the limitation of our model on some particular skills, but it will not impede us to include these type of elements in our content, because for some candidate who have a minimum of level on this type of skill, the result can be more interesting. These results support the studies of [36] where they classified the knowledge into two form, the declarative knowledge that can be learned based on suitable content and the procedural one that need more practice.

The system is more efficient for persons who are initiated in the fields, this can be explained by the reason that qualified people are more able to understand concept that are related to what they master.

The results of the interviews with the persons in charge of the recruitment brought out that they were aware that some candidates have followed a training, and they valued it positively. This statement drives us to explore the opportunity of applying this system within the companies during the integration of new recruits.

To sum up, this work showed us the importance of education in improving the employability of job seekers, and how can a job-oriented learning lead us to better results, these comply with different studies carried out in this field [38, 39, 40].

7 Limitations

As with all studies, there are limitations. In our case, we applied our model on one job offer and collect data related to the job seekers looking for this job, this can be done for other jobs and different populations to make our work more global and confirm the generalizability of the finding.

8 Conclusion and Future Works

Online learning provide people a new way to improve their skills in different area, In our case we focused on it use to enhance job seekers chances to satisfy the jobs requirements. Study have revealed the role of education in employment and job performance. In this work, we designed an Adaptive Educational Hypermedia System for Job Seekers "AEHS-JS" to evaluate the utility of job oriented education on increasing the employability and job performance.

We used for this work the Overlay Modeling and Felder and Silverman's Learning Styles Model for Job Seekers. Our model is based on two principals element, the first one is the model of learner and the second one is the job model, the main goal is to establish a learning experience able to make the student fits more to the profession he is looking for. By this approach, we are ensuring the link between learning systems and business requirements. The challenge is to build a system based on this model that works for businesses and job seekers both.

Like many studies, the results of our work confirm the importance of education in improving employment opportunities, a job oriented education can in enhance chances of succeeding for a job seeker by more than a half (in a similar context of the one

used in our test case). Moreover, even job seekers who did not succeed the opened position were interested in the experience for other job offers in future.

The same model can be used by companies to build a training program that help employees evolve from one position to another by pursuing an individual training plan. The next step will consist on working on a probabilistic approach of adaptation based on Bayesian Network with a new step added to the learning path "*revaluation of the learning path". This will be useful for the implementation and will allow trying out another adaptation algorithm and more data collection on different populations.

9 Acknowledgement

We would like to thank the recruiting team who made the effort to provide their feedback on this model as well as the candidates who willingly agreed to give their time and participate in the learning experience.

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11 Authors

Aymane Qodad, Abdelilah Benyoussef and **Abdallah El Kenz** work at Mohammed V University as Faculty of Sciences in Rabat, Morocco. Aymane Q is the corresponding author.Aymane2006@gmail.com

Mourad El Yadari works for Moulay Ismail University in Meknes, Morocco.

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Online Self-Regulated Learning Strategies in MOOCs:

A Measurement Model

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Mohd Muslim Md Zalli (✉)
Universiti Pendidikan Sultan Idris, Perak, Malaysia
muslim@fpm.upsi.edu.my

Hasniza Nordin, Rosna Awang Hashim
Universiti Utara Malaysia, Kedah, Malaysia

Abstract—Massive Open Online Course (MOOC) is among disruptive innovations in online learning environments that attract a significant interest among students. MOOCs require learners to be actively involved and to utilize an individual process of self-regulated learning. The development of a measurement model for online self-regulated learning (SRL) has been found to be lacking when compared with the traditional, face-to-face context. This research has the objective of developing a model for measuring online self-regulation strategies in Malaysian MOOCs. Data collection was carried out using a sample of 384 learners in three MOOCs operated under the openlearning.com platform. A confirmatory factor analysis was executed to indicate the goodness-of-fit and validate the measurement model. Findings have shown that the measurement model and the data have a good fit after performing model modification procedures. Thus, the model is suitable for measuring online SRL in the setting of MOOC learning. Further, this study recommends several suggestions regarding the applicability of the measurement model with other variables related to teaching and learning in MOOC.

Keywords—Self-regulated learning, online learning, measurement model, Massive Open Online Course, MOOC

1 Introduction

There is a discernible increase in interest in the issue of teaching and learning in Massive Open Online Courses (MOOCs). MOOCs are free of charge and targeted at students of all types, which means they attract a bigger following in comparison with other platforms of online learning [1]. MOOCs have been growing tremendously and has prompted scholars in this discipline to conduct research into the teaching and learning aspects in MOOCs; from motivations [2], pedagogies [3, 4], participations [5], integrations [6], satisfactions [7, 8] and learning strategies [9, 10].

In the matter of learning strategies, self-regulation becomes a crucial factor for successful learning in MOOC [11]. A self-regulated learner is actively involved in

their learning process. This process comprises three steps, namely forethought (before), performance (during), and self-reflection (after) phases [12]. Students who possess high self-regulated learning (SRL) are more able to participate in learning by setting study objectives individually (forethought phase), determining the practical methods to learn (performance phase), and tracking the achievement of their goals (self-reflection phase) [13]. With the increase in learners' responsibility as well as their autonomy in MOOCs, self-regulation is necessary for MOOCs [11, 14].

In the process of improving learners' self-regulation skills in MOOCs, it is essential that the online self-regulation construct can be measured. Previous studies have developed and validated questionnaires associated with self-regulation in MOOCs [15, 16]. For instance, [15] developed the 'Self-regulated Online Learning Questionnaire' from 4 existing questionnaires for measuring SRL in a conventional and online learning context. This questionnaire has further been revised by [17] in the Netherlands and found to be improved in terms of usability, reliability and validity.

Moreover, [16] adapted the Online Self-Regulated Learning Questionnaires (OSLQ) introduced by [18] in a Russian MOOC. The OSLQ consists of six sub-scales measuring online self-regulation strategies namely: task strategies, help-seeking, environment structuring, goal setting, self-evaluation, and time management. However, findings demonstrated complications in the modification of the measurement model and the convergent validity was not achieved the acceptable value after conducting the confirmatory factor analysis [16]. Since OSRL is applicable to multicultural research [19], the validation of OSLQ could be beneficial if it could be tested to the other diverse context.

Therefore, because of the significance of self-regulation in MOOCs and the dearth of studies on measuring SRL skills in a MOOC environment [15], especially in a developing country like Malaysia, the existing study develops a model for measuring online SRL strategies in Malaysian MOOCs.

2 Methodology

2.1 Participants

In this quantitative study, participants were recruited from 3 Malaysian MOOCs operated under the openlearning.com platform. Of 2257 learners who enrolled in these MOOCs, 384 participants responded to the web-based questionnaire, resulting in the response rate of 17.0%. A majority of the participants 206 (53.6%) were from a MOOC named Introduction to Entrepreneurship, while 92 (24.0%) participants from Principles of Economics, and the remaining 86 (22.4%) of participants from International Business MOOC. More than half of the participants 249 (64.8%) have experience learning in MOOCs while 208 (54.2%) participants have successfully completed their MOOC and got the certificate.

2.2 Measure

In order to develop a measurement model of self-regulation among MOOC learners, this study adapted and translated the Online Self-Regulated Learning (OSLQ) questionnaire created by [18]. A total of 24 elements in a 5-point Likert scale were incorporated in the first questionnaire, which ranges from 1 to signify 'Strongly Disagree' to 5 to signify 'Strongly Agree'. For the purposes of this study, some changes were made to the original questionnaire. As suggested by [20], this study incorporated a 7-point Likert scale for increasing the variability of the data. Four items were excluded due to the conceptual lack of clarity. Thus, certain elements had to be rephrased so that the features of the MOOC-related online courses are matched appropriately. As a result, there are 20 items with 6 dimensions to assess the SRL strategies remain for the measurement.

2.3 Data analysis

A Confirmatory Factor Analysis (CFA) through IBM SPSS AMOS was performed to validate the proposed factor loading for each dimension and the construct validity of the measure [21, 22]. Generally, the higher the factor loading, the better; and typically loadings of below 0.3 are not interpreted. The criterion for an adequate factor loading is above 0.5 or ideally 0.7 [23], which indicate that values lower than 0.5 should be deleted to achieve a satisfactory model fit. Further, the goodness-of-fit measures resulting from the CFA were used to indicate the model fit. In performing this work, the fitness of model was assessed by the probability value of chi-square (p-value), normed chi-square (chisq/df), root mean square error of approximation (RMSEA), comparative fit index (CFI), incremental fit index (IFI), Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR). The threshold utilized to evaluate the model fit as suggested by [23] is shown in Table 1.

Table 1. Level of acceptance of fit indices

Fit index	Level of acceptance
Probability value (p-value)	$p<0.05$
Normed chi-square (chisq/df)	<3
Root Mean Square Error of Approximation (RMSEA)	<0.08
Comparative Fit Index (CFI)	>0.9
Incremental Fit Index (IFI)	>0.9
Tucker-Lewis Index (TLI)	>0.9
Standardized Root Mean Square Residual (SRMR)	<0.08

3 Findings

3.1 Assessment of the measurement model

The goodness-of-fit indices results of the proposed measurement model can be seen in Table 2. All of the absolute fit indices meet the satisfactory threshold values except the normed chi-square (chisq / df) value was 3.336 and a little above the acceptable threshold of a model fit. Consequently, based on the overall goodness-of-fit indices, the measurement model doesn't fit the data adequately. Therefore, model modification is necessary to improve the goodness-of-fit.

Table 2. Goodness-of-fit (GOT) indices

GOT indices	p-value	chisq/df	RMSEA	CFI	IFI	TLI	SRMR
Measurement model	0.000	3.336	0.078	0.941	0.941	0.932	0.070
Acceptable value	<0.05	<3	<0.08	>0.9	>0.9	>0.9	<0.08

Model modification was carried out by checking the standardized factor loadings and modification indices. Examination of the factor loadings shows no values that below 0.5. Hence, no item is suggested for deletion to improve model fit. Further, the modification indices (MI) were inspected in order to identify the redundant items that could cause model misfit. A review of the modification indices reveals one extremely high MI values for the path between e9 (error term for item TS9) and e10 (error term for item TS10) with an MI value of 60.743. In order to improve the model fit, these two error terms need to be covariate as suggested by numerous work of literature [24, 25].

After performing the model modification procedures, the fit indices of the modified model demonstrate a satisfactory fit (Figure 1). In particular, the p-value is significant, chisq/df=2.957 is below than 3, CFI=0.951, IFI=0.951, and TLI=0.943 are above the threshold of 0.9 and RMSEA=0.071 and SRMR=0.059 are below 0.08. Hence, the improved measurement model is considered appropriate to proceed with validity and reliability assessment.

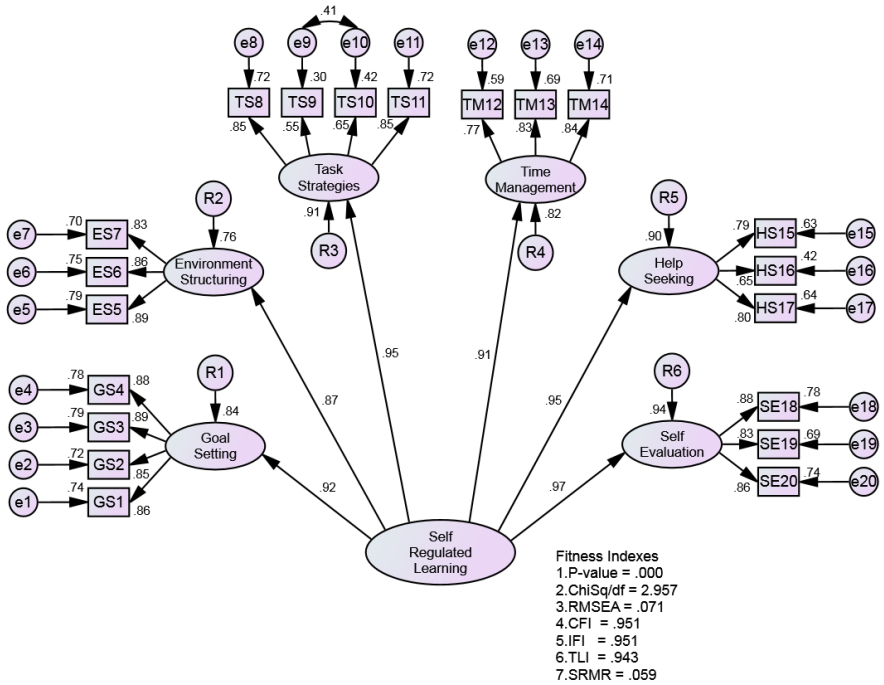

Fig. 1. The improved measurement model of Online Self-Regulated Learning

3.2 Assessment of reliability and validity

With the confirmation of the model fit, the constructs were then assessed for reliability and validity. The rule of thumb for good validity and reliability is the values for construct reliability (CR) should be above 0.7 and the average variance extracted (AVE) above 0.5 [23]. As seen in Table 3, the CR ranges from 0.795 to 0.926, while the AVE ranges from 0.543 to 0.758. Further, the factor loadings for all items are significant and more than 0.5. For the second-order construct of self-regulated learning, the factor loading of the first-order constructs ranges from 0.875 to 0.968, the CR value is 0.974 and the AVE is 0.864. As such, the results show that the constructs are reliable and valid.

Table 3. Evaluation of validity and reliability of the measurement model

First-order constructs	Second-order construct	Item	Factor Loading	CR	AVE
Goal Setting (GS)		GS1	0.860	0.926	0.758
		GS2	0.850		
		GS3	0.888		
		GS4	0.884		
Environment Structuring (ES)		ES5	0.891	0.898	0.746
		ES6	0.865		
		ES7	0.834		
Task Strategies (TS)		TS8	0.850	0.821	0.543
		TS9	0.551		
		TS10	0.652		
		TS11	0.848		
Time Management (TM)		TM12	0.768	0.856	0.665
		TM13	0.833		
		TM14	0.843		
Help-Seeking (HS)		HS15	0.793	0.795	0.565
		HS16	0.651		
		HS17	0.802		
Self-Evaluation (SE)		SE18	0.884	0.893	0.735
		SE19	0.828		
		SE20	0.859		
	Self-Regulated Learning (SRL)	GS	0.919	0.974	0.864
		ES	0.875		
		TS	0.953		
		TM	0.908		
		HS	0.950		
		SE	0.968		

4 Discussion and Conclusions

The objective of the study is to formulate a measurement model of online SRL strategies in the context of learning in MOOCs. The findings show that the values for goodness-of-fit indices, factor loading, composite reliability and average variance extracted to measure the convergent and construct validity were satisfactory and possess validity and reliability. These results point to the conclusion that all items measured the same construct in agreement. In particular, all of six constructs measuring online self-regulated learning were validated.

The findings of this work further contribute to the applicability of OSLQ in measuring online self-regulation in MOOCs that have been identified in the previous studies [15] – [17]. Moreover, this research demonstrates that the implementation of CFA also supports the reliability and validity of the measurement model, which can add to the knowledge on the area of self-regulated learning.

However, this research is not intended to investigate any hypotheses but a development of a measurement model for online SRL strategies. The results would carry more weight or implications if the model could be tested on other dependent

variables such as in examining the relationship between self-regulation strategies on learners' achievement and satisfaction in MOOCs. Thus, this model of online SRL could be considered as a second-order reflective construct in assessing the success and efficiency of any MOOCs.

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7 Authors

Mohd Muslim Md Zalli is a PhD student at Universiti Utara Malaysia and lecturer at Universiti Pendidikan Sultan Idris. He has published several journal articles and chapters in book related to self-regulated learning, community of inquiry, and Massive Open Online Courses (MOOCs).

Hasniza Nordin is Senior Lecturer at the School of Education and Modern Languages, Universiti Utara Malaysia. She is also the Deputy Director (Training), University Teaching and Learning Centre.

Rosna Awang Hashim is Professor of educational psychology and editor-in-chief of the Malaysian Journal of Learning and Instruction.

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