01.2023

iJIM

International Journal:
Interactive Mobile Technologies

Papers

Table of Contents

Papers

Adventuring Physics: Integration of Adventure Game and Augmented Reality Based on Android in Physics Learning

https://doi.org/10.3991/ijim.v17i01.35211

Iqbal Ainur Rizki, Hanandita Veda Saphira, Yusril Alfarizy, Aulia Dwi Saputri, Riski Ramadani, Nadi Suprapto(✉)
Universitas Negeri Surabaya, Surabaya, Indonesia
nadisuprapto@unesa.ac.id

Abstract—One of the physics learning difficulties is the low learning motivation. It is to learn because physics materials are considered to be complex, boring, and abstract for students. Therefore, this research developed an Augmented Reality (AR)-integrated game application "Adventuring Physics" based on android to create more fun physics learning and provide concept visualization on abstract materials so that the students become easier to understand. This study aims to develop a valid and practical application of Adventuring Physics games on physics learning. This research used Research and Development (R&D) design to develop the application. It has two main features: 'play games' and 'augmented reality'. Furthermore, the game's concept in this application is adapted to the physics materials. The AR feature can create visualizations in the form of 3D image projections of the material. The results of the validity assessment show that this application is declared valid, feasible, and reliable. In addition, the results of the practicality assessment showed that it is very practical to be used and worth to be implemented in physics learning. This research has implications as an application of Adventuring Physics that can motivate students to learn physics, and apply digital technology in education, and physics learning.

Keywords—adventuring physics, adventure game, augmented reality

1 Introduction

Physics is a branch of science that examines ideas, rules, concrete, and hypothetical phenomena. Understanding material concepts and using them in practical situations is the essence of physics learning [1]. However, there are many difficulties for students in learning physics. One of these difficulties is the low motivation to learn because the materials are considered as difficult and boring for students. This is supported by [2–5] research which states about the low motivation of students' learning physics subjects. In addition, the results of preliminary studies at SMAN 1 Taman and SMAN 3 Sidoarjo from March-August 2022 in 115 showed that 67.82% or 78 students admitted that they have lack motivation to learn physics. Also, 63.47% or 73 students admitted that learn-

ing physics was boring. Another problem is that there are misconceptions in some physics materials due to the difficulty of visualization, abstract thinking, and complexity, such as in magnetic field subject [6–8]. Supported by preliminary study data, 78.26% or 90 students admitted that it was difficult to understand abstract and microscopic materials because they could not be seen and difficult to visualize.

Responding to this problem, the rapid development of information technology in the world of education is inevitably influenced on educational aspects [9,10]. Educational innovation by utilizing information technology, such as smartphone games will provide a different atmosphere for student appreciation during learning process. Smartphones have been used in schools for various educational purposes, including physics learning [11,12]. Android-based smartphone is a learning tool that can support students in their understanding of learning physics. It is an appropriate learning resources, particularly for current technological advancements [13]. Android-based application is expected to simplify the students receiving and understanding of learning material. On the other hand, it also simplifies the teachers' delivery of learning material.

The android platform can be a physics learning medium that integrates adventure games and Augmented Reality (AR) [14–16]. This is because the concept of an adventure game has a continuous storyline to give its users a high and sustained curiosity [17,18]. Moreover, this game includes game missions and physics problems that must be solved by applying physics concepts. This activity can increase student learning motivation. Meanwhile, AR can visualize into abstract and microscopic objects and also concepts in physics materials well so students can easily understand this game [19–22]. The integration between games and AR is a potential medium to increase students' motivation and enthusiasm for learning physics. Preliminary data also support that 85.21% or 98 students agreed to apply some adventure game to physics learning, and 100 out of 115 (86.96%) students agreed if the game added AR.

Therefore, this research developed an AR-integrated game application, "Adventuring Physics" based on android. It can create more fun physics learning and provide concept visualization on abstract materials so that the students become more accessible to understand the material. This research contributes to innovate an interactive mobile technology in physics learning which leads to positive student learning outcomes. In addition, this research can also help to realize the acceleration of the digitalization on educational field in the "*Merdeka Belajar*" era which is relevant to the Indonesian curriculum and the current development of Information and Communication Technology. This study aims to produce a valid and practical application of Adventuring Physics games.

2 Literature review

2.1 Android-based mobile learning

Android has recently become the operating system of choice for most Indonesian students' smartphones [23]. It is affordable because they can be purchased as a means of communication by almost anyone [24]. Various platforms, such as mobile learning

application, can be installed on the Android system. It is a learning method that provides the opportunities for the students to learn regardless of time or location [25]. Mobile learning has become an applied innovation. Implementation of mobile learning can utilize educational games to facilitate material understanding, increase student thinking power, and increase student interest in learning. Many studies have developed various educational games based on Android, such as for learning English [26], chemistry [27], mathematics [28], computer science [29], coding skills [30], and pharmacy [31], even for inclusive students with visual impairments [32]. More specifically, the use of android-based games is very considerable in learning physics because most students perceive that learning physics is boring and not fun [2], which will be developed in this study.

2.2 Adventure game

According to Culley et al. [33], a program that simulates a small universe and places the player inside of it is called an adventure game. This type of game that emphasizes on the storyline and the player's thinking skills in analyzing places visually or summarizing various events. Integrating adventure games into routine classroom activities is the most common way to be used in education [34]. But until now, there are few studies that still use adventure games in learning. For example, Mulyati et al. [35] who has developed an adventure game on fluid physics material and is declared valid by media and material experts. Lin & Shih [36] have designed and evaluated the effectiveness of a digital game-based adventure education course and got the results that participants have a positive attitude towards this course. An interesting thing related to the use of this type of adventure game is that it can increase the curiosity of players because of the levels that must be completed gradually. Thus, this type of game can attract users to continue playing and has a positive influence if applied in learning.

2.3 Augmented reality

A technology known as augmented reality (AR) combines virtual objects that are either two-dimensional or three-dimensional into a true three-dimensional environment [37]. Then, it instantaneously projects these virtual objects. So, augmented reality can be a useful tool to help users to interact with and perceive the real world. Virtual objects display information that aids users in performing tasks in the real world. AR can be utilized in various functions, one of which is in education and learning that can attract, motivate, and provide real visuals for someone to understand a material concept that requires a high level of reasoning and imagination [38]. Several studies have developed and implemented AR-based media in learning [39–42]. For example, Suprapto et al. [43] conducted an AR-based pocketbook trial on the study of planetary motion physics subject. The results showed the improvement of pretest-posttest scores in students' learning achievement. Based on this study, the researcher recommends to use AR-based media on other abstract physics concepts. Current research will focus on developing AR for physics learning on abstract materials, namely magnetic fields.

2.4 Related works

Research by Dinis *et al.* [44] developed Virtual Reality (VR) and Augmented Reality game-based applications for Civil Engineering Education. The study discussed various interfaces for using gaming environments in engineering education, along with the learning process results. As a preliminary study, it can be said that incorporating VR and AR game-based interfaces made it easier for participants in learning activities to transfer knowledge to one another. Additionally, incorporating VR and AR into games can help promote civil engineering and inspire students while learning.

Research by Trista [45] conducted the interactive and augmented reality games for Indonesian history lessons. The results of this study showed the potential of using augmented reality and game-based learning to support and improve educational experiences nationwide in institutions of higher learning. Furthermore, users of the application will not experience any confusion because it is simple to use and understand.

Research by Boletsis *et al.* [46] developed the gaming project, namely "The Table Mystery", which emphasizes creating a stimulating, enjoyable, and educational environment with a secondary goal of small-scale knowledge transfer. The Table Mystery game study aims to lay the foundation for a more comprehensive investigation into augmented reality educational games. So far, it shows promising potential and has received positive feedback from groups of experts and students who have reviewed and played it.

Research by Hao [47] developed four AR games and investigated their influence on learning in a Grade 5 English course by integrating theories of digital game-based learning, the attention relevance confidence–satisfaction (ARCS) model, and different types of digital games. In this study, students who received instruction using AR games performed better on the post-test than students in the control group, but there was no appreciable difference in learning effectiveness between the two groups. However, there was a significant difference in the four dimensions of ARCS learning motivation between the experimental and control groups.

Another research by Sarifah [48] developed an android-based educational game to increase elementary school students' interest in learning mathematics. The results of this study show that the developed applications can effectively increase students' interest in learning. However, this study still does not explain what type of game to use and not use in AR.

Overall, the review results on related works can be seen in Table 1, which shows the novelty of this study. Based on the table, the differences between this study and previous research are: student-level target is senior high school, physics subjects, android-based digital game media, types of adventure games, and integrated with AR.

Table 1. The difference between current research and related works

Reference	Grade	Subject	Game Media	Game Type	AR
Dinis et al. [44]	University	Civil Engineering	Digital	-	Yes
Trista [45]	Senior High School	History	Digital	-	Yes
Boletsis et al. [46]	Junior High School	Chemistry	Conventional	Adventure	Yes
Hao [47]	Elementary	English	Digital	Role Playing, Quiz, Puzzle, and Matching Games	Yes
Sarifah et al. [48]	Elementary	Math	Digital	-	No
Rizki et al. (This Work)	Senior High School	Physics	Digital	Adventure	Yes

3 Method

3.1 General background

This research used Research and Development (R&D) design to present a development model used as the basis for developing a product to be produced [49]. The basis of this development research is a procedural model that refers to the 4D (Define, Design, Develop, Dissemination) development model which aims to develop and perfect existing products in terms of form and function. The flow of this research stages can be seen in Figure 1.

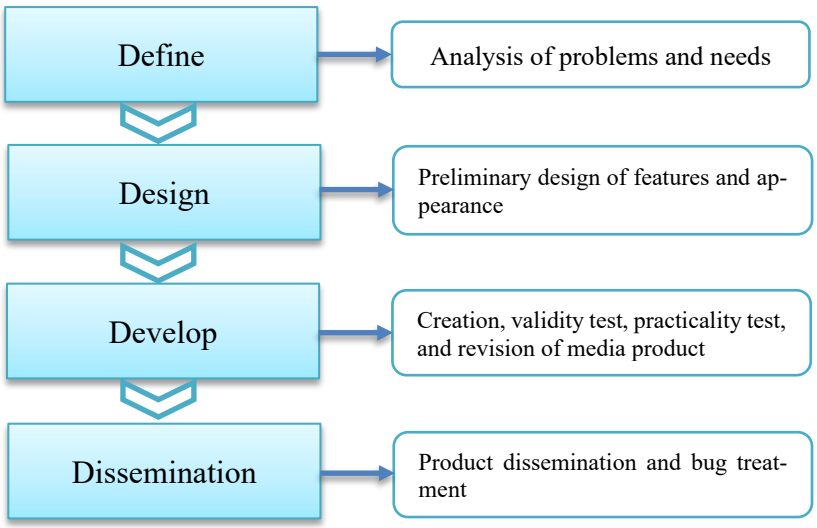

Fig. 1. Research flow and procedures

3.2 Instrument and data collection

This research instrument employed a questionnaire for experts, practitioners, and students using the Likert scale adopted from Nieveen [50]. The questionnaires for experts consists of two parts: a questionnaire to measure the validity of the content and the construct validity. Meanwhile, questionnaires for practitioners and students were used to measure the practicality of the application with indicators: Effective, Interactive, Efficient, and Creativity [51]. Data collection for validity aspects used a questionnaire given to three experts in learning physics, learning media, and educational technology. The goal of the validity test is the content and construct of the application product that has been created. After the product was revised and declared valid, data collection proceeds on the practicality aspect of the application. Data collection was carried out through a questionnaire which was assessed by three practitioners or teachers of physics subjects. In addition, the practicality test also involved 11 students who were selected by simple random sampling.

3.3 Data analysis

Data from the validity assessment results were carried out with descriptive analysis (mean) to determine the criteria for the validity of products and devices that have been developed. In addition, validity result data was used to determine the reliability of products and devices through the Cronbach Alpha (α) value. Products and devices are said to be reliable if the value of $\alpha > 0.6$ [52]. Data from the practicality assessment by teachers and students are also carried out descriptively (mean) to determine the practicality of the Adventuring Physics application product that has been developed. The criteria for determining validity and practicality can be seen in Table 2.

Table 2. Determination of validity and practicality criteria [53]

Validity Criteria		Practicality Criteria	
3.25 - 4.00	Very Valid	> 4.00	Very Practical
2.50 - 3.24	Valid	3.00 – 3.99	Practical
1.75 - 2.49	Less Valid	2.00 – 2.99	Quite Practical
1.00 - 1.74	Not Valid	1.00 – 1.99	Not Practical
		< 1.00	Very Not Practical

4 Results and discussion

4.1 Rational development of the Adventuring Physics

The application development of Adventuring Physics is based on several theories, namely the theories of structural gamification, the experience of the cone edgar dale, multi-representation, and constructivism. The theory of structural gamification by Kapp [54] applies the game element to encourage learners without any change in the content of the magnetic field. The content is not transformed into a game but only the structure.

It will be modelled into missions that the player must complete. The main focus of gamifying structure types in Adventuring Physics is to motivate players through content and involve them in the learning process using the 'reward' system.

Edgar Dale's theory related to the cone of experience states that a person's learning outcomes are obtained through direct (concrete) experience, the reality that exists in one's living environment through artificial objects to verbal (abstract) symbols [55,56]. Based on these experiences, the highest level of memory and comprehension (80-90%) will be obtained if students do the role-play, simulate, and work on the real thing [57]. This theory is very supportive in developing the Adventuring Physics application media because it directly involves students in physics learning so that they will better remember the physics concepts included in the game.

The theory of multi representation, according to Izsak and Saherin, states that teaching by involving multi representation provides a rich context for students to understand a concept [58]. This view implies that multi-representation is a way of expressing a concept through various means and forms. In Adventuring Physics applications, multi representations are presented in the form of graphics, visual, verbal, and images, especially in AR which provide the students to learn in various ways depending on the type of intelligence. Multi-representation serves three main purposes in learning: a compliment, limiting interpretation, and building understanding [59].

According to the theory of learning constructivism by Piaget and Vygotsky, the most important principle in educational psychology is that the teacher does not simply give knowledge to students [60]. However, the student must also establish his own knowledge in his mind. Therefore, teachers can provide preliminary information regarding material relevant to Adventuring Physics, after which it can allow students to discover, apply, or develop their own ideas based on that initial information through missions contained in the game application [61].

4.2 Adventuring physics performance

Adventuring Physics app provides several specifications: app size of 125 MB, no internet access required, android version minimum of 7.0 (API 24), making it easy to access by users and compatible or user friendly. To download this application, it can be accessed through the following link: https://play.google.com/store/apps/details?id=com.Asics.AdventuringPhysics. Figure 2 shows the app's home page. This page contains two main features, namely *Play Game* (for playing games) and *Augmented Reality*, as well as two other options, namely *leaderboard* and *setting*. The *leaderboard* aims to provide information on the extent of a player's success rate with each other and be able to compare their abilities with others. This is also an encouragement to players so who are trying to improve their performance so that they are not left behind by other players. Meanwhile, the settings serve to regulate the audio components and about the application.

Fig. 2. App home view

When the user selects the play game feature, then the user will enter the game arena with the concept of strategy that the player must find a way out as soon as possible. Players will be required to create magnetic field-based weapons to fight existing enemies. There are three stages for players to create weapons: designing tools and materials on the item rack, selecting the batteries on the battery rack, and looking for handles. The display of selecting material tools and batteries can be seen in Figure 3. Students' critical thinking skills will be trained when choosing the relevant types of tools, materials, and batteries, accompanied by structured and valid reasons or arguments [62,63]. This is because when the player mistakenly takes an item or battery, the player will lose. The relevant physics concepts in the case of proper battery selection are Ohm's Law and Biot-Savart's Law, as in Equations 1 & 2 [64]. Based on the equations, it can be known that the voltage value is directly proportional to the currents strength, then the it is directly proportional to the magnetic field. So that if the player chooses a relatively small battery voltage, then the magnetic field generated will be small and it cannot attract enemy weapons.

$$V = I \,.\, R \rightarrow V \sim I \tag{1}$$

$$dB = \frac{\mu_0 \, I \, dl \sin\theta}{4\pi r^2} \rightarrow B \sim I \text{ and } B \sim 1/r^2 \tag{2}$$

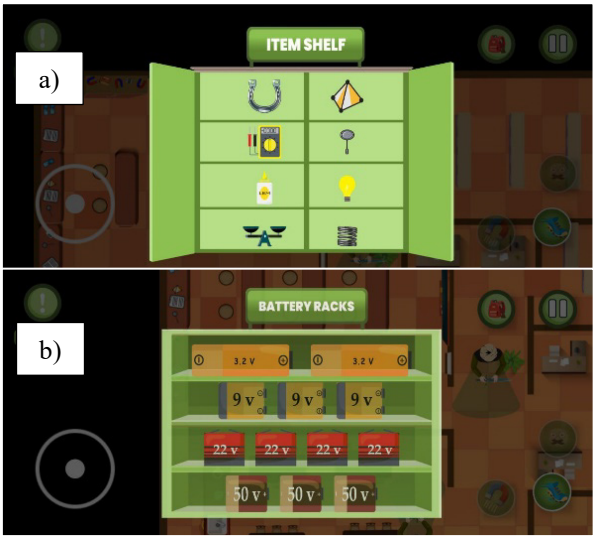

Fig. 3. Display of (a) Item shelf and (b) Battery racks

After the players finish making weapons, they must defeat each enemy by pulling the weapon and knocking it out. When attracting enemy weapons, the concept of Biot-Savart's law still applies to the distance variable. Based on Equation 2, it can be known that the value of the magnetic field is inversely proportional to the square of the distance so that the longer the player's distance from the enemy, the magnetic field weapon cannot attract the enemy's weapon. After the player successfully completes the mission, the time record will be known during the completion of the mission. The group of students who fastest complete the mission, they will be the winners and get rewards from the teacher.

The performance of this application is very suitable to be applied today due to the rapid increase in the use of information and digital technologies in learning, especially in physics [65]. High school students typically use digital games to teach physics [66]. Designing game-based learning media that can organize condition learning situations to create more interesting, challenging, and fun situations can increase student involvement in concept exploration activities. Learning concepts that cannot be practiced in class, providing interactive experiences, strengthening concepts, and evaluating concepts are the important thing for success to teach physics concepts for the students [67]. Supported by an attractive game appearance and easy to use, the theme taken is also interesting so that it can provide a fun learning process for students.

A range of media and teaching methods will increase the enjoyment of learning physics. It will no longer be novel that make boring to students. Students' aptitudes advance with their curiosity, and they are more driven than ever to learn physics [68]. Although the improvement in students' abilities is not immediately apparent, it is expected that the more laid-back learning atmosphere for physics, it will discourage students from procrastinating during class. If it can create enjoyable and comfortable

learning for students, all of the materials taught by complicated and straightforward teachers is much easier to comprehend [69].

Besides the game features, students can access AR features to aid their understanding of complex materials that require visualization assistance, such as the concept of strong current and magnetic fields on a straight wire with electricity (Figure 4). The AR media application works simply; after opening its application, it will appear on the smartphone camera, which can be pointed directly at the supported (pocket)book. The pocketbook can be accessed at the link: https://drive.google.com/file/d/1p5scnaMEHJ0xsXBaRzFvZd6hNqatTss/view?usp=sharing. A marker is then available and the application will detect, causing 3D animated objects to show on the smartphone screen.

This application media is consistent with the '*Merdeka Belajar*' curriculum concept which declares that students need to have skills which are appropriate for the 21st century [70]. This research is supported and in line with the research conducted by [43] that the integration of virtual objects (text, images, and animations) into the real world is made possible by AR. This study results align with the research conducted by [71] which states that the skills in utilizing the internet and computer media both for students and teachers in the learning process are the factors that can affect the level of physics understanding. The literature review looked at the use of AR in education, followed by an overview of some previous studies which used AR applications [72,73].

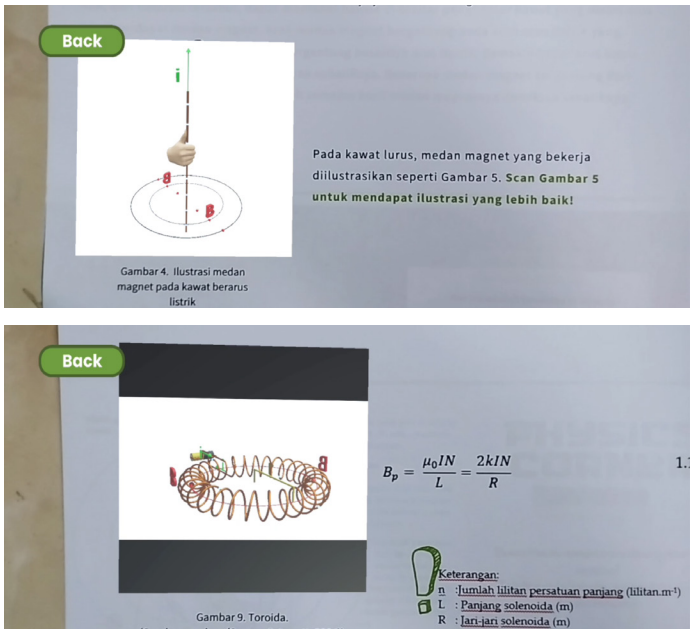

Fig. 4. AR features in the Adventuring Physics app

4.3 Validity assessment

Three experts: physicist learning experts, learning media experts, and educational technology experts, have assessed the application of Adventuring Physics. The assessment focuses on the content and constructs of the application. Content assessment, in general, includes: (1) the suitability of the game's storyline with the achievement of learning, (2) the representation of the application to the students' understanding, (3) the media provides a pleasant learning experience, (4) the suitability of the game's characters and storyline, and (5) the suitability of the application content to basic competencies and competency indicators. Meanwhile, the general construct assessments includes (1) consistency of button layout, (2) ease of starting and ending applications, (3) attractiveness of background colors and designs, (4) level of interactivity, (5) clarity of AR objects and (6) ease of application operations. The results of the validity assessment can be seen in Table 3.

Table 3. Assessment of the Adventuring Physics application validity

Content				**Construct**			
Validity		***Reliability***		***Validity***		***Reliability***	
3,48	Very Valid	0,72	Reliable	3,51	Very Valid	0,94	Reliable

The data from the validity assessment results show that the Adventuring Physics application is declared very valid and reliable, both for content and constructs. This latest application has: (1) integrating adventure games and augmented reality in one application, (2) its application in physics subjects. According to expert validators, this application is declared suitable for use after minor revisions [74]. After corrections were made based on their recommendations, the application of Adventuring Physics was continued with practicality assessment.

4.4 Practicality assessment

The practicality test focuses on Adventuring Physics application products with several indicators: effective, interactive, efficient, and creativity. Three teachers and eleven students carried out the assessment. The results of the assessment of the application's practicality can be seen in Table 4.

Table 4. Results of the Adventuring Physics application practicality test

Practicality Aspects	**Teacher Assessment**		**Student Assessment**	
	Average	***Criteria***	***Average***	***Criteria***
Effective	4,58	Very Practical	4,04	Very Practical
Interactive	4,66	Very Practical	3,93	Practical
Efficient	4,83	Very Practical	4,36	Very Practical
Creativity	4,16	Very Practical	4,22	Very Practical
Average	4,55	Very Practical	4,13	Very Practical

Based on the results of the practicality test, the *Adventuring Physics* application has an average score of 4.55 or is very practical according to the teacher's assessment. While according to the student's assessment, the app has an average score of 4.13 or is very practical. The results of the practicality assessment show that 1) this medium can be used to explain the material; 2) AR projection can appear easily; 3) interactive application which all buttons can be used well and user friendly; 4) flexible and easy to play anywhere; 5) application design can make students interested in learning; 6) can help students actively in learning. In line with research by [75], practical and interactive multimedia-based physics learning can positively influence students' interest in learning and learning outcomes. Games have a positive impact on the education world and have been researched much [76,77].

5 Conclusion

Adventuring Physics is an android-based integrated game application with AR in physics learning. This application has two main features: '*play games*' and '*augmented reality*'. The game's storyline and concept in this application is adapted to the physics materials. The AR feature in this application can create visualizations in the form of 3D image projections of the material. The results of the validity assessment show that this application is declared valid, feasible, and reliable. In addition, the results of the practicality assessment show that this application is very practical both according to teachers and students. Thus, the app is worth applying in physics learning. This research has implications as an application of Adventuring Physics that can motivate students in learning physics, applying digital technology in education, and applied in physics learning. Future research is to be able to apply this application to test its effectiveness in physics learning.

6 Acknowledgment

We would like to thank the Directorate of Learning and Student Affairs, the Indonesian Ministry of Education, Culture, Research, and Technology, and Universitas Negeri Surabaya for providing funding for this research through the Social Humanities Research Student Creativity Program (PKM-RSH). In addition, we also thank SMAN 1 Taman and SMAN 3 Sidoarjo for granting research permits.

7 References

[1] Mudjid, R. M., Supahar, Putranta, H., & Hetmina, D. S. (2022). Development of Android Physics Learning Tools Based on Local Wisdom Traditional Game Bola Boy as a Learning Source. *International Journal of Interactive Mobile Technologies*, *16*(6), 92–112. https://doi.org/10.3991/ijim.v16i06.27855

[2] Jufrida, J., Kurniawan, W., Astalini, A., Darmaji, D., Kurniawan, D. A., & Maya, W. A. (2019). Students' attitude and motivation in mathematical physics. *International Journal of*

Evaluation and Research in Education, *8*(3), 401–408. https://doi.org/10.11591/ijere.v8i3.20253

[3] Marshman, E., & Singh, C. (2015). Framework for understanding the patterns of student difficulties in quantum mechanics. *Physical Review Special Topics - Physics Education Research*, *11*(2), 20119. https://doi.org/10.1103/PhysRevSTPER.11.020119

[4] Keller, M. M., Neumann, K., & Fischer, H. E. (2017). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *Journal of Research in Science Teaching*, *54*(5), 586–614. https://doi.org/10.1002/tea.21378

[5] Mendez, D., & Slisko, J. (2013). Software Socrative and smartphones as tools for implementation of basic processes of active physics learning in classroom: An initial feasibility study with prospective teachers. *European Journal of Physics Education*, *4*(2), 17–24.

[6] Bestiantono, D. S., Sa'diyah, E. H., Rachmatya, R., Mubarok, H., Adam, A. S., & Suprapto, N. (2019). University Students' Misconception in Electromagnetism. *Journal of Physics: Conference Series*, *1417*(1). https://doi.org/10.1088/1742-6596/1417/1/012074

[7] Turgut, U., Colak, A., & Salar, R. (2016). The Effect of 7E Model on Conceptual Success of Students in The Unit of Electromagnetism. *European Journal of Physics Education*, *7*(3), 1–37.

[8] Mandagi, A. F., Iswanto, B. H., & Sugihartono, I. (2021). Virtual Microscopic Simulation (VMS) for physics learning of the photoelectric effect in high school. *Journal of Physics: Conference Series*, *2019*(1), 12013. https://doi.org/10.1088/1742-6596/2019/1/012013

[9] Webb, M., Gibson, D., & Forkosh-Baruch, A. (2013). Challenges for information technology supporting educational assessment. *Journal of Computer Assisted Learning*, *29*(5), 451–462. https://doi.org/10.1111/jcal.12033

[10] Spitzer, M. (2014). Information technology in education: Risks and side effects. *Trends in* Neuroscience *and Education*, *3*(3), 81–85. https://doi.org/10.1016/j.tine.2014.09.002

[11] Rizal, R., Rusdiana, D., Setiawan, W., & Siahaan, P. (2020). Students' Perception of Learning Management System Supported Smartphone: Satisfaction Analysis in Online Physics Learning. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 600–610. https://doi.org/10.15294/jpii.v9i4.25363

[12] Wirjawan, J. V.D., Pratama, D., Pratidhina, E., Wijaya, A., Untung, B., & Herwinarso. (2020). Development of smartphone app as media to learn impulse-momentum topics for high school students. *International Journal of Instruction*, *13*(3), 17–30. https://doi.org/10.29333/iji.2020.1332a

[13] Rahayu, M. S. I., Kuswanto, H., & Pranowo, C. Y. (2021). Android-Based Carrom Game Comics Integrated with Discovery Learning for Physics Teaching BT. *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020)*, 555–560. https://doi.org/10.2991/assehr.k.210305.081

[14] Kurniawan, R. D., & Hidayah, R. (2021). Validity of Kimi Kimo Adventure Game Based on Android as Learning Media in Chemical Bonds BT - Proceedings of the International Joint Conference on Science and Engineering 2021 (IJCSE 2021). *Proceedings of the International Joint Conference on Science and Engineering 2021*, 247–253.

[15] Arulanand, N., Babu, A. R., & Rajesh, P. K. (2020). Enriched Learning Experience using Augmented Reality Framework in Engineering Education. *Procedia Computer Science*, *172*, 937–942. https://doi.org/10.1016/j.procs.2020.05.135

[16] Zourmpakis, A.-I., Papadakis, S., & Kalogiannakis, M. (2022). Education of preschool and elementary teachers on the use of adaptive gamification in science education. *International Journal of Technology Enhanced Learning*, *14*(1), 1–16. https://doi.org/10.1504/IJTEL.2022.120556

[17] Kartika, Y., Wahyuni, R., Sinaga, B., & Rajagukguk, J. (2019). Improving Math Creative Thinking Ability by using Math Adventure Educational Game as an Interactive Media. *Journal of Physics: Conference Series*, *1179*, 12078. https://doi.org/10.1088/1742-6596/1179/1/012078

[18] Andreou, P., Nicou, G., Polycarpou, I., Germanakos, P., & Paspallis, N. (2017). CodeAdventure: An Adventure Game for Computer Science Education BT - Learning and Collaboration Technologies. Novel Learning Ecosystems (P. Zaphiris & A. Ioannou (eds.); pp. 423–432). Springer International Publishing. https://doi.org/10.1007/978-3-319-58509-3_33

[19] Suprapto, N., Prahani, B. K., & Deta, U. A. (2021). Top 100 Cited Publications in Physics Education in The Last Thirty Years: A Bibliometric Analysis. *Library Philosophy and Practice*, *5928*, 1–13. https://digitalcommons.unl.edu/libphilprac/5928

[20] Suprapto, N., Nandyansah, W., & Mubarok, H. (2020). An evaluation of the "PicsAR" research project: An augmented reality in physics learning. *International Journal of Emerging Technologies in Learning*, *15*(10), 113–125. https://doi.org/10.3991/ijet.v15i10.12703

[21] Cai, S., Liu, C., Wang, T., Liu, E., & Liang, J.-C. (2021). Effects of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning. *British Journal of Educational Technology*, *52*(1), 235–251. https://doi.org/10.1111/bjet.13020

[22] Zain, F. M., Sailin, S. N., Kasim, M., Abdul Karim, A. M., & Zameri, N. N. (2022). Developing an Augmented Reality Immersive Learning Design (AILeaD) Framework: A Fuzzy Delphi Approach. *International Journal of Interactive Mobile Technologies (IJIM)*, *16*(11 SE-Papers), 65–90. https://doi.org/10.3991/ijim.v16i11.30063

[23] Asmianto, Hafiizh, M., Rahmadani, D., Pusawidjayanti, K., & Wahyuningsih, S. (2022). Developing Android-Based Interactive E-Modules on Trigonometry to Enhance the Learning Motivation of Students. *International Journal of Interactive Mobile Technologies (IJIM)*, *16*(02 SE-Short Papers), 159–170. https://doi.org/10.3991/ijim.v16i02.27503

[24] Gunawan, A. A. S., William, Hartanto, B., Mili, A., Budiharto, W., Salman, A. G., & Chandra, N. (2017). Development of Affordable and Powerful Swarm Mobile Robot Based on Smartphone Android and IOIO board. *Procedia Computer Science*, *116*, 342–350. https://doi.org/10.1016/j.procs.2017.10.057

[25] Abbas, M., Hwang, G.-J., Ajayi, S., Mustafa, G., & Bilal, M. (2021). Modelling and exploiting taxonomic knowledge for developing mobile learning systems to enhance children's structural and functional categorization. *Computers and Education: Artificial Intelligence*, *2*, 100007. https://doi.org/10.1016/j.caeai.2021.100007

[26] Yunanto, A. A., Herumurti, D., Rochimah, S., & Kuswardayan, I. (2019). English Education Game using Non-Player Character Based on Natural Language Processing. *Procedia Computer Science*, *161*, 502–508. https://doi.org/10.1016/j.procs.2019.11.158

[27] Sari, S., Anjani, R., Farida, I., & Ramdhani, M. A. (2017). Using Android-Based Educational Game for Learning Colloid Material. *Journal of Physics: Conference Series*, *895*(1), 12012. https://doi.org/10.1088/1742-6596/895/1/012012

[28] Risnawati, Amir, Z., & Wahyuningsih, D. (2018). The Development of Educational Game as Instructional Media to Facilitate Students' Capabilities in Mathematical Problem Solving. *Journal of Physics: Conference Series*, *1028*(1), 12130. https://doi.org/10.1088/1742-6596/1028/1/012130

[29] De Troyer, O., Lindberg, R., & Sajjadi, P. (2019). TrueBiters, an educational game to practice the truth tables of propositional logic: Development, evaluation, and lessons learned. *Smart Learning Environments*, *6*(1), 27. https://doi.org/10.1186/s40561-019-0105-2

[30] Papadakis, D. S. (2022). Apps to Promote Computational Thinking and Coding Skills to Young Age Children: A Pedagogical Challenge for the 21st Century Learners. *Educational Process: International Journal*, *11*(1), 7–13. https://doi.org/10.22521/edupij.2022.111.1

[31] Oestreich, J. H., & Guy, J. W. (2022). Game-Based Learning in Pharmacy Education. *Pharmacy (Basel, Switzerland)*, *10*(1), 11. https://doi.org/10.3390/pharmacy10010011

[32] Neto, L. V., Fontoura Junior, P. H. F., Bordini, R. A., Otsuka, J. L., & Beder, D. M. (2020). Design and implementation of an educational game considering issues for visually impaired people inclusion. *Smart Learning Environments*, *7*(1), 4. https://doi.org/10.1186/s40561-019-0103-4

[33] Kristiadi, D. P., Hasanudin, M., Sutrisno, S., & Suwarto, S. (2019). The Effect of Adventure Video Games on the Development of Student's Character and Behavior. *International Journal for Educational and Vocational Studies*, *1*(4), 330–334. https://doi.org/10.29103/ijevs.v1i4.1456

[34] Ke, F. (2016). Designing and integrating purposeful learning in game play: a systematic review. *Educational Technology Research and Development*, *64*(2), 219–244. https://doi.org/10.1007/s11423-015-9418-1

[35] Muliyati, D., Wahdaniyah, N., & Bakri, F. (2021). Development of Educational Adventure Game on Fluid Physics Material. *Journal of Physics: Conference Series*, *2019*(1), 12062. https://doi.org/10.1088/1742-6596/2019/1/012062

[36] Lin, C.-H., & Shih, J.-L. (2015). Evaluations to the gamification effectiveness of digital game-based adventure education course-GILT. *Journal of E-Learning and Knowledge Society*, *11*(3), 41–58.

[37] Hamzah, M. L., Ambiyar, A., Rizal, F., Simatupang, W., Irfan, D., & Refdinal, R. (2021). Development of Augmented Reality Application for Learning Computer Network Device. *International Journal of Interactive Mobile Technologies (IJIM)*, *15*(12 SE-Papers), 47–64. https://doi.org/10.3991/ijim.v15i12.21993

[38] Afnan, Muhammad, K., Khan, N., Lee, M.-Y., Imran, A. S., & Sajjad, M. (2021). School of the Future: A Comprehensive Study on the Effectiveness of Augmented Reality as a Tool for Primary School Children's Education. In *Applied Sciences* (Vol. 11, Issue 11). https://doi.org/10.3390/app11115277

[39] Daineko, Y., Tsoy, D., Ipalakova, M., Kozhakhmetova, B., Aitmagambetov, A., & Kulakayeva, A. (2022). Development of an Interactive Mobile Platform for Studying Radio Engineering Disciplines Using Augmented Reality Technology. *International Journal of Interactive Mobile Technologies (IJIM)*, *16*(19 SE-Papers), 147–162. https://doi.org/10.3991/ijim.v16i19.32373

[40] Carrion Silva, A. J., Reyes Calderon, A. M., Giraldo Retuerto, M., & Andrade-Arenas, L. (2022). Application of Augmented Reality in Teaching and Learning in Engineering Programs. *International Journal of Interactive Mobile Technologies (IJIM)*, *16*(15 SE-Papers), 112–124. https://doi.org/10.3991/ijim.v16i15.31695

[41] Elmira, O., Rauan, B., Dinara, B., & Prevalla Etemi, B. (2022). The Effect of Augmented Reality Technology on the Performance of University Students. *International Journal of Emerging Technologies in Learning (IJET)*, *17*(19 SE-Papers), 33–45. https://doi.org/10.3991/ijet.v17i19.32179

[42] Campos-Pajuelo, E., Vargas-Hernandez, L., Sierra-Liñan, F., Zapata-Paulini, J., & Cabanillas-Carbonell, M. (2022). Learning the chemical elements through an augmented reality application for elementary school children. *Advances in Mobile Learning Educational Research*, *2*(2), 493–501. https://doi.org/10.25082/amler.2022.02.018

[43] Suprapto, N., Ibisono, H. S., & Mubarok, H. (2021). The Use of Physics Pocketbook Based on Augmented Reality on Planetary Motion To Improve Students' Learning Achievement.

Journal of Technology and Science Education, *11*(2), 526–540. https://doi.org/10.3926/jotse.1167

[44] Dinis, F. M., Guimarães, A. S., Carvalho, B. R., Pedro, J., & Martins, P. (2017). Virtual and augmented reality game-based applications to civil engineering education. *IEEE Global Engineering Education Conference (EDUCON)*, 1683–1688. https://doi.org/10.1109/EDUCON.2017.7943075

[45] Trista, S., & Rusli, A. (2020). HistoriAR: Experience indonesian history through interactive game and augmented reality. *Bulletin of Electrical Engineering and Informatics*, *9*(4), 1518–1524. https://doi.org/10.11591/eei.v9i4.1979

[46] Boletsis, C., & McCallum, S. (2013). The table mystery: An augmented reality collaborative game for chemistry education. *Lecture Notes in Computer Science*, *8101 LNCS*, 86–95. https://doi.org/10.1007/978-3-642-40790-1_9

[47] Hao, K. C., & Lee, L. C. (2021). The development and evaluation of an educational game integrating augmented reality, ARCS model, and types of games for English experiment learning: an analysis of learning. *Interactive Learning Environments*, *29*(7), 1101–1114. https://doi.org/10.1080/10494820.2019.1619590

[48] Sarifah, I., Rohmaniar, A., Marini, A., Sagita, J., Nuraini, S., Safitri, D., Maksum, A., Suntari, Y., & Sudrajat, A. (2022). Development of Android Based Educational Games to Enhance Elementary School Student Interests in Learning Mathematics. *International Journal of Interactive Mobile Technologies (IJIM)*, *16*(18 SE-Papers), 149–161. https://doi.org/10.3991/ijim.v16i18.32949

[49] Richey, R. C., & Klein, J. D. (2014). *Design and development research: Methods, strategies, and issues*. Routledge. https://doi.org/10.4324/9780203826034

[50] Nieveen, N. (1999). *Prototyping to Reach Product Quality BT - Design Approaches and Tools in Education and Training* (J. van den Akker, R. M. Branch, K. Gustafson, N. Nieveen, & T. Plomp (eds.); pp. 125–135). Springer Netherlands. https://doi.org/10.1007/978-94-011-4255-7_10

[51] Arifin, A. M., Pujiastuti, H., & Sudiana, R. (2020). Pengembangan media pembelajaran STEM dengan augmented reality untuk meningkatkan kemampuan spasial matematis siswa. *Jurnal Riset Pendidikan Matematika*, *7*(1), 59–73. https://doi.org/10.21831/jrpm.v7i1.32135

[52] Sujarweni, V. W. (2015). *SPSS untuk Penelitian*. Pustaka Baru Press.

[53] Erika, F., Prahani, B. K., Supardi, Z. A. I., & Tukiran. (2018). Development of a graphic organiser-based argumentation learning (GOAL) model for improving the self-efficacy and ability to argue of chemistry teacher candidates. *World Transactions on Engineering and Technology Education*, *16*(2), 179–185.

[54] Kapp, K. M. (2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. Pfeiffer. https://doi.org/10.1145/2207270.2211316

[55] Firmansyah, F. H., Sari, I. P., Permana, F. C., & Hernawan, A. H. (2020). Development of Interactive Learning Media Based on Google Application for Distance Learning in Universitas Pendidikan Indonesia. *Proceedings of the International Conference on Educational Research and Innovation (ICERI 2019)*, 185–190. https://doi.org/10.2991/assehr.k.200204.034

[56] Marpanaji, E., Mahali, M. I., & Putra, R. A. S. (2018). Survey on How to Select and Develop Learning Media Conducted by Teacher Professional Education Participants. *Journal of Physics: Conference Series*, *1140*, 12014. https://doi.org/10.1088/1742-6596/1140/1/012014

[57] Ken, M. (2019). Preparation of nursing students for operating room exposure : a South African perspective . *African Journal of Health Professions Education*, *11*(3), 71. https://doi.org/10.7196/AJHPE.2019.v11i3.1215
[58] Karakok, G., Soto-Johnson, H., & Dyben, S. A. (2015). Secondary teachers' conception of various forms of complex numbers. *Journal of Mathematics Teacher Education*, *18*(4), 327–351. https://doi.org/10.1007/s10857-014-9288-1
[59] Yanti, H., Distrik, I. W., & Rosidin, U. (2019). The Effectiveness of Students' Worksheets Based on Multi-Representation in Improving Students' Metacognition Skills in Static Electricity. *Journal of Physics: Conference Series*, *1155*, 12083. https://doi.org/10.1088/1742-6596/1155/1/012083
[60] Arends, R. I. (2011). *Learning to Teach* (Ninth). McGraw-Hill Education.
[61] Schunk, D. H. (2011). *Learning Theories: An Educational Perspective* (6th ed.). Pearson.
[62] Alsaleh, N. J. (2020). Teaching Critical Thinking Skills: Literature Review. *TOJET: The Turkish Online Journal of Educational Technology*, *19*(1), 21–39.
[63] Glassner, A., & Schwarz, B. B. (2007). What stands and develops between creative and critical thinking? Argumentation? *Thinking Skills and Creativity*, *2*(1), 10–18. https://doi.org/10.1016/j.tsc.2006.10.001
[64] Serway, R. A., & Jewett, J. W. (2014). *Physics for Scientists and Engineers with Modern Physics* (Ninth Edit). Brooks/Cole Cengage Learning. https://doi.org/10.5860/choice.34-3910
[65] Hariadi, B., Sunarto, M. J. D., Sagirani, T., Prahani, B. K., & Jatmiko, B. (2021). Higher Order Thinking Skills for Improved Learning Outcomes Among Indonesian Students: A Blended Web Mobile Learning (BWML) Model. *International Journal of Interactive Mobile Technologies*, *15*(7), 4–16. https://doi.org/10.3991/ijim.v15i07.17909
[66] Anderson, J. L., & Barnett, M. (2013). Learning Physics with Digital Game Simulations in Middle School Science. *Journal of Science Education and Technology*, *22*(6), 914–926. https://doi.org/10.1007/s10956-013-9438-8
[67] Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior*, *54*, 170–179. https://doi.org/10.1016/j.chb.2015.07.045
[68] Videnovik, M., Trajkovik, V., Kiønig, L. V., & Vold, T. (2020). Increasing quality of learning experience using augmented reality educational games. *Multimedia Tools and Applications*, *79*(33), 23861–23885. https://doi.org/10.1007/s11042-020-09046-7
[69] Shi, T. (2018). A Study of the TPR Method in the Teaching of English to Primary School Students. *Theory and Practice in Language Studies*, *8*(8), 1087. https://doi.org/10.17507/tpls.0808.25
[70] Indarta, Y., Jalinus, N., Waskito, W., Samala, A. D., Riyanda, A. R., & Adi, N. H. (2022). Relevansi Kurikulum Merdeka Belajar dengan Model Pembelajaran Abad 21 dalam Perkembangan Era Society 5.0. *Edukatif: Jurnal Ilmu Pendidikan*, *4*(2), 3011–3024. https://doi.org/10.31004/edukatif.v4i2.2589
[71] Gökalp, M. S. (2013). Perceptions of the internet and education: A study with physics education website users. *International Journal of Environmental and Science Education*, *8*(2), 289–302. https://doi.org/10.12973/ijese.2013.210a
[72] Chiang, T. H. C., Yang, S. J. H., & Hwang, G. J. (2014). An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities. *Educational Technology and Society*, *17*(4), 352–365.
[73] Gopalan, V., Zulkifli, A. N., & Bakar, J. A. A. (2016). A study of students' motivation using the augmented reality science textbook. *AIP Conference Proceedings*, *1761*(1), 20040. https://doi.org/10.1063/1.4960880

[74] Plomp, T. (2013). Preparing education for the information society: The need for new knowledge and skills. *International Journal of Social Media and Interactive Learning Environments*, *1*(1), 3–18. https://doi.org/10.1504/IJSMILE.2013.051651

[75] Djamas, D., Tinedi, V., & Yohandri. (2018). Development of interactive multimedia learning materials for improving critical thinking skills. *International Journal of Information and Communication Technology Education*, *14*(4), 66–84. https://doi.org/10.4018/IJICTE.2018100105

[76] Syahidi, A. A., Supianto, A. A., & Tolle, H. (2019). Design and Implementation of Bekantan Educational Game (BEG) as a Banjar Language Learning Media. *International Journal of Interactive Mobile Technologies (IJIM)*, *13*(03 SE-Papers), 108–124. https://doi.org/10.3991/ijim.v12i7.9257

[77] Yoon, C. S., & Khambari, M. N. M. (2022). Design, Development, and Evaluation of the Robobug Board Game: An Unplugged Approach to Computational Thinking. *International Journal of Interactive Mobile Technologies (IJIM)*, *16*(06 SE-Papers), 41–60. https://doi.org/10.3991/ijim.v16i06.26281

8 Authors

Iqbal Ainur Rizki is a fourth-year undergraduate student in the Physics Education Study Programme, Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. His research interest in educational technology, mobile learning, and physics learning innovation.

Hanandita Veda Saphira is a fourth-year undergraduate student in the Physics Education Study Programme, Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. Her research interest in physics education and learning innovation.

Yusril Alfarizy is a fourth-year undergraduate student in the Physics Education Study Programme, Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. His research interest in learning assesment and mathematical physics.

Aulia Dwi Saputri is a fourth-year undergraduate student in the Information System Study Programme, Department of Informatics Engineering, Faculty of Engineering, Universitas Negeri Surabaya. Her research interest in UI/UX design.

Riski Ramadani is a third-year undergraduate student in the Physics Study Programme, Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. His research interest in robotics and intrumentation physics.

Nadi Suprapto is a Professor in the Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. His research interests in bibliometrics, local wisdom of physics, philosophy, and physics education curriculum (Email: nadisuprapto@unesa.ac.id).

Article submitted 2022-09-07. Resubmitted 2022-11-08. Final acceptance 2022-11-17. Final version published as submitted by the authors.

The Impact of Instruction-Based LEGO WeDo 2.0 Robotic and Hypermedia on Students' Intrinsic Motivation to Learn Science

https://doi.org/10.3991/ijim.v17i01.35663

Aseel Ajlouni
Al-Ahliyya Amman University, Amman, Jordan
a.ajlouni@ammanu.edu.jo

Abstract—Robots and hypermedia have been used as effective technological tools in the educational field. Despite their educational benefits, there are no studies investigating their impact on primary students' intrinsic motivation in the field of science. For these reasons, the study aims to recognize the impact of employing LEGO WeDo 2.0 robotic and hypermedia on intrinsic motivation to learn science among primary students. The study implemented the quasi-experimental approach with a dual group design. The experimental group (n=25) was instructed on the force and motion topic using instruction-based LEGO WeDo 2.0 robotic and hypermedia, while the control group (n=25) was instructed using traditional instruction. The study conducted in Jordan involved fifty primary students. The data was gathered by administering the developed Intrinsic Motivation Towards Learning Science Scale to both groups at pre and post-points; ANCOVA analysis revealed a significant effect in favor of the experimental group in increasing intrinsic motivation to learn science at $\alpha = 0.05$. These results recommend science instructors employ robots and hypermedia to foster students' intrinsic motivation. It also encourages decision-makers in educational institutions to make decisions related to the science curriculum and its instructional methods.

Keywords—robot, hypermedia, intrinsic motivation, science, instruction

1 Introduction

The rapid growth of technology in the twenty-first century imposed on educational institutions the need to integrate learning environments and instructional methods with digital tools to enhance the learning and teaching processes. Therefore, researchers have been conducting studies that employ several technological tools in several disciplines at K-12 and higher education levels, such as robots and hypermedia. The use of technological tools in education was not limited to enhancing the cognitive and skill aspects but also included the psychological ones such as motivation, which is one of the learning conditions and the most prominent factor affecting human behavior and the learning process. It is the force that motivates behaviors and directs them toward

achieving the goal [1]. It helps in acquiring knowledge and skills [2-3]. Due to the important role of motivation in the learning process, researchers have conducted many studies that involved motivation among students across all subjects.

The importance of motivation for learning sciences comes from the importance of science education, which is considered the most integral part of today's education [4]. It constructs the scientific culture and prepares productive individuals for society. Consequently, there has been an excessive concentration on technological tools that foster motivation toward learning science. Interest in introducing robotics into science education has rapidly grown over the past few years. It has several advantages such as developing a conceptual understanding of scientific concepts; fostering student collaboration; motivation; interest in learning science and problem-solving [5-12]. Also, Hypermedia was integrated into learning science, which is a combination of hypertext and multimedia elements [8]. Teachers employ it in science curricula regarding its benefits in improving students' learning, self-regulated learning, scientific processing skills, acquisition of scientific concepts, problem-solving skills, and students' motivation [12–15]. Consequently, integrated robotics with hypermedia could improve learning science and students' motivation towards it among all students.

Despite the several global reform movements that appeared in science curricula there are notable worldwide weakening in enrollment, academic results, attitude, and motivation in the science learning context [16-18]. More precisely, in Jordan, the outcomes of the Trend in International Mathematics and Science Study (TIMSS) test discovered weaknesses in science among Jordanian students [19]. As well, fifth-grade are within the stage of concrete operations stage according to Piaget's classification; they, as they face difficulty in verbal reasoning and cannot form abstract concepts. They are unable to think logically unless it is linked to sensory experiences [20-21]. Therefore, they need higher motivation to learn science and its concepts; Further, no conducted study in the literature examines the impact of employing robots and hypermedia on students' intrinsic motivation to learn science. These shed light on the need to conduct new researches that examine the effect of employing robot with hypermedia in boosting the motivation to learn science among primary students. Therefore, this study could bridge the gap in motivation to learn science literature related to robots and hypermedia and it could encourage science instructors to employ good practices to enhance students' intrinsic motivation.

This study aims to reveal the impact of using robots and hypermedia instruction in developing intrinsic motivation toward learning science among fifth-grade students in Jordan. This study specifically attempts to answer the following question:Are there significant differences in the development of intrinsic motivation to learn science attributable to the instructional method (instruction-based LEGO WeDo 2.0 robotic and hypermedia vs. traditional) at the significance level ($\alpha < 0.05$)?

The following section reviews the theoretical frameworks of the research and the state-of-the-art literature that have investigated students' intrinsic motivation to learn science, the next section introduces our methodology, then the findings of the research were presented and discussed, finally the research ends with a conclusion, limitations of the study and some recommendations for future researches.

2 Literature review and theoretical framework

2.1 Motivation and learning in a science context

Motivation has a vital role in an effective learning and teaching process. It has attracted the attention of several researchers and psychologists across numerous contexts. There is no single definition of motivation. It is conceptualized as an internal construct that initiates, changes, or sustains goals, actions, and preferences. It is the power that stimulates the learner to handle all learning complications, difficulties, and challenges. It enables learners to realize their goals by engaging them in learning tasks [22-25]. Motivation is considered the underlying reason for an individual's behavior [26] and is associated with learning outcomes and academic activities [27-29]. It reflects students' engagement and learning involvement. Low-motivated students should be encouraged to participate and engage in learning activities [30], but how students' motivation can be provoked still preoccupies researchers, educators, and psychologists till now [31].

Many theories explain motivation, such as the Self-determination Theory (STD), according to it there are two types of motivation; a) intrinsic motivation where an inner force that motivates individuals such as interest and enjoyment, b) extrinsic motivation, where the individual's motivated by external contingencies such as rewards or punishments. Intrinsic motivation to learn involves engaging in learning tasks for the reason that they are seen as enjoyable, interesting, or related to achieving individuals' essential psychological needs [32]. In light of STD fulfillment of basic psychological needs (ie. autonomy, relatedness, and competence) in the educational environment works to develop the intrinsic motivation of students toward their learning, then they become more self-determined so they accept educational tasks with more comfort, In turn, intrinsic motivation encourages high-quality learning [32- 37]. This shows how important it is for the teacher and the instructional designer to meet students' needs and boost their intrinsic motivation to learn in all subjects.

The researchers began employing many strategies, models, and technological tools in an attempt to improve motivation quality among students at all levels of education using several tools. On the other hand, several factors impact students' motivation, such as teaching methods, administrative practices, and the school environment [20]. The teacher should be raising students' interest in the subject of learning and encourage students' participation.

Study findings have confirmed that students struggle and face difficulty understanding science, especially the basic physical concepts because some of them are connected to other concepts that make it more difficult to understand and conceive by students [37-38]. Besides, according to Piaget's cognitive development theory, abstract concepts are difficult to comprehend in primary students because they are in the concrete operational stage, they can resolve problems related to concrete concepts [39]. As a result, primary students require increased effort and motivation to conceptualize abstract concepts and learn science. Difficulties in learning science can be overcome using appropriate practice and instructional strategies by instructors [37]. Therefore, researchers should integrate technology to motivate students and simulate abstract concepts to enhance science learning. Consequently, Kommers [40] recommends using metaphors.

Ajlouni and Jaradat recommended using hypermedia to offer simulation for abstract concepts [12], while Badeleh and others used robots to motivate and engage students in learning science [41-42].

2.2 Robots and learning science subjects

The robot attracted the consideration of educators and researchers in educational settings across the world. Some countries focused on employing robots to support learning STEM curricula; in other countries, robot-based curricula were limited to school robot camps, after-school activities, and enrichment classes [43]. In general, the Robot Olympiad appeared in most countries, and its national and international competitions were spread to encourage students to learn STEM subjects [44]. A robot is defined as a device that has sensors and can be programmed [45]. It is a computer-controlled machine that can sense, hold, and move objects [46]. The term "educational robot" (ER) refers to a specialized field in which three different experiences intersect; robotics, pedagogy, and psychology.

Several types of educational robots have emerged, which vary in their form, equipment, software systems, and behavioral products [47]. Educational robots are classified into two main categories: use bots such as turtles and build bots such as LEGO robots [48]. However, they are used in the educational context based on the research of Papert, Vygotsky, and Jean Piaget to build meaningful learning experiences [49]. Catlin and Balmires also made guidelines for Educational Robotic Applications (ERA) that tell designers and teachers how to use robots in the classroom [50].

Literature on Educational Robots points out numerous benefits to employing them in the learning and teaching processes. They provide an active environment that facilitates learning by doing, provides a fun and engaging learning environment, opportunities to employ scientific skills and knowledge in a meaningful way, and enhances motivation to learn, imagination, achievements, and the acquisition of scientific concepts; develops digital competencies and an understanding of STEM topics [51-60].

Previous studies indicated the possibility of employing the robot and mastering its programming skills in different age groups, starting with pre-kindergarten children [61-64]. Therefore, educators and researchers integrate robots into teaching and learning in several disciplines across several age groups [65]. Despite this, the conducted studies that investigated the impact of employing robots on motivation in science subjects at the primary school stage were characterized by scarcity. There is also no study in the Arabian context. Therefore, this study relied on conducted studies that employed it among different age groups of students across different countries, for example, in Italy [66] they conducted a study that integrated robots to teach physics concepts to high-school students. The result showed a significant enhancement in the student's understanding of physics concepts and principles. Also, Elaz [67] conducted an experimental study among fifth-grade students, the study's findings revealed a positive impact of employing LEGO WeDo 2.0 robotics on students' attitudes and science achievements. As well, in the United States [68] conducted a study that employed robots in teaching undergraduate general physics, the findings of the study found that the activities of

robot-building and programming enhance group learning skills to learn physics concepts and foster students' motivation. Similarly, [69] conducted a study in Spain that found robots enhanced interest, scientific curiosity, and social skills among secondary school students. Further, [70] conducted a quantitative and qualitative study method among high school students that revealed participation in a robotics workshop increases student motivation to learn physics. In Turkey, [71] found that robotic education can help high school students with their science performance and enhance students' relationships. In Jordan, [72] found that integrating hypermedia with robots enhances the acquisition of physical concepts among primary students.

2.3 Hypermedia and learning science subjects

Researchers recognized hypermedia in the educational field as an effective technological tool and considered it an extension of multimedia. Hypermedia is a combination of hypertext and multimedia elements [8]. It is also defined as storing and organizing elements that include text, images, sound, and animation in a complex way that allows nonlinear navigation [73]. Hypermedia is an effective technique for recognizing learners' differences such as learning styles and abilities [74].

The literature on hypermedia reports several benefits of using it in education, such as supports: Individual, constructivist, and Collaborative learning [75]. Hypermedia could take into account individual differences and stimulate students' motivation toward learning [76]. Further, it supports various skills such as metacognition, planning and control skills, self-regulated learning, students' independence, and problem-solving skills [1], [77-79]. Besides this, it has all the educational advantages of multimedia [75]. Theng [80] indicated that designing successful learning experiences in a hypermedia environment requires the designer of hypermedia to achieve the principles of desire to learn, learning by doing, providing feedback, and easing content comprehension [11]. Furthermore, [10] stated that hypermedia designers should consider the cognitive pattern because independent students require higher levels of control while browsing the hypermedia environment, whereas students who are dependent on their learning require support, such as more guidance while browsing. Other researchers proposed principles for designing instructional hypermedia to help designers simulate students' learning patterns [11]. Thus, to take advantage of the capabilities of hypermedia in the educational process, the designer of educational hypermedia must take advantage of the technical capabilities and take into account the challenges facing the hypermedia learning environment. As a result, educators should use well-designed hypermedia that adheres to instructional hypermedia principles because hypermedia design is the foundation of being an effective learning tool or causing students to lose focus and attention, distracting them from learning and increasing their cognitive load.

Researchers conducted studies that investigated the impact of integrating hypermedia in several disciplines [81. For example, [82] conducted pre-experimental research using one group design to study the impact of using hypermedia on students' attitudes toward learning physics and problem-solving skills. The study involved thirty-one students from Universitas Muhammadiyah Makassar. The results revealed that hypermedia improved students' problem-solving skills and they were happy with using it in

physics learning. Further, [83] directed a study to reveal the impact of inquiry-based hypermedia on higher thinking skills among eleventh-grade students in physics. The study was based on a quasi-experimental method with dual design groups, including fifty-four students. The results revealed that hypermedia enhanced higher thinking skills as students had a positive response through learning using hypermedia. Also, [84] conducted a study in Nigeria to investigate the impact of hypermedia on the academic performance of high school students in chemistry. The research follows quasi-experimental methods and found that hypermedia improves academic performance in chemistry and makes it more enjoyable. Further, [85] conducted qualitative research that studied the intervention of hypermedia based on VARK (visual, aural, read/write, and kinesthetic) learning styles in science education. It specified that taking into account pedagogy and differences in learning styles is very important to simplify students' acquisition of meaningful knowledge. In addition to that, the study by [12] revealed a positive impact of using hypermedia on the acquisition of scientific concepts among primary students in Jordan. Despite the importance of integrating robots and hypermedia into teaching and learning processes, there is no previous study that investigated their impact on primary students' intrinsic motivation towards learning science, this highlighted the need to conduct such a study, especially in an Arabian context.

In light of the above literature review and theoretical framework, the conceptual framework of this research was formulated and displayed in Figure 1. This study hypothesized that students' intrinsic motivation to learn science could be enhanced using good instruction and practice (ie. employing robots with hypermedia) that supports students' basic psychological needs such as autonomy, relatedness, and competence.

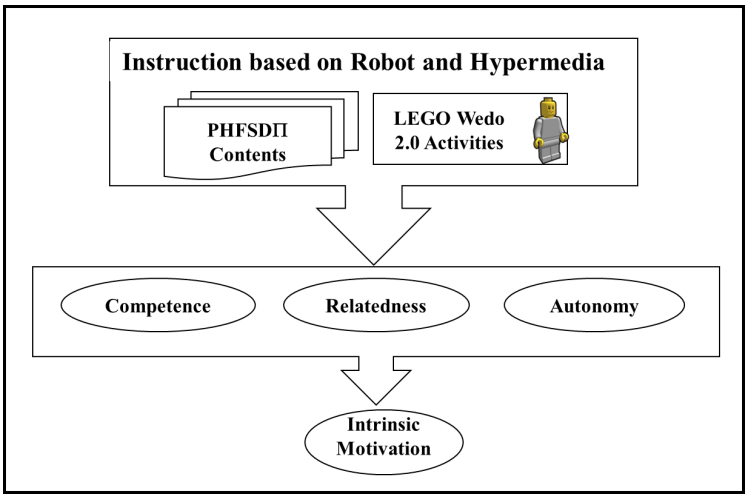

Fig. 1. Conceptual framework of the research

3 Methodology

The study implemented the quasi-experimental approach with a design of dual groups. The study sample was comprised of fifty students from grade five in one of the private schools in Amman. Their age ranged from 10–11 years on average. They were all female students. The private school was purposefully selected concerning the availability of required equipment, such as Wi-Fi and a smartboard. The pilot sample is comprised of forty-five fifth-grade students from another private school located in Amman. After getting permission from the Jordanian Ministry of Education, the study was conducted in the 2019-2020 school year.

The dependent variable of the study is student intrinsic motivation to learn science, while the independent variables are the instructional methods (traditional vs. LEGO WeDo 2.0 robotics and Hypermedia). The SPSS software was used to analyze the data and see how the instruction-based LEGO WeDo 2.0 robotics and Hypermedia affected students' motivation to learn science.

Two classes were randomly assigned into experimental groups (n=25) studied using instruction-based LEGO WeDo 2.0 robotic and Hypermedia and a control group (n=25) studied using traditional instruction. The Motivation Towards Learning Science (MTLSS) was applied to the members of groups before and after instruction on the topic of force and motion. Both groups were taught by the same science teacher for 18 hours over 2 months.

The robot used in this study is the LEGO WeDo 2.0 robotic kit, which is a suitable type of educational robot for students who do not have any experience in robotics and programming. Students use WeDo 2.0 Software to program and control the robot, which is a visual way of coding appropriate for primary students that depend on dragging icons and dropping them. The LEGO WeDo 2.0 robotic kit contains a Smart hub, a motor, a motion sensor, a tilt sensor, and 280 bricks. The robot activities used in this study were developed by [86]. It aligned with the science curriculum for the Ministry of education in Jordan. It was reviewed and approved by an expert as it was implemented on a pilot sample. It's effective in acquiring scientific concepts [72]. Each robotic activity contains worksheets, manuals, and reflection tasks. Besides this, the hypermedia used in this study is PHFSD∏, which was developed by [87] to teach the topic of force and motion to fifth-grade students. It was developed based on the science curriculum of the Ministry of Education in Jordan; PHFSD∏was designed according to the 6-D model. It has a very good quality [87] and is effective in acquiring scientific concepts [12]. It includes multi-content representations, non-linear control, as well as remedial and enrichment plans. Each lesson includes a set of instructional elements such as interactive presentations, instructional videos and games, a glossary, and assessments as well as group-based activities. It includes all the necessary materials, such as remedial, enrichment, and prerequisite.

Students who belong to the control group learn according to the traditional instruction method using science textbooks, paper-based worksheets, and science laboratory tools. They are learned in small groups during science class sessions. The science instructor used the smartboard for writing and presenting videos. While students who belong to an experimental group learn using the instruction-based LEGO WeDo 2.0

robotic and hypermedia, the students use PHFSD∏ nested within a science textbook. The instructor's role in the experimental group was restricted to facilitating the learning process through questioning, discussion, and help. The students were active and led the learning process, in which they can access PHFSD∏ at any time; they can use it outside the class sessions as well to recall their prerequisite knowledge, use enrichment materials, or practice. Students can use it according to their own learning pace. During class sessions, students learn in small groups, where each group has a LEGO WeDo 2.0 robotic kit and a tablet to access the PHFSD∏. Students work cooperatively to design, build, and program the robot and solve the worksheets.

3.1 Study instrument

The IMTLSS was developed based on literature related to intrinsic motivation and relevant motivation toward science scales [88-93]. It consisted of 23 items that measure the construct of students' intrinsic motivation toward learning science. It adopted the 4-Likert scale and requires approximately 35 minutes to respond to its items. The mean values of IMTLSS scores ranged between 1.0 and 2.0, representing a low level of motivation to learn science, 2.01–3 representing a moderate level, and 3.01–4.0 representing a high level.

The content validity of the IMTLSS was ensured by a panel of experts. The internal construction validity and reliability were also confirmed by administering the IMTLSS to a pilot sample of 45 primary students. Table 1 shows that the Pearson correlation coefficients (PCC) between each item and the total IMTLSS score ranged between 0.30 and 0.82 and were all significant. These results prove the internal consistency of IMTLSS. Also, researchers confirmed the reliability of the scale using the test-retest method. The PCC between the test and retest of Cronbach's alpha was 0.93. These values indicate that the IMTLSS is a reliable and valid scale.

Table 1. The Pearson correlation coefficients between each item and the total score of MTLSS

Item	PCC with a total score	Item	PCC with a total score
1	0.60**	13	0.80**
2	0.71**	14	0.82**
3	0.56**	15	0.68**
4	0.63**	16	0.64**
5	0.78**	17	0.72**
6	0.61**	18	0.60**
7	0.36*	19	0.36*
8	0.66**	20	0.65**
9	0.60**	21	0.71**
10	0.66**	22	0.73**
11	0.53**	23	0.30*
12	0.62**		

*: significant at $p<0.05$, **: significant at $p<0.01$.

3.2 Data analysis

The research question was answered by extracting the descriptive statistics and performing an ANCOVA test to inspect the impact of the instruction-based LEGO WeDo 2.0 robotic and hypermedia on developing intrinsic motivation toward learning science. The researcher extracted the Eta square to find out the effect size of the instructional method. The statistical analysis was performed using the SPSS program.

4 Results and discussion

To answer the research question: RQ: Are there significant differences in the development of intrinsic motivation towards learning science attributable to the instructional method instruction-based LEGO WeDo 2.0 robotic and Hypermedia vs. traditional) at the significance level ($\alpha < 0.05$)? The descriptive statistic Means and Standard deviations) of the study groups' responses on IMTLSS before and after the instruction, were extracted, and then ANCOVA analysis was performed. The two study groups' responses to IMTLSS before and after instruction are shown in Table 2.

Table 2. The descriptive statistics of Study Groups' Scores on MTLSS before and after the instruction

Group	Before Instruction	After Instruction
	M* ± *SD	***M* ± *SD***
Experimental (n=25)	2.9 ± 0.36	3.20 ± 0.24
Control (n=25)	2.9 ± 0.26	2.86 ± 0.25

Note. M: mean, SD: Standard Deviations.

The results presented in Table 2 indicate that the student's intrinsic motivation levels for learning science for the two study groups before the instruction were similar, as the mean of the control group's scores on the IMTLSS was similar to that of the experimental group, which reached (2.9). The means of the IMTLSS scores for both groups after the instruction showed that there were apparent differences in the students' intrinsic motivation level, as the mean for the members of the experimental group that learned using LEGO WeDo 2.0 robotic and hypermedia instruction was (3.20), with a difference of (0.34) score in favor of the experimental group students. The ANCOVA method was used to determine whether the differences in mean values between the two groups are statistically significant at the level ($\alpha < 0.05$). Also, the Eta square was extracted to know the effect size of the instructional method on developing intrinsic motivation towards learning science. Table 3 shows the ANCOVA results.

Table 3. ANCOVA analysis of Study Groups' Scores on IMTLSS after instruction

Source of Variation	Sum Square	Df	Mean Square	F	Sig	(η2)
Before Instruction	2.475	1	2.475	343.444	0.000	0.880
Instructional Method	1.444	1	1.444	200.420	0.000	0.810
Error	0.339	47	0.007			
Adjusted Total	4.236	49				

Note. Sig: significant, Df: degrees of freedom, F: F-test, and η2: Eta square.

Table 3 shows that students' IMTLSS scores after instruction differ significantly ($\alpha < 0.05$) between instructional methods ($F = 200.420$, $P = 0.000$), indicating that instructional methods influence students' intrinsic motivation to learn science. It was also clear from the data in Table 3 that there was an effect of the instructional methods on the intrinsic motivation towards learning science, as the Eta square amounted to (0.81), which indicates that 81% of the variation in the intrinsic motivation towards learning science among the study groups is attributable to the method of instruction. To find out which instructional methods were favored, the adjusted means of two study groups' scores on IMTLSS after the instruction were extracted and appear in Table 4.

Table 4. Adjusted Means and Standard Errors of IMTLSS Scores after instruction

Group	AM	SE
Experimental	3.20	0.02
Control	2.86	0.02

Note. SE: Standard Error and AM: Adjusted Means.

It was found that the adjusted mean of IMTLSS for students in the experimental group was (3.20), which is greater than the students in the control group who learned in the traditional method (2.86). It means that the experimental group's students who learned using the LEGO WeDo 2.0 robotic and hypermedia kit had a higher level of motivation. This indicates that the use of LEGO WeDo 2.0 robotic and Hypermedia in science instruction has a positive impact on raising the level of students' intrinsic motivation towards learning science.

The researcher attributes this positive impact to a set of factors, most notably that the instruction-based LEGO WeDo 2.0 robotic and hypermedia provides an active technological learning environment that supports basic psychological needs (ie. autonomy, competent, relatedness) that stimulates students' intrinsic motivation to learn science. First, the robot activities include experiences based on team and group work. These activities provide a cooperative working environment that satisfies students' needs for relatedness, so they can communicate and interact with each other and with the environment around them. Satisfaction of relatedness contributes to enhanced self-determination among students that improve students' intrinsic motivation [33-34]. Additionally, Hypermedia provides nonlinear navigation that provides the ability to move between the learning contents, allowing students to learn according to their abilities. For example, students can replay any part of the videos and instructional games until they master and understand the relevant content which supports their need for competence. Moreover, hypermedia provides multiple content representations that evoke visual and

audio channels that minimize their cognitive load and facilitate their learning [94]. Hypermedia also provides simulation for abstract physical concepts that help primary students in their concrete operations stage to comprehend and learn the concepts effectively [21,39]. The verbal reinforcement methods contained in the hypermedia elements, games, lessons, and computerized tests encourage students to continue the learning process and move forward with it, which contributes to enhancing their competence needs and then raising their intrinsic motivation to learn science. Moreover, hypermedia provides several options for control and opportunities to repeat the instructional elements, such as games, videos, exercises, and computerized tests, which contribute to raising their self-efficacy and competence in learning science, this helps make an individual more intrinsically motivated [35-37].

The hypermedia and robotic activities provide multiple opportunities for choice and flexibility that support the need for autonomy. Also, Hypermedia provides multiple content representations, alternative elements, additional links, and various methods of navigation and control that allow students to participate in the choice of representation of content that is consistent with their learning style and to choose the learning time. Students have the option to learn at the time and place they want, and we provide them with diversified content, which encourages them to engage in self-learning and supports their autonomy, which contributes to raising motivation, as it is one of an individual's basic psychological needs [35-37]. On the other hand, the robot activities provide students with several options to choose their group and role, as well as to think freely about doing tasks, including designing, building, and programming the robot to find the optimal solution. Freedom of choice motivates students to learn and keep trying until they reach their goals, and it also helps them learn how to learn on their own [95]. These factors support satisfying the basic psychological needs of the students which in turn makes them more intrinsically motivated.

This finding is in line with the results of previous studies [65-70] that found the use of robots in learning science had a positive attitude among students, fueled motivation, and enhanced interest and scientific curiosity. Also, this result is consistent with the findings by [82-84] that revealed employing hypermedia in learning science had a positive impact where the students had a positive response through learning with hypermedia, enjoyed learning, and became happy. So, the instruction-based robot and hypermedia make it more motivated for primary school students to learn science.

5 Conclusions

The novelty of this study is that it is the first one that investigates the impact of using LEGO WeDo 2.0 robotic and hypermedia instruction in developing intrinsic motivation toward learning science. It has contributed to filling a gap in educational literature related to intrinsic motivation to learn science. The study was applied to fifty students from a grade five private school located in Jordan. The study implemented a quasi-experimental design with dual groups. The control group learned the subject of force and motion using traditional instruction, whereas the students of the experimental group

learned the same topic using LEGO WeDo 2.0 robotic and PHFSD∏. The study's findings proved the existence of a significant impact of using instruction-based LEGO WeDo 2.0 robotic and Hypermedia in developing the intrinsic motivation toward learning science.

Employing an educational robot with hypermedia in science learning provided incredible educational benefits that combined the advantages of hypermedia and educational robots. It gave students a fun and active place to learn science by giving them many options for how they wanted to learn, taking into account their different learning styles and abilities, their independence in learning, and raising their autonomy and competence. All of these things helped students meet their basic psychological needs, which made them intrinsically motivated to learn science.

The study's limitations related to the study sample were first, the sample size was 50 students from one private school. second, the sample of the study is comprised of female students only because most schools in Jordan separate male and female students according to the culture of Jordanian society. These limitations encourage researchers in the field of education to repeat the study on male students and to conduct further studies that examine the impact of using hypermedia and robots in developing intrinsic motivation toward learning science among other samples.

The findings of the study encourage science teachers to employ LEGO WeDo 2.0 robotic and Hypermedia to enhance students' intrinsic motivation. The results of the study also provide information for decision-makers in educational institutions that helps them make decisions related to the science curriculum and its instructional methods.

6 References

[1] Negovan, V. & Bogdan, C. (2013) Learning Context And Undergraduate Students' Needs For Autonomy And Competence, Achievement Motivation And Personal Growth Initiative. Procedia-Social And Behavioral Sciences, vol.78, p. 300-304. https://doi.org/10.1016/j.sbspro.2013.04.299

[2] Al-Zogoul, I. (2020). Principles of Educational Psychology", Amman: Dar Al-Masirah.A..

[3] Olimat, (2019). The effect of electronic bags on learning motivation and achievement in science for eighth grade students in Jordan, Journal of Educational Sciences Studies, vol. 46, no. 1, p.629-643.

[4] Kalogiannakis, M. & Papadakis, S. & Zourmpakis, A.-I. (2021). Gamification in Science Education. A Systematic Review of the Literature. Educ. Sci. 11, 22. https://doi.org/10.3390/educsci11010022

[5] Chambers, M., Carbonaro, M. & Murray, H. (2008). Developing conceptual understanding of mechanical advantage through the use of Lego robotic technology." Australasian Journal of Educational Technology 24.4. https://doi.org/10.14742/ajet.1199

[6] Taylor, K. (2016). Collaborative robotics, more than just working in groups: Effects of student collaboration on learning motivation, collaborative problem solving, and science process skills in robotic activities.

[7] Moshe, B. & Zadok, Y. (2007). Robotics Projects and Learning Concepts in Science, Technology and Problem Solving." International Journal of Technology and Design Education 19.3: 289–307. https://doi.org/10.1007/s10798-007-9043-3

[8] Tahmasebi, M., Fotouhi, F. & Esmaeili, M. (2019). Hybrid Adaptive Educational Hypermedia Recommender Accommodating User's Learning Style And Web Page Features. Journal Of AI And Data Mining, vol. 7, no. 2, p. 225-238.
[9] Khanlari. A. (2013). Effects of educational robots on learning STEM and on students' attitude toward STEM. 2013 IEEE 5th conference on engineering education (ICEED). IEEE. https://doi.org/10.1109/ICEED.2013.6908304
[10] Chen, S. (2002). A Cognitive Model For Non–Linear Learning In Hypermedia Programmes". British Journal Of Educational Technology, vol.4, p 449-460. https://doi.org/10.1111/1467-8535.00281
[11] Garzotto, F., Retalis, S., Tzanavari, A. & Cantoni, I. (2004). From pedagogical paradigms to hypermedia design patterns: Where to start? EdMedia+ Innovate Learning, 4221-4226.
[12] Ajlouni, A. & Jaradat, S. (2020). The Effect of Pedagogical Hypermedia on Acquisition of Scientific Concepts among Primary School Students, International Journal of Education and Practice, 8(3), pp. 615–624. https://doi.org/10.18488/journal. 61.2020.83.615.624
[13] Azevedo. R. (2008). The role of self-regulated learning about science with hypermedia. Recent innovations in educational technology that facilitate student learning.: 127-156.
[14] Aksit, O., & Wiebe, E. N. (2020). Exploring force and motion concepts in middle grades using computational modeling: A classroom intervention study. Journal of Science Education and Technology, 29(1), 65-82. https://doi.org/10.1007/s10956-019-09800-z
[15] Amin, B. D., & Mahmud, A. (2016). The Development of Physics Learning Instrument Based on Hypermedia and Its Influence on the Student Problem Solving Skill. Journal of Education and Practice, 7(6), 22-28.
[16] Zaytoun, A. (2010). Contemporary global trends in science curricula and teaching, Amman: Dar Al-Shorouk Publishing.
[17] Brígido, M., Borrachero, A. B., Bermejo, M. L., & Mellado, V. (2013). Prospective primary teachers' self-efficacy and emotions in science teaching. European journal of teacher education, 36(2), 200-217. https://doi.org/10.1080/02619768.2012.686993
[18] Sjøberg, S., Schreiner, C. (2012). Results and Perspectives from the Rose Project. In Science Education Research and Practice in Europe; Sense Publishers: Rotterdam, The Netherlands; pp. 203–236. https://doi.org/10.1007/978-94-6091-900-8_9
[19] Martin, M. O., Mullis, I. V. S., Foy, P & Hooper,.M.(2016). TIMSS 2015 International Results In Science". Retrieved From Boston College, TIMSS & PIRLS International Study Center, Retrieved March, 2019, From: Http://Timssandpirls.Bc.Edu/Timss2015/International-Results.
[20] Adas, A., & Qatami, Y. (2008). Educational Psychology", Jordan, Amman: Dar Al-Fikr.
[21] Ghazi, S. R., Khan, U. A., Shahzada, G., & Ullah, K. (2014). Formal Operational Stage of Piaget's Cognitive Development Theory: An Implication in Learning Mathematics. Journal of Educational Research (1027-9776), 17(2).
[22] Amrai, K., Motlagh, S. E., Zalani, H. A., & Parhon, H. (2011). The relationship between academic motivation and academic achievement students. Procedia-Social and Behavioral Sciences, 15, 399-402. https://doi.org/10.1016/j.sbspro.2011.03.111
[23] Bzuneck, J.A. (2001). Motivação Do Aluno: Aspectos Introdutórios. In E. Boruchovitch & J. A. Bzuneck (Orgs.), A Motivação Do Aluno: Contribuições Da Psicologia Contemporânea, 3, 9-36.
[24] Beluce, A. C., & Oliveira, K. L. D. (2015). Students' motivation for learning in virtual learning environments. Paidéia (Ribeirão Preto), 25, 105-113. https://doi.org/10.1590/1982-43272560201513

[25] Gopalan, V., Bakar, J. A. A., & Zulkifli, A. N. (2020). A review of motivation theories, models and instruments in learning environment. Journal of Critical Reviews, 7(6), 554-559. https://doi.org/10.31838/jcr.07.06.100
[26] Guay, F., Chanal, J., Ratelle, C. F., Marsh, H. W., Larose, S., & Boivin, M. (2010). Intrinsic, identified, and controlled types of motivation for school subjects in young elementary school children. British journal of educational psychology, 80(4), 711-735. https://doi.org/10.1348/000709910X499084
[27] Georgiou, Y., & Kyza, E. A. (2018). Relations between student motivation, immersion and learning outcomes in location-based augmented reality settings. Computers in Human Behavior, 89, 173-181. https://doi.org/10.1016/j.chb.2018.08.011
[28] Rahardjo, A., & Pertiwi.S. (2020). Learning motivation and students' achievement in learning English." JELITA 1.2: 56-64.
[29] Tokan, M. K., & Imakulata, M. M. (2019). The effect of motivation and learning behaviour on student achievement. South African Journal of Education, 39(1). https://doi.org/10.15700/saje.v39n1a1510
[30] Gopalan, V., Bakar, J. A. A., Zulkifli, A. N., Alwi, A., & Mat, R. C. (2017, October). A review of the motivation theories in learning. In AIP Conference Proceedings (Vol. 1891, No. 1, p. 020043). AIP Publishing LLC. https://doi.org/10.1063/1.5005376
[31] Nawfal, M. (2011). Differences in learning motivation based on the theory of self-report among a sample of students in educational sciences faculties in Jordanian universities", An-Najah University Journal for Research - Humanities, 25(2).
[32] Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American psychologist, 55(1), 68. https://doi.org/10.1037/0003-066X.55.1.68
[33] Behzadnia, B., & FatahModares, S. (2020). Basic psychological need-satisfying activities during the COVID-19 outbreak. Applied Psychology: Health and Well-Being, 12(4), 1115-1139. https://doi.org/10.1111/aphw.12228
[34] Beluce. A. & Oliveira. K. (2015). Students' Motivation for Learning in Virtual Learning Environments. Paidéia,Ribeirão Preto, 25 (60), 105-113. https://doi.org/10.1590/1982-43272560201513
[35] Olafsen, A. H., Deci, E. L. & Halvari H. (2018). Basic Psychological Needs and Work Motivation: A Longitudinal Test of Directionality". Motivation and Emotion, 42(2), 178- 189. https://doi.org/10.1007/s11031-017-9646-2
[36] Sheldon, K. & Filak,V. (2008), Manipulating Autonomy, Competence, and Relatedness Support in a Game-Learning Context: New Evidence that all Three Needs Matter, British Journal of Social Psychology, 47 (2), 267-283. 2008. https://doi.org/10.1348/014466607–X238797
[37] Erfan, M. & Ratu, T. (2018). Analysis of student difficulties in understanding the concept of newton's Law of Motion, JIP. 3, (1). https://doi.org/10.26737/jipf.v3i1.161
[38] Mufit, F.(2019). A study about understanding the concept of force and attitude towards learning physics on first-year students in the course of General Physics; As preliminary investigation in development research," INA-Rxiv. https://doi.org/10.31227/osf.io/8n6ep
[39] S. R. Ghazi, K. Ullah, and F. A. Jan, " Ghazi, S. R., Khan, U. A., Shahzada, G., & Ullah, K. (2014). Formal Operational Stage of Piaget's Cognitive Development Theory: An Implication in Learning Mathematics. Journal of Educational Research (1027-9776), 17(2).
[40] Kommers, P. (2004), Cognitive support for learning: Imagining the unknown. IOS Press.
[41] Badeleh. A. (2019). The Effects Of Robotics Training On Students' Creativity And Learning In Physics. Education And Information Technologies, 1-13., 2019.

[42] Ferrarelli, Paola, and Luca Iocchi. (2021). Learning Newtonian Physics through Programming Robot Experiments. Technology, Knowledge and Learning 26.4: 789-824. APA. https://doi.org/10.1007/s10758-021-09508-3
[43] Kim, C., Yuan, J., Kim, D., Doshi, P., Thai, C. N., Hill, R. B., & Melias, E. (2019). Studying the usability of an intervention to promote teachers' use of robotics in STEM education. Journal of Educational Computing Research, 56(8), 1179-1212. https://doi.org/10.1177/0735633117738537
[44] Pang, Y. J., Hussin, H., Tay, C. C., & Ahmad, S. S. S. (2019). Robotics Competition-Based Learning For 21st Century STEM Education. Journal of Human Capital Development (JHCD), 12(1), 83-100.
[45] Raucci. R. (1999). Personal Robotics. Natick, Massachusettes: A.K. Peters.
[46] Walker, P. M. (1988). Chambers science and technology dictionary.
[47] Jung, S. E., & Won, E.S. (2018). Systematic review of research trends in robotics education for young children, Sustainability. 10(4), p. 905, https://doi.org/10.3390/su10040905
[48] Catlin, D., Kandlhofer, M., Holmquist, S., Csizmadia, A. P., Angel-Fernandez, J., & Cabibihan, J. J. (2018). Edurobot Taxonomy And Papert's Paradigm. In Constructionism 2018: Constructionism, Computational Thinking And Educational Innovation. Faculty Of Philosophy Vilnius University, Vilnius, Lithuania, 20 Aug 2018 -25 Aug 2018.
[49] Scaradozzi, D., Screpanti, L., & Cesaretti, L. (2019). Towards a definition of educational robotics: a classification of tools, experiences and assessments. In Smart learning with educational robotics (pp. 63-92). Springer, Cham. https://doi.org/10.1007/978-3-030-19913-5_3
[50] Catlin, D., & Blamires, M. (2010). The Principles of Educational Robotic Applications (ERA): A framework for understanding and developing educational robots and their activities. The 12th EuroLogo Conference.
[51] Barker, B. S., & Ansorge, J. (2007). Robotics as means to increase achievement scores in an informal learning environment. Journal of research on technology in education, 39(3), 229-243. https://doi.org/10.1177/0735633117738537
[52] Athanasiou, L., Mikropoulos, T. A., & Mavridis, D. (2018, June). Robotics interventions for improving educational outcomes-A meta-analysis. In International Conference on Technology and Innovation in Learning, Teaching and Education (pp. 91-102). Springer, Cham. https://doi.org/10.1007/978-3-030-20954-4_7
[53] Johnson, J. (2003). Children, robotics, and education. Artificial Life and Robotics, 7(1), 16-21. https://doi.org/10.1007/BF02480880
[54] McGill, M., (2012). Learning to program with Personal Robots: Influences on student motivation, ACM trans. comput. educ., 12(1), pp. 1–32. https://doi.org/10.1145/2133797.2133801
[55] Falah, B., & Noreddine, H. (2017). Pedagogical Robotics–A Way to Experiment and Innovate in Educational Teaching in Morocco. International Journal of Education and Learning Systems, 2.
[56] Eguchi, A., (2015). Integrating educational robotics to enhance learning for gifted and talented students, in Human-Computer Interaction, IGI Global, pp. 1467–1495. https://doi.org/10.4018/978-1-4666-8789-9.ch071
[57] Toh, L. P. E., Causo, A., Tzuo, P. W., Chen, I. M., & Yeo, S. H. (2016). A review on the use of robots in education and young children. Journal of Educational Technology & Society, 19(2), 148-163.
[58] Ro, D., et al., (2015). Inirobot: A Pedagogical Kit to Initiate Children to Concepts of Robotics and Computer Science.

[59] Papadakis, S., & Kalogiannakis, M. (2022). Learning computational thinking development in young children with Bee-Bot educational robotics. In Research Anthology on Computational Thinking, Programming, and Robotics in the Classroom (pp. 926-947). IGI Global. https://doi.org/10.4018/978-1-6684-2411-7.ch040

[60] Papadakis, S., Vaiopoulou, J., Sifaki, E., Stamovlasis, D., & Kalogiannakis, M. (2021). Attitudes towards the use of educational robotics: Exploring pre-service and in-service early childhood teacher profiles. Education Sciences, 11(5), 204. https://doi.org/10.3390/educsci11050204

[61] Sullivan, A., & Bers, M. U. (2016). Robotics in the early childhood classroom: learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade. International Journal of Technology and Design Education, 26(1), 3-20. https://doi.org/10.1007/s10798-015-9304-5

[62] Papadakis, S., & Orfanakis, V. (2018). Comparing novice programing environments for use in secondary education: App Inventor for Android vs. Alice. International Journal of Technology Enhanced Learning, 10(1-2), 44-72. https://doi.org/10.1007/s10798-015-9304-5

[63] Papadakis, S. (2018). Is pair programming more effective than solo programming for secondary education novice programmers?: A case study. International Journal of Web-Based Learning and Teaching Technologies (IJWLTT), 13(1), 1-16. https://doi.org/10.4018/IJWLTT.2018010101

[64] Papadakis, S., Vaiopoulou, J., Sifaki, E., Stamovlasis, D., Kalogiannakis, M., & Vassilakis, K. (2021, April). Factors That Hinder in-Service Teachers from Incorporating Educational Robotics into Their Daily or Future Teaching Practice. In CSEDU (2) (pp. 55-63). https://doi.org/10.5220/0010413900550063

[65] Souza, Isabelle ML, et al. (2018). A Systematic Review on the use of LEGO® Robotics in Education.2018 IEEE Frontiers in Education Conference (FIE). IEEE. https://doi.org/10.1109/FIE.2018.8658751

[66] Ferrarelli, Paola, and Luca Iocchi. "Learning Newtonian Physics through Programming Robot Experiments." Technology, Knowledge and Learning 26.4 (2021): 789-824. https://doi.org/10.1007/s10758-021-09508-3

[67] Usengül, L., & Bahçeci, F. (2020). The Effect of LEGO WeDo 2.0 Education on Academic Achievement and Attitudes and Computational Thinking Skills of Learners toward Science. World Journal of Education, 10(4), 83-93. https://doi.org/10.5430/wje.v10n4p83

[68] Seetala, N., & Jno-Baptiste, J. (2019). Building and programing robots–a group activity for enhanced learning of undergraduate general physics. in edulearn19 Proceedings, pp. 10470-10475. https://doi.org/10.21125/edulearn.2019.2638

[69] Arís, N., & Orcos, L. (2019). Educational robotics in the stage of secondary education: Empirical study on motivation and STEM skills. Education Sciences, 9(2), 73. https://doi.org/10.3390/educsci9020073

[70] Saad, D., & Verner, I. (2019). A Robotics Workshop Approach for Motivating Middle School Seniors to Study High School Physics. In EDULEARN19 Proceedings, pp. 4766-4773. https://doi.org/10.21125/edulearn.2019.1186

[71] Karahoca, Dilek, Adem Karahoca, and Hüseyin Uzunboylub. (2011). Robotics teaching in primary school education by project based learning for supporting science and technology courses. Procedia Computer Science 3: 1425-1431. https://doi.org/10.1016/j.procs.2011.01.025

[72] Ajlouni, A. O., & Jaradat, S. (2021). The Effect of Integrating an Educational Robot with Hypermedia on Students' Acquisition of Scientific Concepts: The Case of Fifth-Grade Students. International Journal of Interactive Mobile Technologies, 15(11). https://doi.org/10.3991/ijim.v15i11.18537

[73] Tahmasebi, M., Fotouhi, F., & Esmaeili, M. (2019). Hybrid Adaptive Educational Hypermedia Recommender Accommodating User's Learning Style and Web Page Features. Journal of AI and Data Mining, 7(2), 225-238.
[74] Mirzaeifard. S., (2018). Hypermedia Design. The TESOL Encyclopedia Of English Language Teaching, p. 1-6. https://doi.org/10.1002/9781118784235.eelt0413
[75] Mubarez, M., & Ismail, S. (2010). Multimedia Technology Applications, Amman, Jordan: Dar Al-Fikr.
[76] Al-Gharib, H., Saeed, A. & Hayat, M., (2012). The Impact of Blended Learning with Ultra-Media on Achievement and First Aid Skills for Students of the Department of Physical Education and Sports in the State of Kuwait", Information Studies, (13), 55-86.
[77] Sáiz-Manzanares, M. C., Marticorena-Sánchez, R., Díez-Pastor, J. F., & García-Osorio, C. I. (2019). Does The Use Of Learning Management Systems With Hypermedia Mean Improved Student Learning Outcomes?. Frontiers In Psychology, 10. https://doi.org/10.3389/fpsyg.2019.00088
[78] Azevedo, R., (2018). Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning." Educational psychologist. Routledge, 199-209. https://doi.org/10.1207/s15326985ep4004_2
[79] Amin, B. D., Haris, A., & Swandi, A. (2019). Implementation of physics learning based on hypermedia to enhance student's problem solving skill. International Journal of Teaching and Education, 7(2), 1-11. https://doi.org/10.20472/TE.2019.7.2.001
[80] Theng, Y. L. (1999). Better design and development of hypermedia materials for teaching and learning on the Internet. Internet-based Teaching and Learning (IN-TELE 98)., Peter Lang, Frankfurt/Main/Berlin/Bern/Brüssel/New York/Wien, 231-236.
[81] Vieira, A. I. D. C. (2016). Promoting self-regulation and mathematics achievement: the role of a hypermedia application (Doctoral dissertation).
[82] Amin, B. D., Haris, A., & Swandi, A. (2019). Implementation of physics learning based on hypermedia to enhance student's problem solving skill. International Journal of Teaching and Education, 7(2), 1-11. https://doi.org/10.20472/TE.2019.7.2.001
[83] Nurmalasari, M., & Hertanti, E. (2021, March). The effect of guided inquiry based hypermedia on students' high order thinking skills in thermodynamics concepts. In Journal of Physics: Conference Series (Vol. 1836, No. 1, p. 012062). IOP Publishing. https://doi.org/10.1088/1742-6596/1836/1/012062
[84] Abanikannda, M. O. (2019). Effectiveness of hypermedia and multimedia learning strategies on the academic performance of chemistry students in Nigeria. Labor et Educatio, (7), 201-214. https://doi.org/10.4467/25439561LE.19.011.11528
[85] Zulfiani, Z., Suwarna, IP., & Miranto, S. (2019). The use of pedagogical intervention in developing hypermedia science based on learning style', Empowering Science and Mathematics for Global Competitiveness: Proceedings of the Science and Mathematics International Conference, November 2-4, 2018, Jakarta, Indonesia, pp. 223-232. 2019. https://doi.org/10.1201/9780429461903-33
[86] Chiazzese, G., Arrigo, M., Chifari, A., Lonati, V., & Tosto, C. (2018, October). Exploring the effect of a robotics laboratory on computational thinking skills in primary school children using the bebras tasks. In Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality (pp. 25-30). https://doi.org/10.1145/3284179.3284186
[87] Ajlouni, O. A. (2020). The effectiveness of an instructional program based on using robot and hypermedia in acquiring scientific concepts and developing motivation towards learning science among fifth grade students in Jordan. Unpublished Doctoral Dissertation, the University of Jordan, Jordan.

[88] Ajlouni, O. A., & Jaradat, A. S. (2020). Teaching science with technology: A pedagogical hypermedia for the science discipline. International Journal of Psychosocial Rehabilitation, 8(24), 13900-13914.
[89] Ansiou, A., (2017). The impact of blended learning on the achievement of tenth grade students in life sciences in UNRWA schools in Jordan and their motivation towards learning", unpublished doctoral thesis, University of Jordan, Amman, Jordan.
[90] Al-Tabbaa,R., (2014). The impact of teaching biology on scientific activities and computer simulation on predictive thinking and motivation towards biology among ninth grade students in Jordan", unpublished doctoral thesis, Jordan University of Islamic Sciences.
[91] Tuan*, H. L., Chin, C. C., & Shieh, S. H. (2005). The development of a questionnaire to measure students' motivation towards science learning. International journal of science education, 27(6), 639-654. https://doi.org/10.1080/0950069042000323737
[92] S. Aydın, S., Yerdelen, S., Gürbüzoğlu, and V., Göksu. "Academic Motivation Scale for Learning Biology: A Scale Development Study." Education & Science/Egitim ve Bilim, 2014, 39, no. 176. https://doi.org/10.15390/EB.2014.3678
[93] Liu, Y., Ferrell, B., Barbera, J., & Lewis, J. E. (2017). Development and evaluation of a chemistry-specific version of the academic motivation scale (AMS-Chemistry). Chemistry Education Research and Practice, 18(1), 191-213. https://doi.org/10.1039/C6RP00200E
[94] Vallerand, R. J., Pelletier, L. G., Blais, M. R., Briere, N. M., Senecal, C., & Vallieres, E. F. (1992). The Academic Motivation Scale: A measure of intrinsic, extrinsic, and amotivation in education. Educational and psychological measurement, 52(4), 1003-1017. https://doi.org/10.1177/0013164492052004025
[95] Zumbach, J. & Mohraz, M. (2008). Cognitive load in hypermedia reading comprehension: Influence of text type and linearity," Comput. Human Behav., vol. 24, no. 3, pp. 875–887. https://doi.org/10.1016/j.chb.2007.02.015
[96] Sun, Yanyan, and Fei Gao. (2020). An investigation of the influence of intrinsic motivation on students' intention to use mobile devices in language learning." Educational Technology Research and Development 68.3. 2020: 1181-1198. https://doi.org/10.1007/s11423-019-09733-9

7 Author

Aseel Ajlouni is an assistance professor of Educational Technology in the department of curriculum and instruction at Al-Ahliyya Amman University. She earned her PhD in Educational Technology from the University of Jordan, Jordan in 2020. She has published several research papers on integrating technology in the classroom, online teaching and learning.

Article submitted 2022-09-27. Resubmitted 2022-11-04. Final acceptance 2022-11-14. Final version published as submitted by the author.

Depression Detection Through Smartphone Sensing: A Federated Learning Approach

https://doi.org/10.3991/ijim.v17i01.35131

Nawrin Tabassum(✉), Mustofa Ahmed, Nushrat Jahan Shorna,
MD Mejbah Ur Rahman Sowad, H M Zabir Haque
Ahsanullah University of Science and Technology, Dhaka, Bangladesh
nawrintabassum14@gmail.com

Abstract—Depression is one of the most common mental health disorders which affects thousands of lives worldwide. The variation of depressive symptoms among individuals makes it difficult to detect and diagnose early. Moreover, the diagnosing procedure relies heavily on human intervention, making it prone to mistakes. Previous research shows that smartphone sensor data correlates to the users' mental conditions. By applying machine learning algorithms to sensor data, the mental health status of a person can be predicted. However, traditional machine learning faces privacy challenges as it involves gathering patient data for training. Newly, federated learning has emerged as an effective solution for addressing the privacy issues of classical machine learning. In this study, we apply federated learning to predict depression severity using smartphone sensing capabilities. We develop a deep neural network model and measure its performance in centralized and federated learning settings. The results are quite promising, which validates the potential of federated learning as an alternative to traditional machine learning, with the added benefit of data privacy.

Keywords—depression prediction, federated learning, mHealth, smartphone sensors, data security

1 Introduction

Depression is a mental health illness that adversely affects how people think, feel, and behave. It causes them feelings of sadness and loss of interest in their daily activities. Depression also leads to various emotional and physical difficulties. It decreases a person's ability to function well at work [1] and at home [2]. These effects of depression lead to high societal [3] and economic burdens [4]. There was a 25% increase in depression and anxiety worldwide in the first year of the COVID-19 pandemic [5]. In 2018, the economic burden of depression for adults in the United States alone was $US 326.2 billion [6]. Even though depression is not curable [7], various treatments can minimize its adverse impacts. A recent study found that nearly 80% of people suffering from depression eventually respond well to treatment [8]. Early detection of depression followed by treatment also allows for a better prognosis [9].

A possible solution for the timely detection of depression can be achieved through smartphones. Smartphones have various built-in sensors that allow us to collect and interpret information about the users' social interactions, physical movements, and daily activities [10], [11]. A study revealed that an average user spends 145 minutes on their smartphones daily [12]. Considering the time a user spends on the smartphone combined with the ability of the smartphone to collect information, it is possible to detect depression severity in a person. As stated in [13], there had been a 79% increase in smartphone users in 2022 compared to 2016. This finding proves the scalability of using smartphones to detect depression severity in a person.

Traditional methods of diagnosing depression require filling out relevant questionnaires, face-to-face interviews, and more, which are prone to human errors. An example is when a doctor incorrectly judges a patient's mental state, as the symptoms shown by the patient are often inconsistent. Another source of error is that the patient fails to precisely recall how they have felt over a long period during self-reporting [14]. Apart from these scopes of errors, a considerable constraint that entails the traditional method is that it heavily relies on the people to initiate the treatment. However, a person undergoing depression feels hesitant to do so because they prefer being isolated during that phase. So, the traditional methods of diagnosing depression are highly unreliable.

Numerous research studies [15] – [20] successfully detected depression severity in a person using data collected through smartphones. However, apart from [17], these studies have not addressed the users' data privacy concerns. These studies used traditional machine learning approaches, which centralize users' private data. Building a good machine learning model depends on the amount and quality of data fed to the model. As our study is related to a person's mental health, it is of utmost importance to train a model using rich and diverse data that will accurately predict depression severity in a person. However, users' preference for sharing their private data for mHealth purposes varies depending on the collected data and the benefit they are receiving [21]. So, data privacy concerns hinder building a suitable model in practical cases. Hence, we need to find a strategy through which we can train a machine learning model without making the users concerned regarding their data privacy.

To overcome the data privacy gap, we used federated learning. Federated Learning (FL) is a privacy-preserving machine learning technique [22] that allows us to train a machine learning model without passing any raw data of the users to the central server. As the users' private data is never uploaded and can not be seen by the server, it resolves the data privacy concerns of the users. Another aim of our study is to compare the performance of a model that was trained using federated learning and centralized machine learning approaches. Although the authors at [17] have used federated learning on mobile data to predict depression severity, they only performed a simulation of federated learning using the TensorFlow Federated framework (TFF) [23]. The primary aim of our study is to fill this gap by showing a working demonstration of federated learning for mHealth purposes. We have developed an android application that will predict depression severity in a person using federated learning.

In our study, we determined the depression severity in a person by using 9-question Patient Health Questionnaire (PHQ-9) [24], which we considered to be the ground

truth. The PHQ-9 is a diagnostic tool used to identify the presence and severity of depression in a person. A total of 145 individuals participated in our study and were asked to complete the PHQ-9 questionnaire. The participants installed an android application through which passive sensor data were collected. Data were collected at regular intervals and stored in a real-time database. Federated Learning is an approach where we do not need to centralize the users' data. However, in our case, we centralized the users' data which allowed us to pre-train the global model before deploying it to the android smartphones. The federated learning application was developed using the Deep Learning for Java (DL4J) framework [25]. Our implementation is unlike any other existing studies, as they were limited to only performing a simulation of federated learning using the TFF.

The remaining paper is structured as follows: Section 2 contains the background study and relevant works. Section 3 gives an overview of data collection and data preprocessing. Section 4 contains the methodology of our study. Section 5 and Section 6 comprise the results and discussion respectively. Lastly, Section 7 concludes the paper.

2 Background

This section describes the core tools and approaches of our research. We further present a discussion on relevant studies and their shortcomings.

2.1 Artificial intelligence

The replication of human intelligence by machines, particularly computer systems, is referred to as artificial intelligence (AI). To replicate intelligent human behavior by automated means, researchers studying AI set out to understand the formal processes that went into games like chess, language processing, and medical diagnosis [26]. Three cognitive abilities – learning, reasoning, and self-correction are the main topics of AI programming [27]. A wide range of distinct sorts of technologies includes AI, such as machine learning (ML) – the technology of getting a computer to act without programming.

2.2 Machine learning

Machine Learning (ML) works by using data and algorithms to simulate how humans learn and gradually increasing the system's accuracy in identifying a pattern in data. ML has many fundamental strategies, and we have used supervised learning in our study. Developing algorithms for supervised machine learning involves taking samples from the outside world to create general patterns and hypotheses that can be used to anticipate how future samples will turn out [28]. Building a model for allocating class labels in respect of predictor features is the objective of supervised learning. If the predictor features are known and the value of the class label is unknown, the model can be used to predict class labels for the corresponding data [29].

2.3 Federated learning

Federated learning (FL) is a new field of study in AI for learning on decentralized data and is a privacy-preserving distributed ML paradigm. Decentralized algorithms were initially conceived to compute the mean of data collected from numerous edge devices [30]. FL provides a privacy-preserving mechanism to effectively leverage those decentralized computing resources inside end devices to train ML models. In FL, a central server connects with numerous clients such as smartphones, smart watches, IoT devices, etc. Globally, there are billions of these devices, and their combined computing power is much more than that of a sizable data center. As the availability of smartphones increases, the potential for FL increases as well. FL is a remarkably different ML approach that avoids collecting data in a centralized server. In traditional machine learning or deep learning (DL) pipelines, data are collected from numerous sources and kept in a central location, like data center. The traditional ML and DL models are trained from all the acquired data that are private and sensitive to the users. On the other hand, the users' sensitive data is safe in an FL setting. FL allows us to train an ML model using the users' data without disclosing any personal information. FL trains machine learning models using local data that are present in local nodes without explicitly exchanging the data samples.

Considering a standard FL network has three nodes and a single server. Here nodes are the smartphone devices having data and computational resources. Firstly, the server initializes a global model and sends it to the nodes. In some cases, the global model can be pre-trained using centralized data instead of random initialization. This global model is trained locally using each node's private data, and only the local update of the model is sent to the central server. Finally, the central server aggregates the updated model weights received from the nodes to generate a better model with high accuracy. These steps repeat and return better results with each iteration [31]. Depression detection requires dealing with the privacy-sensitive data of users. For this reason, we chose the federated learning approach that maintains users' privacy. This approach also cuts server and computational costs by transmitting only model parameters to the central server. A visual representation of federated learning is shown in Figure 1.

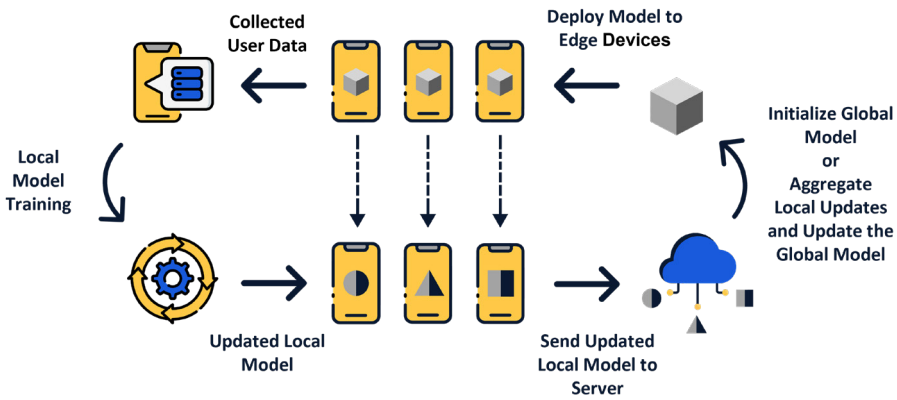

Fig. 1. Working flow of federated learning

2.4 Smartphone sensors, mHealth and PHQ-9

Android smartphones come with built-in sensors [32] that measure different useful parameters of a phone. For example, the accelerometer and the gyroscope can measure the smartphone's acceleration and angular rotational velocity, respectively. The gravity sensor determines the device's axes by interpreting the accelerometer and gyroscope data. Similarly, the magnetometer can detect the strength of the magnetic field. In our study, we used these four sensors to collect the data. Apart from these sensors, we also kept track of the battery level of the smartphones. The World Health Organization's Global Observatory for eHealth (GOe) addresses mHealth (mobile health) as a medical and public health practice assisted by mobile devices [33]. mHealth apps provide increased access to healthcare services and enhanced interaction with medical experts. The Patient Health Questionnaire (PHQ-9) is a measure used to test the presence and severity of depression and assess treatment response. The questions concern feeling down or depressed, sleeping difficulties, eating habits, self-perception, suicidal thoughts, etc. Each response group receives a score of 0, 1, 2, or 3 [34]. The overall score is computed by summing the results of the nine questions. Anyone scoring above the threshold on this scale should consult a doctor or a mental health practitioner [35].

2.5 Related works

There exist various successful studies that have used the data collected from smartphones to detect the presence of depression in a person. Using the data collected from smartphones, the authors in [15] found that students who slept less and engaged in fewer and shorter conversations were more likely to be depressed. As stated in [36], the presence of depression is associated with low performance in language lessons. The authors at [37] used a different approach and found correlations similar to [15]. Instead of complete passive sensing using smartphones, they used active input

from users. This study also reported a strong correlation between depression severity in a person and voice diary sentiment. Although most studies used various sensors and required frequent user interaction, [19] and [20] used only GPS sensor data to predict depression severity in a person. Using the GPS sensor data and time, they derived numerous features like location variance, entropy, number of places visited by the user, and more. Data analysis of these derived features revealed some distinctive habits of people with different depression severity. Due to the rising concern of data privacy, the authors at [16] used less privacy-sensitive data like total daily mobile usage duration, the number of calls received, and more to predict depression severity in a person. Furthermore, this study revealed that including privacy-sensitive data like gender and age of the users' resulted in a better-performing machine learning model. This finding shows the importance of including privacy-sensitive data for mHealth purposes.

Many studies on areas other than mHealth have used the federated learning approach. For example, the authors have used federated learning on smartphone data to perform human activity recognition in [38]. The authors at [39] have applied federated learning to image and audio data collected using webcams and microphones, respectively, and predicted human emotion. Federated learning is also widely explored in the medical field. Data collected from patients are highly confidential, and in no circumstances can they be shared. However, to develop a good machine learning model, it is essential to train the model using data from various institutions. Federated learning makes it possible without centralizing the patients' privacy-sensitive data.

Despite federated learning being used widely in other areas, it is primarily untapped in mHealth. Apart from [17] and [40], very few studies on mHealth have used this privacy-preserving approach. Therefore, in our study, we have used the federated learning approach to fill the data privacy gap in the existing studies. Also, the mentioned studies are limited to using the TensorFlow Federated framework to perform only a federated learning simulation. These studies do not show any working demonstration or implementation of federated learning. So, it is not feasible to anticipate the performance of federated learning in practical cases from the findings of these studies. So, in our study, we have developed a federated learning application for android smartphones to predict the severity of depression in a person.

3 Dataset

This section contains a detailed description of how our data was collected and preprocessed.

3.1 Data collection

We employed an android application developed by the authors at [41] to collect data. A group of students from the Computer Science and Engineering department at Ahsanullah University of Science and Technology was recruited for data collection. The interested volunteers were provided with a Google Form link that contained the

PHQ-9 questionnaire and a Google Drive link to download the app. Sensor data was collected from their smartphones for two weeks. The app was running in the device's background, and readings from the accelerometer, gyroscope, gravity, and magnetometer sensors were taken once every five minutes. Then the data was uploaded and stored in a real-time database called Firebase. A total of 205 participants filled in the PHQ-9 questionnaire, of which only 145 downloaded the app. However, we accumulated sufficient data from only 80 volunteers. Around 90% of them were aged between 21-25. Amongst them, 66.25% of the participants were male, and the remaining 33.75% were female. So, the collected data was not from a diverse group. As shown in Figure 2, the dataset was also heavily imbalanced.

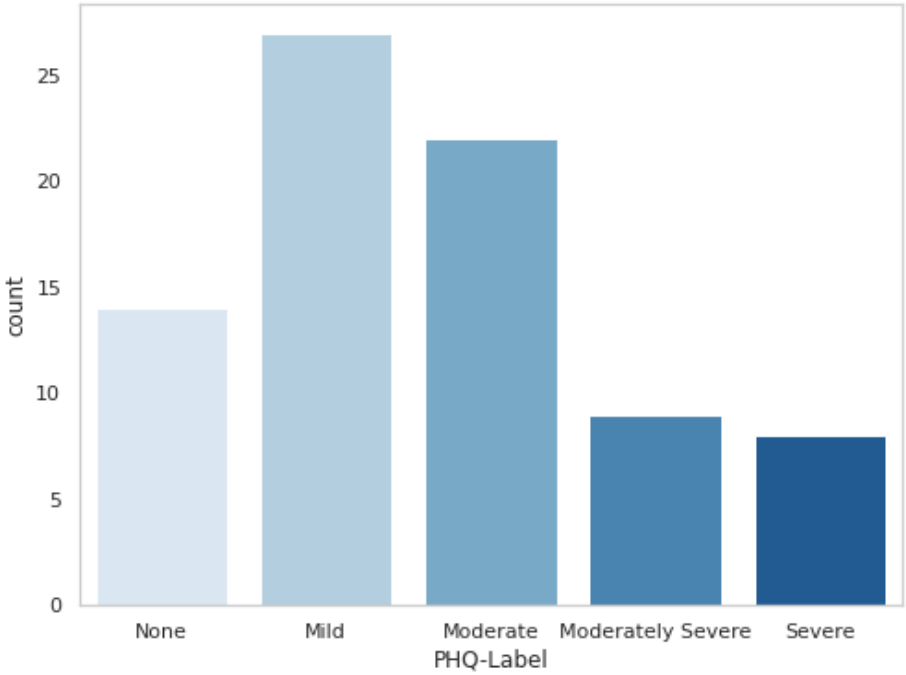

Fig. 2. Data distribution of PHQ-label

3.2 Data preprocessing

The data collected from the participants were stored in Firebase in JSON format. The data was then parsed into excel format with custom python scripts. As part of the data cleaning steps, we first removed the samples that contained invalid or too many missing values. We also considered a sample invalid if all the values from a particular sensor were 0. For example, we excluded the sample if the gravity sensor had a value of 0 on the x, y, and z-axis. In the next step, we standardized all the numeric features.

4 Methodology

In this section, we describe the methodology in detail. We further describe the working procedure of our federated learning app.

4.1 Fully connected neural network

A neural network has multiple hidden layers between input and output layers. Each layer is comprised of neurons connected to all the neurons in the next layer through a weighted link [42]. Using the input vector, each of these neurons applies a linear transformation through a weight matrix. This output then undergoes a non-linear transformation known as the activation function. The activation function determines whether the neuron should be activated or not. These steps are repeated for each neuron, and this whole process is known as forward propagation. During the training period of the neural network, the actual output is known, which helps the neural network to learn from the incorrect predictions it makes. The model's performance is evaluated based on the value calculated by the loss function. The loss function will show a higher number if the predictions are completely off. The backpropagation process then calculates the gradients for all the weights with respect to the loss function. Afterward, the optimizer uses the calculated gradient to adjust the neurons' weights. The amount of weight update is controlled by using a parameter known as the learning rate. If the value of the loss function diminishes as the neural network trains, it implies that the model's performance is improving. The neural network is trained using the same data many times. It is considered one epoch when the neural network is trained using the entire training data for one time. Within an epoch, the batch size is the number of training data samples the neural network trains on before the model weights are updated.

In our centralized neural network, we have used two hidden layers. The layers consisted of 500 and 1000 neurons, respectively. We chose *Softmax* and *Relu* activation functions for the output and hidden layers, respectively. Negative log-likelihood was used for calculating the loss. Finally, for adjusting the neural network weights, we chose the SGD optimizer, and the learning rate was set to 0.001. We trained the model for a total of 20 epochs, and the batch size we used was 8.

4.2 Transfer learning

The computation of a high number of parameters is necessary for training a neural network with several layers, which raises computational expense and energy use. Again, a significant quantity of data is required for training a large neural network. Sensor data collected in real-time for on-device training is quite limited and can not contribute significantly to training a complete deep model. The notion of transfer learning can be utilized to resolve this issue. Transfer learning uses a pre-trained model that has been trained on a big dataset, eliminating the need to train the model from scratch [43]. The pre-trained model's first few layers are fixed, and the remaining layers are fine-tuned for the specific task with the limited training data. So, we

trained a model using the data we acquired and used this model as the global model on the edge devices instead of applying random initial weights. Then local training is performed, and parameters are updated only for the last layer of the model. Transfer learning is ideal for mobile scenarios since it allows for the reduction of the training cost, an improvement in training speed, and a decrease in energy consumption.

4.3 Federated learning app

The application was built using Android Studio version 2021.2.1. To develop this app, we considered some frameworks such as TensorFlow Federated (TFF) [23], PySyft [44], and Deep Learning for Java (DL4J) [25]. Most of these frameworks lack the components required for the actual implementation of FL. In TFF and PySyft, data must be distributed from a central location rather than being directly collected from the edge devices for training. So, they mainly focus on performing a simulation and do not provide any client-server communication environment. In this study, our aim was to utilize real sensor data from smartphones and execute a client-server implementation of FL. So, we chose Deep Learning for Java (DL4J) as the framework for developing our android application (Figure 3). DL4J enables us to create and adjust a wide range of basic and complicated deep learning networks, as well as execute transfer learning in mobile devices. It comes with ND4J, a linear algebra library that simplifies mathematical and deep learning operations. In our work, we have employed version 1.0.0-beta4 of DL4J.

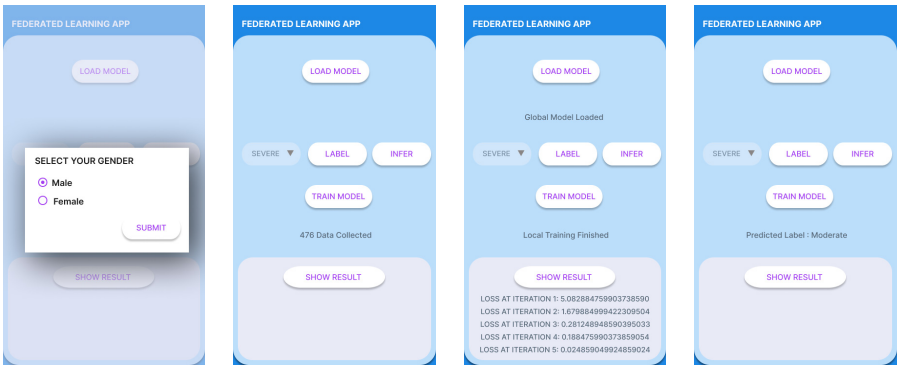

Fig. 3. Snapshot of our federated learning application

We selected five participants to train the local model on their devices. They received the app through a Google Drive link and installed it on their smartphones. To run the application, Android version 8.0 or higher is required. The app collects data from smartphone sensors and determines the depression severity of a user based on the collected data. Before the local training is carried out, the global model is used to make predictions. When the local training is completed, the prediction is performed based on the local model, providing the user with a more personalized result. Through the user's initiative to label the data, a new training dataset is stored in the device, and

then local training is performed. A batch size of 8 and an SGD optimizer with a learning rate of 0.001 are used as the hyperparameters. Local training is limited to one epoch to minimize the computational load on edge devices. To ensure data security, the local dataset is automatically deleted from the device after local training.

The communication method is implemented using Firebase. We have used Firebase cloud storage version 19.2.0 and Firebase real-time database version 19.4.0. The global weights saved in the Firebase are downloaded to the edge devices for local training. After the local training, the updated weights are uploaded back to Firebase. Then, FedAVG [45] is performed using Java to aggregate the local updates. FedAVG is an optimization technique that computes the average value of the local weights obtained from clients. Finally, the aggregated model is sent back to Firebase as the new global model. The communications are carried out for five rounds in this study, with five clients participating in each round. The complete client-server communication process is shown in Figure 4.

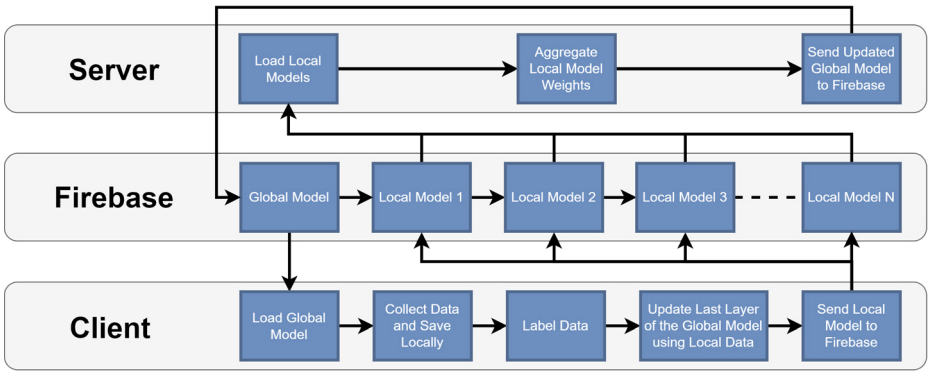

Fig. 4. Client-server communication architecture

5 Results

The findings of our experiment are described in this section. Before federated training, a centralized neural network was trained based on smartphone sensor data, and then prediction was performed on the test set. 20% of the data was utilized for testing, while 80% was used for training. To evaluate the model, we used accuracy, precision, recall, and F1-score as the performance metrics. Accuracy can be defined as how frequently the classifier makes the correct prediction. The ratio of samples that are accurately classified as positive to all the samples that are classified or misclassified as positive is known as precision. On the other hand, recall is the proportion of correctly categorized positive samples to all positive samples. F1-score is the harmonic mean of recall and precision. The model's performance was measured by accuracy, precision, recall, and F1-score using the test data after 20 epochs of training. The accuracy of the model was 0.68, and the precision, recall, and F1-score were 0.70, 0.48, and 0.52, respectively.

Local training was performed on five android devices through the app. Since smartphone sensors generate data at a relatively high frequency, gathering training data of a constant size is challenging. Hence, the training data size was different for the clients in our experiment. Each client used the same label in their respective training rounds to represent that each client had a particular level of depression severity. The performance of FL was evaluated using our test data. The accuracy, precision, recall, and F1 score of the global model were 0.65, 0.69, 0.46, and 0.47, respectively, after five training rounds. Table 1 presents the states of the global model after each round. FL showed some decline in performance due to the imbalanced and skewed dataset. However, the performance of FL was almost the same as that of centralized machine learning. The confusion matrixes of centralized machine learning and federated learning are presented in Table 2 and Table 3.

Table 1. Performance of the global model after each round

Performance Metrics	Round1	Round2	Round3	Round4	Round5
Accuracy	0.6854	0.6792	0.6661	0.6576	0.6517
Precision	0.6899	0.7146	0.7224	0.7110	0.6978
Recall	0.4844	0.4821	0.4793	0.4731	0.4665
F1-Score	0.5215	0.5139	0.5056	0.4914	0.4759

Table 2. Confusion matrix for the global model before federated training

		Predicted				
		None	Mild	Moderate	Moderately Severe	Severe
Actual	None	413	152	136	0	1
	Mild	55	1258	257	2	0
	Moderate	75	374	946	7	3
	Moderately Severe	7	58	23	33	0
	Severe	8	43	29	0	7

Table 3. Confusion matrix for the global model after federated training

		Predicted				
		None	Mild	Moderate	Moderately Severe	Severe
Actual	None	541	31	128	0	2
	Mild	218	894	460	0	0
	Moderate	192	136	1073	1	3
	Moderately Severe	43	28	32	18	0
	Severe	22	20	38	0	7

6 Discussion

6.1 Challenges of data collection

Data centralization is not required in real federated learning as model training takes place in edge devices. However, we gathered data from research participants for training a centralized deep learning model. Around 44% population dropped out of the data collection phase. They might have stopped contributing to the study out of concern for their data privacy. Again, the sensor data collector app needed to run continuously in the mobile background for data collection. Some participants might have forgotten to run the app, resulting in a high participant drop rate. We also asked the participants to fill up the PHQ-9 to acquire the ground truth of our study. Although the resulting score from this survey is self-reported, it is clinically tested and widely used for depression monitoring. It should be noted that instead of measuring the presence of depressive symptoms continuously, we assessed it once using PHQ-9. It is unlikely that the symptoms would change radically over the two weeks of the study.

6.2 Data representation

The sensor data derived from smartphones correspond to the motion and position of a person. Previous studies have shown that smartphone sensor data has a high potential for correctly predicting depression severity [15], [20]. Another key factor in determining the degree of depression is demographic data, such as age and gender [16], [18]. We collected the participants' age and gender information during the data collection phase. However, only gender was used as the demographic factor in the current study. Most of the participants were between the ages of 21 and 25, indicating that the data was not truly representative of all age groups. So, we decided to exclude the age of the participants from this study. Nonetheless, the results are positive, suggesting that combining only gender information with sensor data can assist in diagnosing depression. Only android users were the subject of our study, given that sensor data was collected from android smartphones, and an android app was developed to implement federated learning.

6.3 Advantages of pre-trained model

The centrally trained model was used as a pre-trained model for on-device training with local data. Federated learning involves refining a global model with local data to update the global model without sending data to the server. A pre-trained model eliminates the necessity of starting the training from scratch and results in fast convergence. In our experiment, we fixed the neural network's first three layers and only trained the last layer in the edge devices. Using the knowledge gained from the pre-trained model, the local training was performed in less time with reduced battery consumption.

6.4 Effectiveness of FL to detect depression

Our main goal was to test the usability of the federated learning technique to predict the severity of depression. We achieved an accuracy of 65% using this technique. We also compared FL with traditional ML and showed that we can preserve user data privacy by compromising accuracy to an acceptable extent. Another objective of our study was to demonstrate the feasibility of using this approach so that it might be used in other domains where data privacy is a concern. Several past research studies performed depression detection using mobile data, but barely any of them solved the data privacy problem. Our study resolved this issue and obtained a well-performing federated model.

6.5 Prospects of the app

We have developed the application only for demonstration purposes of federated learning. Currently, it needs manual labeling of depression severity. The app is developed as a prototype, so it requires proper updates before launching publicly i.e., the interface needs more development to make it user-friendly. This app can be integrated into different health apps that take user movement data to detect various health issues. This can also open huge opportunities to make the application commercial and apply federated learning in other health areas. Depression is a very sensitive matter, so it is suggested to take a clinical test before coming to any conclusion. Still, the result of the app can be considered for primary detection.

6.6 Limitations

A significant limitation of our work is that we did not create any server to aggregate local updates from users. Instead, we used a real-time database to simulate the communication method. Another constraint includes not being able to collect data continuously from the passive sensors, as we faced limitations in resources. So, we took readings from the sensors once every five minutes. If the collected data were continuous, we could have applied Convolutional Neural Network (CNN) or Long Short-Term Memory (LSTM) to detect mobility patterns of the participants. CNN and LSTM are excellent at detecting patterns in time series data. If the data were continuous, it would open the possibility of developing a pre-trained model that could perform better in detecting depression severity. Another limitation of our study is that we could not find a correlation between raw sensor data and depression severity. Previous studies show it is possible to find a correlation between derived sensor data [19], [20] and depression severity. Due to resource constraints, we were only able to demonstrate a working prototype using sensor data.

7 Conclusion

The societal and economic burden of depression is increasing day by day. Early detection and follow-up by treatment can drastically reduce these impacts of depression. Previous studies have shown how smartphones can be a feasible option for detecting the presence of depression in a person. However, these existing studies had to centralize users' privacy-sensitive data, which raised concern among users that their private data might get exploited. So, in practical scenarios, users might not be willing to use methods that access their private data directly. Considering this data privacy concern, we developed an android application that predicts depression severity in a person using the federated learning approach. In other words, this application allows us to train a machine learning model that detects the severity of depression in a person without centralizing users' privacy-sensitive data. A natural progression of our study would be to experiment with other smartphone data like call duration, application usage, text messages, etc., to identify the presence of depression. Our android application can also be extended for other mHealth purposes like stress or anxiety detection.

8 References

[1] K.-O. Park, M. G. Wilson, and M. S. Lee, "Effects of social support at work on depression and organizational productivity," *American Journal of Health Behavior*, vol. 28, no. 5, pp. 444–455, 2004. https://doi.org/10.5993/AJHB.28.5.7

[2] P.-W. Wang *et al.*, "Association between problematic cellular phone use and suicide: The moderating effect of family function and depression," *Comprehensive Psychiatry*, vol. 55, no. 2, pp. 342–348, 2014. https://doi.org/10.1016/j.comppsych.2013.09.006

[3] K. B. Wells *et al.*, "Overcoming barriers to reducing the burden of affective disorders," *Biological Psychiatry*, vol. 52, no. 6, pp. 655–675, 2002. https://doi.org/10.1016/S0006-3223(02)01403-8

[4] P. S. Wang, G. Simon, and R. C. Kessler, "The economic burden of depression and the cost-effectiveness of treatment," *International Journal of Methods in Psychiatric Research*, vol. 12, no. 1, pp. 22–33, 2003. https://doi.org/10.1002/mpr.139

[5] "COVID-19 pandemic triggers 25% increase in prevalence of anxiety and depression worldwide," *Who.int*. [Online]. Available: https://www.who.int/news/item/02-03-2022-covid-19-pandemic-triggers-25-percent-increase-in-prevalence-of-anxiety-and-depression-worldwide [Accessed: 15-Aug-2022].

[6] P. E. Greenberg *et al.*, "The economic burden of adults with major depressive disorder in the United States (2010 and 2018)," *Pharmacoeconomics*, vol. 39, no. 6, pp. 653–665, 2021. https://doi.org/10.1007/s40273-021-01019-4

[7] S. G. Hess *et al.*, "A survey of adolescents' knowledge about depression," *Archives of Psychiatric Nursing*, vol. 18, no. 6, pp. 228-234, 2004. https://doi.org/10.1016/j.apnu.2004.09.005

[8] M. Erickson, "Experimental depression treatment is nearly 80% effective in controlled study," *News Center*. [Online]. Available: https://med.stanford.edu/news/all-news/2021/10/depression-treatment.html [Accessed: 15-Aug-2022].

[9] S. M. Guilfoyle, S. Monahan, C. Wesolowski, and A. C. Modi, "Depression screening in pediatric epilepsy: evidence for the benefit of a behavioral medicine service in early detec-

tion," *Epilepsy & Behavior*, vol. 44, pp. 5–10, 2015. https://doi.org/10.1016/j.yebeh.2014.12.021

[10] G. M. Harari, S. R. Müller, M. S. H. Aung, and P. J. Rentfrow, "Smartphone sensing methods for studying behavior in everyday life," *Current Opinion in Behavioral Sciences*, vol. 18, pp. 83–90, 2017. https://doi.org/10.1016/j.cobeha.2017.07.018

[11] A. Alam, A. Das, Tasjid, and A. Al Marouf, "Leveraging Sensor Fusion and Sensor-Body Position for Activity Recognition for Wearable Mobile Technologies," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 17, pp. 141-155, 2021. https://doi.org/10.3991/ijim.v15i17.25197

[12] P. Nelson, "We touch our phones 2,617 times a day, says study," *Network World*, 07-Jul-2016. [Online]. Available: https://www.networkworld.com/article/3092446/we-touch-our-phones-2617-times-a-day-says-study.html [Accessed: 01-Sep-2022].

[13] "Smartphone subscriptions worldwide 2027," *Statista*. [Online]. Available: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/ [Accessed: 23-Aug-2022].

[14] J. E. Wells and L. J. Horwood, "How accurate is recall of key symptoms of depression? A comparison of recall and longitudinal reports," *Psychological Medicine*, vol. 34, no. 6, pp. 1001–1011, 2004. https://doi.org/10.1017/S0033291703001843

[15] R. Wang *et al.*, "StudentLife: assessing mental health, academic performance and behavioral trends of college students using smartphones," *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, pp. 3–14, 2014. https://doi.org/10.1145/2632048.2632054

[16] R. Razavi, A. Gharipour, and M. Gharipour, "Depression screening using mobile phone usage metadata: a machine learning approach," *Journal of the American Medical Informatics Association*, vol. 27, no. 4, pp. 522–530, 2020. https://doi.org/10.1093/jamia/ocz221

[17] X. Xu *et al.*, "Privacy-Preserving Federated Depression Detection From Multisource Mobile Health Data," *IEEE Transactions on Industrial Informatics*, vol. 18, no. 7, pp. 4788–4797, 2021. https://doi.org/10.1109/TII.2021.3113708

[18] S. Thomée, A. Härenstam, and M. Hagberg, "Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults-a prospective cohort study," *BMC Public Health*, vol. 11, no. 1, pp. 1–11, 2011. https://doi.org/10.1186/1471-2458-11-66

[19] S. Saeb, E. G. Lattie, S. M. Schueller, K. P. Kording, and D. C. Mohr, "The relationship between mobile phone location sensor data and depressive symptom severity," *PeerJ*, vol. 4, p. e2537, 2016. https://doi.org/10.7717/peerj.2537

[20] S. Saeb *et al.*, "Mobile phone sensor correlates of depressive symptom severity in daily-life behavior: an exploratory study," *Journal of Medical Internet Research*, vol. 17, no. 7, p. e4273, 2015. https://doi.org/10.2196/jmir.4273

[21] A. A. Atienza *et al.*, "Consumer attitudes and perceptions on mHealth privacy and security: findings from a mixed-methods study," *Journal of Health Communication*, vol. 20, no. 6, pp. 673–679, 2015. https://doi.org/10.1080/10810730.2015.1018560

[22] B. McMahan, E. Moore, D. Ramage, S. Hampson, and B. A. y Arcas, "Communication-efficient learning of deep networks from decentralized data," *Artificial Intelligence and Statistics*, pp. 1273-1282. PMLR, 2017. https://doi.org/10.48550/arXiv.1602.05629

[23] "TensorFlow Federated", *TensorFlow*. [Online]. Available: https://www.tensorflow.org/federated [Accessed: 26-Aug-2022].

[24] K. Kroenke, R. L. Spitzer, and J. B. W. Williams, "The PHQ-9: validity of a brief depression severity measure," *Journal of General Internal Medicine*, vol. 16, no. 9, pp. 606–613, 2001. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

[25] "Deeplearning4j Suite Overview," *Konduit.ai*. [Online]. Available: https://deeplearning4j.konduit.ai/ [Accessed: 26-Aug-2022].
[26] A. Pannu, "Artificial intelligence and its application in different areas," *Artificial Intelligence*, vol. 4, no. 10, pp. 79–84, 2015.
[27] W. Wang and K. Siau, "Artificial intelligence, machine learning, automation, robotics, future of work and future of humanity: A review and research agenda," *Journal of Database Management (JDM)*, vol. 30, no. 1, pp. 61–79, 2019. http://dx.doi.org/10.4018/JDM.2019010104
[28] A. Singh, N. Thakur, and A. Sharma, "A review of supervised machine learning algorithms," *2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom)*, pp. 1310-1315. IEEE, 2016.
[29] S. B. Kotsiantis, I. Zaharakis, and P. Pintelas, "Supervised machine learning: A review of classification techniques," *Emerging Artificial Intelligence Applications in Computer Engineering*, vol. 160, no. 1, pp. 3–24, 2007.
[30] T. Sun, D. Li, and B. Wang, "Decentralized federated averaging," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 2022. https://doi.org/10.1109/TPAMI.2022.3196503
[31] Q. Yang, Y. Liu, T. Chen, and Y. Tong, "Federated machine learning: Concept and applications," *ACM Transactions on Intelligent Systems and Technology (TIST)*, vol. 10, no. 2, pp. 1–19, 2019. https://doi.org/10.1145/3298981
[32] "Sensors," *Android Developers*. [Online]. Available: https://developer.android.com/guide/topics/sensors/ [Accessed: 26-Aug-2022].
[33] B. Martínez-Pérez, I. De La Torre-Díez, and M. López-Coronado, "Mobile health applications for the most prevalent conditions by the World Health Organization: review and analysis," *Journal of Medical Internet Research*, vol. 15, no. 6, p. e2600, 2013. https://doi.org/10.2196/jmir.2600
[34] K. Kroenke and R. L. Spitzer, "The PHQ-9: a new depression diagnostic and severity measure," *Psychiatric Annals*, vol. 32, no. 9, pp. 509–515, 2002. https://doi.org/10.3928/0048-5713-20020901-06
[35] R. L. Spitzer, J. B. W. Williams, K. Kroenke, R. Hornyak, J. McMurray, and Patient Health Questionnaire Obstetrics-Gynecology Study Group, "Validity and utility of the PRIME-MD patient health questionnaire in assessment of 3000 obstetric-gynecologic patients: the PRIME-MD Patient Health Questionnaire Obstetrics-Gynecology Study," *American Journal of Obstetrics and Gynecology*, vol. 183, no. 3, pp. 759–769, 2000. https://doi.org/10.1067/mob.2000.106580
[36] A. Stathopoulou *et al.*, "Mobile Assessment Procedures for Mental Health and Literacy Skills in Education," *International Journal of Interactive Mobile Technologies*, vol. 12, no. 3, pp. 21–37, 2018. https://doi.org/10.3991/ijim.v12i3.8038
[37] S. Nickels *et al.*, "Toward a mobile platform for real-world digital measurement of depression: User-centered design, data quality, and behavioral and clinical modeling," *JMIR Mental Health*, vol. 8, no. 8, p. e27589, 2021. https://doi.org/10.2196/27589
[38] K. Sozinov, V. Vlassov, and S. Girdzijauskas, "Human activity recognition using federated learning," *2018 IEEE Intl. Conf. on Parallel & Distributed Processing with Applications, Ubiquitous Computing & Communications, Big Data & Cloud Computing, Social Computing & Networking, Sustainable Computing & Communications (ISPA/IUCC/BDCloud/SocialCom/SustainCom)*, pp. 1103-1111. IEEE, 2018. https://doi.org/10.1109/BDCloud.2018.00164
[39] P. Chhikara, P. Singh, R. Tekchandani, N. Kumar, and M. Guizani, "Federated learning meets human emotions: A decentralized framework for human–computer interaction for

iot applications," *IEEE Internet of Things Journal*, vol. 8, no. 8, pp. 6949–6962, 2020. https://doi.org/10.1109/JIOT.2020.3037207

[40] J. C. Liu, J. Goetz, S. Sen, and A. Tewari, "Learning from others without sacrificing privacy: Simulation comparing centralized and federated machine learning on mobile health data," *JMIR mHealth and uHealth*, vol. 9, no. 3, p. e23728, 2021. https://doi.org/10.2196/23728

[41] M. N. Chowdhury, H M Zabir Haque, K. T. Tahmid, F.-T.-Z. Salma, and N. Ahmed, "A novel approach for product recommendation using smartphone sensor data," *International Journal of Interactive Mobile Technologies*, vol. 16, no. 16, pp. 190–204, 2022. https://doi.org/10.3991/ijim.v16i16.31617

[42] B. Ramsundar and R. B. Zadeh, "Chapter 4. fully connected deep networks," *TensorFlow for Deep Learning: From Linear Regression to Reinforcement Learning*, pp. 81–102, 2018.

[43] C. Tan, F. Sun, T. Kong, W. Zhang, C. Yang, and C. Liu, "A survey on deep transfer learning," *International Conference on Artificial Neural Networks*, pp. 270-279. Springer, Cham, 2018. https://doi.org/10.1007/978-3-030-01424-7_27

[44] "OpenMined," *Openmined.org*. [Online]. Available: https://www.openmined.org/ [Accessed: 26-Aug-2022].

[45] J. Konečný, H. B. McMahan, F. X. Yu, P. Richtárik, A. T. Suresh, and D. Bacon, "Federated learning: Strategies for improving communication efficiency," *arXiv preprint arXiv:1610.05492*, 2016. https://doi.org/10.48550/arXiv.1610.05492

9 Authors

Nawrin Tabassum is currently doing B.Sc in Computer Science and Engineering at Ahsanullah University of Science and Technology, Dhaka, Bangladesh (Email: nawrintabassum14@gmail.com).

Mustofa Ahmed is currently doing B.Sc in Computer Science and Engineering at Ahsanullah University of Science and Technology, Dhaka, Bangladesh (Email: mustofahmed24@gmail.com).

Nushrat Jahan Shorna is currently doing B.Sc in Computer Science and Engineering at Ahsanullah University of Science and Technology, Dhaka, Bangladesh (Email: nushrat.j01@gmail.com).

MD Mejbah Ur Rahman Sowad is currently doing B.Sc in Computer Science and Engineering at Ahsanullah University of Science and Technology, Dhaka, Bangladesh (Email: mejbahurrahman13@gmail.com).

H M Zabir Haque is an Assistant Professor at Ahsanullah University of Science and Technology, Dhaka, Bangladesh. He has received his Master of Science in Computer Science from the University of Saskatchewan, Canada, and a Bachelor's degree in Computer Science and Engineering from Ahsanullah University of Science and Technology, Dhaka, Bangladesh. His research interests include Bioinformatics, Computational Biology, and Machine Learning (Email: zabir.haque.cse@aust.edu).

Article submitted 2022-09-02. Resubmitted 2022-11-27. Final acceptance 2022-11-30. Final version published as submitted by the authors.

Using New Technologies and Mobiles for Students with Disabilities to Build a Sustainable Inclusive Learning and Development Ecosystem

https://doi.org/10.3991/ijim.v17i01.36359

Eleni Karagianni, Athanasios Drigas(✉)
Net Media Lab Mind Brain R&D, IIT, NCSR "DEMOKRITOS", Athens, Greece
dr@itt.demokritos.gr

Abstract—Nowadays, the educational policy, in many countries, promotes equal access for all students, including those with disabilities, to the general school, against all forms of social exclusion. Inclusion, in an innovative sense of the concept of diversity, focuses on the active participation and interaction of a heterogeneous student population in the general classroom. "E-inclusive" pedagogy refers to teachers' decisions about the use of technology in the educational process with a view of compensating their developmental deficits and making functional use of their strengths. The aim of this paper is to propose tech tools and e-services for the access and active participation of students with sensory and motor disabilities in the educational procedures of the mainstream school and examine the role of teachers in realizing their inclusion / e-inclusion, as the main facilitators and modulators of the classroom settings to an open learning and development student-centered ecosystem. The results showed that teachers who accept as equal members of the school community all their students and incorporate flexibly new technologies into their teaching strategies to meet their unique needs, providing them with authentic opportunities for interaction and learning, contribute catalytically to their academic and social achievements, preparing them for substantial employment and integration opportunities in community life.

Keywords—inclusion / e-inclusion, new technologies, students with disabilities, self-regulated learning, socio-emotional development

1 Introduction

Worldwide, one of the greatest challenges for education systems is providing equal educational opportunities to an increasingly heterogeneous student population, including students with disabilities, who broaden the boundaries of traditional schooling [1]. The inclusive approach to education, starting from the USA and Italy, was established by the Universal Declaration of Salamanca (UNESCO, 1994), which promoted the right of all students to receive quality education, equally with their peers [2]. This school reconstruction process also includes the concept of social inclusion and recognition of the value of all children, regardless of their diversity or abilities [3].

Although the heterogeneity initially concerned culture, language and socio-economic level, it is then enlarging, also for students with disabilities and special educational needs, by creating an open education model, where the value of diversity is diffused in the school culture and the curriculum, which according to the US "No Child Left Behind" Act (NCLB, 2001), is required to involve them in all mainstream school activities [1]. The inclusion of these students is legislated internationally, however it is perceived and implemented in a variety of ways, reflecting underlying differences in education policy, socio-economic and political conditions and cultural backgrounds.

On the other hand, the development of effective inclusion practices, in the traditional classroom, requires a universal design with the cooperation of researchers, teachers, parents and students of the class, as well as the respective government policy, which must primarily invest in learning, providing the necessary educational resources and infrastructure, which will ensure them consistent access to information and knowledge [4]. Therefore, in order to achieve the inclusion, which aims at the empowerment and emancipation of students with disabilities [5], a new standard of education that respects the heterogeneity and a new model of educational services in the general classroom, is required, where the teachers invest in educational goals for all their students [6], by implementing beneficial teaching and pedagogical strategies, which incorporate the use of new technologies, based on individual differences. Teachers usually display more positive attitudes to the e-inclusive practices, when they are familiar with using technology and the classroom has access to technology equipment [7]. In addition, a catalytic factor for meaningful inclusion is the appropriate regulation and adaptation of the learning environment and their willingness to use assistive and instructional technology in the educational activities, which bridges the digital gap between children of typical and atypical development [8]. Thus, by making appropriate planning for the use of the tech tools and e-services, students with physical (fine / gross motor) and sensory (vision / hearing) disabilities, gain access to the provision of quality education, aiming to increase and enhance their functionality, for their active engagement in cognitive resources and social interaction experiences within the school environment, which lay the foundations for a sustainable future [7], [9], [10].

Hence, there is no doubt that the role of systematic training, either as initial teacher education (ITE) or as continuous professional development (CPD), for a deeper understanding of the substance and results of inclusion [2], but also for the effective implementation of the e-inclusive pedagogy, in the everyday life of the classroom, is considered crucial [11] [12].

2 Inclusion / E-Inclusion

"Inclusion" is a multidimensional conceptual construct, which adopts the model of diversity as a natural state of the individual [13]. It is based on socio-cognitive theory and concerns the equal access and participation of all students, including those with disabilities, in the local school community [14].

This concept has emerged in the 1990s, replacing the previous terms "incorporation" and "integration", ending social discrimination and providing equal opportunities to all

children in the educational programs of mainstream schools, in terms of maximizing their potential, in important areas of human development. Therefore, inclusion, as a multifaceted process, means not just placing students with disabilities in the general classroom, but mainly the active participation in a wide range of activities of a coherent curriculum, providing them with a sense of social acceptance and allowing them to develop new academic skills and dynamic interactions, which promote their socialization and reinforce their cognitive development [15], [16]. Therefore, this new approach, through the radical restructuring of educational structures, focuses on the social and environmental characteristics of educational settings [17].

"E-inclusive" pedagogy is a sub-field of inclusive education and includes the decisions of the teaching staff, which reflect their beliefs and attitudes towards diversity and the functional incorporation of ICTs in educational processes and activities, as tools to remove digital inequality, with the support of which the inclusion is essentially implemented in a holistic way. The digital divide in education, which according to Miller (2007) should be considered as an inability to make digital decisions of access, learning, motivation and skills, with a negative impact on every area of human development [11] is a result of: a. the lack of sufficient digital resources that motivate teachers to implement innovative educational strategies b. the inadequacy of their knowledge for the effective use of technology in order to differentiate their teaching and c. the absence of the students' physical access to them [8].

E-inclusive pedagogy involves adapting the content of the common curriculum, and personalizing it, so that it becomes meaningful for each student, but also the modification of the inclusive classroom environment by introduction, on a consistent, non-disruptive basis, of educational technology tools and services, designed to compensate for the absence or deficient presence of some skills, allowing students with disabilities to become participants in authentic situations of self-regulated learning and development [4]. The level of commitment of the educational community to their use in teaching practices, differentiating flexibly the curriculum, is related to their perceptions as reliable learning and development skills tools and to their knowledge about their effective use in the educational procedure [11].

3 Bridging the digital gap for students with disabilities

The critical role of technology is recognized, on a global scale, with the perspectives it provides, through a wide range of digital tools and e-services, integrated into a universally designed learning environment, to maximize the academic learning and social-emotional development of all students, including those with disabilities, providing differentiated ways of teaching and learning, aligned to the different functional requirements of each child, with a view to upgrading their quality of life indicators [9], [18]. Highlighting the functionality of technology in inclusive education, Abbott (2007) points out that a. provides access to learning b. supports educational process and practice opportunities and c. using it makes learning possible for all students [5].

According to the European Agency (2013a), the educational policy and legislation of each country must promote the digital access and inclusion of each student. In recent

decades, European education policy, in the context of Sustainable Development, has been steadily oriented towards facilitating the universal accessibility of children with disabilities in the Information Society, aiming to provide quality education and equal opportunities for lifelong learning, eliminating any inequality, with access to the suitable technology tools, digital hardware and software, to support personalized learning and maximize each child's potential. In this direction, Universal Design for Learning (UDL), which envisages the proactive design by the teacher of an open learning and development ecosystem, provides the supporting framework that allows the differentiation of the curriculum, with an emphasis on the use of technology, as an integral part of educational strategies, which provides innovative and intuitive means of representing information, engaging and expressing students [9], [18]. Moreover, it also provides the possibility of adjustments, such as the accessibility settings in the computer operating systems of Apple, Macintosh and Microsoft Windows, which aim at flexible approaches to self-regulated learning by offering the educational material in digital format, [5] to maintain their effort and commitment to completing their assignments [18].

More specifically, the assistive technology for students with sensory and physical disabilities, provides medical-type aids, such as hearing amplifiers and devices that boost motor functionality, but also educational-type equipment, such as touch screens, alternative keyboards and mice, alternative and augmentative technology devices, speech-to-text devices, word processors, scanners and a wide range of digital applications and services [4], [5].

For the suitable selection of the appropriate technological equipment, ease of use and transport, safety and reliability in its use, technical characteristics and adaptation to different environments must be taken into account. Above all, however, the support of their functional incorporation in carefully designed student-centered activities, guided by educational goals, their previous experiences and unique characteristics [4], [18], [19], [20]. At the same time, by providing students with the opportunity to participate in the selection of the necessary tools and to reflect on their usefulness and the type of support provided, the cultivation of their self-awareness, regarding their capabilities, is enhanced, increasing the prospects of a self-regulated learning [18]. The determination and use of technological equipment must be individualized by assessing, on a regular basis, the changing needs of students [20]. It is vital, however, its integration as part of an interactive educational procedure, in the students' daily schedule and the regularity of the classroom, while it is considered appropriate to model its correct use [19], as well as the establishment and implementation of rules and realistic performance expectations [20]. In this planning, some models and projects can guide teachers, which provide them with strategy instructions for the proper use of resources, environment and technology and monitoring their impact on the progress of their students, such as SETT (Student, Environment, Task, Tool), MPT (Matching Person and Technology) [9], [20], WRITE (Writing Strategies for Instructional Technology in Education), GPAT (Georgia Project for Assistive Technology), TECH, TAM (Technology Acceptance Model) and TPACK (Technological Pedagogical Content Knowledge) [20].

However, it is pointed out that the effective development of learning through technology must be based on the assessment of the children's educational needs [21] and requires systematic planning at the level of the classroom and school unit [22]. In any

case, the use of technology should motivate these students to focus on their own unique abilities and become more efficient, in order to prepare themselves socially and professionally for the job market of the future [20]. Furthermore, the incorporation of digital tools and e-services in the educational process for the planning of teaching and learning activities, record keeping, student monitoring and assessment procedures, in order to surpass the barriers to their development, contributes to the acquisition of literacy, decision-making and problem-solving skills. But mainly, aims at the cultivation of balanced relationships with the other members of the classroom, so that they are dynamically engaged in the interactive processes of a cooperative learning, which highlights the unique value of each student, increasing their self-esteem, acceptance by their peers and the sense of equal member of the classroom [9], [23], [24]. Thus, the use of digital resources in the inclusive classroom should not be an end in itself, but be used purposefully, multiplying the opportunities to communicate information and knowledge, providing motivation and encouragement to students with disabilities to develop a sense of co-responsibility in their learning and promote a self-directed model of work [4], [18].

4 Students with physical (motor) disabilities

To enter information, while performing a task on the computer, students with physical disabilities need an input device adapted to their reduced motor functionality, due to their difficulty with the size and position of the keys on common keyboards [22].

- "Intellikeys™" are alternative keyboards on which custom overlays are placed, containing a portion of the keyboard or specialized graphics, depending on the nature of the user's work.
- "BAT Personal Keyboard" belongs to the category of chording keyboards, with fewer keys that must be pressed in combination to enter text, while in addition, they can be configured to display frequently used words.
- "WinMini" and "MacMini" are miniature keyboards, easy to carry and require less finger movements on the keys.
- "On-screen keyboards" have the above features, such as "Discover: Screen", and the keystrokes are directed by a mouse or other clicking device [22].
- Input devices with virtual manipulatives, such as alternative keyboards and specialized mice, controlled with head pointers, eye-gaze systems, large buttons, switches and joysticks.
- Keyboards computers, where the keys are controlled with a stick fitted to the child's mouth or head, or computers where track balls, head trackers and touch screens replace the traditional mouse, and other keyboards with specially adapted key layouts for children where their functionality is limited in one of their hands [4], [9], [19], [22].
- "Touch screens", where the computer monitor is overlaid with a touch sensitive grid, which presents the graphics and characters of the screen, while a touch of the screen is enough for the desired command of the user.

- Alternative input systems such as speech input and recognition systems, using specialized software and sound cards. With the speech recognition program (SR), students enter into the computer written tasks or texts that they produce only with their voice - provided that the words are pronounced correctly and intelligibly [22].
- "Graph paper" and "Number Navigator" software help students with fine mobility limitations to perform arithmetic operations that require placing numbers in rows and columns.
- The graphical interface of the "Graph Calc" calculator on Windows is indicated for students, who have difficulty using the common calculator [18], [21].
- Using a joystick on a common computer, equipped with audio cards and "Axe" software (Harmonix Co.), they can explore music files or produce their own musical patterns [22].
- Children with severe motor deficits are provided with the emulation of a keyboard with a scanner and the input of Morse code, which operates with specialized switches that are controlled by the voluntary movement of a muscle of the head or mouth or knee. During scan input letters are scanned by lights and cursors and symbols appear on the computer screen or other external device. The users can take control of their computer as they speak letters or words using specific speech recognition (SR) software. Word prediction and abbreviation extension software work are useful to text input and typing, while on-screen keyboards move the user to the next or previous page [4].
- For younger students with motor impairment and mild to severe learning disabilities, an innovative intuitive tabletop using a "tangible user interface" (TUI) has been designed to develop an interactive game in a simple and friendly environment, allowing them to understand physical objects while interacting with them. At the same time, however, it allows e-accessibility, as the activities performed, based on the educational objectives, which involve the students physically and cognitively, are transferred as commands to the screen of a connected computer, through the "Trackmate" platform. Thus, the TUI interface, through physical manipulations that represent abstract concepts, interconnects the physical and digital worlds, as users monitor the progress of their work. Additionally, cooperative learning is enhanced, as two children can work together on the computer, using their right or left hand. In the same direction is the interactive tabletop of the TUI interface, since many students can simultaneously move, monitor and interact sequentially, including students in wheelchairs [25].

5 Students with sensory disabilities

Students with sensory disabilities face difficulties in typical receiving educational material, completing academic tasks, communicating and sometimes social marginalization [22].

- Using the "Learning Ally Link" app, students with sensory disabilities get access to e-books and audiobooks of "The Learning Ally library" [18].

- "Inastec" (Inclusive Assistive Technology) adaptive technology, based on the Internet of Things (IoT), has been introduced into the educational procedures of the curriculum of Argopuro Jember University of Technology, Indonesia, providing quality education, with positive results in task completion and supporting students with visual and hearing impairments in inclusive environments [26]. IoT refers to global communication networks connecting physical and virtual objects, which are identified through RFID radio frequencies and sensors, integrating modern technology with knowledge and leveraging artificial intelligence perspectives, in the context of inclusive practices, related to the organization of learning and providing the required resources for its implementation [27]. Inastec technology is based on programming languages algorithms and its operation uses the Internet in connection with a hardware system. The algorithm application uses Google's cloud platform as storage for communication services and the Raspberry Pi server to convert text to audio. Using a Raspberry Pi B+ equipped with a sound card, the text is played from the speakers of an RPI Monitor server to blind students. If the RPI Monitor is connected to a computer and LED projector, it converts audio to visual text for deaf students. In addition, teachers are provided with the possibility of remotely monitoring the progress of their students by connecting their smartphones or laptops to the Raspberry Pi server via Bluetooth [26].

5.1 Students with visually impaired / blind

- Asstech (Assistive technology) offers quality learning tools and services that utilize the senses of touch and hearing, as they cannot have the typical access to printed or digital visual materials, in order to perceive and understand the learning objects. These include tangible objects, embossed images and the use of Braille [21].
- Common keyboards can be used with Braille labels on the keys or provide access to Braille input devices. Thus, the ordinary scanner, using "Optical Braille Recognition" (OBR) software, scans documents written in Braille, analyzes the dot pattern, translates the text and displays it on the computer screen. Renewable Braille displays translate computer screen text into this writing, which can then be printed with a Braille printer. OCR scanners scan a printed text and store it in digital form, which can, then, be read by a speech synthesizer or printed in Braille, using the appropriate Braille software and printer. Thus, they can independently have access to the educational materials - printed and digital - of the curriculum and successfully perform their homework [4].
- Speech output systems and "text-to-speech" (TTS) software, such as "Screen Reader", "JAWS" and "Thunder", are used to transcribe the text displayed on the monitor screen into sound, which is then provided audio by a recording device [21].
- The "JAWS" (Job Access with Speech) software provides students with multiple possibilities to adjust the volume, tone, timbre of the voice, as well as the reading pace, while with the use of headphones neutralize sound distractions.
- With "speech synthesis", the text is read by the computer analyzing each word into its phonemes, helping in its identification and understanding of the text [4], [22].

- "Talking books" give them recorded lessons on audio cassettes and operate as recording study material, useful information or even entire lectures, as well as for audio submission of their homework.
- The "descriptive video service" (DVS) describes, automatically, verbally everything that appears on the computer screen, providing them with a complete "picture" of the knowledge offered [4], [22].
- The "VOCAROO" service offers the possibility of recording their voice for free [23].
- "Speech recognition" (SR) systems read the text on the computer's screen. Then, scanners, with "Optical Character Reader" (OCR) software, digitally store the text on the computer so it can be printed in large font for students with low vision or entered into a word processor for editing or read using speech synthesis.
- For students with low vision there are large printed labels for keyboard keys, enlarged symbols and graphics for the computer screen or printer, in order to edit a text, use email or other software. Using an anti-glare screen or adjusting its colors appropriately makes it easier for photosensitive children to read [4], [22].

5.2 Students with hearing and / or speech impairments

Considering that their way of learning is very different and is provided through the sensory pathway of vision, user interfaces use information embedded in videos or include symbols with expressive pictures, photo albums, articulation diagrams, visual elements for practicing or correcting speech and language acquisition.

- The "Trobosan" application supports many educational activities, in the context of the learning process, while the "I-Chat" (I Can Hear and Talk) application is a language acquisition and / or learning tool for the specific student population.
- For children with speech intelligibility problems, advanced "speech synthesizers" can replace their voices so they can be intelligible, giving them the opportunity to participate in classroom discussions [21].
- Particularly assistive for students with hearing impairment is a personal listening system, consisting of a wireless transmitter with a microphone worn by the speaker and a receiver with an earphone worn by the listener, so that the speaker's voice is transmitted directly to the ear of the user, by eliminating environmental distractions [24].
- Using the "text-telephones" application they can type and read the telephone conversations, while with the computerized speech recognition (SR) software, the computer converts a spoken text into readable written text [4].
- Message switches, telephone amplifiers and image systems are still used for communication needs [19].
- Older school-aged children are motivated by communication and manipulation through "virtual or real robots" in virtual or augmented reality [7].
- Programming languages such as "Logo" or the modern 'Microsoft Visual Basic" are using for teaching basic artificial intelligence concepts to deaf students and contribute to their acquisition of problem-solving skills [22].

6 Discussion

The change in the values and philosophy of education, which implies the transformation of the school ethos, constitutes the driving force for the implementation of the inclusion and wider social integration of students with disabilities, as equal members of the school community. But in order to change society's attitude, teachers need to face diversity as a creative challenge [4] and the national political strategy to provide the required financial support and promote the equal distribution of open educational resources to exploit the potential of technology by all students [5]. Furthermore, it is necessary to update the deficit education model, which focuses on the developmental deficits of students, towards a holistic education culture, which focuses on the possibility, the cultivation of self-esteem, the understanding of each individual need, but also the coordinated cooperation of teachers to the universal design of the learning of all their students. However, even if social prejudices have receded, there are still inherent problems, which incite teacher skepticism and are related to the absence of new curricula that promote the common goals of inclusive education and to the inadequacy of resources and planning time, of necessary technical know-how and their systematic training in technologies that are constantly evolving.

On the other hand, the functional incorporation of new technologies in educational activities lays the foundations for a self-directed way of learning and forms an inclusive framework, which provides strong incentives for experiential learning, which has as a reference point the knowledge and experiences of the students' daily life [27], activating thinking, promoting experimentation (trial-error) and the search for the acquisition of new knowledge and developing decision-making and problem-solving skills [20], [24]. As schools are becoming increasingly open, it is a challenge internationally, for educational policy makers, a more coordinated and participatory effort in the planning and implementation of teacher training programs, as the main contributors to the educational policy of equality, aiming to promote positive attitudes and initiatives for the realization of inclusion and the diffusion of good practices that promote e-accessibility, removing the digital inequality with the cooperation of all education professionals. More importantly, inclusive schools by modeling educational approaches to meet different needs, using technology as a bridge to the learning and development of all students, can be the cornerstone for building a society without discrimination and exclusion [4], [9].

At the same time, it becomes noticeable, due to the enhanced technical know-how that the teachers acquire, they attempt to model the educational design, based on their new knowledge and practical experiences, providing an educational project of high standards for all their students [20], who learn to accept heterogeneity as the regularity of the classroom and develop digital literacy skills, which are among the basic skills of the 21st century, for their dynamic integration in an open, competitive and sustainable knowledge-based society [5]. This is in line with the findings of research that have proven the higher degree of diversity in the learning environment as an important factor that maximizes learning outcomes for all classroom members [28].

Finally, the incorporation of digital technologies, in education domain, is very productive, successful and facilitates and improves the educational procedures via Mobiles

[29-34], various ICTs applications [35-63], AI & STEM [64-68], and games [69-72]. Additionally, various strategies and techniques can be incorporated in educational approaches via IoT and the combination of ICTs with theories and models of metacognition, mindfulness, meditation and emotional intelligence cultivation [73-99] as well as with environmental factors and nutrition [100- 103], accelerates and improves more over the educational practices and results.

In this perspective, further research, observation and evaluation of the findings from the use of technology in inclusive classrooms, is needed, for the design and development of more sophisticated tech tools and e-services, based on these theories and the emerging technologies.

7 Conclusion

To sum up, efforts for an education without restrictive divisions, where teachers with their attitudes and practices facilitate the integration of technology into the classroom routine, include progressive goals, physical, academic, and social inclusion of students with disabilities, with main purpose, the optimization of educational services provided and the willingness of all parties involved to cooperate, in order to successfully build a sustainable learning and development student-centered ecosystem. Within this open ecosystem, students with disabilities must be supported and encouraged to develop not only academic, but mostly, communication, information-seeking, decision-making, problem-solving skills to become potential digital content creators. The open access portal for children with developmental asynchronies to this interactive ecosystem is new technologies, which make even the most challenging educational goals achievable, transforming the ways of learning, in order to synchronize with their changing educational need and paving the way for the acquisition of functional life skills, through living authentic learning experiences, which boost independence, self-esteem, self-regulation, active participation, sociability and provide quality opportunities for achievement and self-realization of all students.

8 References

[1] M. Dingle, M. A. Falvey, C. C. Givner, & D. Haager, Essential Special and General Education Teacher Competencies for Preparing Teachers for Inclusive Setting, *Issues in Teacher Education, 13(1)*, pp. 35-50, 2004.

[2] S. Costello, & C. Boyle, Pre-service Secondary Teachers' Attitudes Towards Inclusive Education., *Australian Journal of Teacher Education, 38(4),* pp. 129-143, 2013. https://doi.org/10.14221/ajte.2013v38n4.8

[3] E. Avramidis, & B. Norwich, Teachers' attitudes towards integration / inclusion: a review of the literature, *European Journal of Special Needs Education, 17(2),* pp. 129-147, 2002. https://doi.org/10.1080/08856250210129056

[4] F.K. Ahmad, Use of assistive technology in inclusive education: making room for diverse learning needs, *Transcience, 6(2)*, pp. 62-77, 2015.

[5] M. Turner-Cmuchal, & S. Aitken, ICT as a tool for supporting inclusive learning opportunities, *In Implementing inclusive education: Issues in bridging the policy-practice Gap.* Emerald Group Publishing Limited, 2016. https://doi.org/10.1108/S1479-36362016000000–8010

[6] J. Brownlee, & S. Carrington, Opportunities for authentic experience and reflection: A teaching program designed to change attitudes towards disability for pre-service teachers, *Support for Learning, 15(3),* pp. 99-105, 2000. https://doi.org/10.1111/1467-9604.00157

[7] W. Zilz, & Y. Pang, Application of assistive technology in inclusive classrooms. Disability and Rehabilitation: *Assistive Technology, 16(7)*, pp. 684-686, 2021. https://doi.org/10.1080/17483107.2019.1695963

[8] B. AlSadrani, M. Alzyoudi, N. Alsheikh, & E. E. Elshazly, The digital divide in inclusive classrooms, I*nternational Journal of Learning, Teaching and Educational Research, 19(3)*, 69-85, pp. 2020. https://doi.org/10.26803/ijlter.19.3.5

[9] D. Chambers, Assistive technology supporting inclusive education: Existing and emerging trends. Assistive technology to support inclusive education, *International Perspectives on Inclusive Education, 14,* pp. 1–16, 2020. https://doi.org/10.1108/S1479-3636202000000–14001

[10] A. L. Patti, & K. Vince Garland, Smartpen applications for meeting the needs of students with learning disabilities in inclusive classrooms, *Journal of Special Education Technology, 30(4),* pp. 238-244, 2015. https://doi.org/10.1177/0162643415623025

[11] N. Beacham, & K. McIntosh, Student teachers' attitudes and beliefs towards using ICT within inclusive education and practice., *Journal of Research in Special Educational Needs, 14(3),* pp. 180-191, 2014. https://doi.org/10.1111/1471-3802.12000

[12] S. Arulsamy, & A. Murugaiyan, Attitude of student teachers towards integration of assistive technology in inclusive classrooms, *International Journal of Teacher Educational Research, 2(4),* pp. 1-8, 2013.

[13] E. Avramidis, P. Bayliss, & R. Burden, Student teachers' attitudes towards the inclusion of children with special educational needs in the ordinary school, *Teaching and Teacher Education, 16(3)*, pp. 277–293, 2000. https://doi.org/10.1016/S0742-051X(99)00062-1

[14] R. Ross-Hill, Teacher attitude towards inclusion practices and special needs students, *Journal of Research in Special Educational Needs, 9(3),* pp. 188–198, 2009. https://doi.org/10.1111/j.1471-3802.2009.01135.x

[15] D. Bricker, The challenge of inclusion. J*ournal of Early Intervention, 19(3),* pp. 179–194, 1995. https://doi.org/10.1177/105381519501900301

[16] F. L. Wilczenski, Measuring attitudes toward inclusive education, *Psychology in the Schools, 29(4)*, pp. 306–312, 1992. https://doi.org/10.1002/1520-6807(199210)29:4%3C306::AID-PITS2310290403%3E3.0.CO;2-1

[17] D. Morley, R. Bailey, J. Tan, & B. Cooke, Inclusive Physical Education: teachers' views of including pupils with Special Educational Needs and/or disabilities in Physical Education, European *Physical Education Review, 11(1)*, pp. 84–107, 2005. https://doi.org/10.1177/1356336X05049826

[18] M. W. Ok, & K. Rao, Digital tools for the inclusive classroom: Google chrome as assistive and instructional technology, *Journal of Special Education Technology, 34(3),* pp. 204-211, 2019. https://doi.org/10.1177/0162643419841546

[19] C. G. Simpson, R. McBride, V. G. Spencer, J. Lodermilk, & S. Lynch, Assistive technology: Supporting learners in inclusive classrooms, *Kappa Delta Pi Record, 45(4)*, pp. 172-175, 2009. https://doi.org/10.1080/00228958.2009.10516540

[20] A. Evmenova, Implementation of assistive technology in inclusive classrooms, *In Assistive technology to support inclusive education*. Emerald Publishing Limited, 2020. https://doi.org/10.1108/S1479-363620200000014014

[21] M. Jannah, A. Mu'ammar, & E. F. Fahyuni, Asstech Application Based E-Learning System to Improve the Quality Of 21st Century Inclusive Education, *Studia Religia: Jurnal Pemikiran dan Pendidikan Islam, 3(2)*, pp. 233-244, 2019.

[22] J. B. Merbler, A. Hadadian, & J. Ulman, Using assistive technology in the inclusive classroom. Preventing School Failure: *Alternative Education for Children and Youth, 43(3)*, pp. 113-117, 1999. https://doi.org/10.1080/10459889909603311

[23] J. Quenneville, Tech Tools for Students with Learning Disabilities: Infusion into Inclusive Classrooms, Preventing School Failure: *Alternative Education for Children and Youth, 45(4),* pp. 167-170, 2001. https://doi.org/10.1080/10459880109603332

[24] A.N. Liman, R.O. Adebisi, J.E. Jerry, & H.G. Adewale, Efficacy of assistive technology on the educational program of children with learning disabilities in inclusive classrooms of Plateau State Nigeria, *Journal of Educational Policy and Entrepreneurial Research, 2(2),* pp. 23-32, 2015.

[25] M. Zajc, & A. Istenic Starcic, Potentials of the tangible user interface (TUI) in enhancing inclusion of people with special needs in the ICT-Assisted learning and e-accessibility, *In KES International Symposium on Agent and Multi-Agent Systems: Technologies and Applications* (pp. 261-270). Springer, Berlin, Heidelberg, June 2012. https://doi.org/10.1007/978-3-642-30947-2_30

[26] A. Jazuly, L.A. Yaum, K.Y. Udhiyanasari, & R. Kismawiyati, INNOVATION OF ADAPTIF TECHNOLOGY BASED ON INTERNET OF THINGS FOR INCLUSIVE STUDENT, *Logic: Jurnal Rancang Bangun dan Teknologi, 22(2),* pp. 127-131, 2022. https://doi.org/10.31940/logic.v22i2.134-138

[27] R. Nurdin, A. Hufad, D. Tarsidi, & I.D. Aprilia, The Effect of Internet of Things Implementation on Inclusive Practices in High School, In *2nd International Conference on Educational Sciences (ICES 2018)* (pp. 149-151). Atlantis Press, July 2019.

[28] S.S. Oyelere, I.F. Silveira, V.F. Martins, M.A. Eliseo, Ö. Y Akyar, V. Costas Jauregui, ... & L. Tomczyk, Digital storytelling and blockchain as pedagogy and technology to support the development of an inclusive smart learning ecosystem. *In the World Conference on Information Systems and Technologies* (pp. 397-408). Springer, Cham, April 2020. https://doi.org/10.1007/978-3-030-45697-9_39

[29] A. Stathopoulou, D. Loukeris, Z. Karabatzaki, E. Politi, Y. Salapata, and A. S Drigas, "Evaluation of Mobile Apps Effectiveness in Children with Autism Social Training via Digital Social Stories," *Int. J. Interact. Mob. Technol. (iJIM); Vol 14, No 03*, 2020. https://doi.org/10.3991/ijim.v14i03.10281

[30] A. Stathopoulou, Mobile assessment procedures for mental health and literacy skills in education. *International Journal of Interactive Mobile Technologies*, 12(3), pp.21-37, 2018. https://doi.org/10.3991/ijim.v12i3.8038

[31] A. S Drigas, G. Kokkalia & M.D Lytras, Mobile and Multimedia Learning in Preschool Education. *J. Mobile Multimedia*, pp. 119–133, 2015.

[32] A. Stathopoulou, Z. Karabatzaki, G. Kokkalia, E. Dimitriou, P.I. Loukeri, A. Economou, and A. S Drigas, Mobile assessment procedures for mental health and literacy skills in education, *International Journal of Interactive Mobile Technologies (iJIM),* pp. 21-37, 2018. https://doi.org/10.3991/ijim.v12i3.8038

[33] G. K. Kokkalia and A. S. Drigas, Mobile learning for special preschool education, *International Journal of Interactive Mobile Technologies*, *vol. 10 (1),* pp. 60-67, 2016. https://doi.org/10.3991/ijim.v10i1.5288

[34] A Stathopoulou, Z Karabatzaki, D Tsiros, S Katsantoni, A Drigas, Mobile apps the educational solution for autistic students in secondary education, *International Association of Online Engineering,* 2022.
[35] A.S. Drigas, J. Vrettaros, L. Stavrou, D. Kouremenos, E-learning Environment for Deaf people in the E-Commerce and New Technologies Sector, *WSEAS Transactions on Information Science and Applications*, Issue 5, Volume 1, November 2004.
[36] A.S. Drigas, D. Kouremenos, An e-learning system for the deaf people. In: *WSEAS transaction on advances in engineering education*, *vol 2, issue 1*, pp. 20–24, July 2005.
[37] A.S. Drigas, M. Pappas and M. Lytras, "Emerging technologies for ict based education for dyscalculia: Implications for computer engineering education," *International Journal of Engineering Education*, vol. 32, no. 4, pp. 1604–1610, 2016.
[38] A. Drigas & G. Kokkalia, ICTs and Special Education in Kindergarten, *International Journal of Emerging Technologies in Learning 9* (4), pp. 35–42, June 2017. https://doi.org/10.3991/ijet.v9i4.3662
[39] A. Drigas and L. Koukianakis, A Modular Environment for E-learning and E-psychology Applications*, WSEAS Transactions on Information Science and Application*, *Vol. 3*, 2004, pp. 2062-2067, 2004.
[40] A. Drigas, P. Leliopoulos, Business to consumer (B2C) e-commerce decade evolution, *Int. J. Knowl. Soc. Res. (IJKSR)*, pp.1–10, October 2013. https://doi.org/10.4018/ijksr.2013100101
[41] M. Pappas, A. Drigas, Y. Papagerasimou, H. Dimitriou, N. Katsanou & S. Papakonstantinou, Female Entrepreneurship and Employability in the Digital Era: The Case of Greece. *Journal of Open Innovation: Technology, Market, and Complexity*, May 2018. https://doi.org/10.3390/joitmc4020015
[42] G. Papanastasiou, A. Drigas, Ch. Skianis, M. Lytras & E. Papanastasiou, "Patient-Centric ICTs based Healthcare for students with learning, physical and/or sensory disabilities," *Telemat Inform*, vol. 35, no. 4, pp. 654–664, 2018. https://doi.org/10.1016/j.tele.2017.09.002
[43] A. Drigas & M.T.L. Kontopoulou, ICTs based Physics Learning, *International Journal of Engineering Pedagogy (iJEP)*, pp. 53-59, July 2016. https://doi.org/10.3991/ijep.v6i3.5899
[44] G. Papanastasiou, A. Drigas, C. Skianis and M. Lytras, Brain computer interface-based applications for training and rehabilitation of students with neurodevelopmental disorders. A literature review, *Heliyon 6*, September 2020. https://doi.org/10.1016/j.heliyon.2020.e04250
[45] A. S. Drigas, J. Vrettaros, and D. Kouremenos, "An e-learning management system for the deaf people," AIKED '05: *Proceedings of the Fourth WSEAS International Conference on Artificial Intelligence, Knowledge Engineering Data Bases*, article number 28, July 2006.
[46] M. Pappas, E. Demertzi, Y. Papagerasimou, L. Koukianakis, D. Kouremenos, I. Loukidis, and A. Drigas, E-Learning for deaf adults from a user-centered perspective, *Education Sciences 8*, pp. 3-15, November 2018. https://doi.org/10.3390/educsci8040206
[47] A. M. Pappas, E. Demertzi, Y. Papagerasimou, L. Koukianakis, N. Voukelatos, and A. Drigas, Cognitive Based E-Learning Design for Older Adults, *Social Sciences 8*, p.6, January 2019. https://doi.org/10.3390/socsci8010006
[48] A. Drigas, L. Koukianakis, Government online: An e-government platform to improve public administration operations and services delivery to the citizen, *WSKS*, *volume 5736 de Lecture Notes in Computer Science*, pp. 523–532. Springer, September 2009. https://doi.org/10.1007/978-3-642-04754-1_53
[49] P. Theodorou, A. Drigas, ICTs and Music in Generic Learning Disabilities, *Int. J. Emerg. Technol. Learn.*, pp.101–110, April 2017. https://doi.org/10.3991/ijet.v12i04.6588

[50] M.A. Pappas & A.S. Drigas, ICT based screening tools and etiology of dyscalculia, *International Journal of Engineering Pedagogy*, pp. 61-66, August 2015. https://doi.org/10.3991/ijep.v5i3.4735

[51] A. Drigas & I. Kostas, On Line and other ICTs Applications for teaching math in Special Education, *International Journal of Recent Contributions from Engineering, Science & IT (iJES), 2(4)*, pp-46, October 2014. https://doi.org/10.3991/ijes.v2i4.4204

[52] A. Alexopoulou, A. Batsou and A. Drigas, Resilience and academic underachievement in gifted students: causes, consequences and strategic methods of prevention and intervention, *International Journal of Online and Biomedical Engineering (iJOE), vol. 15, no. 14*, pp. 78, October 2019. https://doi.org/10.3991/ijoe.v15i14.11251

[53] M.A. Pappas & A. Drigas, ICT Based Screening Tools and Etiology of Dyscalculia, *International Journal of Engineering Pedagogy*, August 2015.

[54] A. Drigas & G. Papanastasiou, Interactive White Boards in Preschool and Primary Education, *International Journal of Online and Biomedical Engineering (iJOE), 10(4),* pp.46–51, June 2014. https://doi.org/10.3991/ijoe.v10i4.3754

[55] A.S Drigas, and S. Politi-Georgousi, Icts as a distinct detection approach for dyslexia screening: A contemporary view, *International Journal of Online and Biomedical Engineering (iJOE)*, pp. 46–60, September 2019. https://doi.org/10.3991/ijoe.v15i13.11011

[56] N. L. Bakola, N. D. Rizos, A. S. Drigas, ICTs for Emotional and Social Skills Development for Children with ADHD and ASD Co-existence, *International Journal of Emerging Technologies in Learning (iJET)*, March 2019. https://doi.org/10.3991/ijet.v14i05.9430

[57] E.Z. Kontostavlou & A.S. Drigas, The Use of Information and Communications Technology (ICT) in Gifted Students, *International Journal of Recent Contributions from Engineering, Science and IT*, *7(2),* pp. 60-67, June 2019. https://doi.org/10.3991/ijes.v7i2.10815

[58] A. Drigas and J. A. Vlachou, "Information and communication technologies (ICTs) and autistic spectrum disorders (ASD)," *Int. J. Recent Contrib. Eng. Sci. IT (iJES), vol. 4, no. 1*, p. 4, 2016. https://doi.org/10.3991/ijes.v4i1.5352

[59] A. Drigas, L. Koukianakis, Y. Papagerasimou, An elearning environment for nontraditional students with sight disabilities, *Frontiers in Education Conference, 36th Annual. IEEE*, p. 23-27, October 2006. https://doi.org/10.1109/FIE.2006.322633

[60] A. Drigas and L. Koukianakis, An open distance learning e-system to support SMEs e-enterprising, In proceeding of *5th WSEAS International conference on Artificial intelligence, knowledge engineering, data bases,* February 2006.

[61] A.S. Drigas, L.G. Koukianakis, Y.V. Papagerasimou, A system for e-inclusion for individuals with sight disabilities, *Wseas transactions on circuits and systems 4 (11*), pp. 1776-1780, 2005.

[62] L. Bakola, I. Chaidi, A. Drigas, C. Skianis, C. Karagiannidis, Women with Special Educational Needs. Policies & ICT for Integration &Equality, *Technium Social Sciences Journal*, 2022. https://doi.org/10.47577/tssj.v28i1.5708

[63] M. Karyotaki, L. Bakola, A. Drigas, C. Skianis, Women Leadership via Digital Technology and Entrepreneurship in business and society, *Technium Social Sciences Journal*, 2022. https://doi.org/10.47577/tssj.v28i1.5708

[64] J. Vrettaros, A. Tagoulis, N. Giannopoulou & A. Drigas, An empirical study on the use of Web 2.0 by Greek adult instructors in educational procedures, *World Summit on Knowledge System (WSKS)*, pp. 164-170, September 2009. https://doi.org/10.1007/978-3-642-04757-2_18

[65] A. Drigas, A. Dourou, A Review on ICTs, E-Learning and Artificial Intelligence for Dyslexic's Assistance, *iJet*, pp. 63-67, June 2013. https://doi.org/10.3991/ijet.v8i4.2980

[66] P. Anagnostopoulou, V. Alexandropoulou, G. Lorentzou, A. Lykothanasi, P. Ntaountaki, & A. Drigas, Artificial intelligence in autism assessment, *International Journal of Emerging Technologies in Learning*, pp. 95-107, March 2020. https://doi.org/10.3991/ijet.v15i06.11231
[67] M. Pappas & A. Drigas, Incorporation of artificial intelligence tutoring techniques in mathematics, *International Journal of Engineering Pedagogy*, pp.12–16, November 2016. https://doi.org/10.3991/ijep.v6i4.6063
[68] N. Lytra, A. Drigas, STEAM education-metacognition–*Specific Learning Disabilities Scientific Electronic Archives 14 (10),* 2021. https://doi.org/10.36560/141020211442
[69] I. Chaidi, A. Drigas, Digital games & special education, *Technium Social Sciences Journal 34,* pp. 214-236, 2022. https://doi.org/10.47577/tssj.v34i1.7054
[70] G. Kokkalia, A. Drigas, A. Economou, P. Roussos & S. Choli, The use of serious games in preschool education, *International Journal of Emerging Technologies in Learning*, pp.15-27, December 2016. https://doi.org/10.3991/ijet.v12i11.6991
[71] A. Doulou, A. Drigas, Electronic, VR & Augmented Reality Games for Intervention in ADHD *Technium Social Sciences Journal*, 2022. https://doi.org/10.47577/tssj.v28i1.5728
[72] G. Kokkalia, A. Drigas & A. Economou, The role of games in special preschool education, *International Journal of Emerging Technologies in Learning (iJET)*, pp. 30-35, December 2016. https://doi.org/10.3991/ijet.v11i12.5945
[73] A. Drigas & E. Mitsea, 8 Pillars X 8 Layers Model of Metacognition: Educational Strategies, Exercises &Trainings, *International Journal of Online & Biomedical Engineering*, pp. 115-134, August 2021. https://doi.org/10.3991/ijoe.v17i08.23563
[74] A. Drigas, C. Papoutsi, The Need for Emotional Intelligence Training Education in Critical and Stressful Situations: The Case of COVID-19, *Int. J. Recent Contrib. Eng. Sci. IT*, pp. 20–35, September 2020. https://doi.org/10.3991/ijes.v8i3.17235
[75] A. Drigas & E. Mitsea, The Triangle of Spiritual Intelligence, Metacognition and Consciousness, *International Journal of Recent Contributions from Engineering, Science & IT (iJES)*, pp. 4-23, March 2020. https://doi.org/10.3991/ijes.v8i1.12503
[76] G. Kokkalia, A. Drigas, A. Economou, & P. Roussos, School readiness from kindergarten to primary school, *International Journal of Emerging Technologies in Learning, 14(11),* 4-18, 2019. https://doi.org/10.3991/ijet.v14i11.10090
[77] A. Drigas & E. Mitsea, Metacognition, stress-relaxation balance & related hormones, *International Journal of Recent Contributions from Engineering, Science & IT (iJES), 9(1)*, pp. 4–16, March 2021. https://doi.org/10.3991/ijes.v9i1.19623
[78] M. Pappas, A. Drigas, Computerized Training for Neuroplasticity and Cognitive Improvement, *International Journal of Engineering Pedagogy*, pp.50-62, August 2022. https://doi.org/10.3991/ijep.v9i4.10285
[79] C. Papoutsi and A. Drigas, Empathy and Mobile Applications, *International Journal of Interactive Mobile Technologies,* pp. 57- 66, April 2017. https://doi.org/10.3991/ijim.v11i3.6385
[80] C. Papoutsi & A. Drigas, Games for Empathy for Social Impact, *International Journal of Engineering Pedagogy*, pp. 36-40, November 2016. https://doi.org/10.3991/ijep.v6i4.6064
[81] M. Karyotaki & A. Drigas, Online and other ICT Applications for Cognitive Training and Assessment, *International Journal of Online and Biomedical Engineering*, pp. 36-42, March 2015. https://doi.org/10.3991/ijoe.v11i2.4360
[82] C. Papoutsi, A. Drigas & C. Skianis, Emotional intelligence as an important asset for HR in organizations: Attitudes and working variables, *International Journal of Advanced Corporate Learning*, pp. 21–35, November 2019. https://doi.org/10.3991/ijac.v12i2.9620

[83] I. Chaidi and A. Drigas, "Autism, Expression, and Understanding of Emotions: Literature Review*," Int. J. Online Biomed. Eng., vol. 16, no. 02*, pp. 94–111, 2020. https://doi.org/10.3991/ijoe.v16i02.11991

[84] A.S. Drigas & M. Karyotaki, A Layered Model of Human Consciousness, *International Journal of Recent Contributions from Engineering, Science & IT (iJES), 7(3)*, pp. 41- 50, September 2019. https://doi.org/10.3991/ijes.v7i3.11117

[85] A.S Drigas, M. Karyotaki & C. Skianis, An Integrated Approach to Neuro-development, Neuroplasticity and Cognitive Improvement, *International Journal of Recent Contributions from Engineering, Science & IT (iJES)*, 6(3), pp. 4-18, November 2018. https://doi.org/10.3991/ijes.v6i3.9034

[86] M. Karyotaki and A. Drigas, "Latest trends in problem solving assessment," *International Journal of Recent contributions from Engineering, Science & IT (iJES)*, vol. 4, no. 2, 2016. https://doi.org/10.3991/ijes.v4i2.5800

[87] E. Mitsea, A. Drigas, and P. Mantas, "Soft Skills & Metacognition as Inclusion Amplifiers in the 21st Century," *Int. J. Online Biomed. Eng. IJOE*, *vol. 17, no. 04,* Art. no. 04, Apr. 2021. https://doi.org/10.3991/ijoe.v17i04.20567

[88] E. Angelopoulou, A. Drigas, Working Memory, Attention and their Relationship: A theoretical Overview, *Research. Society and Development*, pp.1-8, May 2021. https://doi.org/10.33448/rsd-v10i5.15288

[89] A. Tourimpampa, A. Drigas, A. Economou & P. Roussos, Perception and text comprehension. It's a matter of perception, *International Journal of Emerging Technologies in Learning (iJET)*, pp. 228-242, June 2018. https://doi.org/10.3991/ijet.v13i07.7909

[90] A. Drigas & E. Mitsea, A metacognition based 8 pillars mindfulness model and training strategies. *International Journal of Recent Contributions from Engineering, Science & IT,* 2020. https://doi.org/10.3991/ijes.v8i4.17419

[91] C. Papoutsi, A. Drigas, C. Skianis, Virtual and augmented reality for developing emotional intelligence skills*, Int. J. Recent Contrib. Eng. Sci. IT (IJES) 9 (3),* 35-53, 2021. https://doi.org/10.3991/ijes.v9i3.23939

[92] S. Kapsi, S. Katsantoni, A. Drigas, *The Role of Sleep and Impact on Brain and Learning, Int. J. Recent Contributions Eng. Sci. IT 8 (3)*, 59-68, 2020. https://doi.org/10.3991/ijes.v8i3.17099

[93] A. Drigas, E. Mitsea, C. Skianis, The Role of Clinical Hypnosis and VR in Special Education, *International Journal of Recent Contributions from Engineering Science & IT*, 2021. https://doi.org/10.3991/ijes.v9i4.26147

[94] V. Galitskaya, A. Drigas, The importance of working memory in children with Dyscalculia and Ageometria*, Scientific Electronic Archives 14 (10)*, 2021. https://doi.org/10.36560/141020211449

[95] I. Chaidi, A. Drigas, Parents' Involvement in the Education of their Children with Autism: Related Research and its Results*, International Journal Of Emerging Technologies In Learning (Ijet) 15 (14*), 2020. https://doi.org/10.3991/ijet.v15i14.12509

[96] A Drigas, E Mitsea, Neuro-Linguistic Programming & VR via the 8 Pillars of Metacognition X 8 Layers of Consciousness X 8 Intelligences, *Technium Soc. Sci. J. 26,* 159, 2021. https://doi.org/10.47577/tssj.v26i1.5273

[97] A. Drigas, E. Mitsea, Conscious Breathing: a Powerful Tool for Physical & Neuropsychological Regulation. The role of Mobile Apps, *Technium Social Sciences Journal,* 2022. https://doi.org/10.47577/tssj.v28i1.5922

[98] E Mitsea, N Lytra, A Akrivopoulou, A Drigas, Metacognition, Mindfulness and Robots for Autism Inclusion, *Int. J. Recent Contributions Eng. Sci. IT 8 (2),* 4-20, 2020. https://doi.org/10.3991/ijes.v8i2.14213

[99] A. Drigas, E. Mitsea, C. Skianis, Clinical Hypnosis & VR, Subconscious Restructuring-Brain Rewiring & the Entanglement with the 8 Pillars of Metacognition X 8 Layers of Consciousness X 8 Intelligences, *International Journal of Online & Biomedical Engineering 18 (1),* 2022. https://doi.org/10.3991/ijoe.v18i01.26859

[100] Th. Stavridou, A.M. Driga, A. Drigas, Blood Markers in Detection of Autism, *International Journal of Recent Contributions from Engineering Science & IT (iJES)*, pp.79-86, 2021. https://doi.org/10.3991/ijes.v9i2.21283

[101] A. Zavitsanou, & A. Drigas, Nutrition in mental and physical health. *Technium Soc. Sci. J.*, pp. 23, 67, 2021. https://doi.org/10.47577/tssj.v23i1.4126

[102] A.M Driga, A. Drigas, Climate Change 101: How Everyday Activities Contribute to the Ever-Growing Issue, *International Journal of Recent Contributions from Engineering*, Science & IT, vol. 7(1), pp. 22-31, 2019. https://doi.org/10.3991/ijes.v7i1.10031

[103] A.M. Driga and A. Drigas, ADHD in the Early Years: Pre-Natal and Early Causes and Alternative Ways of Dealing, *International Journal of Online and Biomedical Engineering (IJOE)*, *vol. 15, no. 13*, p. 95, 2019. https://doi.org/10.3991/ijoe.v15i13.11203

9 Authors

E. Karagianni is with the Institute of Informatics and Telecommunications - Net Media Lab & Mind-Brain R&D, Agia Paraskevi, 153 10, Athens, Greece (e-mail: karagiannieleni10@hotmail.com).

A. Drigas is a Research Director at N.C.S.R. 'Demokritos', Institute of Informatics and Telecommunications - Net Media Lab & Mind-Brain R&D, Agia Paraskevi, 153 10, Athens, Greece (e-mail: dr@iit.demokritos.gr).

Article submitted 2022-10-24. Resubmitted 2022-11-16. Final acceptance 2022-11-16. Final version published as submitted by the authors.

A Proposed Model for E-learning Adaptability Measurement During COVID-19 Pandemic Using Data Mining Techniques

https://doi.org/10.3991/ijim.v17i01.35731

Ibrahim Nasir Mahmood[1](✉), Mustafa Ali Abuzaraida[2]
[1] Basra University of Oil and Gas, Basra, Iraq
[2] Misurata University, Misrata, Libya
ibrahim.mahmood@buog.edu.iq

Abstract—E-learning became the main medium of education in the world for the past two years. COVID-19 virus has pushed all the universities and academic institutions to utilize and activate E-learning platforms and systems. The sudden and urgent transformation from the regular traditional learning system to E-learning system has involved many challenges and limitations. Therefore, the need to evaluate and enhance the current E-learning mechanism in Iraq became very urgent and critical need. The target level was students at higher education institutes which include university students in Basra city. The data collected based on students' evaluation and opinions about E-learning based on their interaction and usage during two years under COVID-19 spread era. This research involved applying data mining techniques to sample dataset and utilizing the obtained results as feedback for a proposed model suggested by the authors to measure adaptability. The proposed model is derived from the idea of the Technology Acceptance Model (TAM) with focus on the positivity as the main factor to measure adaptability. The results of the research showed approximate adaptation level of 52% which is very close compared to the actual situation in real life which involve limitations and challenges faced by Iraqi students.

Keywords—e-learning, computer aided learning, data mining, e-learning adaptation model, web based learning

1 Introduction

E-learning is a term used to define a method of teaching and learning based on technology [1]. E-learning is a digital form of delivering knowledge and lectures to students. It is a distance based learning environment where students can get their knowledge anywhere and anytime. Furthermore, it employs the internet services as transmission medium to publish lectures and materials electronically [1]. It can take different modes and shapes as it could be synchronous or asynchronous learning environment [2]. Asynchronies E-learning mode doesn't require students/teachers be available at the same time to get/deliver knowledge [3]. While, synchronize E-learning mode

requires both students and teachers be available at specific time according to specific schedule to get and deliver the knowledge and lectures [3].

E-learning is a term used to define a method of teaching and learning based on technology [1]. E-learning is a digital form of delivering knowledge and lectures to students. It is a distance based learning environment where students can get their knowledge anywhere and anytime. Furthermore, it employs the internet services as transmission medium to publish lectures and materials electronically [1]. It can take different modes and shapes as it could be synchronous or asynchronous learning environment [2]. Asynchronies E-learning mode doesn't require students/teachers be available at the same time to get/deliver knowledge [3]. While, synchronize E-learning mode requires both students and teachers be available at specific time according to specific schedule to get and deliver the knowledge and lectures [3]. The advantages of E-learning include cost savings, flexibility of time and venue, and joyful learning experience [4]. On the other hand, the disadvantages of E-learning could involve interrupted internet services, poor of IT skills and background, low quality of electrical power, and isolated learning environment [5].

In Iraq, E-learning was recently applied and become the main mode of learning in higher education due to the crisis of COVID-19 pandemic. The same situation applies to other countries worldwide such as India [6]. Before COVID-19 pandemic occurs, E-learning was developing gradually in slow rate worldwide [7]. A significant change to online education has occurred during COVID-19 pandemic globally [8]. Higher education in Iraq follows the regular classroom learning mode as the main education method. E-learning approach in Iraq was first applied on 2020 when COVID-19 pandemic took place and forced all the education institutes as well as most of the facilities to close and operate remotely. Therefore, it is considered as new experience for Iraqi student and teachers to go through and to experience during their lifetime.

Applying E-learning in Iraq faced many challenges and limitations due to the poor of Information Technology (IT) infrastructure in Iraq. The poor IT infrastructure includes and not limited to low quality internet services, poor computer networks infrastructure for high education institutes, low quality power services, and poor IT culture for both staff and students. The IT infrastructure for most of the universities is not established. Providing the needed ICT infrastructure is the key point in the success of E-learning [9]. The internet and power services are not stable and go through many cut off periods. In addition, most of the student and faculty doesn't know how to use E-learning applications.

In Iraq, E-learning was recently applied and become the main mode of learning in higher education due to the crisis of COVID-19 pandemic. Higher education in Iraq follows the regular classroom learning mode as the main education method. E-learning approach in Iraq was first applied on 2020 when COVID-19 pandemic took place and forced all the education institutes as well as most of the facilities to close and operate remotely. Therefore, it is considered as new experience for Iraqi student and teachers to go through and to experience during their lifetime.

Applying E-learning in Iraq faced many challenges and limitations due to the poor of Information Technology (IT) infrastructure in Iraq. The poor IT infrastructure in-

cludes and not limited to low quality internet services, poor computer networks infrastructure for high education institutes, low quality power services, and poor IT culture for both staff and students. The IT infrastructure for most of the universities are not established. The internet and power services are not stable and go through many cut off periods. In addition, most of the student and faculty doesn't know how to use E-learning applications. Moreover, COVID-19 pandemic along with these limitations made the situation more complicated as curfew is applied which limits the movement of support staff in case of any support is needed.

Therefore, this paper discusses and measures the adaptability level of students towards E-learning after 2 years of applying it at the higher education institutes. It is the first paper to study the adaptability level towards E-learning in Iraq as new real education experience. One of the most joy factors to determine the efficiency of learning system is to study and analyze students' contentment [10]. The research done in this paper is based on data collected from students representing their opinions in E-learning. Data mining techniques are utilized to analyze this data in order to drive patterns and hidden knowledge that can help to measure students' adaptability level. Furthermore, a proposed model called PUNM is suggested to measure students' adaptability for E-learning experience.

Therefore, this paper discusses and measures the adaptability level of students towards E-learning after 2 years of applying it at the higher education institutes. It is the first paper to study the adaptability level towards E-learning in Iraq as new real education experience. The research done in this paper is based on data collected from students representing their opinions in E-learning. Data processing techniques are utilized to analyze this data in order to drive patterns and hidden knowledge that can help to measure students' adaptability level. Furthermore, a proposed model called PUNM is suggested to measure students' adaptability for E-learning experience.

2 Methodology

2.1 Literature review

The learning system in Iraq was forced to switch to E-learning form totally on the academic year of 2019-2020 due to the wide speared of Covid-19 virus. Most of the world facilities was shifted to electronic and online form of business due to the pandemic. Some universities switched back to remote learning and education system after short period of covid-19 infections [11].

E-learning was totally new experience for both academic staff and students in Iraq. The spread of Covid-19 continued during the following academic year of 2020-2021. Therefore, E-learning became the main out look of the higher education system in Iraq. There were many limitations, complications, and complains by both students and staff towards the utilization of E-learning system. Therefore, measuring the adaptability of students towards E-learning became an urgent need to understand their needs and to improve the current E-learning approach in Iraq.

The acceptance of E-learning was examined by Almajali [12]. The study focused on the relationship among different factors including Infrastructure for knowledge management, benefits of E-learning, and system usage complexity level. Almajali [12] focused on the Jordanian users at university level as scope of work and study. In addition, Almajali [12] utilized the technology acceptance model (TAM) to study E-learning acceptance in Jordan. They used 300 survey respondents from Jordan to analyze the data and was categorized according to gender and major. The study of Almajali [12] concluded that cultural knowledge infrastructure factor didn't affect the relationship between E-learning acceptance and usefulness factor. However, it found that the cultural knowledge infrastructure significantly affected the relationship between E-learning acceptance and ease of use factor [12].

According to Habes [13], the acceptance of E-learning was studied using sample of 314 college students in Sahiwal, Pakistan [13]. Habes [13] categorized the data according to gender, study year, and residence area. The study applied different types of analysis techniques including intercoder reliability analysis and univariate Pearson correlation, Analysis of variance, and linear regression analysis. The study of Habes [13] found that there is a strong positive relationship between E-learning acceptance and students [13]. In addition, it concluded that E-learning has positive impact on students' academic performance.

On the other hand, Shazhad [14] studied the quality of E-learning systems by making comparison between respondents based on gender. Shazhad [14] study was applied to Malaysian University student's both in undergraduate and postgraduate levels. The data collected was classified according to gender, age, experience level with E-learning, and graduate level. According to Shazhad [14], the majority of data collected was submitted by female students due to high enrollments of females in Malaysian universities. After, analyzing the collected data and performing the needed assessments based on gender groups, Shazhad [14] study resulted in positive relationships between E-learning portals and system quality and user satisfaction for female model. And found that information quality and system quality has positive impact on user satisfaction in male model [14].

A recent research on E-learning acceptance in Indonesia carried out by Tussardi [15] which tested students' acceptance towards CeLOE LMS in Telkom University. CeLOE LMS is the E-learning platform utilized by Telkom University staff and students. Tussardi [15] has applied the Unified Theory of Acceptance and Use of Technology Model (UTAUT). The UTAUT model used to assess the level of acceptance of new technology. Tussardi [15] collected the data through a survey designed used google forms. Furthermore, Tussardi [15] categorized the collected data according to age, gender, experience, and voluntariness of use. The results reached by Tussardi [15] is that the average students accepted the CeLOM LMS at Telkom University [15].

In this research, the data collected from Iraqi university students located in Basra city. Feedback received from 928 students represents the dataset. Students' response towards E-learning was collected in terms of positivity, negativity, enjoyment of the system, evaluation of the whole new experience, and some other factors related to E-learning platforms and digital devices.

The method followed in this paper is based on new adaptability model suggested by the authors. The proposed model is derived from the Technology Acceptance Model

(TAM). TAM is a generic model to measure acceptance according to actual system usage [16]. It utilizes perceived usefulness and perceived ease of use as main factors to measure acceptance [16]. The proposed model in this paper consider positive, negativity, and perceived ease of use. The suggested model is specific to measure adaptability towards E-learning. The authors decided to call it PUNM model. This paper used the results of applying data processing techniques as input variables to the proposed model in order to measure the adaptability level of Iraqi students towards E-learning during covid-19 pandemic.

2.2 Data mining techniques

Data processing is one of the most valuable and useful tools used in computer science applications [17]. It utilizes large volumes of data in order to extract useful knowledge and hidden patterns [18]. It uses large amount of data that stored in databases, datacenters, and other data storage techniques [18].

Data processing can be employed in various fields such as machine learning, artificial intelligence, database technology, image and signal processing, high-performance computing, and data visualization [18]. Data processing phase is applied to clean and organize the dataset by correcting syntax errors, manipulation of missing values, and removal of outliers [17]. Finally, the clean and structured dataset can be analyzed and explored to identify relationships between target variables.

The data analysis and exploration phase was applied to the collected data in order to get deep insight about the knowledge hidden in the dataset. Furthermore, it helps to discover patterns that can help to understand student's orientation towards E-learning as first time experience. In addition, the results of this phase is used to measure the adaptability level of Iraqi students towards the new learning environment and the new experience of E-learning in Iraq.

Data collection and pre-processing. The data processing approach in this research is based on data which collected from university students who attend universities in Basra city. The target was undergraduate students because they represent the large sample of students who exposed to the new technology of E-learning. The data collected using Google form populated with some questions that represents the data needed to be collected.

The collected data includes student's preferred learning style (LS) whether it is E-learning, traditional, or blended style. It also includes the desired learning platform (LP), the preferred interactive learning platform(IP), the advantages of E-learning, the disadvantage of E-learning, the desired lectures style (Lec.S) which could be interactive lecture, recorded lecture with PPT slides, or PPT slides only. In addition, the collected attributes included the evaluation level of E-learning experience from student's point of view (EE), the digital device used by students for E-learning (DD), and the enjoyment level. The total response received was 928 records.

Table 1 represents sample of data collected for this study. It shows the main factors used in this study besides other attributes collected as additional attributes which can be used in further studies about the evolving of E-learning in Iraq. The values of the data in Table 1 are abbreviated and they are explained in details in the results section.

For instance, LC refers to low cost, PI indicates poor interaction, and IL represents interactive lecture.

Table 1. Sample of the collected data

Positivity	Negativity	Lectures	Evaluation	Device	Enjoyment
LC	UGD	PPT + RVL	Average	Smart Phone	Yes
OPE	PI	IL	Poor	Smart Phone	No
OPE	UGD	IL	Average	Smart Phone	Yes
ALR	PI	IL	Average	Smart Phone	No
ALR	RISE	PPT + RVL	Poor	Smart Phone	No
TVF	LCW	PPT + RVL	Average	Desktop	Yes

Data preprocessing and cleaning phase has been applied and considered during the design and implementation of the response collection form. The questions in the survey form were all designed as MC questions in order to avoid any noisy data such as missing values, syntax errors, and empty values. Therefore, time and efforts for data cleaning was saved proactively and embedded efficiently in data collecting phase. Figure 1 shows a proof of the cleanness of the data. It represents student's preference in terms of lecture style. The lecture style has three modes which include MS Power Point slides only, interactive lecture style, and MS Power Point slides plus previously recorded video lecture. The majority of Iraqi students desire the lectures to be posted on E-learning platform as recorded video lecture supported by MS Power Point slides as study material.

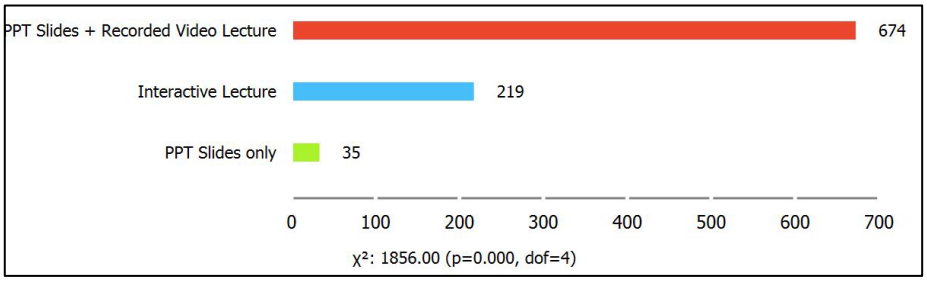

Fig. 1. Proof of clean data – lecture style data

The prefernce of Iraqi students regarding the learning system settings is displayed in Figure 2. The learning system factor invloved three modes of the education system. The first mode is the regular learning which refer to the traditional learning system based on attending lectures in the regular classroom at university. The second mode is E-learning mode which is the new mode that was applied and implemented during COVID-19 spread period. The E-learning mode represnts the remote learning system which is utilize distance communications based on the internet and Information Technology applications. Blended learning is the third facotor which reprsents a mixture between E-learning and regular learning systems. Some of the courses in

blended learning are taught in the regular classroom while other ones are taught using E-learning applications and platforms.

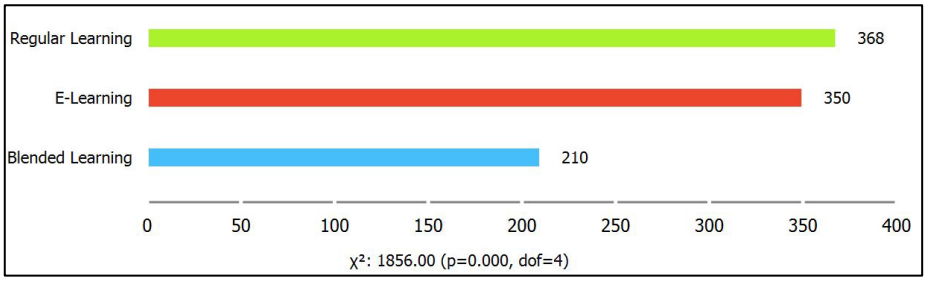

Fig. 2. Data of learning system preferences

In addition, the digital device used by Iraqi students as main communication tool for E-learning is represented in Figure 3. It is important to understand and record which device is used by students in order to determine the capabilities and tools available for students to perform E-learning tasks and activities. Knowing the digital device utilized by students also useful to understand the limitations and challenges faced during E-learning experience. The majority of students used their own smart phones to attend online lectures, submitting assignments, and sitting online quizzes and exams.

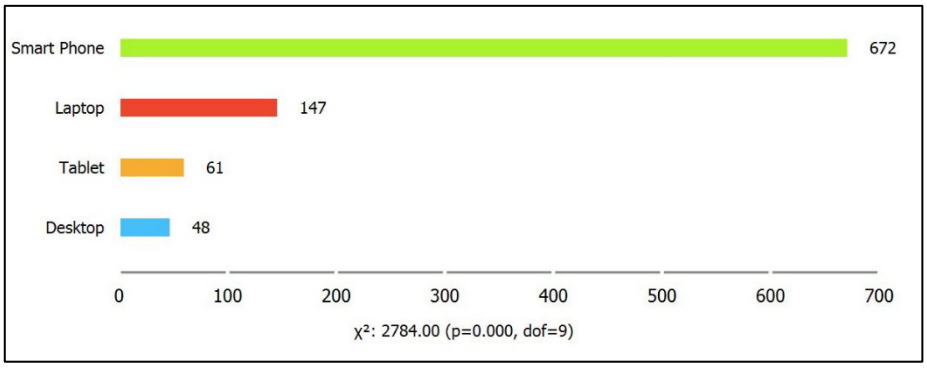

Fig. 3. Data of digital devices

Data analysis and exploration. In terms of learning environment and based on the first phase of data exploration and visualization, we found about 39% of students prefer the traditional (regular classroom) learning style, about 37% of students prefer the E-learning style, and about 22% prefer the blended learning style which is a mix of regular and E-learning learning environment. In terms of learning platform, around 99% of students' favor is Google Classroom. In addition, about 88% of students selected Google Meet, about 5% of students selected Zoom, about 5% of students picked FCC, and around 1% choose Microsoft team as their desired interactive lecture presenting platform.

In terms of positivity and negativity of E-learning based on Iraqi student's opinion, about 47% of students were positive about the availability of recorded lecture anywhere and anytime. Moreover, about 23% of students were positive about the low cost of E-learning, around 16% of students were optimistic regarding the flexibility of time and place of lectures provided by E-learning. Positively, around 13% of them desired the open book exams which became available for them as first experience because of applying E-learning.

On the other hand, around 27% of students choose the lengthy computer based work as one of the disadvantages of E-learning, and its health consequences which affect them. Negatively, about 22% of them selected the poor practical experiment as another disadvantage. Moreover, around 22% of students choose the unfair distribution of grades due to online resources based plagiarism, and around 9% of them were negative about the availability of ready solutions for exams over the internet. The poor interaction between students and teachers resulted by E-learning was among the disadvantages of E-learning and was selected by 17% of Iraqi students.

Moreover, the Iraqi students use different types of electronic devices to perform E-learning activities. About 72% of the Iraqi students use smart phones as electronic medium to attend lectures and study E-learning materials. They use smart phones as the main device for all E-learning activities including homework submissions and exam attendance. And 16% of them use laptops which is more flexible and effective. In addition, 7% of them use tablets as their E-learning device, and 5% of them use desktop computers.

Furthermore, students' evaluation of the E-learning experience was distributed at poor, average, and excellent learning environment. Around 46% of them evaluated E-learning as average learning environment, 34% of them thought of E-learning as poor learning approach, and 20% of them ranked it as excellent learning environment. On the other hand, 53% of them enjoyed the new experience of E-learning in Iraq, while the remaining 47% though it is not joy able as the traditional learning environment.

Data exploration is the phase where data is deeply investigated in order to make it more understandable. The structure of data and relationship among various variables become very clear and discoverable during this phase. The organization and distribution of values and characteristics of the data become more noticeable and obvious during data exploration [17].

This paper utilizes Sieve diagram to explore the dataset. Sieve Diagram is graphical representation of frequencies in contiguous table [19]. It utilizes frequencies to outline the links between categorical variables [19]. In addition, it uses color to represent positive and negative deviation from independence. The Red color means negative deviation while the Blue means positive deviation from independence. The results obtained is described in the results section.

Moreover, Mosaic diagram is used to confirm the results obtained using Sieve diagram calculations. Mosaic diagram is a graphical display which is used to display data from two or more variables to help recognize relationships between them [23]. Mosaic plot under Orange visual programming environment was utilized to achieve the required measurements in this study.

2.3 Measurement of adaptability level

In this study, suggested a novel model for estimating E-learning adaptability level. The proposed model is based on the Technology Acceptance Model (TAM) idea with some modifications due to the limitations faced by E-learning in Iraq. The suggested model is specified only to measure student's adaptability towards E-learning. It focuses on four major factors that affect students' behavior towards E-learning.

These factors include student's evaluation of E-learning as new learning environment. The evaluation factor is rated according to poor, average, and excellent. The evaluation factor measures students' interaction and engagement with E-learning under the special circumstance of low quality internet and power services. The second factor is student's enjoyment level which helps to understand student's benefit and comfort level. When students benefit from a system and feel comfortable about it then they must enjoy it.

The third factor of this model is positivity which is derived from four sub-factors that measure the level of confidence and eagerness of students towards E-learning. Positivity reveals people's favorable judgement of reality [20]. In addition, it reflects peoples' satisfaction in regard to experience or an event [20]. The sub factors of positivity include low cost, open books exam, availability of recorded lectures, and time and venue flexibility.

The fourth factor is Negativity which measures students' uncertainty and disapproval of E-learning. Negativity is measured depending on five sub-factors. These sub-factors include poor interaction, unfair grade distribution, lengthy computer work, availability of ready solutions for exams, and poor practical experiment. Negativity is important factor to include in the suggested model because it reflects people's disagreement towards specific experience or system.

The suggested approach to measure adaptability in this paper is based on the total of positivity gain. The reason behind utilizing positivity as the main factor to measure adaptability level of Iraqi students toward E-learning is that positivity has significant impact on student's adaptation to school life [21]. In addition, empirical studies and researches showed that adaptation is rapid and surely complete in response to positive experiences [22].

Therefore, this paper suggests that E-learning adaptability level is measured based on positivity total gain. Positivity and negativity total gain is calculated based on the results of calculating positive and negative effects by employing both Mosaic and Sieve diagrams. Sieve diagram exploration helps to differentiate positive and negative deviations. Mosaic diagram is used to identify the relationships between variables and show the positive responses. Moreover, the standardized Pearson residual (SPR) is used as measurement of positive effects and negative effects based on its value. The value of SPR is used to determine the impact of each factor in terms of positivity or negativity. SPR positive value means the actual value was more than the expected one which indicates positive impact. SPR negative value means the actual value was less than the expected one which indicate negativity. SPR is the difference between the observed response count and the actual response count [24] [25].

Figure 4 shows the proposed model, and its component which represents the main factors used to estimate E-learning adaptation level. It also shows the sub factors of each main factor and the relationships between them. The perceived usefulness of E-learning is estimated based on both students' evaluation and enjoyment of the system. In addition, each of low cost, open book exams, time and venue flexibility, and the availability of recorded lectures represents the positive sub factors. Moreover, negativity sub factors were derived from the negative feedbacks about E-learning in Iraq. It included unfair grade distribution, poor interaction between students and teachers, poor hand on practical experiments, lengthy computer work, and the availability of ready solution on the internet.

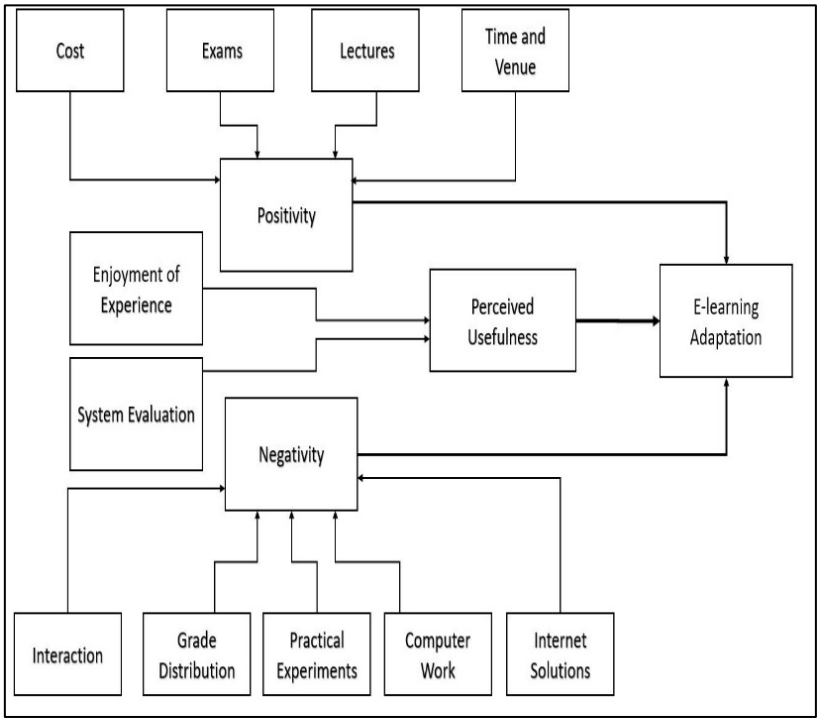

Fig. 4. The proposed model – PUNM

3 Results and discussion

The results reached in this paper is based on calculation of positivity effect of E-learning by using Mosaic and Sieve diagrams in order to perform data exploration of the dataset. In addition, the standardized Pearson residual is used to validate the positive and negative impact of each factor. There were 34% negative feedback in regard to E-learning evaluation, 20% average, and 46% excellent evaluation responses. Therefore, the total positive feedback of evaluation responses is 66%. The enjoyment of E-learning was implemented as 53% positive responses and 47% negative response. Hence, the

total positive impact form enjoyment factor was 53%. For the positivity factors and based on the data exploration process, 16% of positive effect of time and venue of lectures factor (TVF), and 47% of positive feedback of the availability of recorded lectures factor (ARL). The other two factors which are the open book exams (OPE) and low cost (LC) were reported as negative factors according to Sieve Diagram and SPR. calculations. Thereupon, the total positive effect of positivity factors was 63%.

In terms of the negativity factor, the only positive effect on E-learning adaptation was lengthy computer work (LCW) with 24% effect ratio. The adaptation level is estimated based on averaging the total effect of the four main factors and the result was approximately 52%. The achieved result is very close and accurate to the actual situation in real life. The following tables and Figurers illustrates the achieved results.

The enjoyment factor exploration in regard to positive and negative impact is showed in Figure 5 which represents the results of Sieve diagram. The positive impact is represented in Blue with 53% level and 47% of negative impact which is represented in Red.

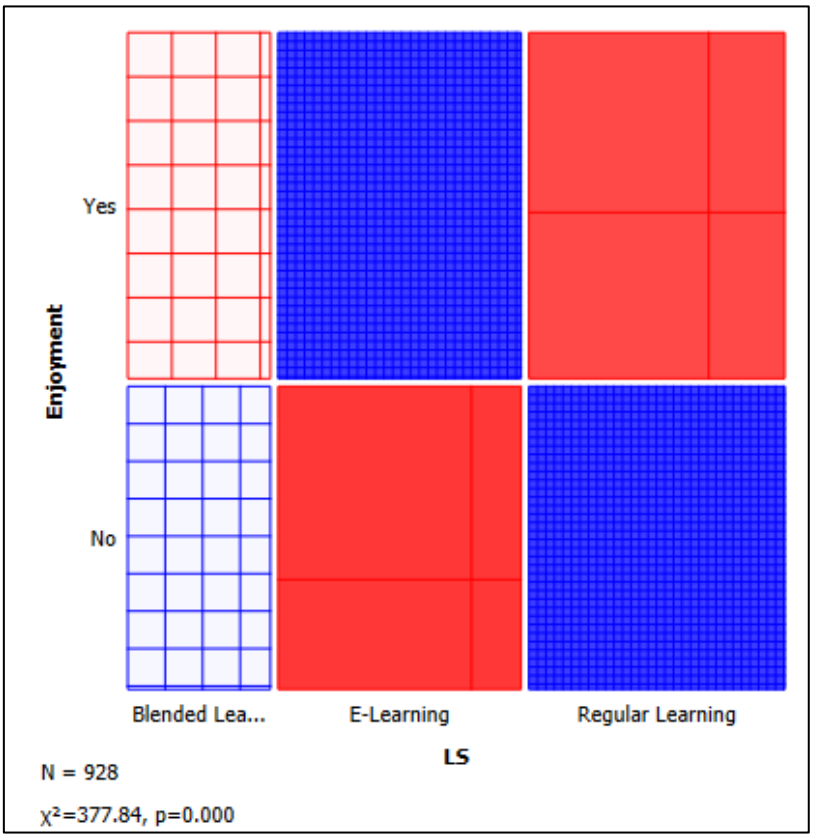

Fig. 5. Positive and negative impact of the enjoyment factor

In addition, Sieve diagram for the evaluation factor is showed in Figure 6. The positive effect in terms of evaluation factor is represented in Blue, and it represents both the excellent and average evaluation. The level of positivity in terms of evaluation factor is 66% while the Red which represents the negative effect of evaluation factor is 44%.

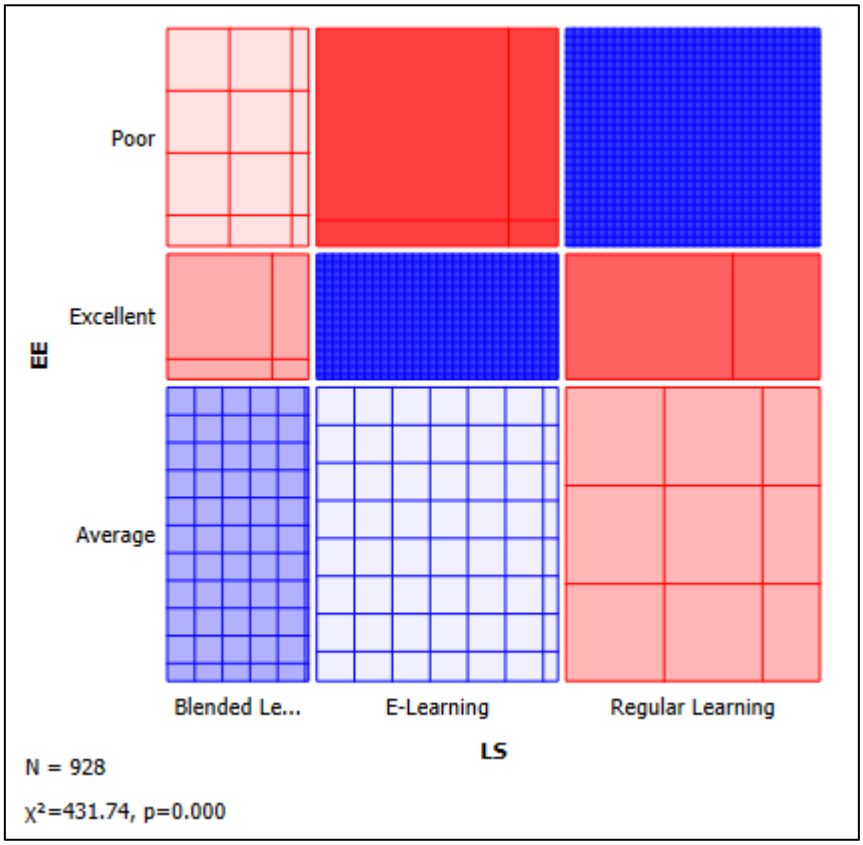

Fig. 6. Positive and negative impact of the evaluation factor

Moreover, the positive and negative outcome for the negativity sub factors are showed in Figure 7. It was negative outcome for the unfair grade distribution (UGD), ready internet exam solutions for exam (RISE), poor practical experiments (PPE), and poor interaction (PI) sub factors. While positive outcome is achieved for the lengthy computer based work (LCW) with 24% positive level.

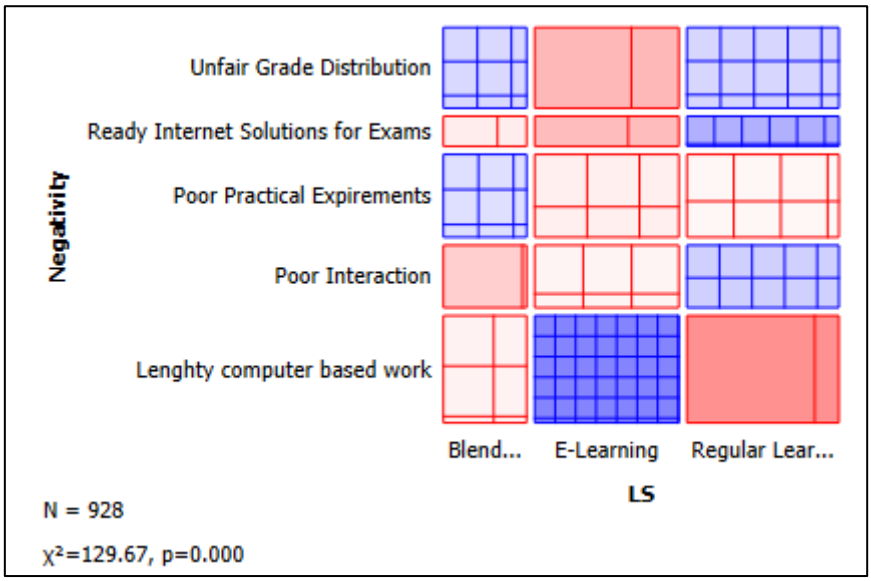

Fig. 7. Positive and negative impact of the negativity factors

The positivity factors and their related positive and negative results are showed in Figure 8. The sub factors of time and venue flexibility (TVF) and availability of recorded lectures (ARL) recorded positive impact of 63%. On the other hand, the sub factors of open book exams (OPE) and low cost (LC) achieved negative impact of 47%.

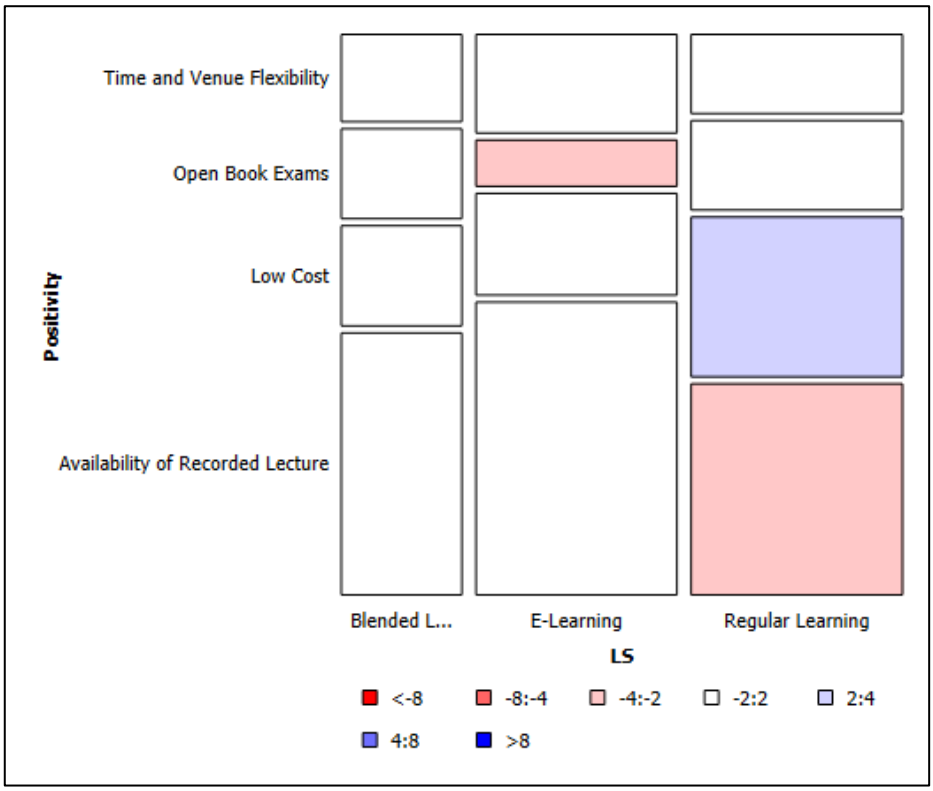

Fig. 8. Positive and negative impact of the positivity factors

Furthermore, the Mosaic diagram is used to validate the relationship between the factors presented in the proposed model PUNM. In addition, it is used to compute the standardized Pearson residual (SPR) in order to confirm the positive and negative effect of each sub-factor. Figure 9 represent the Mosaic diagram for the enjoyment factor with SPR value of 9.6.

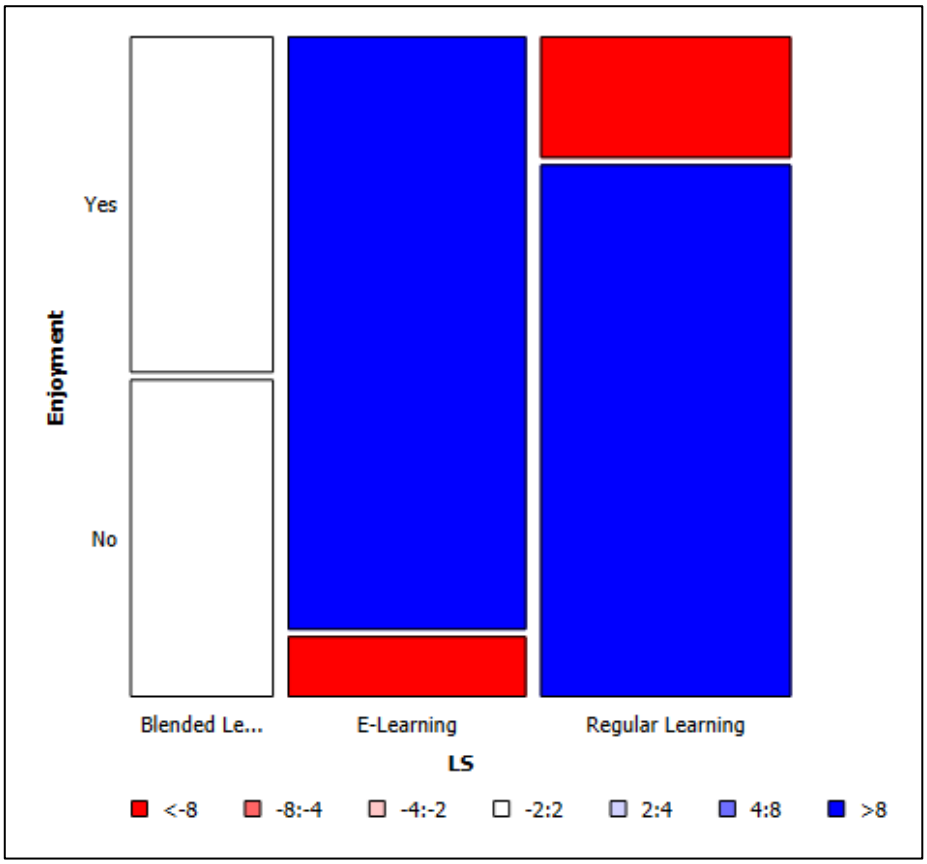

Fig. 9. SPR of the enjoyment factor

The Mosaic diagram for the evaluation factor is showed in Figure 10. The SPR value for the evaluation of E-learning is 11.9. It reflects excellent and average evaluation feedback of E-learning.

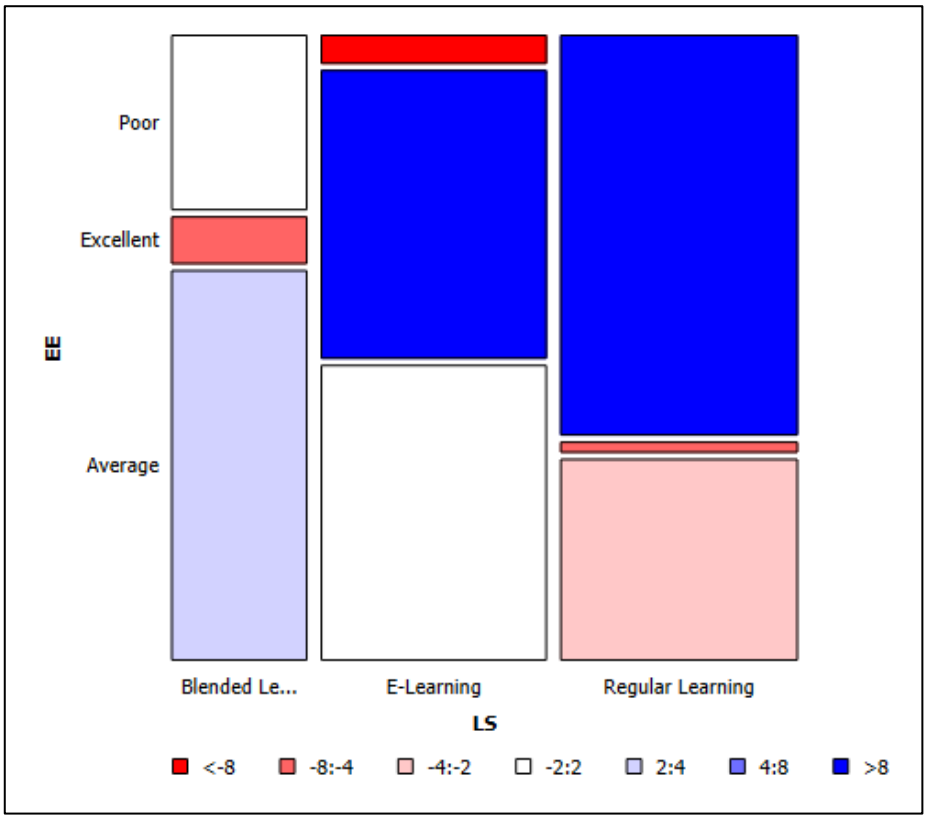

Fig. 10. SPR of the evaluation factor

The positivity and negativity impact of the negativity sub factors is validated using the Mosaic diagram in Figure 11. The UGD sub factor achieved SPR value of -3.5, the RISE recorded SPR value of -3.3, the value of SPR for the PPE was -0.8, the PI achieved SPR value of -0.5, and the SPR value of LCW sub factor was positive and equal to 6.1.

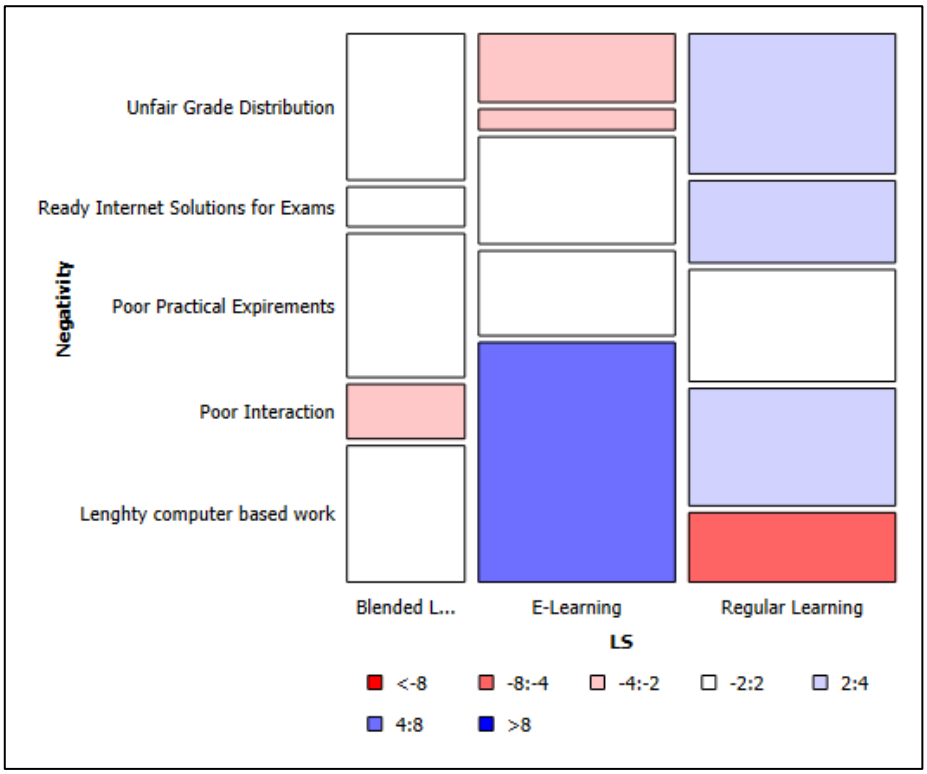

Fig. 11. SPR of the negativity

The Mosaic diagram showed in Figure 12 is for the positivity sub factors. Both ARL and TVF sub factors recorded positive SPR value of 2.0 and 0.9 respectively. While, the LC and OPE sub factors achieved negative SPR value of -1.6 and -2.5 respectively.

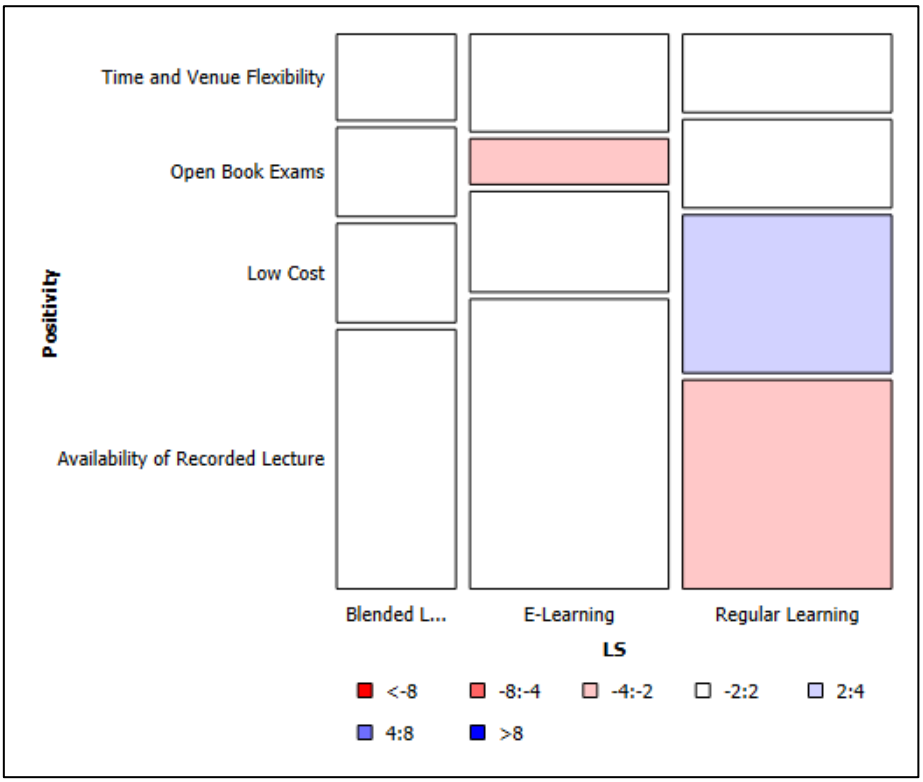

Fig. 12. SPR of the positivity factors

The values of SPR of each sub factor is combined in Table 2 to clearly recognize and distinguish the positive effect for each sub factor in order to calculate the overall positive impact contribution to find out the level of adaptation.

Table 2. SPR value for each factor

Variable	Factor	SPR
Positivity	LC	-1.6
	ARL	2.0
	OPE	-2.5
	TVF	0.9
Usefulness of Use	Enjoyment	9.6
	Evaluation	11.9
Negativity	UGD	-3.5
	RISE	-3.3
	PPE	-0.8
	PI	-0.5
	LCW	6.1

Table 3 and Table 4 represent the percentage of contribution of each sub factor of the proposed model PUNM. The percentage is calculated based on the results of responses received and analyzed using data processing techniques described earlier. The distribution of the positive and negative impact of each sub factor in Table 3 and Table 4 is based on the results obtained using data exploration by employing Sieve and Mosaic diagrams alongside with SPR values.

Table 3. Adaptaiton and Inadequacey level for each fator

	Evalutation	**Enjoyment**	**Positivty**	**Negativity**	**Level Gain**
Adaptability Level	66%	53%	63%	24%	51.5 %
Inadequace Level	34%	47%	63%	76%	48.5%

Table 4. E-learning Adaptation level

E-Learning Evaluation (EE)					
Poor	***Average***	***Excellent***		***E-learning Gain***	
34%	20%	46%		66%	
E-learning Enjoyment					
Yes		***No***		***E-learning Gain***	
53%		47%		53%	
Positivty Factors					
TVF	***OPE***	***LC***	***ARL***	***E-learning Gain***	
16%	14%	23%	47%	47%	
Negativity Factors					
UGD	***RISE***	***PPE***	***PI***	***LCW***	***E-learning Gain***
22%	9%	23%	17%	24%	24%

As a result, the final results achieved are shown in Table 4. It shows that the adaptation level of Iraqi students towards E-learning during COVID-19 pandemic and based on the proposed model PUNM is almost 52%.

4 Conclusion

E-learning is the alternative learning and teaching system utilized by the Iraqi academic institutes to face the sudden and wide spread of COVID-19. It helped to reduce and mitigate the number of infections among students and staff during the past two academic years. In Iraq, the application of E-learning faced many challenges and limitations which made the service provided of average quality. There is the issue of electricity cutoff which sometimes happens during online exams or during interactive lectures. In addition, the poor IT infrastructure and low quality of internet services provided in the country caused E-learning to be affected negatively. Furthermore, the weak

technological background for most of the staff and students was another factor to co-exist along the application of E-learning process in Iraq.

Therefore, there is important and critical need to understand the current actual level of Iraqi students' adaptation to the new education system (E-learning). A system that requires availability of electricity, high quality internet services, and good background in IT techniques and tools. Knowing the actual level of students' adaptation helps to identify weak points of the applied system in order to find permanent solutions and improve the overall experience of E-learning. A powerful E-learning system means high quality academic throughput and achievements.

This study helped to find out very approximate accurate results of the adaptation level of students after using and experience E-learning for two academic years in Iraq. The authors proposed new model to measure adaptability level. The new model is based on the general model used to measure technology acceptance (TAM). The suggested model is more specific to measure adaptability of students towards E-learning. Therefore, it is E-learning specific model. The proposed model is called PUNM because it depends on three factors when measuring adaptability. The three main factors of the new proposed model are Positivity, Usefulness, and Negativity.

The proposed model utilizes the applications of data processing techniques on sample dataset to measure adaptability. The target were colleges' and universities' students who are based in Basra city as sample dataset. The dataset size consisted of 928 record represents data collected based on students' feelings and opinions. The data included students' evaluation of E-learning, enjoyment, digital device used, positivity factors affected students, negativity factors, preferred classroom platform, and favorited interactive lecture platform. The dataset is analyzed and processed using Sieve and Mosaic diagrams in Orange visual programming environment which is used to calculate positivity versus negativity associated with each factor. Finally, the results obtained from data exploration is fed to the new proposed model to calculate the adaptability level. The output of the PUNM model showed that the current level of adaptation towards E-learning in Iraq is nearly 52% based on students' feedbacks. The results and the other data collected in this research can help to launch other researches which specify weak points that can be rectified to improve the adaptation level and enhance the overall experience of E-learning in Iraq.

5 References

[1] Abou El-Seoud, M., Taj-Eddin, I., Seddiek, N., El-Khouly, M. and Nosseir, A., (2014). E-Learning and Students' Motivation: A Research Study on the Effect of E-Learning on Higher Education. *International Journal of Emerging Technologies in Learning (iJET)*, 9(4), p.20. https://doi.org/10.3991/ijet.v9i4.3465

[2] Suryawanshi, V. and Suryawanshi, D. (2021). Fundamentals of E-Learning Models: A Review. *IOSR Journal of Computer Engineering (IOSR-JCE)*, pp.107-120.

[3] Shailaja, J. and Sridaran, R. (2014). Taxonomy of E-Learning Challenges and an Insight to Blended Learning. *2014 International Conference on Intelligent Computing Applications*. https://doi.org/10.1109/icica.2014.70

[4] T. B., L. and P. S., S. (2021). *An Analysis on E-Learning and Its Recommendations*. https://doi.org/10.4018/978-1-7998-8061-5.ch009

[5] Noreen, K., Umar, M., Sabir, S. and Farooq, A. (2020). SWOC analysis of e-learning educational services at Rawalpindi Medical University in the midst of COVID-19. *Journal of Rawalpindi Medical College*, 24(Supp-1), pp.37-43. https://doi.org/10.37939/jrmc.v24iSupp-1.1423

[6] Shete, A., Garkal, K. and Somwanshi, N. (2020). Perceptions of MBBS Students Regarding E-learning during COVID-19 Lockdown. *International Journal of Health Sciences and Research*, 10(9).

[7] Alqahtani, A. and Rajkhan, A. (2020). E-Learning Critical Success Factors during the COVID-19 Pandemic: A Comprehensive Analysis of E-Learning Managerial Perspectives. *Education Sciences*, 10(9), p.216. https://doi.org/10.3390/educsci10090216

[8] Jose, J. and Lal, T. (2021). STUDY ON EFFECT OF E-LEARNING PROCESS DURING COVID 19 PANDEMIC. *nternational Journal of Creative Research Thoughts*, 9(2).

[9] Mutegi, R. (2020). ICT Inequalities And E-Learning In The Wake Of Covid-19 In Kenya. *International Interdisciplinary Journal of Education*, 9(4), p.220. https://doi.org/10.36752/1764-009-004-015

[10] Mubeen S, Aijaz A, Mubeen H, Ahmed H, Fahmi S, Samreen T. (2020). Analysis of theELearning Educational Atmosphere During Covid 19 Pandemic: Empirical Evidence from MedicalUniversities of Urban Pakistan. Med Forum 2020; 31(11):179-183.

[11] Bahl, R., Eikmeier, N., Fraser, A., Junge, M., Keesing, F., Nakahata, K. and Reeves, L. (2021). Modeling COVID-19 spread in small colleges. *PLOS ONE*, 16(8), p.e0255654. https://doi.org/10.1371/journal.pone.0255654

[12] ALMAJALI, D., HAMMOURI, Q. and BARAKAT, S. (2021). E-learning through COVID-19 crisis in Developing Countries. *International Journal of Pharmaceutical Research*, 13(01). https://doi.org/10.31838/ijpr/2021.13.01.732

[13] Habes M. et al. (2021). E-Learning Acceptance During the Covid-19 Outbreak: A Cross-sectional Study. In: Musleh Al-Sartawi A.M., Razzaque A., Kamal M.M. (eds) Artificial Intelligence Systems and the Internet of Things in the Digital Era. EAMMIS 2021. Lecture Notes in Networks and Systems, vol 239. Springer, Cham. https://doi.org/10.1007/978-3-030-77246-8_7

[14] Shahzad, A., Hassan, R., Aremu, A., Hussain, A. and Lodhi, R. (2020). Effects of COVID-19 in E-learning on higher education institution students: the group comparison between male and female. *Quality & Quantity*, 55(3), pp.805-826. https://doi.org/10.1007/s11135-020-01028-z

[15] Tussardi, R., Izzati, B. and Saputra, M. (2021). Analysis of E-Learning Acceptance During Distance Learning Using Unified Theory Of Acceptance and Use of Technology (UTAUT). *JATISI (Jurnal Teknik Informatika dan Sistem Informasi)*, 8(2), pp.465-479. https://doi.org/10.35957/jatisi.v8i2.767

[16] Dimitrijević, S. and Devedžić, V. (2020). Usability Factors in e-Learning Acceptance Models. *Conference: ICIST 2020 - 10th International Conference on Information Society and Technology*.

[17] Mahmood, I., Aliedane, H. and Abuzaraida, M. (2021). Applications of Data Mining in Mitigating Fire Accidents Based on Association Rules. *International Journal of Interactive Mobile Technologies (iJIM)*, 15(12), p.158. https://doi.org/10.3991/ijim.v15i12.22687

[18] Olufemi Ogunleye, J., 2021. The Concept of Data Mining. *Artificial Intelligence* (2021). https://doi.org/10.5772/intechopen.99417

[19] Hidayatullah, R., Cholifah, W., Ambarsari, E., Kustian, N. and Julaeha, S., (2021). Sieve Diagram For Data Exploration of Instagram Usage Habit Obtained From Indonesia Questioner's Sample. *Journal of Physics: Conference Series*, 1783(1), p.012028. https://doi.org/10.1088/1742-6596/1783/1/012028

[20] Hoorens, Vera. (2014). Positivity bias. Encyclopedia of Quality of Life and Well-Being Research. Springer. https://doi.org/10.5772/intechopen.99417

[21] Chang, C., Hsieh, H., Huang, H. and Huang, Y. (2020). The Effect of Positive Emotion and Interpersonal Relationships to Adaptation of School Life on High School Athletic Class Students. *International Journal of Environmental Research and Public Health*, 17(17), p.6354. https://doi.org/10.5772/intechopen.99417

[22] Lyubomirsky, S. (2010). Hedonic Adaptation to Positive and Negative Experiences. *Oxford Handbooks Online*. https://doi.org/10.1093/oxfordhb/9780195375343.013.0011

[23] Hofmann, H., Siebes, A. and Wilhelm, A. (2000). Visualizing association rules with interactive mosaic plots. *Proceedings of the sixth ACM SIGKDD international conference on Knowledge discovery and data mining - KDD*. https://doi.org/10.1145/347090.347133

[24] Midi, H. and Ariffin, S. (2013). Modified Standardized Pearson Residual for the Identification of Outliers in Logistic Regression Model. *Journal of Applied Sciences*, 13(6), pp.828-836. https://doi.org/10.3923/jas.2013.828.836

[25] Martin, J., Adana, D. and Asuero, A., (2017). Fitting Models to Data: Residual Analysis, a Primer. *Uncertainty Quantification and Model Calibration*. https://doi.org/10.5772/68049

6 Authors

Ibrahim Nasir Mahmood is a lecturer in computer science field working at Basra University of Oil and Gas, Basra, Iraq. He received his BSc degree in Software Engineering on 2008. He holds Master's degree in Computer Science from University of Bridgeport, CT, USA. He received his Master's degree with Academic Achievement Award and Honors on 2013. Ibrahim is a member of the UPE International Computing Society. He works at the Department of Chemical Engineering and Oil Refinery in the Faculty of Oil and Gas Engineering, Basra University of Oil and Gas. His research interests include data mining, data science, machine learning, IoT, E-learning, and Algorithms. The author can be reached through his official email address which is: ibrahim.mahmood@buog.edu.iq.

Dr. Mustafa Ali Abuzaraida is associate professor. He obtained his master degree in (Intelligent System) from University Utara Malaysia (UUM) in 2006 and a Ph.D. in (Computer Science) from International Islamic University Malaysia (IIUM) in 2015. His research interest is on Image processing, Data science, Data mining, Artificial intelligence application, and Natural Language Processing (NLP) mainly on text normalization and sentiment analysis and recognizing online handwritten text. He is a former international lecturer at University Utara Malaysia, and currently, he is working at Faculty of Information technology, Misurata University Libya as associate professor. The author can be reached through his official email address which is: abuzaraida@it.misuratau.edu.ly.

Article submitted 2022-08-30. Resubmitted 2022-10-23. Final acceptance 2022-11-09. Final version published as submitted by the authors.

Adaptive Hiding Algorithm Based on Mapping Database

https://doi.org/10.3991/ijim.v17i01.36723

Ismael AbdulSattar Jabbar[1](✉), Shaimaa Hameed Shaker[2]
[1] Computer department, University of Mustansiriyah, Baghdad, Iraq
[2] Computer department, University of technology, Baghdad, Iraq
ismaelabdul@uomustansiriyah.edu.iq

Abstract—Information hiding one of the important field of security which provide secure level for the information. Achieving multi levels of security system often researchers used cryptography side by side with steganography. Utilizing message digest algorithm to play the role of crypto which is extracted from secret created database. Message digest algorithm (MD5) used two times as one-way function to provide data integrity. The implemented system evaluated based on peak signal to noise ratio (PSNR) metric and the best value reaches 62.46. the proposed system works in adaptive behavior due to the different use of images as well as the selected point could be used to generate the hash code as well. The implemented system reaches up to sufficient level of security through using both steganography and cryptography.

Keywords—information hiding, hash function, message digest 5 (MD5), database, stego-systems

1 Introduction

Information security become in need due to the increasing transferring for sensitive information through the internet. A lot of available works in the information security system trying to mix two or more levels of security that's depends on the user demands and the importance of the information itself these levels can be achieved using steganography and cryptography as well [1-4]. In the cryptography algorithms the secrete message encrypted to achieve conditionality for the information the steganography used to hide the encrypted message in the appropriate cover this process one of a several ways to use steganography and cryptography. The general steganography models can show in the Figure 1.

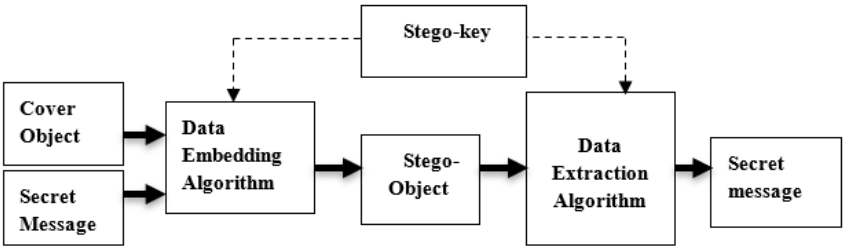

Fig. 1. General stenographic model [5]

Hash functions A hash function H is a transformation that takes a variable-size input m and returns a fixed-size string, which is called the hash value h (that is, h = H(m)) [6, 7]. Hash functions with just this property have a variety of general computational uses, but when employed in (cryptography, steganography) the hash functions are usually chosen to have some additional properties. The basic properties of the hash function [6]:

a) the input can be of any length,
b) the output has a fixed length,
c) H(x) is relatively easy to compute for any given x.
d) H(x) is one-way,
e) H(x) is collision-free.

Hash functions used for many kinds of security areas the main role is to achieve the integrity. Hash function used [8]

a) Used Alone
   - File integrity verification.
   - Public key fingerprint.
   - Password storage.
b) Combined with encryption functions.
c) Information hiding.

In this paper message digest 5 (MD5) Hash function used for two times, first combined with encryption and second achieve integrity verification. MD5 is an improved version of MD4. Although more complex than MD4, it is similar in design and also produces a 128-bit hash [9, 10]. While database created as secret database available in the sender and receiver side.

The main loop of the MD5 algorithm can be shown with in Figure 2.

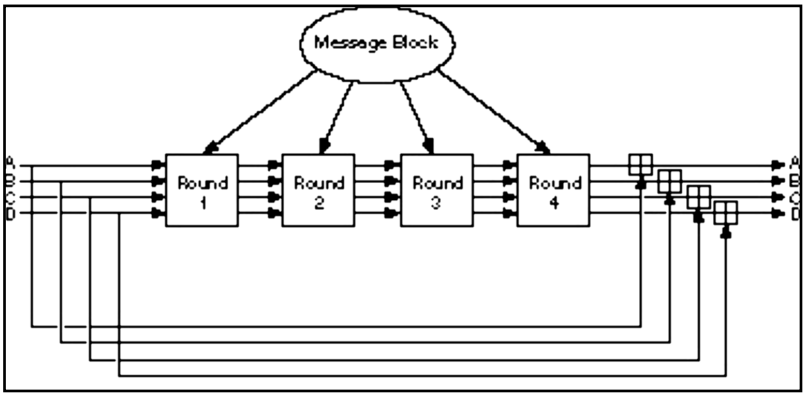

Fig. 2. MD5 main loop

The main loop of the MD5 algorithm contains 4 round these lops continue for running 512-bit length of the message as required. The four variable copied into other variables like (a copied A, and b copied B and so on). At each round the different operation applied in 16 times in such a way that each operation process nonlinear operation on variables a, b, c, and d. the functions can be applied at each operation.

$\oplus, \wedge, \vee, \neg$ denote the XOR, AND, OR, and NOT operations respectively. These functions are designed so that if the corresponding bits of *X, Y,* and *Z* are independent and unbiased, then each bit of the result will also be independent and unbiased. The function F is the bitwise conditional: If *X* Then *Y* Else *Z*. The function H is the bitwise parity operator**.** One MD5 operation can illustrated using Figure 3.

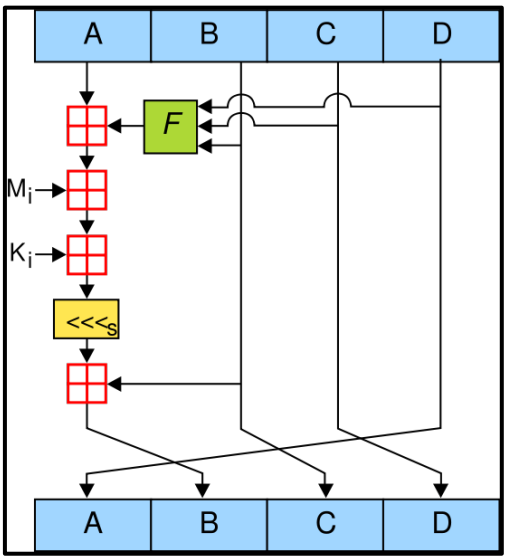

Fig. 3. One MD5 operation

Sample 10 of the created spider database images can be shown with the Figure 4.

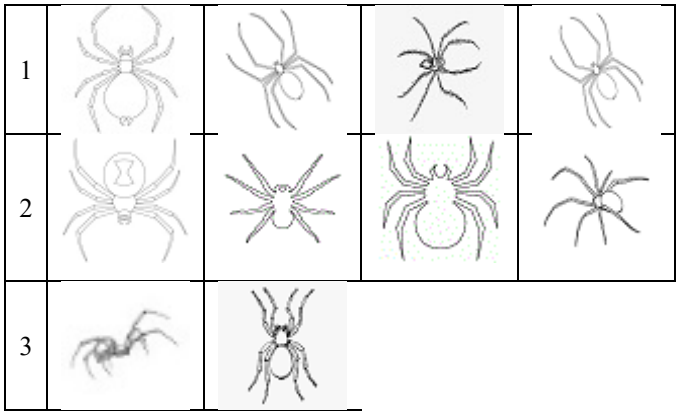

Fig. 4. Spider database sample

From the Figure 4 which contains set of samples of spider images it's clear that each image of the spider has different direction as well as different size of the spiders. And thus, different directions with different size provide good possibility of variation to choose places in cover images, because such points will affect the MD5 output algorithm.

The proposed system in this paper evaluated using peak signal to noise ratio (PSNR). The PSNR value depend on the mean square error (MSE). The MSE value can compute using the Eq. (1)

$$MSE = \frac{1}{MNK}\sum_{i=1}^{M}\sum_{j=1}^{N}\sum_{r=1}^{K}[(I_{(i,j,r)} - I'_{(i,j,r)})^2] \quad (1)$$

Where, MNK are the values of the RGB image. $I_{(i,j,r)}$ represent the original image (cover image) and $I'_{(i,j,r)}$ represent image after processing (stego image). When the value of MSE obtained the PSNR value calculated based on the Eq. (2) [11, 12].

$$PSNR = 10\ \log_{10}(\frac{{MAX_I}^2}{MSE}) \quad (2)$$

The MAX_I value represent the highest scale value in the image

The database contains 150 images of different sizes each one of these images have index. Such data have to be available to start hiding and extracting secret messages in the designed implemented proposed system. The proposed system as security system could work not only in secure hide information in medical images [13-17], but also in homomorphic hiding side by side with database prototype [17-20].

2 Proposed system

There are two main algorithms proposed first for hiding and the second algorithm for extracting. The cover media used in this system is RGB image and the secret message of text type. The following steps shows hiding algorithm:

Proposed Hiding algorithm
Input: plain text (p), spider database (Sdp), cover image (RGB)
Output: stego-object
Process:

1. Generate Hashes for the database using message digest algorithm.

$$\text{Hdp} = MD_5(Sdp) \tag{3}$$

"Hdp will be sent as secret key which is hidden at the end of the message"

2. Select random picture from spider database (Sdp).
3. Mapping the selected picture from the database on the center of the cover image to obtain the set of ends eight points $S_p = \{p_1..p_8\}$.
4. Obtain hashes for set of eight points S_p. Where

$$H_p = MD_5(S_p) \tag{4}$$

5. Encrypt the plain text based on the Eq. (5) and Eq. (6).

$$c_0 = H_p \oplus p \tag{5}$$

$$c_1 = c_0 \oplus Hdp \tag{6}$$

6. Calculate hiding starting point (H_{sp}) using the following process:
   I $H_{sp} = MD_5(H_m + W_k)$. Such that W_k, H_M represent the width and height of the cover image.
   II H_{sp} length will be 128 bits divided into two parts of 64-bit length.
   III apply X-or operation getting 64-bit.
   IV obtaining 16 bits by division and x-or operation is sequences of step II and IV.
   V The 16 bit will be divided into 8 bit each (X, Y) converted to decimal
   $W_n = (X \ mod \ W_k)$,
   and $H_n = Y \ mod \ H_M$.
   The hiding starting point (H_{sp}) will be (W_n, H_n).
7. The hiding will be in the valid pixels range V_r , $V_r = T_p - S_p$, such that T_p represent the total number of pixels in the cover image.
8. Hiding targeting 6th and 7th bits in the valid pixels range V_r.

The proposed hiding algorithm in system can be represented with following flowchart as show in the Figure 5.

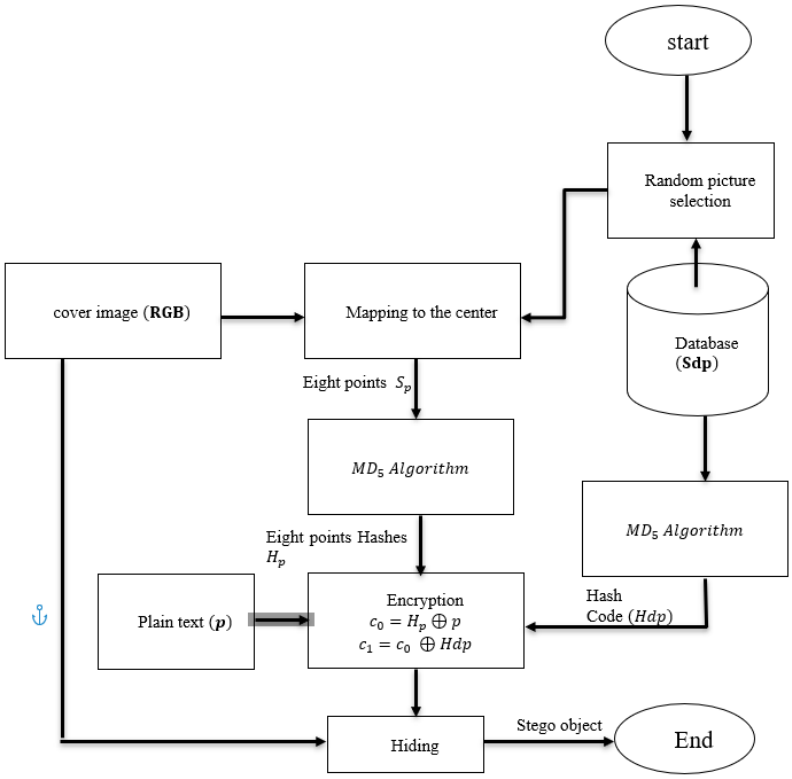

Fig. 5. The proposed hiding flowchart

The end of the process of hiding will produce a stego-object which is represented by the cover image as well as encrypted plain text hidden inside. One of the important things have to be mentioned that the value of the hash code will be send as secret key such code generated from spider images database to add one more of security level for the proposed system.

The receiver will get a stego-object and hash database will use them as input for the extraction algorithm and the aim for this algorithm is to get plain text (secret message) the extracting algorithm as follow:

Proposed extracting algorithm
Input: Stego-object, Hashes database Hdp
Output: Plain text (p).
Processes

1. Determine required database picture based on received Hdp.
2. Mapping the selected picture from the database on the center of the Stego-object to obtain the set of ends eight points $S_p = \{p_1..p_8\}$.
3. Obtain hashes for set of eight points S_p. Where

$H_p = MD_5(S_p)$.

4. Obtain extracting starting point (H_{sp}) using the following process:
   I $H_{sp} = MD_5(H_m + W_k)$. Such that W_k, H_M represent the width and height of the Stego-object.
   II H_{sp} length will be 128 bit divided into two parts of 64-bit length.
   III apply X-or operation getting 64-bit.
   IV obtaining 16 bits by division and x-or operation is sequences of step II and IV.
   V The 16 bit will be divided into 8 bit each (X, Y) converted to decimal
   $W_n = (X \ mod \ W_k)$, and $H_n = Y \ mod \ H_M$.
   The extracting starting point (H_{sp}) will be (W_n, H_n).
5. The hiding will be in the valid pixels range V_r , $V_r = T_p - S_p$, such that T_p represent the total number of pixels in the Stego-object.
6. Collecting 6th and 7th bits in the valid pixels range V_r. To get $\boldsymbol{c_1}$. While the last 128 bit representing Hdp for checking.
7. Decrypt the plain text based on the Eq. (7). And Eq. (8)

$$p_1 = c_1 \oplus \mathrm{Hdp} \tag{7}$$

$$\mathrm{p_0} = \mathrm{H_p} \oplus \mathrm{p_1} \tag{8}$$

Thus, $\mathrm{p_0}$ represent the plain text.

The proposed extracting algorithm can be showed with following Figure 6.

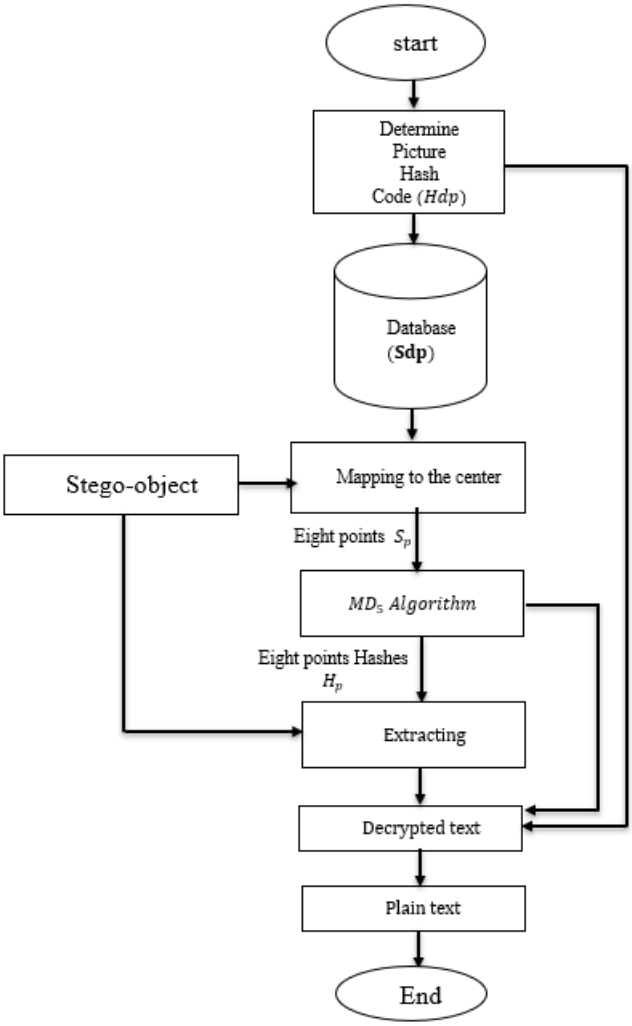

Fig. 6. Proposed extracting flowchart

Taking sample for secret message of two bytes (16 bits) to be hide in the cover image using the proposed hiding algorithm. After determining the starting points (H_{sp}) and valid range of the cover image (V_r) the hiding process starting in the 6th and 7th bits as shown in the Figure 7.

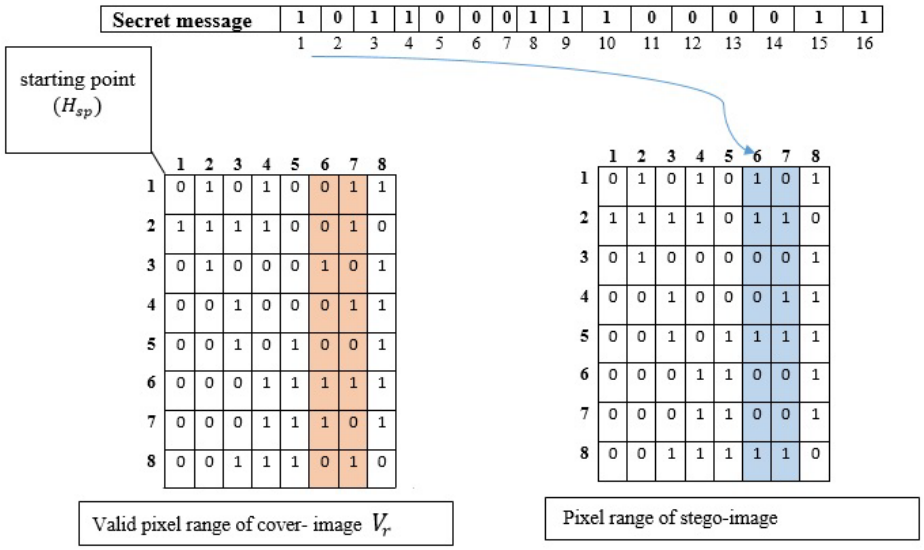

Fig. 7. Hiding 16-bits secret message in 8 pixels

The valid pixel range in the cover image shows with the orange-coloured Colum on the left side which represent only one band of the colour image of (RGB). On the other hand, the right side of the Figure 7 show the stego-image which contains the secret message with blue colour.

3 Results and discussion

The result of the proposed system measured based on PSNR metrics for the quality of the system. Table 1 shows the size of the cover image with the size of the secret images and the randomly selected the image as well as the generated hashes Md5 for the image while the finial column clearing the values of the PSNR for each run process in rows.

Table 1. Results evaluation based on PSNR metric

Cover image size (pixels)	Secret message size (kilobyte)	Selected image (indexed)	MD5 for image	Peak signal to noise ratio (PSNR)
128* 128	1	18	8c95757bec1bc9d4795 342ecfb39887f	57.8
256* 256	2	9	5fcb74cd63e960be707 c45ec7c98a994	60.12
300* 300	3	5	2ae45841d10b816ab86 ff1d2772dc848	61.82
512* 512	4	23	bfe228f7c5ace87abc52 20d7b511a501	62.46

There are a lot of consequences have to be considered when achieving hiding process and one of the most important one is to take care of the subjective and objective metric to measure the efficiency of the proposed system. The PSNR is the common metric used I most of the paper to validate the hiding process that is obtained for the various run of the system with different size of cover images as well as different size of the secret messages and the minimum vale of PSNR is 57.8 to hide 1 K secret message inside 128*128 pixel cover image while maximum value of PSNR is 62.46 to hide 4K of secret message within 512*512 pixel cover image.

4 Conclusion

This kind of security system will be complex enough to protect may types of information because of using database of images which is shared between sender and receiver as well. Utilizing of hash function MD5 which is generated to secure the selection of the image database. As advantages of using such system is to obtain 128 bit using MD5 on the eight points through mapping the images on the cove such bits used in the encryption process. The proposed system used mechanism for determine the starting point of the hiding based on the height and width of the cove image. The value of the PSNR shows system work well when the cover image size increased as well as the size of the secret message increased also.

5 References

[1] H. T. Elshoush, I. A. Ali, M. M. Mahmoud, and A. Altigani, "A Novel Approach to Information Hiding Technique using ASCII Mapping Based Image Steganography," *J. Inf. Hiding Multim. Signal Process.,* vol. 12, no. 2, pp. 65-82, 2021.

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

[3] R. Bansal and N. Badal, "A novel approach for dual layer security of message using Steganography and Cryptography," *Multimedia Tools and Applications,* pp. 1-16, 2022. https://doi.org/10.1007/s11042-022-12084-y

[4] I. A. Aljazaery, and M. R. Aziz, "Combination of hiding and encryption for data security," *International Journal of Interactive Mobile Technologies,* Article vol. 14, no. 9, pp. 34-47, 2020, https://doi.org/10.3991/ijim.v14i09.14173

[5] M. M. Sadek, A. S. Khalifa, and M. G. Mostafa, "Video steganography: a comprehensive review," *Multimedia tools and applications,* vol. 74, no. 17, pp. 7063-7094, 2015. https://doi.org/10.3991/ijim.v14i09.14173

[6] H. Rajeswari, R. Yegireddi, and V. G. Rao, "Performance Analysis of Hash Algorithms and File Integrity," *Hanumantu Rajeswari et al, International Journal of Computer Science and Information Technologies,* vol. 5, no. 6, pp. 7376-7379, 2014.

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

[8] H. S. Abdulah, M. A. H. Al-Rawi, and D. N. Hammod, "Message Authentication Using New Hash Function," *Al-Nahrain Journal of Science,* vol. 19, no. 3, pp. 148-153, 2016. https://doi.org/10.22401/JNUS.19.3.20

[9] A. F. Najib, E. H. Rachmawanto, C. A. Sari, K. Sarker, and N. Rijati, "A comparative study MD5 and SHA1 algorithms to encrypt REST API authentication on mobile-based application," in *2019 International Conference on Information and Communications Technology (ICOIACT)*, 2019: IEEE, pp. 206-211.

[10] N. Alseelawi, and H. T. Hazim, "A Novel Method of Multimodal Medical Image Fusion Based on Hybrid Approach of NSCT and DTCWT," *iJOE,* vol. 18, no. 03, p. 115, 2022. https://doi.org/10.3991/ijoe.v18i03.28011

[11] D. R. I. M. Setiadi, "PSNR vs SSIM: imperceptibility quality assessment for image steganography," *Multimedia Tools and Applications,* vol. 80, no. 6, pp. 8423-8444, 2021. https://doi.org/10.1007/s11042-020-10035-z

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

[13] A. Gutub and F. Al-Shaarani, "Efficient implementation of multi-image secret hiding based on LSB and DWT steganography comparisons," *Arabian Journal for Science and Engineering,* vol. 45, no. 4, pp. 2631-2644, 2020. https://doi.org/10.1007/s13369-020-04413-w

[14] B. A. Hameedi, M. M. Laftah, and A. A. Hattab, "Data Hiding in 3D-Medical Image," *International Journal of Online & Biomedical Engineering,* vol. 18, no. 3, 2022. https://doi.org/10.1007/s13369-020-04413-w

[15] N. A. H. Hala A. Naman, and M. L. Al-dabag, "Encryption System for Hiding Information Based on Internet of Things," International Journal of Interactive Mobile Technologies (iJIM), vol. 15, no. 2, 2021. https://doi.org/10.3991/ijim.v15i02.19869

[16] M. K. Abdul-Hussein and H. Salim, "Evaluation of the Interference's Impact of Cooperative Surveillance Systems Signals Processing for Healthcare," 2022. https://doi.org/10.3991/ijim.v15i02.19869

[17] A. H. M. Alaidi, A. S. Abdalrada, and F. T. Abed, "Analysis the Efficient Energy Prediction for 5G Wireless Communication Technologies," International Journal of Emerging Technologies in Learning (iJET), vol. 14, no. 08, pp. 23-37, 2019. https://doi.org/10.3991/ijet.v14i08.10485

[18] A. Kusyanti, N. Santoso, P. Ainunnazah, and L. Maulana, "The Implementation of zk-SNARK HH Authentication on IoT Protocols," *International Journal of Online & Biomedical Engineering,* vol. 18, no. 6, 2022. https://doi.org/10.3991/ijoe.v18i06.28893

[19] I. A. Aljazaery, H. T. S. ALRikabi, and A. H. M. Alaidi, "Encryption of Color Image Based on DNA Strand and Exponential Factor," *iJOE,* vol. 18, no. 03, p. 101, 2022. https://doi.org/10.3991/ijoe.v18i06.28893

[20] S. H. Abbood, M. Rahim, and A. H. M. Alaidi, "DR-LL Gan: Diabetic Retinopathy lesions synthesis using Generative Adversarial Network," *International journal of online and biomedical engineering,* vol. 18, no. 3, pp. 151-163, 2022. https://doi.org/10.3991/ijoe.v18i03.28005

6 Authors

Ismael Abdul Sattar Jabbar is a Ph.D holder in computer science from Informatics Institute for postgraduate studies. He gets M.Sc. degree in computer science from Delhi

University, Faculty of Mathematical Sciences in 2012; B.Sc. degree in computer science in 2006 from Al-Mustansiriyah University, Collage of Science. He has published more than 17 research papers in national or international journals and conferences with 7 books in various fields in computer science (E-mail: ismaelabdul@uomustansiriyah.edu.iq).

Shaimaa Hameed Shaker, Computer department, University of technology, Baghdad, Iraq.

Article submitted 2022-10-09. Resubmitted 2022-11-20. Final acceptance 2022-11-21. Final version published as submitted by the authors.

A Comprehensive Systematic Review of Neural Networks and Their Impact on the Detection of Malicious Websites in Network Users

https://doi.org/10.3991/ijim.v17i01.36371

Javier Gamboa-Cruzado[1](✉), Juan Briceño-Ochoa[1], Marco Huaysara-Ancco[1], Alberto Alva-Arévalo[2], Caleb Ríos-Vargas[2], Magaly Arangüena Yllanes[3], Liset S. Rodriguez-Baca[1]
[1] Universidad Autónoma del Perú, Lima, Perú
[2] Universidad Nacional de San Martín, Tarapoto, Perú
[3] Universidad Nacional José María Arguedas, Apurímac, Perú
jgamboa65@hotmail.com

Abstract—The large branches of Machine Learning represent an immense support for the detection of malicious websites, they can predict whether a URL is malicious or benign, leaving aside the cyber attacks that can generate for network users who are unaware of them. The objective of the research was to know the state of the art about Neural Networks and their impact for the Detection of malicious Websites in network users. For this purpose, a systematic literature review (SLR) was conducted from 2017 to 2021. The search identified 561 963 papers from different sources such as Taylor & Francis Online, IEEE Xplore, ARDI, ScienceDirect, Wiley Online Library, ACM Digital Library and Microsoft Academic. Of the papers only 82 were considered based on exclusion criteria formulated by the author. As a result of the SLR, studies focused on machine learning (ML), where it recommends the use of algorithms to have a better and efficient prediction of malicious websites. For the researchers, this review presents a mapping of the findings on the most used machine learning techniques for malicious website detection, which are essential for a study because they increase the accuracy of an algorithm. It also shows the main machine learning methodologies that are used in the research papers.

Keywords—machine learning, neural network, web site detection, malicious web sites, algorithms, systematic literature review

1 Introduction

Nowadays, websites offer services of all kinds to network users, such as e-mail, social networks, online shopping, among others. These websites store users' confidential information. Fraudsters always try to steal users' confidential information by using misleading URL text [41]. Researchers have been applying different types of algorithms for example Sequential Minimum Optimization (SMO), logistic regression and naive

bayes, decision tree, K nearest neighbors, among others. These algorithms achieve reliable and accurate results when detecting malicious websites [10]. In order to evaluate the performance of the models and algorithms, some experiments are carried out using a set of comparative data: accuracy and area under the receiver operating characteristic (ROC), receiver operating characteristic (ROC) and area under the curve (AUC) [41]. In this work, we identified the algorithms most commonly used by researchers from different studies with the aim of detecting malicious websites.

In this SLR we obtained papers related to the topic, but not focused on the prediction of malicious websites with a comparative approach using neural networks. However, the papers reviewed propose algorithms for the prediction of these websites thus giving their effectiveness for this detection process.

In the general study for the prediction process Sahingoz, Buber, Demir and Diri [45] propose to use two lists, Whitelist (whitelist) and Blacklist (blacklist), to classify legitimate and malicious websites. Whitelist-based website detection systems create safe and legitimate websites to provide the necessary information. Every website that is not on the whitelist is considered malicious. In the study of the prediction process there are a number of algorithms that give different results for different varieties of malicious websites.

Authors Gandotra and Gupta [15] use machine learning algorithms SVM, Random Forest (RF), Neural Network, Logistic Regression and Naïve Bayes (NB); to differentiate suspicious websites from benign ones.

Authors P. Yang, Zhao and Z. Yang [47] argue that deep learning (Deep Learning) is a research direction of neural networks that can discover hidden information within complex data through level-by-level learning. CNN is an artificial deep feedback deep neural network. Compared with traditional back propagation neural networks, CNNs adopt a weight sharing network structure similar to that of a biological neural network, and its neurons are sparsely connected, which reduces the complexity of the network model and improves the training performance.

According to Haider and Singh [1], phishing is a deception technique that aims to steal sensitive personal information such as passwords, credit cards, identity theft and other fraudulent activities by an individual or a group. Intruders can take this information using phishing techniques (e.g., when a user enters their data on a phishing website, their data is stolen and they are then redirected to the original site).

Al-Milli and Hammo [43] claim that convolutional neural network (CNN) is one of the most successful methods used recently in classification problems. CNN is used for complex classification problems. More specifically, CNN is used in the image processing domain.

The uniqueness of this research is the use of the Mendeley tool useful for the management of the papers, as well as the use of artificial intelligence for the generation of the bigrams, trigrams and bibliometric networks that show relevant information, as well as a comparison between the keywords in the reviewed papers.

The main objective is to determine the current state of the art of worldwide experimental research on Neural Networks and their influence on the Detection of Malicious Websites in network users. The structure of the paper is organized as follows; section II presents an interpretation of previous research and what the study aims to achieve.

Section III details the methodology to be used for the systematic literature review and this was developed according to Kitchenham and Charters [83]. Section IV shows the results of each question and also a comparison with a review paper. Section V finally gives conclusions and recommendations.

2 Review methodology

2.1 Review protocol

This research followed the model and steps proposed by Kitchenham and Charters [83]; it covered the following: research questions, sources of information, identified studies, exclusion criteria, quality assessment, data extraction, and synthesis of findings (Figure 1).

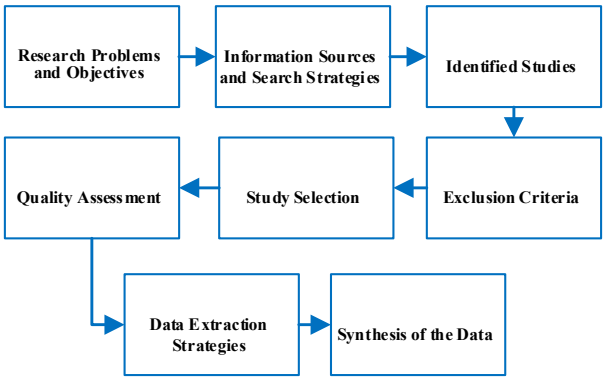

Fig. 1. RSL process

2.2 Research problems and objectives

For the SLR, research questions (RQs) were developed that are necessary for the data search, extraction and analysis strategy. Each research question has an objective, which are shown in Table 1.

Table 1. Research questions and objectives

Research Question	Objetive
RQ1: What types of algorithms are being considered to detect malicious websites in web users?	Identify the most considered types of algorithms for detecting malicious websites in network users
RQ2: What machine learning methodologies are used to detect malicious websites?	Report the machine learning methodologies that are used for malicious website detection
RQ3: What are the criteria for measuring the overall effectiveness of neural networks with machine learning?	Determine what are the criteria for measuring the overall effectiveness of neural networks with machine learning

RQ4: What are the most commonly used and relevant keywords about neural networks and their influence on the process of detecting malicious websites in network users?	Determine which are the most used and relevant keywords, on neural networks and their influence on the process of detecting malicious websites in network users.
RQ5: What are the keywords that show co-occurrence in neural network research and their influence on the process of malicious website detection in network users?	Detect which keywords present co-occurrence in neural network research and their influence on the process of detecting malicious websites in network users

2.3 Information sources and search strategies

Figure 2 shows the sources used in the search for research papers.

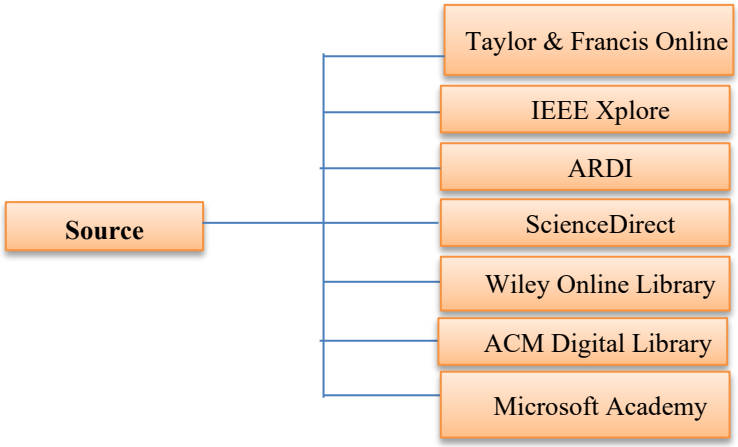

Fig. 2. Sources of information

For the search strategy of the studies, the thematic descriptors and their synonyms were identified (See Table 2).

Table 2. Search descriptors

Descriptor	Variable
neural network / machine learning	Independent
website / URL detection	Dependent

For the search of the papers, equations were used for each source of information, as shown in Table 3.

Table 3. Information sources and search equations

Source	Search equation
Taylor & Francis Online	[[All: "neural network"] OR [All: "machine learning"]] AND [[All: "website detection"] OR [All: URL*]]
IEEE Xplore	("Neural network" OR "Machine Learning") AND ("website detection" OR URL*)
ARDI	("Neural network" OR "Machine Learning") AND (" website detection" OR URL*)
Science Direct	("neural network" OR "machine learning") AND (website detection OR URL OR URLS)
Wiley Online Library	""neural network" OR "machine learning"" anywhere and ""website detection" OR URL*" anywhere
ACM Digital Library	[[All: "neural network"] OR [All: "machine learning"]] AND [[All: website detection] OR [All: URL*]
Microsoft Academic	("Neural network" OR "Machine Learning") AND ("website detection" OR "URL*")

2.4 Identified studies

The papers identified in each source are shown in Figure 3.

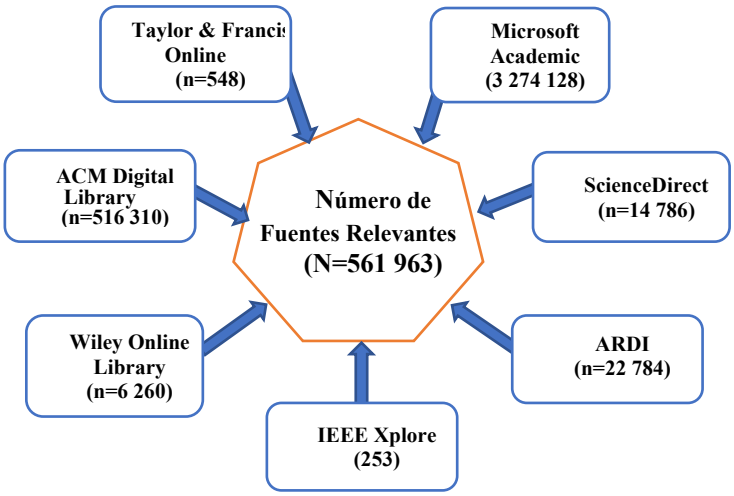

Fig. 3. Number of relevant studies

2.5 Exclusion criteria

Al Some exclusion criteria (EC) were necessary for the filtering and selection of the papers:

CE1.The papers are older than 5 years old
CE2. The papers are not written in English
CE3. The papers are not published in Conferences or Journals
CE4. The papers are repeated
CE5. The titles and keywords of the papers are not very appropriate
CE6. There is not enough information to make the assessment
CE7. The abstracts of the papers are not very relevant

2.6 Studio selection

Initially, 561963 papers were obtained, based on the search performed using the keywords relevant to the study.

Then, a series of selection and filtering steps were applied, as shown in Figure 4.

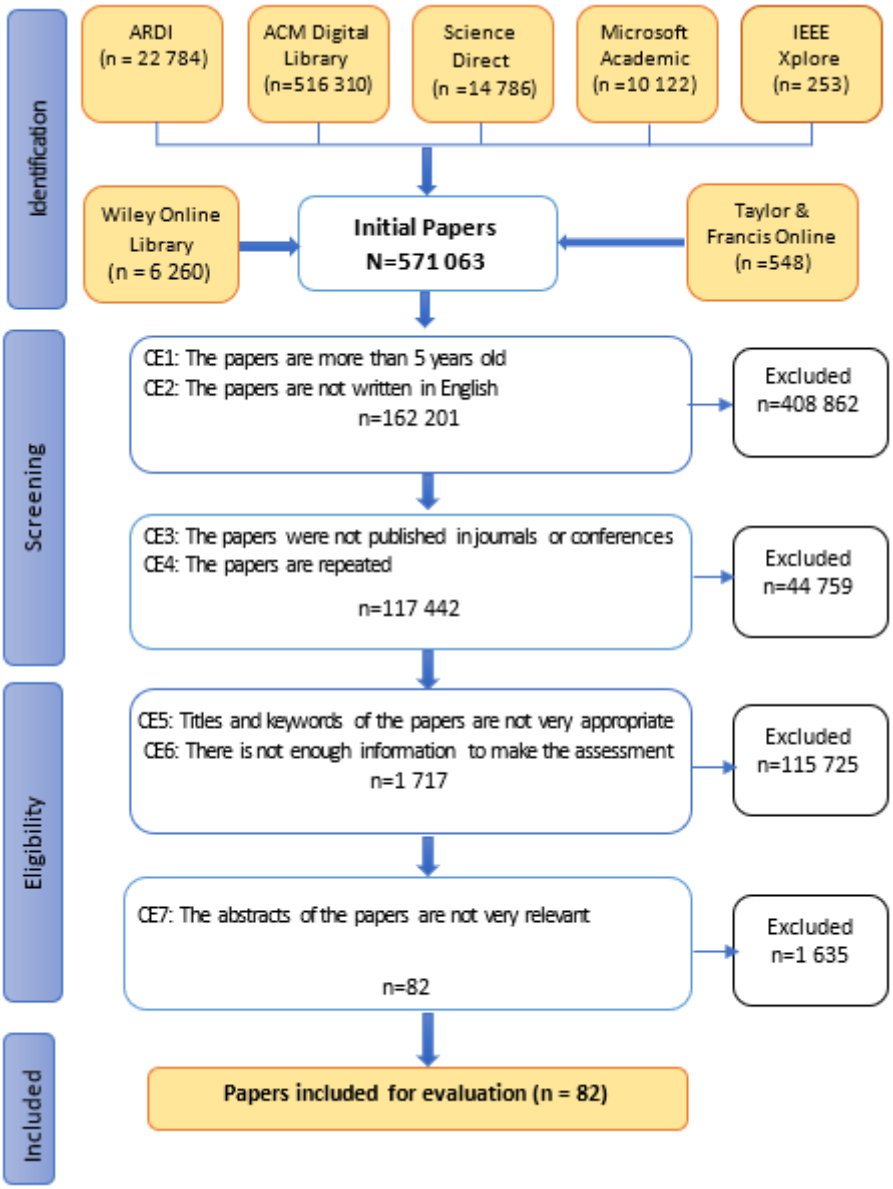

Fig. 4. PRISMA flow chart

2.7 Quality assessment

An important phase in rigorously evaluating the final list of papers was the quality assessment criteria (QAs). These were applied to measure the quality of the research papers. Seven QAs were identified:

QA1. Is the purpose of the research clearly explained?
QA2. Are the research findings clearly explained?
QA3. Is the paper well organized?
QA4. Does the document include practical experiments?
QA5. Are data collection and measurements adequately described?
QA6. Are the results of the experiments performed clearly identified and reported?
QA7. Is the document considered useful?

In general, the use of these 7 QAs ensures that these findings could make a valuable contribution to the review. Each of the 7QAs was rated on a dichotomous scale. Therefore, the research described in the papers is understandable and their results can be relied upon. Of the studies evaluated for quality assurance, the 82 papers have been retained.

2.8 Strategies of data extraction

For the final data extraction, the list of total papers was integrated in order to answer the research questions formulated.

The information extracted from each paper included the following: ID of the paper, title of the paper, URL, source, year, country, number of pages, language, publication type, publication name, authors, affiliation, number of citations, abstract, keywords, sample size. The Mendeley desktop tool was used to perform the data extraction.

2.9 Synthesis of the data

The data collected for research questions RQ1-RQ5 were tabulated and presented as quantitative data that were used to develop a statistical comparison between the various solutions for each question, taking into account research conducted in the last 5 years.

3 Results and discussion

3.1 General description of studies

Eighty-two papers were selected for the review, which were evaluated for their quality and the data extraction and analysis strategy was applied. Figure 5 shows the number of papers published per year. This indicates that the year in which the most papers were published was 2020.

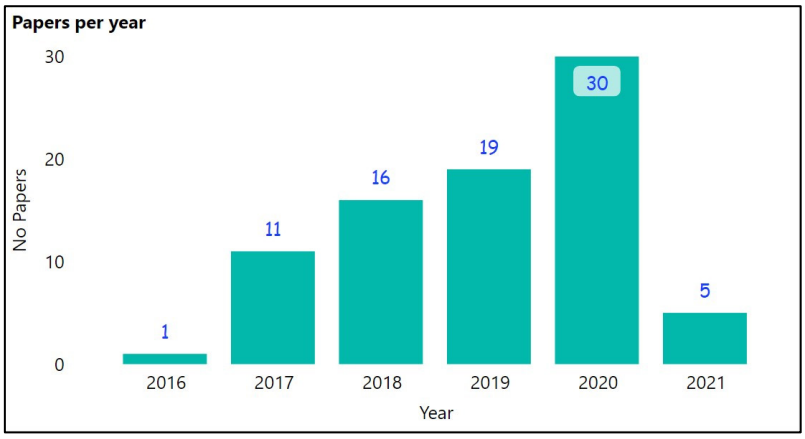

Fig. 5. Papers by year

Figure 6 details the number of papers by country, this shows that the country with the highest number of papers for the research was India as well as China. It can be seen that India and China are the countries that have a greater focus on the detection of malicious websites with machine learning by the number of papers published and the countries that have less participation are Jordan and Slovenia.

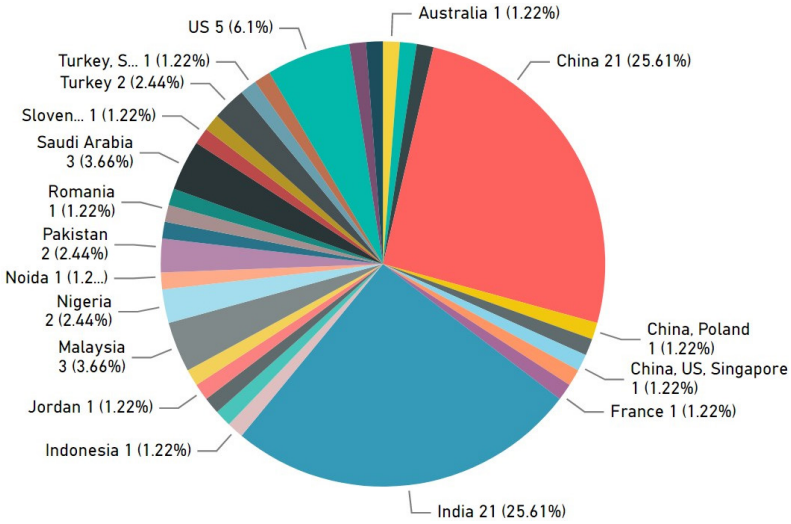

Fig. 6. Number of papers by country

Figure 7 shows the papers by type of publication. As shown in the figure, a total of 82 papers were found, of which 40% were published in Conferences and the remaining 60% were published in Journals.

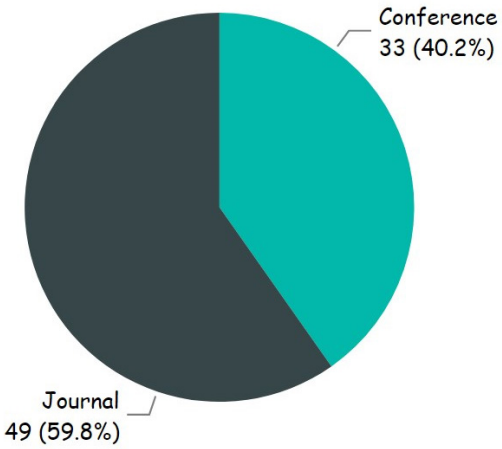

Fig. 7. Papers by publication type

Figure 8 shows the most common words in the abstracts of the papers reviewed. It can be seen that the most used word was phishing, this was even the most common word in the keywords. This is followed by the words learning and detection.

Fig. 8. Most recurrent words in the abstract

3.2 Answers to research questions

The following are the answers (results) for each of the RQs formulated, which were obtained after an exhaustive review of the 82 papers selected.

RQ1: What types of algorithms are being applied to detect malicious websites in network users? The results shown in Table 4 indicate which were the most used machine learning algorithms in the area of malicious website detection in network users. In this research 10 algorithms were considered, it is observed that the one with the highest percentage of references are neural networks with 23%, it can be said that it is the most popular in this area of malicious website detection, the second most applied type of algorithm was Super Vectore Machine with 19%.

Table 4. Machine learning algorithms

ML algorithm	Reference	Qty. (%)
Neural network	[1][3][4][5][7][8][9][16][18][19][20][23][26][21] [22][28][34][44] [54] [57] [64][69][82]	24 (23)
K-nearest neighbors	[4][8][11][12][15][25][26][21][30] [35]	10 (10)
Decision tree	[4][10][11][14][25][30][35] [44] [54] [65]	10 (10)
Logistic regression	[7][10][11][21][30][35][47] [65] [77]	10 (10)
Random forest	[4][8][10][11][15][25][30] 54][65] [69]	10 (10)
Naive Bayes	[7][8][14][15][16][26][30]35][44][46][47][54][57] [62]	14 (14)
Super Vector Machine	[4][7][8][11][12][14][15][16][25][21][28][35][44] [46] [47][54] [57] [69] [77]	19 (19)
Extreme machine learning (ELM)	[21][79]	2 (2)
Ripper algorithm	[60]	1 (1)
Cultural Algorithm	[1]	1 (1)

According to authors Badawi and Jourdan [89], in their research question they refer what mechanisms are available to detect cybercriminal activities; it answers that the models that offer the best results are random forest with an accuracy of 99%, another algorithm model that also stands out in their answer is SVM with an accuracy of 97.9%.

According to the authors Gheewala and Patel [86], neural networks are a widely used data mining algorithm for detecting malicious websites and it in turn depends on the proper selection of its features, such as model performance and the level of prediction accuracy of the algorithm.

RQ2: What machine learning methodologies are used to detect malicious websites? To answer the question the following machine learning methodologies in neural networks were considered: convolutional neural network and artificial neural network as the most considered in the research papers, this is because these methodologies offer better results in the area of malicious website detection, on the other hand convolutional

neural network was mentioned in many papers that have more than 5 citations (See Table 5).

Table 5. Machine learning methodologies

ML Methodologie	Reference	Qty. (%)
Convolutional Neural Network (CNN)	[9][7][23][26][28][35][43][47][5][54][64][69][77][82]	14 (34)
Deep Neural Network	[10][23][41][46][47] [57][64]	7 (17)
Artificial Neural Network	[1][3][4][11][16][18][19][20][21][22][34][44][49][54][57]	15 (36)
Recurrent Neural Network	[5][7][9][28][54][82]	5 (13)

From the point of view of authors Odeh, Keshta and Abdelfattah [85], they argue that convolutional neural networks and long short-term memory (LSTM), are widely used techniques for website phishing detection, but when both are used in a study both CNN and LSTM get better results. A clear example of this is that CNN learns from URL features and sends them to LSTM for final resolution. This approach motivates other researchers to design a model using a combination of deep learning models.

RQ3: What are the criteria for measuring the overall effectiveness of neural networks with machine learning? To answer this question, the criteria for measuring the effectiveness of Machine Learning were taken into account. The most commonly used criteria are the ROC curve and AUC to determine the accuracy in the tests performed statistically based on the machine learning algorithms proposed in the papers studied (See Table 6).

Table 6. Criteria for measuring ML effectiveness

Criteria	Reference	Qty. (%)
ROC CURVE	[5][7][10][19][30][57] [69][82][2][3][9][36] [43]	12 (43)
AUC	[4][7][10][19][28][82] [2][3][36][41][43][51]	12 (43)
PCA	[8][14][16] [9]	4 (14)

According to Dou, Khalil, Khreishah, Al-Fuqaha and Guizani [88], ROC curves can be used as comparisons between two or more models or techniques of algorithms thus giving greater efficiency in terms of the result, it is also possible to interpret that in the combination of these algorithms a result greater than 90% is achieved taking into account the characteristics given in the combination.

RQ4: What are the most frequently used and relevant keywords about neural networks and their influence on the process of detecting malicious websites in network users? Figure 9 shows the keywords with more frequency in the papers, in first place is "machine learning", this word is repeated in 25 papers, in addition, this word was key when searching the papers and it is also the independent variable in Table 3. In second place is the keyword "phishing" with 17 repetitions, a very common word when searching for papers related to the detection of malicious websites in network users.

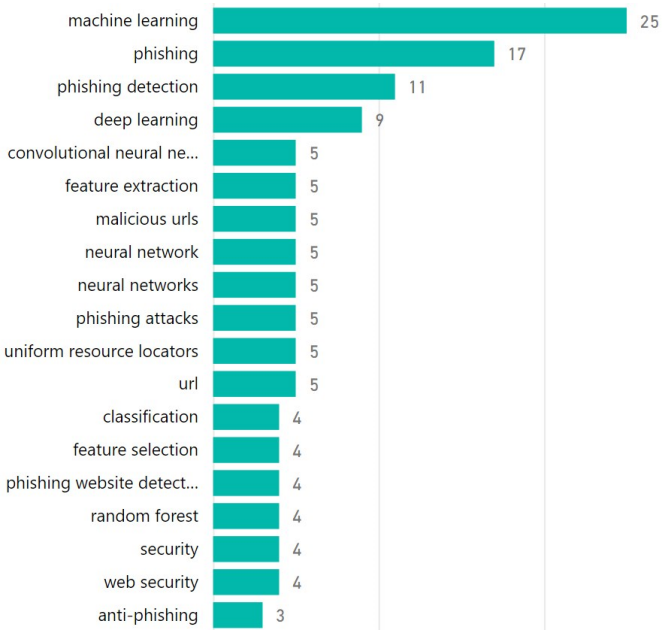

Fig. 9. Keyword repetitions

The authors Mondal, Maheshwari, Pai, and Biwalkar [87], identify "machine Learning" and "pishing" as very common keywords when searching for papers on malicious website detection.

One can also display the most repeated words as a word cloud in Figure 10.

Fig. 10. Cloud of most repeated keywords

RQ5: What are the keywords that show co-occurrence in neural network research and their influence on the process of malicious website detection in network users? In order to answer this RQ, a biometric network of keywords as they appear together in the reviewed research has been elaborated (see Figure 11).

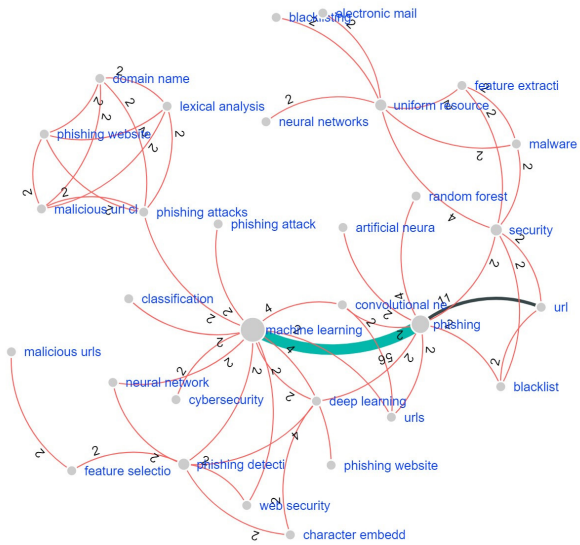

Fig. 11. Keyword bibliometric network

In the bibliometric network it is possible to visualize the keywords most used by the authors together, as well as it can also be visualized that "phishing" and "machine learning" are together in 56 reviewed papers, also "phishing" and "url" are together in 11 papers. Then it is deduced that the words have a relationship, the first one which is phishing and machine learning its relationship is problem-solution because nowadays machine learning method is used for prediction of malicious websites (phishing). The second relationship of phishing and url, its relationship is of similarity because phishing is a technique of deception, in this case it would be through a misleading url impersonating someone close or a particular company in order to steal information.

4 Conclusion

This study has used the SRL methodology proposed by Kitchenham and Charters [83], whose purpose was to respond to the problems posed, so high quality papers that address the RQs formulated have been evaluated. As a result, 82 research papers have been identified, which answer the research questions. These papers were carefully selected by applying exclusion criteria and had a quality assessment. It should be noted that the Mendeley tool was used, which was very helpful for the management of the papers analyzed. In the results section and its discussions, the 5 RQs formulated have been answered, using statistical graphs, tables and the novel bibliometric networks. These were very helpful in answering the research questions and a comparison has been made with many review papers.

Therefore, future research should consider reviewing more recent publications on the process of detecting malicious websites. This will benefit to optimize the inquiry on the topic of malicious website detection process in order to be able to have a wider scope and depth on the topics of cybersecurity.

5 Acknowledgment

We would like to thank the Universidad Autónoma del Perú for its support to our work carried out, specifically the career of de Systems Engineering.

6 References

[1] A. Haider and R. Singh, “Phishing URL Detection using Neural Network Optimized by Cultural Algorithm,” Int. J. Comput. Sci. Eng., vol. 6, no. 7, pp. 860–863, 2018, https://doi.org/10.26438/ijcse/v6i7.860863

[2] A. A. Orunsolu, A. S. Sodiya, and A. T. Akinwale, “A predictive model for phishing detection,” J. King Saud Univ. - Comput. Inf. Sci., no. xxxx, 2020, https://doi.org/10.26438/ijcse/v6i7.860863

[3] A. Basit, M. Zafar, A. R. Javed, and Z. Jalil, “A Novel Ensemble Machine Learning Method to Detect Phishing Attack,” Proc. - 2020 23rd IEEE Int. Multi-Topic Conf. INMIC 2020, no. November, 2020, https://doi.org/10.1109/INMIC50486.2020.9318210

[4] A. Subasi, E. Molah, F. Almkallawi, and T. J. Chaudhery, "Intelligent phishing website detection using random forest classifier," 2017 Int. Conf. Electr. Comput. Technol. Appl. ICECTA 2017, vol. 2018-Janua, pp. 1–5, 2017, https://doi.org/10.1109/INMIC50486.2020.9318210

[5] A. C. Bahnsen, E. C. Bohorquez, S. Villegas, J. Vargas, and F. A. Gonzalez, "Classifying Phishing URLs Using Recurrent Neural Networks," eCrime Res. Summit, eCrime, pp. 1–8, 2017. https://doi.org/10.1109/ECRIME.2017.7945048

[6] A. Aljofey, Q. Jiang, Q. Qu, M. Huang, and J. P. Niyigena, "An effective phishing detection model based on character level convolutional neural network from URL," Electron., vol. 9, no. 9, pp. 1–24, 2020, https://doi.org/10.3390/electronics9091514

[7] A. A. Ubing, S. K. B. Jasmi, A. Abdullah, N. Z. Jhanjhi, and M. Supramaniam, "Phishing website detection: An improved accuracy through feature selection and ensemble learning," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 1, pp. 252–257, 2019, https://doi.org/10.14569/IJACSA.2019.0100133

[8] A. Zamir et al., "Phishing web site detection using diverse machine learning algorithms," Electron. Libr., vol. 38, no. 1, pp. 65–80, 2020, https://doi.org/10.1108/EL-05-2019-0118

[9] A. Vazhayil, R. Vinayakumar, and K. Soman, "Comparative Study of the Detection of Malicious URLs Using Shallow and Deep Networks," 2018 9th Int. Conf. Comput. Commun. Netw. Technol. ICCCNT 2018, pp. 1–6, 2018, https://doi.org/10.1109/ICCCNT.2018.8494159

[10] S. Anwar et al., "Countering Malicious URLs in Internet of Things Using a Knowledge-Based Approach and a Simulated Expert," IEEE Internet Things J., vol. 7, no. 5, pp. 4497–4504, 2020, https://doi.org/10.1109/JIOT.2019.2954919

[11] A. Ghimire, A. K. Jha, S. Thapa, S. Mishra, and A. M. Jha, "Machine learning approach based on hybrid features for detection of phishing URLs," Proc. Conflu. 2021 11th Int. Conf. Cloud Comput. Data Sci. Eng., no. January, pp. 954–959, 2021, https://doi.org/10.1109/Confluence51648.2021.9377113

[12] Y. C. Chen, Y. W. Ma, and J. L. Chen, "Intelligent Malicious URL Detection with Feature Analysis," Proc. - IEEE Symp. Comput. Commun., vol. 2020-July, 2020, https://doi.org/10.1109/ISCC50000.2020.9219637

[13] C. L. Tan, K. L. Chiew, N. Musa, and D. H. Abang Ibrahim, "Identifying the Most Effective Feature Category in Machine Learning-based Phishing Website Detection," Int. J. Eng. Technol., vol. 7, no. 4.31, pp. 1–6, 2018.

[14] A. Crisan, G. Florea, L. Halasz, C. Lemnaru, and C. Oprisa, "Detecting Malicious URLs Based on Machine Learning Algorithms and Word Embeddings," Proc. - 2020 IEEE 16th Int. Conf. Intell. Comput. Commun. Process. ICCP 2020, pp. 187–193, 2020, https://doi.org/10.1109/ICCP51029.2020.9266139

[15] E. Gandotra and D. Gupta, "Improving Spoofed Website Detection Using Machine Learning," Cybern. Syst., vol. 52, no. 2, pp. 169–190, 2021, https://doi.org/10.1080/01969722.2020.1826659

[16] E. Zhu, D. Liu, C. Ye, F. Liu, X. Li, and H. Sun, "Effective phishing website detection based on improved BP neural network and dual feature evaluation," Proc. - 16th IEEE Int. Symp. Parallel Distrib. Process. with Appl. 17th IEEE Int. Conf. Ubiquitous Comput. Commun. 8th IEEE Int. Conf. Big Data Cloud Comput. 11t, pp. 759–765, 2019. https://doi.org/10.1109/BDCloud.2018.00114

[17] E. Zhu, C. Ye, D. Liu, F. Liu, F. Wang, and X. Li, "An effective neural network phishing detection model based on optimal feature selection," Proc. - 16th IEEE Int. Symp. Parallel Distrib. Process. with Appl. 17th IEEE Int. Conf. Ubiquitous Comput. Commun. 8th IEEE

Int. Conf. Big Data Cloud Comput. 11t, pp. 781–787, 2019. https://doi.org/10.1109/BDCloud.2018.00117

[18] E. Zhu, Y. Ju, Z. Chen, F. Liu, and X. Fang, "DTOF-ANN: An Artificial Neural Network phishing detection model based on Decision Tree and Optimal Features," Appl. Soft Comput. J., vol. 95, p. 106505, 2020, https://doi.org/10.1016/j.asoc.2020.106505

[19] E. Zhu, Y. Chen, C. Ye, X. Li, and F. Liu, "OFS-NN: An Effective Phishing Websites Detection Model Based on Optimal Feature Selection and Neural Network," IEEE Access, vol. 7, pp. 73271–73284, 2019, https://doi.org/10.1109/ACCESS.2019.2920655

[20] F. P. Motlagh and A. K. Bardsiri, "Detecting Fake Websites Using Swarm Intelligence Mechanism in Human Learning," Int. J. Eng., vol. 31, no. 10, pp. 1642–1650, 2018, https://doi.org/10.5829/ije.2018.31.10a.05

[21] F. Feng, Q. Zhou, Z. Shen, X. Yang, L. Han, and J. Q. Wang, "The application of a novel neural network in the detection of phishing websites," J. Ambient Intell. Humaniz. Comput., vol. 0, no. 0, pp. 1–15, 2018, https://doi.org/10.1007/s12652-018-0786-3

[22] S. Gayathri, "Phishing websites classifier using polynomial neural networks in genetic algorithm," 2017 4th Int. Conf. Signal Process. Commun. Networking, ICSCN 2017, pp. 16–19, 2017, https://doi.org/10.1109/ICSCN.2017.8085736

[23] G. Vrbančič, I. Fister, and V. Podgorelec, "Swarm Intelligence Approaches for Parameter Setting of Deep Learning Neural Network," pp. 1–8, 2018, https://doi.org/10.1145/3227609.3227655

[24] S. Gupta and S. Sachdeva, "Invitation or Bait? Detecting Malicious URLs in Facebook Events," 2018 11th Int. Conf. Contemp. Comput. IC3 2018, pp. 1–6, 2018, https://doi.org/10.1109/IC3.2018.8530525

[25] G. Harinahalli Lokesh and G. BoreGowda, "Phishing website detection based on effective machine learning approach," J. Cyber Secur. Technol., vol. 5, no. 1, pp. 1–14, 2021, https://doi.org/10.1109/IC3.2018.8530525

[26] H. huan Wang, L. Yu, S. wei Tian, Y. fang Peng, and X. jun Pei, "Bidirectional LSTM Malicious webpages detection algorithm based on convolutional neural network and independent recurrent neural network," Appl. Intell., vol. 49, no. 8, pp. 3016–3026, 2019, https://doi.org/10.1007/s10489-019-01433-4

[27] H. Yuan, Z. Yang, X. Chen, Y. Li, and W. Liu, "URL2Vec: URL modeling with character embeddings for fast and accurate phishing website detection," Proc. - 16th IEEE Int. Symp. Parallel Distrib. Process. with Appl. 17th IEEE Int. Conf. Ubiquitous Comput. Commun. 8th IEEE Int. Conf. Big Data Cloud Comput. 11t, pp. 265–272, 2019. https://doi.org/10.1109/BDCloud.2018.00050

[28] I. Yilmaz, A. Siraj, and D. Ulybyshev, "Improving DGA-Based malicious domain classifiers for malware defense with adversarial machine learning," 4th IEEE Conf. Inf. Commun. Technol. CICT 2020, no. January, 2020, https://doi.org/10.1109/CICT51604.2020.9311925

[29] J. Yuan, G. Chen, S. Tian, and X. Pei, "Malicious URL detection based on a parallel neural joint model," IEEE Access, vol. 9, pp. 9464–9472, 2021, https://doi.org/10.1109/ACCESS.2021.3049625

[30] J. Kumar, A. Santhanavijayan, B. Janet, B. Rajendran, and B. S. Bindhumadhava, "Phishing website classification and detection using machine learning," 2020 Int. Conf. Comput. Commun. Informatics, ICCCI 2020, pp. 20–25, 2020, https://doi.org/10.1109/ACCESS.2021.3049625

[31] N. Sanglerdsinlapachai and A. Rungsawang, "Using domain top-page similarity feature in machine learning-based web phishing detection," 3rd Int. Conf. Knowl. Discov. Data Mining, WKDD 2010, pp. 187–190, 2010, https://doi.org/10.1109/WKDD.2010.108

[32] K. M. Zubair Hasan, M. Z. Hasan, and N. Zahan, "Automated Prediction of Phishing Websites Using Deep Convolutional Neural Network," 5th Int. Conf. Comput. Commun. Chem. Mater. Electron. Eng. IC4ME2 2019, pp. 1–4, 2019, https://doi.org/10.1109/IC4ME247184.2019.9036647

[33] Y. Liang and X. Yan, "Using deep learning to detect malicious URLs," Proc. - IEEE Int. Conf. Energy Internet, ICEI 2019, pp. 487–492, 2019, https://doi.org/10.1109/ICEI.2019.00092

[34] M. E. Pratiwi, T. A. Lorosae, and F. W. Wibowo, "Phishing Site Detection Analysis Using Artificial Neural Network," J. Phys. Conf. Ser., vol. 1140, no. 1, 2018, https://doi.org/10.1088/1742-6596/1140/1/012048

[35] A. R. Abbas, S. Singh, and M. Kau, "Detection of phishing website using machine learning Approach," Lect. Notes Networks Syst., vol. 89, pp. 1307–1314, 2020, doi: 10.1007/978-981-15-0146-3_128. https://doi.org/10.1088/1742-6596/1140/1/012048

[36] M. Maktabar, A. Zainal, M. A. Maarof, and M. N. Kassim, "Content based fraudulent website detection using supervised machine learning techniques," Adv. Intell. Syst. Comput., vol. 734, pp. 294–304, 2018, https://doi.org/10.1007/978-3-319-76351-4_30

[37] A. S. Manjeri, R. Kaushik, A. Mnv, and P. C. Nair, "A Machine Learning Approach for Detecting Malicious Websites using URL Features," Proc. 3rd Int. Conf. Electron. Commun. Aerosp. Technol. ICECA 2019, pp. 555–561, 2019, https://doi.org/10.1109/ICECA.2019.8821879

[38] M. Sameen, K. Han, and S. O. Hwang, "PhishHaven - An Efficient Real-Time AI Phishing URLs Detection System," IEEE Access, vol. 8, pp. 83425–83443, 2020, https://doi.org/10.1109/ACCESS.2020.2991403

[39] M. Korkmaz, O. K. Sahingoz, and B. DIri, "Detection of Phishing Websites by Using Machine Learning-Based URL Analysis," 2020 11th Int. Conf. Comput. Commun. Netw. Technol. ICCCNT 2020, 2020, https://doi.org/10.1109/ICCCNT49239.2020.9225561

[40] M. V. Kunju, E. Dainel, H. C. Anthony, and S. Bhelwa, "Evaluation of phishing techniques based on machine learning," 2019 Int. Conf. Intell. Comput. Control Syst. ICCS 2019, no. Iciccs, pp. 963–968, 2019, https://doi.org/10.1109/ICCS45141.2019.9065639

[41] M. Al-Janabi, E. De Quincey, and P. Andras, "Using supervised machine learning algorithms to detect suspicious URLs in online social networks," Proc. 2017 IEEE/ACM Int. Conf. Adv. Soc. Networks Anal. Mining, ASONAM 2017, pp. 1104–1111, 2017, https://doi.org/10.1145/3110025.3116201

[42] M. Aydin, I. Butun, K. Bicakci, and N. Baykal, "Using Attribute-based Feature Selection Approaches and Machine Learning Algorithms for Detecting Fraudulent Website URLs," 2020 10th Annu. Comput. Commun. Work. Conf. CCWC 2020, no. Dm, pp. 774–779, 2020, https://doi.org/10.1109/CCWC47524.2020.9031125

[43] N. Al-Milli and B. H. Hammo, "A Convolutional Neural Network Model to Detect Illegitimate URLs," 2020 11th Int. Conf. Inf. Commun. Syst. ICICS 2020, pp. 220–225, 2020, https://doi.org/10.1109/ICICS49469.2020.239536

[44] N. Hosseini, F. Fakhar, B. Kiani, and S. Eslami, "Enhancing the security of patients' portals and websites by detecting malicious web crawlers using machine learning techniques," Int. J. Med. Inform., vol. 132, no. March, 2019, https://doi.org/10.1016/j.eswa.2018.09.029

[45] O. K. Sahingoz, E. Buber, O. Demir, and B. Diri, "Machine learning based phishing detection from URLs," Expert Syst. Appl., vol. 117, pp. 345–357, 2019, https://doi.org/10.1016/j.eswa.2018.09.029

[46] P. S. Ezekiel, O. E. Taylor, and F. B. D.- Okuchaba, "A Model to Detect Phishing Websites using Support Vector Classifier and a Deep Neural Network Algorithm," Ijarcce, vol. 9, no. 6, pp. 188–194, 2020, https://doi.org/10.17148/IJARCCE.2020.9632

[47] P. Yang, G. Zhao, and P. Zeng, "Phishing website detection based on multidimensional features driven by deep learning," IEEE Access, vol. 7, no. c, pp. 15196–15209, 2019, https://doi.org/10.1109/ACCESS.2019.2892066
[48] A. K. Singh and N. Goyal, "A Comparison of Machine Learning Attributes for Detecting Malicious Websites," in 2019 11th International Conference on Communication Systems and Networks, COMSNETS 2019, 2019, vol. 2061, pp. 352–358, https://doi.org/10.1109/COMSNETS.2019.8711133
[49] P. Saravanan and S. Subramanian, "A Framework for Detecting Phishing Websites using GA based Feature Selection and ARTMAP based Website Classification," Procedia Comput. Sci., vol. 171, no. 2019, pp. 1083–1092, 2020, https://doi.org/10.1109/COMSNETS.2019.8711133
[50] R. Rajalakshmi, H. Tiwari, J. Patel, A. Kumar, and R. Karthik, "Design of Kids-specific URL Classifier using Recurrent Convolutional Neural Network," Procedia Comput. Sci., vol. 167, no. 2019, pp. 2124–2131, 2020, https://doi.org/10.1016/j.procs.2020.03.260
[51] R. Haidar and S. Elbassuoni, "Website navigation behavior analysis for bot detection," Proc. - 2017 Int. Conf. Data Sci. Adv. Anal. DSAA 2017, vol. 2018-Janua, pp. 60–68, 2017, https://doi.org/10.1016/j.procs.2020.03.260
[52] R. Kumar, X. Zhang, H. A. Tariq, and R. U. Khan, "Malicious URL detection using multi-layer filtering model," 2016 13th Int. Comput. Conf. Wavelet Act. Media Technol. Inf. Process. ICCWAMTIP 2017, vol. 2018-Febru, pp. 97–100, 2017, https://doi.org/10.1016/j.procs.2020.03.260
[53] R. Verma and A. Das, "What's in a URL: Fast feature extraction and malicious URL detection," IWSPA 2017 - Proc. 3rd ACM Int. Work. Secur. Priv. Anal. co-located with CODASPY 2017, pp. 55–63, 2017, https://doi.org/10.1016/j.procs.2020.03.260
[54] S. Shivangi, P. Debnath, K. Saieevan, and D. Annapurna, "Chrome Extension for Malicious URLs detection in Social Media Applications Using Artificial Neural Networks and Long Short Term Memory Networks," 2018 Int. Conf. Adv. Comput. Commun. Informatics, ICACCI 2018, pp. 1993–1997, 2018, https://doi.org/10.1016/j.procs.2020.03.260
[55] S. Nayak, D. Nadig, and B. Ramamurthy, "Analyzing Malicious URLs using a Threat Intelligence System," Int. Symp. Adv. Networks Telecommun. Syst. ANTS, vol. 2019-Decem, pp. 6–9, 2019, https://doi.org/10.1109/ANTS47819.2019.9118051
[56] S. Wen, Z. Zhao, and H. Yan, "Detecting malicious websites in depth through analyzing topics and web-pages," ACM Int. Conf. Proceeding Ser., pp. 128–133, 2018, https://doi.org/10.1145/3199478.3199500
[57] S. G. Selvaganapathy, M. Nivaashini, and H. P. Natarajan, "Deep belief network based detection and categorization of malicious URLs," Inf. Secur. J., vol. 27, no. 3, pp. 145–161, 2018, https://doi.org/10.1080/19393555.2018.1456577
[58] S. Singhal, U. Chawla, and R. Shorey, "Machine Learning Concept Drift based Approach for Malicious Website Detection," 2020 Int. Conf. Commun. Syst. NETworkS, COMSNETS 2020, pp. 582–585, 2020, https://doi.org/10.1109/COMSNETS48256.2020.9027485
[59] S. Sindhu, S. P. Patil, A. Sreevalsan, F. Rahman, and A. N. Saritha, "Phishing detection using random forest, SVM and neural network with backpropagation," Proc. Int. Conf. Smart Technol. Comput. Electr. Electron. ICSTCEE 2020, pp. 391–394, 2020, https://doi.org/10.1109/COMSNETS48256.2020.9027485
[60] S. Thakur, E. Meenakshi, and A. Priya, "Detection of malicious URLs in big data using RIPPER algorithm," RTEICT 2017 - 2nd IEEE Int. Conf. Recent Trends Electron. Inf. Commun. Technol. Proc., vol. 2018-Janua, pp. 1296–1301, 2017, https://doi.org/10.1109/COMSNETS48256.2020.9027485

[61] S. Gupta and A. Singhal, "Phishing URL detection by using artificial neural network with PSO," 2nd Int. Conf. Telecommun. Networks, TEL-NET 2017, vol. 2018-Janua, pp. 1–6, 2018, https://doi.org/10.1109/TEL-NET.2017.8343553
[62] T. Peng, I. Harris, and Y. Sawa, "Detecting Phishing Attacks Using Natural Language Processing and Machine Learning," Proc. - 12th IEEE Int. Conf. Semant. Comput. ICSC 2018, vol. 2018-Janua, pp. 300–301, 2018, https://doi.org/10.1109/TEL-NET.2017.8343553
[63] T. Li, G. Kou, and Y. Peng, "Improving malicious URLs detection via feature engineering: Linear and nonlinear space transformation methods," Inf. Syst., vol. 91, p. 101494, 2020, https://doi.org/10.1109/TEL-NET.2017.8343553
[64] T. Shibahara et al., "Malicious URL sequence detection using event de-noising convolutional neural network," IEEE Int. Conf. Commun., 2017, https://doi.org/10.1109/ICC.2017.7996831
[65] V. Patil, P. Thakkar, C. Shah, T. Bhat, and S. P. Godse, "Detection and Prevention of Phishing Websites Using Machine Learning Approach," Proc. - 2018 4th Int. Conf. Comput. Commun. Control Autom. ICCUBEA 2018, pp. 1–5, 2018, https://doi.org/10.1109/ICCUBEA.2018.8697412
[66] F. Vanhoenshoven, G. Napoles, R. Falcon, K. Vanhoof, and M. Koppen, "Detecting malicious URLs using machine learning techniques," 2016 IEEE Symp. Ser. Comput. Intell. SSCI 2016, 2017, https://doi.org/10.1109/SSCI.2016.7850079
[67] W. Ali, "Phishing Website Detection based on Supervised Machine Learning with Wrapper Features Selection," Int. J. Adv. Comput. Sci. Appl., vol. 8, no. 9, pp. 72–78, 2017, https://doi.org/10.14569/IJACSA.2017.080910
[68] W. Ali and A. A. Ahmed, "Hybrid intelligent phishing website prediction using deep neural networks with genetic algorithm-based feature selection and weighting," IET Inf. Secur., vol. 13, no. 6, pp. 659–669, 2019, https://doi.org/10.1049/iet-ifs.2019.0006
[69] W. Wei, Q. Ke, J. Nowak, M. Korytkowski, R. Scherer, and M. Woźniak, "Accurate and fast URL phishing detector: A convolutional neural network approach," Comput. Networks, vol. 178, no. April, 2020, https://doi.org/10.1016/j.comnet.2020.107275
[70] S. Mondal, D. Maheshwari, N. Pai, and A. Biwalkar, "A Review on Detecting Phishing URLs using Clustering Algorithms," 2019 6th IEEE Int. Conf. Adv. Comput. Commun. Control. ICAC3 2019, pp. 1–6, 2019, https://doi.org/10.1109/ICAC347590.2019.9036837
[71] J. Mao et al., "Detecting Phishing Websites via Aggregation Analysis of Page Layouts," Procedia Comput. Sci., vol. 129, pp. 224–230, 2018, https://doi.org/10.1016/j.procs.2018.03.053
[72] W. Bai, "Phishing website detection based on machine learning algorithm," Proc. - 2020 Int. Conf. Comput. Data Sci. CDS 2020, pp. 293–298, 2020, https://doi.org/10.1109/CDS49703.2020.00064
[73] W. Yang, W. Zuo, and B. Cui, "Detecting Malicious URLs via a Keyword-Based Convolutional Gated-Recurrent-Unit Neural Network," IEEE Access, vol. 7, no. c, pp. 29891–29900, 2019, https://doi.org/10.1109/CDS49703.2020.00064
[74] X. Xiao, D. Zhang, G. Hu, Y. Jiang, and S. Xia, "CNN–MHSA: A Convolutional Neural Network and multi-head self-attention combined approach for detecting phishing websites," Neural Networks, vol. 125, pp. 303–312, 2020, https://doi.org/10.1016/j.neunet.2020.02.013
[75] X. Yan, Y. Xu, B. Cui, S. Zhang, T. Guo, and C. Li, "Learning URL Embedding for Malicious Website Detection," IEEE Trans. Ind. Informatics, vol. 16, no. 10, pp. 6673–6681, 2020, https://doi.org/10.1109/TII.2020.2977886

[76] X. D. Hoang, "A website defacement detection method based on machine learning," Lect. Notes Networks Syst., vol. 63, pp. 116–124, 2019, https://doi.org/10.1007/978-3-030-04792-4_17

[77] X. Yu, "Phishing Websites Detection Based on Hybrid Model of Deep Belief Network and Support Vector Machine," IOP Conf. Ser. Earth Environ. Sci., vol. 602, no. 1, pp. 0–9, 2020, https://doi.org/10.1088/1755-1315/602/1/012001

[78] Y. Xue, Y. Li, Y. Yao, X. Zhao, J. Liu, and R. Zhang, "Phishing sites detection based on Url Correlation," Proc. 2016 4th IEEE Int. Conf. Cloud Comput. Intell. Syst. CCIS 2016, pp. 244–248, 2016, https://doi.org/10.1109/CCIS.2016.7790262

[79] Y. Shi, G. Chen, and J. Li, "Malicious Domain Name Detection Based on Extreme Machine Learning," Neural Process. Lett., vol. 48, no. 3, pp. 1347–1357, 2018, https://doi.org/10.1007/s11063-017-9666-7

[80] Y. Huang, J. Qin, and W. Wen, "Phishing URL Detection Via Capsule-Based Neural Network," Proc. Int. Conf. Anti-Counterfeiting, Secur. Identification, ASID, vol. 2019-Octob, no. December 2016, pp. 22–26, 2019, https://doi.org/10.1109/ICASID.2019.8925000

[81] Y. Lian et al., "Detecting Malicious Web Requests Using an Enhanced TextCNN," in Proceedings - 2020 IEEE 44th Annual Computers, Software, and Applications Conference, COMPSAC 2020, 2020, no. 61872011, pp. 768–777, https://doi.org/10.1109/COMPSAC48688.2020.0-167

[82] Z. Chen, Y. Liu, C. Chen, M. Lu, X. Zhang, and School, "Malicious URL Detection Based on Improved Multilayer Recurrent Convolutional Neural Network Model", Security and Communication Networks, vol. 2021, Article ID 9994127, 13 pages, 2021. https://doi.org/10.1155/2021/9994127

[83] B. Kitchenham and S. Charters, "Guidelines for performing Systematic Literature Reviews in SE," *Guidel. Perform. Syst. Lit. Rev. SE*, pp. 1–44, 2007, [Online]. Available: https://userpages.uni-koblenz.de/~laemmel/esecourse/slides/slr.pdf

[84] A. Arshad, A. U. Rehman, S. Javaid, T. M. Ali, J. A. Sheikh, and M. Azeem, "A Systematic Literature Review on Phishing and Anti-Phishing Techniques," pp. 163–168, 2021, [Online]. Available: http://arxiv.org/abs/2104.01255

[85] A. Odeh, I. Keshta, and E. Abdelfattah, "Machine LearningTechniquesfor Detection of Website Phishing: A Review for Promises and Challenges," 2021 IEEE 11th Annu. Comput. Commun. Work. Conf. CCWC 2021, no. January, pp. 813–818, 2021, https://doi.org/10.1109/CCWC51732.2021.9375997

[86] S. Gheewala and R. Patel, "Machine Learning Based Twitter Spam Account Detection: A Review," Proc. 2nd Int. Conf. Comput. Methodol. Commun. ICCMC 2018, no. Iccmc, pp. 79–84, 2018, https://doi.org/10.1109/ICCMC.2018.8487992

[87] S. Mondal, D. Maheshwari, N. Pai, and A. Biwalkar, "A Review on Detecting Phishing URLs using Clustering Algorithms," 2019 6th IEEE Int. Conf. Adv. Comput. Commun. Control. ICAC3 2019, pp. 1–6, 2019, https://doi.org/10.1109/ICAC347590.2019.9036837

[88] Z. Dou, I. Khalil, A. Khreishah, A. Al-Fuqaha, and M. Guizani, "Systematization of Knowledge (SoK): A Systematic Review of Software-Based Web Phishing Detection," IEEE Commun. Surv. Tutorials, vol. 19, no. 4, pp. 2797–2819, 2017, https://doi.org/10.1109/COMST.2017.2752087

[89] E. Badawi and G. V. Jourdan, "Cryptocurrencies emerging threats and defensive mechanisms: A systematic literature review," IEEE Access, vol. 8, pp. 200021–200037, 2020, https://doi.org/10.1109/ACCESS.2020.3034816

7 Authors

Dr. Javier Gamboa-Cruzado works at the Faculty of Systems Engineering of the Universidad Autónoma del Perú, Lima, Peru. He is Doctor in Systems Engineering and Doctor in Administrative Sciences. He has published several articles in international journals and conferences. His research interests are in machine learning, big data, the internet of things, natural language processing, and business intelligence (email: jgamboa65@hotmail.com).

Juan Briceño-Ochoa is graduate of the Faculty of Engineering and Architecture at the Universidad Autónoma del Perú, Peru. His research interests are in web systems, internet of things, and big data (email: jbricenoo@autonoma.edu.pe).

Marco Huaysara-Ancco is graduate at the Faculty of Engineering and Architecture at the Universidad Autónoma del Perú, with extensive experience in database management and development of mobile applications (email: mhuaysaraa@autonoma.edu.pe).

Dr. Alberto Alva Arévalo is a Professor at the Faculty of Systems Engineering and Informatics of the Universidad Nacional de San Martín, Peru. He is a Systems Engineer, and has a Master's Degree in Sciences with a Mention in Information Technology. His research interests are related to Information Technology and Communications (Email: aalva@unsm.edu.pe).

Dr. Caleb Ríos Vargas is a University Professor, Works Consultant, is a Civil Engineer by profession, graduated from the Universidad Nacional de San Martín - Tarapoto and has a Master of Science with a mention in Transportation Engineering from the National University of Engineering of Lima - Peru, holds a Doctorate in Business Management from the National University of San Martín. His interests are related to research and technological innovation (email: crios@unsm.edu.pe).

Mg. Magaly Arangüena Yllanes is working at the Faculty of Engineering of the José María Arguedas National University, Apurímac, Peru. She has a Master's degree in Magister Scientiae in Computer Science, mention in Management of Information and Communications Technologies. She has published articles in national magazines. Her research interests are Data and Information Analytics and Visualization, Governance and Business Intelligence (email: magalyyllanes@gmail.com).

Dra. Liset S. Rodriguez-Baca, Systems Engineer, graduated in Education, Master in Systems Engineering with Mention in Management and Management in Information Technology, Master in Strategic Business Management, Doctor in Education Sciences. Director of the Professional School of Systems Engineering at the Universidad Autónoma del Perú (email: liset.rodriguez@autonoma.pe).

Article submitted 2022-09-25. Resubmitted 2022-11-13. Final acceptance 2022-11-13. Final version published as submitted by the authors.

Possible Translation Problems, Their Causes, and Solutions in Agile Localization of Software

https://doi.org/10.3991/ijim.v17i01.36367

Marián Kabát
Comenius University in Bratislava, Bratislava, Slovakia
marian.kabat@uniba.sk

Abstract—This paper presents some initial insights into practical translation problems that can occur during agile localization. Although agile localization is not a novel approach to software localization, the range of possible translation problems and their causes and solutions have not yet been described. In order to write this paper, an ad hoc monolingual English corpus made up of user interface strings of one agile localized software product was used. The corpus was analyzed string by string, and various causes of translation problems, mostly relating to lacking context, were identified. The paper presents and discusses sample cases of these problems. This paper tries to show that while agile localization can be used as an alternative to traditional localization, the development team must be open to cooperation with the localization team in order for agile localization to be successfully implemented; otherwise, problems will occur.

Keywords—localization, agile, context, fragmentation, internationalization, translation problems

1 Introduction

In order for software products to be sold abroad, they need to be adapted to the intended target markets. This adaptation process is important since, due to globalization, a product can travel to different cultures in the blink of an eye. Well-adapted software can increase revenue and, of course, needs to have its intended original usability.

Software developers have usually regarded localization as an afterthought, as it was generally carried out only after a product's development. In such a classic waterfall workflow, the release date of a product depended on the translations and possibly resulted in delays and missed deadlines.

An alternative to the waterfall workflow is the agile workflow (or agile methodology) which requires minimal documentation and preferably an on-site presence. The agile methodology quickly spread throughout the development industry and became broadly adapted to the extent that it influenced the process of software localization and created the concept of agile localization.

The aim of this paper is to explore the challenges localizers face when they deal with agile localization. Given that there could be various translation problems in this process, the qualitative analysis mainly focuses on problems dealing with context issues and text

fragmentation since they can both be caused by the nature of the agile methodology reflected in agile localization. The purpose of the analysis is not to give quantitative data (e.g., how often a translation problem is present), as this can change with the application. The aim is focused on the limitations of agile localization.

In order to identify translation problems stemming from agile localization, an English monolingual corpus consisting of one application (a web-based software product) was analyzed.

The empirical part of this paper will show that while many issues can be solved with some success depending on various factors, they nonetheless still constitute translation problems. In this sense, a translation problem is a problem regardless of whether it can be solved or not and regardless of the experience of the translator.

This paper intends to show some of the translation problems that localizers face when they complete agile localization tasks. If these problems are not solved adequately, they can cause localization and translation errors and may even pollute the translation memory that is used. The qualitative analysis provided here is an attempt to explore the possible problems of agile localization.

Since this paper focuses on the novel concept of agile localization, Section 2 covers a brief literature review of the concept. Section 3 introduces the topic of agile methodology as it is understood in the field of software development. Section 4 describes localization before and after agile localization, focusing mainly on the process of agile localization and its benefits and shortcomings. Section 5 presents the methodology of the empirical study, and Section 6 presents the findings in the corpus. Lastly, Section 7 presents the conclusions of the paper.

2 Literature review

The concept of agile localization seems to have been overlooked by academic writing, as there is not a lot of academic literature dealing with it. In fact, only Malte Ressin seems to have dealt with the problems of agile localization, albeit by looking at relationships between a development team and a localization team working on the same project. Ressin's papers [1], [2] and [3] examine agile localization from a psychological standpoint, pointing at different goals, an understanding of each other's subjects, and concepts of the quality of two involved teams. Ressin also completed a dissertation [4] on this matter.

Authors like Esselink [5] or Roturier [6] deal with localization from a practical standpoint, but they only mention agile localization very scarcely, and do not examine the topic in more detail.

Another source of literature on agile localization, albeit not of an academic nature, is the plethora of informative blogposts by different translation and localization agencies. Some recent ones include Pereverzevs [7], Phrase [8], and Trusava [9]. These blogposts have a common structure: the text first introduces agile localization and how it works; then it describes all the benefits of agile localization; then it briefly mentions some negatives, followed by tips on how to implement agile localization; and at last of

all finishes with an offer by the translation or localization agency to implement or help with localization.

As can be seen from the lack of academic literature, agile localization is an overlooked concept that is promoted mostly by the language services industry and has not yet been given much scholarly attention. This is why this paper seeks to shed some light on agile localization from an objective view on the subject rather than a sales-driven perspective.

3 Agile methodology

Agile methodology (agile software development) constitutes a group of software development methodologies that are based on iterative and cross-functional team collaboration approaches [10], [11]; with the increasing use of SaaS platforms, software developers have acquired the chance to update software, fix bugs, and add new features almost in real time. Agile development basically breaks the development process into smaller iterations, so the requirements for a developed product change to a more flexible need that is based on the current need of the product and the development team.

Agile software development can proceed according to several different frameworks and methodologies of software development (e.g., Lean, Kanban, Scrum, and Extreme Programming) which are all based on the central idea of agile development [12]; this idea is described by the Manifesto for Agile Software Development as "the Agile Manifesto".

The Agile Manifesto [13] describes twelve basic principles of agile development that can be summarized as follows: individuals and face-to-face interactions are valued more than processes and tools; working software takes precedence over a lengthy and comprehensive documentation; customer collaboration is more important than contract negotiation; and fast responses to changes are more important than following a strict plan.

Such fast-paced steps and just-in-time manufacturing leads to quick responses by the development team and to the already mentioned breaking up of a product into smaller parts, which in turn leads to faster smaller releases and adjustments to change. Such a process of fast-paced development does not take localization into account; it is a process that takes time, requires context or documentation, and is often regarded as the last step before a product release. What then is the place of localization in agile development?

4 Localization before and after agile

In order to better understand the "new" concept of agile localization, let us first take a look at the "old" or "traditional" form of localization. To make a distinction from agile localization (the "new" concept), the paper will use the term "waterfall localization" for the traditional way of software localization.

4.1 Waterfall localization

There are two main approaches to traditional waterfall localization that are being used [7]:

1. Post-release – localization of a product takes place after the release of a product. In other words, the localizer or the localization team starts to work on the translation after the final product has been delivered. This approach causes delays, as localization can take a lot of time. A company is therefore incapable of making a product release and loses revenue in the process as well.
2. String freeze – during this approach, there is a period during the development process called "string freeze" when strings (i.e., lines of code) that need to be translated are locked and cannot be changed in any way. A string freeze can last several weeks, during which time the localizer or localization team works on a translation which is then sent to the developers before the release of a product. While a portion of the strings is frozen, developers can work on debugging other portions of the software; while the string freeze process saves time, developers must identify the modified string in the code manually.

There is also the problem of two groups of professionals working separately [1] where the development teams do not always expect the impact of a new feature on localization; once this new feature gets to be localized (through either of the two mentioned methods), there is already a more advanced stage of development which may make any significant changes a difficult prospect.

There are also tasks that can be automated by dedicated tools, e.g., software developers manually extracting source content from strings or databases, project managers e-mailing files for localization, and software developers cutting and pasting translated strings from a spreadsheet into a source file.

The biggest issues of traditional waterfall localization are that it is time consuming, can cause delays, and requires a lot of manual work that today can be automated. But at what cost?

4.2 Agile localization

By contrast, in agile localization, "localization is not only an afterthought to software development" [1]; it is (or should be) integrated into the development process so that both processes operate simultaneously. This is usually done by a localization platform which automates the translation process.

The process of agile localization can be broken up into the following steps (adapted from [8]):

- Choosing a localization management tool: a localization management tool is basically a CAT tool with access to API (application programming interface) and often also to an external cloud-based system where new strings are uploaded by the development team. Choosing a localization management tool should be one (if not the first) step in agile localization as the tool will be used throughout the whole

process, preferably by both teams (development and localization); it will contain a translation memory and a terminology database. The localization management tool basically represents a meeting point for the development and localization teams.

- Internationalisation: adapting a software product to different languages and locales. In other words, this is using programming mechanisms that change content (e.g., time and date formatting, currency, images, and texts) based on the selected locale.
- Locale file creation: internationalisation results in a set of resource files, usually with identifiers mapped to strings in the programming language. The strings in the resource files are then extracted and converted into a format the translators can work with, thus creating a locale file in the source language.
- File receipt and translation: the extracted and converted files are then forwarded (usually via a cloud-based platform) to the localization team and translated in a standard way (e.g., using a CAT tool, translation memory, terminology database, or machine translation).
- Review: the finished translation should undergo a review process. Since the whole process can take time, it is beneficial for the localization management tool to have an integrated review functionality. The review process should focus on standard translation properties like accuracy, consistency, and correctness, and it should also pay attention to the number of line breaks, HTML tags, and string length. Such checks can be automated depending on the tool that is used.
- Translation files integration: the translated files are then returned to the development team (usually via the same cloud-based platform) to be converted into the desired file format and then integrated into the code.
- Localization testing: after the translation file integration into the resource files of the target locale, the software product needs to be language tested. Some localization management tools provide an in-context preview system that can speed up the text or product adjustment process if there is a need for one.
- Publishing: once the language testing is finished and the target language version of the software product is complete, the localized software is published or released, thus concluding the process of agile localization.

In order for agile localization to work, it needs to be integrated into the whole product development cycle – starting with the choice of a localization management tool – so that new texts can be translated simultaneously along with the product development. A process like this has its benefits and challenges when compared with the traditional waterfall localization workflow; the following subsections will deal with these.

The benefits of agile localization. Agile product development has its benefits over the waterfall workflow. For instance, agile projects are more likely to be finished on time (65% compared to 40%), they tend to accomplish all goals (75% compared to 56%), and companies adopting agile methodologies grow their revenue 37% faster [14]. These benefits are naturally reflected in agile localization as well. Some of them include (adapted from [9]):

- Faster time-to-market: since localization occurs at the same time as other software development activities, publishing occurs sooner and the process of continuous localization becomes a part of the continuous deployment process. Products get

deployed even when there are imperfections in localization as these can be fixed in future updates.
- Reduced costs for the developer: the localization team only translates new or updated strings, so the development company saves money.
- The time saved by the localizer: since only new or updated strings are worked on, the localization team saves time and can work on other projects as well.
- Easier mistake detection: as the translations are rapidly implemented during the release, potential errors are detected earlier and can be corrected in the next release.
- Less manual work: since the localization management tool communicates with the cloud-based repository, tasks like manual string extraction can be automated and happen automatically.
- Faster localization testing: as translated strings get deployed automatically, localization and language testing can begin sooner.

The challenges of agile localization. The fast-paced processes of agile localization have several drawbacks as well (adapted from [9]):

- The importance of context: since precise documentation is not an important aspect of agile localization [13], translators can lose out on important context details. This is especially alarming when a new translator starts working on an already running project and they are not yet familiar with the product. The issue of lacking context can be remedied by using glossaries and product knowledge bases and adding comments that explain the placeholders and screenshots of the software product.
- Team interactions: the development and the localization teams need to communicate effectively. If the teams are working separately from each other, processes might not be synchronised or there may be synchronisation issues [1].
- Time zones: when a software product gets localized into several languages around the globe, time zones will be an issue as these will inevitably slow down the agile process. If we consider a possible lack of context and the need to consult parts of the text, a simple project can take longer than expected.
- Text fragmentation: as only new or updated strings get translated and prepared for localization, the strings a translator sees in a CAT tool will not necessarily follow each other in a logical way; the source text might become fragmented.

Summary. If speed is a central keyword in agile development or localization, agile localization can either speed the time-to-market up or slow it down depending on other aspects of the process. A functioning source of context, translation guidelines (e.g., a style guide or a glossary), good teamwork, and interactions between the development team and the localization team can speed up agile localization. If the localization process is followed up by localization and linguistic testing, the resulting localized software product can be of a high quality.

The opposite can also be true – if the localization team lacks context or additional information, or if interactions between the development team and the localization team are missing, the resulting localized software product might contain some forms of error which might not be detected in the localization and linguistic testing before release. However, even in this case, agile methodology might prove useful as frequent updates

and releases can contain fixes for errors in localization. On the other hand, fixes cost additional time that was spared in the first (successful) scenario.

5 Methodology

This is a qualitative and descriptive study based on a single monolingual English ad hoc corpus made up of strings of a web-based service applications which was agile localized. The corpus consists of 76,820 source words and 15,254 strings.

The analyzed software product was chosen because it was developed with an agile methodology and has been agile localized. Due to signed non-disclosure agreements, the translation problems that will be used as examples in the following section will be anonymized in order for them to be able to be presented in the findings. Anonymization will take place if a source segment contains a term which would allow for the software product or client to be identified. If a source segment contains such a term, it will be swapped for a generic word with the same or similar meaning (e.g., a segment like "Run Linux" would be anonymized as "Run system", and "Run Bluetooth" would be anonymized as "Run function").

The corpus was manually analyzed segment by segment. Since the aim of this paper was to observe a source text as translators do when they localize a product in order to identify potential problems, a CAT tool was used; the corpus was processed, and the segments were analyzed in the environment of the tool.

The corpus was processed in the same CAT tool, in which the software product is agile localized. The CAT tool is called Smartling Translation Management System, which is a cloud-based tool. The tool follows regular industry segmentation practices and includes standard features (e.g., translation memory and terminology).

In terms of the object of this research, only translation problems related to context have been selected. The following section describes the problems identified during the corpus analysis.

The aim of the analysis is not to give a frequency with which each translation problem comes up in the corpus, as this can change depending on the software product. It is merely to show the possible limitations of agile localization of applications.

6 Findings

This section will present various examples of practical problems related to context issues that can arise during agile localization and discuss their causes and possible solutions. Seven examples will be given. Each example will begin with example strings that will then be followed by an explanation of the problem, the possible cause and ways to remedy the given problem, so as to minimize the risk of producing an incorrect translation.

Example 1:

search box

The first example is a string containing a collocation. Although the collocation is self-explanatory and probably also easy to translate, the problem is that the string begins

with a lower-case letter. In this case, the string can have several functions in the software product:

- it can form a placeholder (the content of the string will be turned into a placeholder and will be inserted into various other strings at a later point): this is a problem for fusional languages, where the content of the string might need to undergo declension; however, once the placeholder content is translated in a grammatical case (the nominative would probably be standard), the same grammatical case will be used whenever the placeholder denoting this collocation is used.
- it can be part of a fragmented sentence: a sentence containing this collocation might have been split up into several strings during either step of agile development or localization. In this case, the translator needs to identify the rest of the sentence in the given project and translate accordingly.

A string like this could be easily translated if the localizer had either visual context in the form of a preview (this would be helpful in the case of fragmentation) or a comment by a developer explaining the purpose of the collocation (this would clarify whether the string will be used as a placeholder later).

Example 2:
Show Unsafe Content
Show unsafe content

This example contains two strings; although they follow each other here, they were separated by several other strings in the corpus. It might not be difficult to translate them, and a CAT tool would help with consistency since a translation memory would suggest a previous translation, but the different capitalization might create problems.

The first string, due to all three words being written with capital first letters, might be a button, a title, or the name of a dialogue box. Depending on the target language, these UI elements might require different grammatical forms (e.g., a button might require an infinitive verb, whereas a title or a dialogue box name might require a verbal noun).

The second string might be the beginning of a fragmented sentence or an option near a check box, again requiring different approaches depending on its position in the software product.

Visual or written context in the form of a picture or a comment would be helpful. The various grammatical forms used in different UI elements should be described in a style guide, but without more information a localizer would be unable to identify the correct element. The worst-case scenario in this case would be guessing, but this might result in a wrong or inconsistent translation and even the pollution of the translation memory.

Example 3:
Rewards has been turned off on this device by your administrator.

In this case, the localizer needs to know what “Rewards” means as this could be a new function of the software product. Otherwise, the English sentence would contain a

grammatical error (correct: "Rewards have…"). Again, a simple comment from a developer would clarify this issue. If the string does not contain any comment, the localizer might think the sentence has a grammatical error and translate it accordingly, which in this case would result in an error. Problems like this highlight the importance of team work as well. Localizers should be a part of the development team, so that they are informed about new functions that will be added to a software product in the upcoming development.

Example 4:
Hide favorites button from toolbar
Show Favorites Button in Toolbar

This example contains two strings that did not follow each other in the corpus. Although the strings are quite similar, the capitalization in the second string might be confusing. Notice that the element "Favorites" will also be used in Example 7, where it was identified as a UI element. In this case, it can be confusing as to why the first string does not capitalize the name of the button. The second string might point to a title since all the words are capitalized.

The problems in this example could be solved either by using comments from the developers or through a more careful approach by them, whereby they would only capitalize words that actually have to be capitalized (e.g., Favorites button).

Example 5:
Schedule

This string containing a single word is a common problem in localization, and not only in agile localization. Without further context, the localizer does not know whether the word should be translated as a noun or a verb, or, should there be more synonyms in the target language, which synonym they should choose.

The localizer could contact the development team, but due to the fast-paced nature of agile localization, an answer might not come in time before the deadline of the project (e.g., due to different time zones).

Example 6:
our team if this issue persists.
Try refreshing the page, and please
Contact.

This example contains three strings following each other in the corpus, and it represents an example of text fragmentation that occurs either during the export from code or during file processing in a CAT tool.

The localizer can be confused by the string order. The strings appear to form a single sentence if reordered ("Try refreshing the page, and please Contact. our team if this issue persists.") Although the sentence makes perfect sense and is probably easy to translate into the target language, the full stop at the end of the third string ("Contact.") is confusing. The third segment might actually not be part of the sentence at all and could be a part of a different fragment, or the full stop might be a typo made by a

developer. The solution to this problem could be provided by communicating with the development team or being given some form of visual context.

Example 7:
Reading list items have moved under "Favorites"
This example contains a UI element in quotation marks, which can be confusing since most other UI elements in the corpus were not inserted into quotation marks. This example could be a case of inconsistent labelling by the development team when one of the developers marks UI strings with quotation marks. Such inconsistency might be confusing, especially for new members of the localization team who are not familiar with the fact that while some UI strings are in quotation marks, they can be ignored. In this case, the developers should adopt a consistent labelling approach in order to not be ambiguous.

6.1 When context fails, communication should follow

Some of the problems stated above already touched upon the possible solution of communication with the developers. While having direct input from the development team would solve possible context issues, even this solution has its limitations.

Firstly, it is still common practice for localization experts to not be part of development teams. As a result, various internalization issues arise during development which then have an impact on the localization process [15]. Getting feedback from a localization professional would benefit the development process and would help with internalization issues (such as in Example 5).

Secondly, interactions and communication between the two teams is problematic due to the possibility of both teams being in different time zones as well as due to the outsourcing of localization. Even if the localization team raises a query caused by ambiguity, the query travels from one outsourcing company to another before reaching the developer; and then the answer has to travel back to the localization team. Such an exchange of information can take longer than a day, and with deadlines being strict and agile localization usually consisting of micro projects of no more than 500 words that need to be translated on the same day the project is received by the localization team, such team interactions or information transfer is simply not helpful.

Possible solutions to this problem could be hiring an in-house localization team, limiting the amount of outsourcing of a single project so that communication is more straightforward or investing adequate resources into localization and linguistic testing.

Of course, the present author is aware that such solutions are not always feasible, especially when localizing into less widely spoken languages. Nonetheless, in order to overcome translation problems in agile localization, resolving possible context issues, adopting a more careful development approach, and streamlining communication between the two teams should be a central concern.

7 Conclusions

Localization is stationed somewhere at the intersection between translation and technology [16], so it is no surprise that with the coming of new programming methodologies it would adapt and create new ways to bridge the gap between different locales, as in the case of agile localization following the lead of agile development.

Agile development has its benefits: it is fast, releases happen often, developers work in teams, and bugs are fixed frequently. These benefits impact agile localization as well: there are daily projects with small word counts to translate; the strings are often missing comments or visual context; and if a localizer is not part of the development from the beginning, the lack of information (given that agile development lacks proper documentation) might leave results up to guesswork.

As this paper has tried to show, agile localization has its drawbacks. If the issues with missing context and teamwork could be remedied, agile localization would surely improve the localization of various software products into other locales. But in order to remedy the shortcomings, localizers as well as developers need to understand the ways languages work and not see localization as just an afterthought. While it is true that developers and localizers live "in different worlds" [1], communication is key in order to bring a perfect product to market and minimize additional language-oriented fixes.

It is now clear that companies need to think about localization from the very start of product development, and they need to provide adequate tools (e.g., visuals or textual information) for localization processes. This need is even stronger in agile localization. Although "agile is the new black" [17], if the end client or developer is not ready to fully adopt an agile localization approach (even if they use agile development) with all its peculiarities, it might be best to wait and prepare, because context, communication, and inclusion are key in agile localization.

8 References

[1] M. Ressin, J. Abdelnour-Nocera, and A. Smith, "Of code and context: collaboration between developers and translators," In CHASE 2011 Conference Proceedings, 2011, pp. 50–52. https://doi.org/10.1145/1984642.1984653

[2] M. Ressin, J. Abdelnour-Nocera, and A. Smith, "Lost in agility? Approaching software localization in agile software development," in *XP 2011, LNBIP 77*, A. Sillitti et al, Eds. Berlin: Springer-Verlag, 2011, pp. 320–321. https://doi.org/10.1007/978-3-642-20677-1_25

[3] M. Ressin, "Defects and agility: localization issues in agile development projects." In Agile Processes in Software Engineering and Extreme Programming – 12th International Conference.

[4] M. Ressin, "An empirical examination of interdisciplinary collaboration within the practice of localization and development of international software," PhD. thesis, University of West London, 2015.

[5] B. Esselink, *A Practical Guide to Localization*. Amsterdam/Philadelphia: John Benjamins Publishing Company, 2000.

[6] J. Roturier, *Localizing Apps. A practical guide for translators and translation students*. London/New York: Routledge, 2015. https://doi.org/10.4324/9781315753621

[7] A. Pereverzevs, "Agile localization: the complete guide," 2019. [Online]. Available: https://lokalise.com/blog/agile-localization/. [Accessed Sept 29, 2022].
[8] Phrase. "Agile localization: the only guide you'll ever need," 2020. [Online]. Available: https://phrase.com/blog/posts/translation-management-agile-localization/. [Accessed Sept 29, 2022].
[9] K. Trusava, "Agile localization: what is it and how is it managed?," 2020. [Online]. Available: https://dzone.com/articles/agile-localization-what-is-it-and-how-is-it-manage. [Accessed Sept 29, 2022].
[10] Martin, Robert Cecil (2002). Agile software development: Principles, patterns, and practices. USA: Prentice Hall.
[11] S, Alsaqqa, S. Sawalha, and H. Abdel-Nabi. "Agile Software Development: Methodologies and Trends," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 14, no. 11 (Jul. 2020), pp. 246-270, 2020. https://doi.org/10.3991/ijim.v14i11.13269
[12] D. Rigby, J. Sutherland, and H. Takeuchi, "Embracing agile," 2016. [Online]. Available: https://hbr.org/2016/05/embracing-agile. [Accessed Sept 29, 2022].
[13] Agile Manifesto Signees, "Manifesto," 2001. [Online]. Available: https://agilemanifesto.org/principles.html. [Accessed Sept 29, 2022].
[14] Pulse, "Capturing the value of project management," 2015. [Online]. Available: https://www.pmi.org/-/media/pmi/documents/public/pdf/learning/thought-leadership/pulse/pulse-of-the-profession-2015.pdf. [Accessed Sept 29, 2022].
[15] E. de la Cova, "Translation challenges in the localization of web applications," *Sendebar*, vol. 27, no. 1, pp. 235–266, 2016.
[16] M. Á. Jiménez Crespo, "The intersection of localization and translation: a corpus study of Spanish original and localized web forms," *Translation and Interpreting Studies*, vol. 5, no. 2, pp. 186-207, 2010. https://doi.org/10.1075/tis.5.2.03jim
[17] M. Magdyiary, "Why we need to adopt an agile approach to translation and localization," 2021. [Online]. Available: https://www.gala-global.org/knowledge-center/professional-development/articles/why-we-need-adopt-agile-approach-translation-and. [Accessed Sept 29, 2022].

9 Author

Marián Kabát is an assistant professor at the Department of British and American Studies, Faculty of Arts, Comenius University in Bratislava, Slovakia. He teaches translation courses (both literary and specialized translation). His research focuses on localization (of software, websites, and video games), machine translation, and post-editing. In 2020 he was awarded the Rising Star Scholarship by GALA. Other than being an avid teacher and researcher, he is also a practicing translator and mostly localizer of various software products.

Article submitted 2022-09-24. Resubmitted 2022-11-14. Final acceptance 2022-11-15. Final version published as submitted by the author.

Smart Healthcare Monitoring System Using IoT

https://doi.org/10.3991/ijim.v17i01.34675

Bzhar Ghafour Mohammed(✉), Dler Salih Hasan
Salahaddin University, Erbil, Iraq
bzhar.mohammed@su.edu.krd

Abstract—The progress in communication and information technology has contributed to the creation of the Internet of Thing (IoT). Internet of Things today plays a crucial role in tracking, documenting, storing, presentation and communication in variety of fields like healthcare, smart cities, engineering, and others. Using an IoT-based monitoring system, the critical parameters of health are tracked and data transmitted via network. Data will be accessed for the benefit of the patient's current condition. This research paper focused on remote monitoring of body temperature (DS18B20), heart rate and SPO2(MAX30100), additionally the position of patient can be obtained on demand using SIM7600E GSM and GNSS HAT (Hardware attached on top) Module. Raspberry Pi 4B used as microcontroller to gather data from health parameter sensors. The data from sensors transmitted into cloud storage through a network. The proposed system uses last version of IoT microcontroller and devices were used which significantly affected the precision and speed of the whole system. A GUI cross platform mobile application was developed for presenting real-time data to both doctors and patients. The system is beneficial for synchronous monitoring of patient's health status hence allowing urgent medical decision by doctors at right time.

Keywords—Internet of Things, healthcare, remote monitoring, SPO2, raspberry pi, GUI, real-time, DS18B20, MAX30100

1 Introduction

The internet has grown particularly as a result of its accessibility to everyone. The Internet of Things results in an electronic access control system that enables a user to do a variety of tasks more quickly, productively, and safely. IoT is a technological advancement that has the potential to improve people's lives by utilizing smart devices and smart sensors that communicate via the internet [1]. With the rapid progression of technology, each country now places a high priority on Internet of Things application. The concept of internet-of-things (IoT) is one of the next revolutionary developments in internet-based computing, and it is now having a positive effect in a wide range of application fields such as smart cities, healthcare, engineering, and others. [2]. Internet of Things (IoT) is the latest internet advancement, including the field of health care study. This remote healthcare monitoring has grown too fast with the use of wearable sensors and smartphones. IoT health screening aids in disease spread prevention as well

as accurate evaluation of health status, regardless location of the doctor furthermore it is facilitating continuous health condition monitoring. The Remote Healthcare Monitoring arrangement enables patients to be observed outside of traditional hospital environments (for example, at home), and increases access to human resources offices while lowering costs [3].

Health care providers can monitor patients' health status using a number of crucial health parameters. Due to major health problems, certain people with chronic diseases require continuous monitoring. These parameters include heart rate, blood pressure, body temperature, spo2, respiratory rate, ECG, and blood sugar. Most of these health parameters can now be tracked using electronic devices with precise sensors thanks to advancements in medical technology. These parameters can be tracked remotely due to developments in communication technology, particularly the internet, making IoT healthcare monitoring possible.

There are several available microcontrollers for Internet of things choosing one of them depends on project requirement and specification, raspberry pi is one of the advanced popular microcontrollers used recently. The Raspberry Pi is a miniature pc that is used for simple computing and networking tasks. It is the primary component of the internet of things. It allows connectivity to the internet, allowing the automation system to be linked to a remote controlling device [4]. Regardless of the kind of microcontroller, there are numerous sensors for receiving signals from the outside world, such as health care monitoring sensors including body temperature sensors, heart rate sensors, pulse oximeter sensors, ECG sensors, blood pressure sensors, and so on. In addition to the sensors other hardware can be added for the microcontroller like GSM, GPS, GNSS and so on. The data from various sensors and hardware after processing by microcontroller should be transmitted to and stored in a cloud storage via a network.

This research paper proposed an IoT system for monitoring health status of patients who are in need for continuous prolonged follow up and monitoring by their doctors. Raspberry Pi 4B microcontroller and python as programming language had been chosen for gathering data from sensors then processing and transmitting into cloud storage through a network. To store data, the MySQL database is employed as cloud storage. The three vital health parameters which are body temperature, heart rate and SPO2 are monitored in real-time through two sensors; body temperature sensor and oximeter sensor. Furthermore, the patient's location determined by a GSM/GPRS/GNSS HAT module if necessary. The aforementioned HAT is also used to send SMS notification via a SIM card in case of abnormal health parameters.

The system also comprised a cross-platform mobile application (i.e., Android and IOS compatible) for GUI to display real-time health parameters' value, alerts and notifications for both patients and paramedics/doctors. The system hardware was configured in a wearable model. The proposed system provides both real-time data and history of health parameters for patients and doctors with sending notifications and alerts in necessary and emergency situations remotely. This allows making life saving decisions by doctors without need for physical presence in clinics and hospitals.

2 Literature survey

The IoT-based Healthcare Monitoring System for War Soldiers by Gondaliaa, et al. in 2018, suggested a system that would enable the soldiers who are missing and wounded in the warfare to track the location in actual time and control their health. It helps to reduce time of the exertion of the army control unit to find and rescue [5].

The research paper of Durán-Vega et al. in 2019, proposed an IoT System for Remote Health Monitoring in Elderly Adults through a Wearable Device and Mobile Application. They employed a biometric bracelet connected to a mobile application, which offers real-time viewing of all the data collected by the sensors in the bracelet (pulse rate, blood oxygen saturation and Body temperature). Caretakers can use this information to make decisions regarding their patients' wellbeing. Their study describes the design and implementation of an IoT system for remote monitoring of elderly persons in nursing homes using a smartphone application and a wearable device. The creation of the prototype demonstrated that it is viable to carry out and implement the research project. Furthermore, it is low-cost and compatible with the IoT paradigm; the most essential features are: real-time monitoring of the general status of the patients [6].

A smart healthcare monitoring system designed by Naik & Sudarshan in 2019.Their IoT platform system based on the Raspberry Pi. The system used Wi-Fi network technologies to identify human body parameters like body temperature, blood pressure, heartbeat, accelerometer, ECG, respiration, and other data on server of the internet of things [7].

In their research paper Valsalan, et al. in 2020, suggested an IoT-based health tracking device with a mobile physiological screening mechanism that can continuously screen the patient’s temperature, heartbeat and other specific necessary parameters. They suggested a continuous monitoring and control instrument to screen the patient status and archive the patient data in a server using a wi-fi based module remote communication [3].

The research paper of D.Acharya & N.Patil in 2020, described IoT-based Health Care Monitoring Kit, the concept and deployment of an IoT-based smart doctor package for a vital medical situation that can provide robust access to IoT data to assist emergency health providers like Intensive Care Units. This system has developed to give the doctors the required history of patient health in real-time [8].

In 2020, Godi et al. published an article in which they presented the E-Healthcare Monitoring System (EHMS), an IoT technology platform that they combined with machine learning (ML) techniques to create an advanced automated system. The patient's data is collected by an IoT wearable sensor. The data obtained from a variety of health monitoring devices is fed into an E-Health care management system. After that, EHMS analyzes the health status by using machine learning techniques on raw data [9].

Sangeethalakshmi, et al. in 2021, published an article in which they presented a patient health monitoring system using IoT, the suggested system included of mobile application and GSM for continuous monitoring of patients remotely. Sensors include a data acquisition unit, a microcontroller (ESP32), and a software system. The system

continuously monitors, shows, and saves patients' temperature, heart rate, ECG, blood pressure, and SPO2, and the same information was sent to doctors [10].

3 System hardware component

3.1 Microcontroller

Raspberry pi 4B. The Raspberry Pi 4B is a single-board computer that features a 64-bit quad-core ARM8 Broadcom BCM2711 1.5 GHz CPU, 4GB LPDDR4 RAM, an expandable MicroSD card and a standard 40-pin GPIO header. Raspberry Pi 4 comes with Gigabit Ethernet, along with onboard wireless networking and Bluetooth [11]. When combined with Wi-Fi and Internet connectivity, it is easy to set it up for remote communication, which makes the Raspberry Pi perfect choice for IoT applications. These were the reasons behind selecting raspberry pi microcontroller in this proposed system.

3.2 Sensors

Body temperature. The DS18B20 temperature sensor used to measure body temperature. The advanced features of the employed temperature sensor include a 1-wire interface and a 64-bit serial stored in an on-board ROM. It runs on a 3.0v-5.5v power supply [12]. This sensor is quite precise, measuring the temperature within about 0.05°C of the actual temperature. It can withstand temperatures as high as 125°C. Because this device contains an integrated analog to digital converter, unlike the other sensors for example TMP36, which is an analog device, DS18B20 is relatively easier to integrate with the Raspberry Pi.

Pulse oximeter. The MAX30100 sensor selected in this proposed system for measuring blood oxygen level (SPO2) and pulse rate. The sensor has a pulse oximetry and heart rate monitor sensor. It includes two LEDs, one of which generates infrared light and the other red light. Only single infrared LED is required to determine the heart rate, and both LEDs are required to measure the oxygen content in the blood. When the heart beats, the oxygenated blood rises, and when the heart is at rest, the oxygenated blood drops. The period between the rise and drop of oxygenated blood can be used to determine the heart rate. Deoxygenated blood absorbs more infrared spectrum of light while passing more red spectrum of light, and oxygenated blood absorbs more red spectrum of light while passing more infrared spectrum of light. The absorption rates for both light sources detected by the sensor are saved in a buffer that may be retrieved using the I2C protocol through the Grove port. The GitHub raspberry pi MAX30100 library is used to calculate the pulse rate and SpO2 levels from sensor input. The MAX30100's accuracy was compared to the commercial HR and SpO2 monitoring instrument General care®. the sensor output data's error rate and accuracy, resulting in a relatively low error value of 2.89% and an accuracy of 97.11% for the heart rate data. The data calibration of SpO2 also provides favorable results, with an error value of 1.15% and a high accuracy rate of 98.84% [13] [14].

3.3 Hardware extension

4G GSM, GPRS and GNSS HAT module. For efficient communication and tracking location, this HAT was attached to the raspberry pi microcontroller with the following features:

- Enables LTE Cat-4 4G / 3G / 2G Communication & GNSS Positioning
- Compatible With Raspberry Pi
- Dial-Up on Windows/Linux
- Communication protocols supported are TCP/UDP/FTP/FTPS/HTTP/HTTPS
- Telephone Call & SMS Support

Figure 1 shows all hardware components of the proposed system.

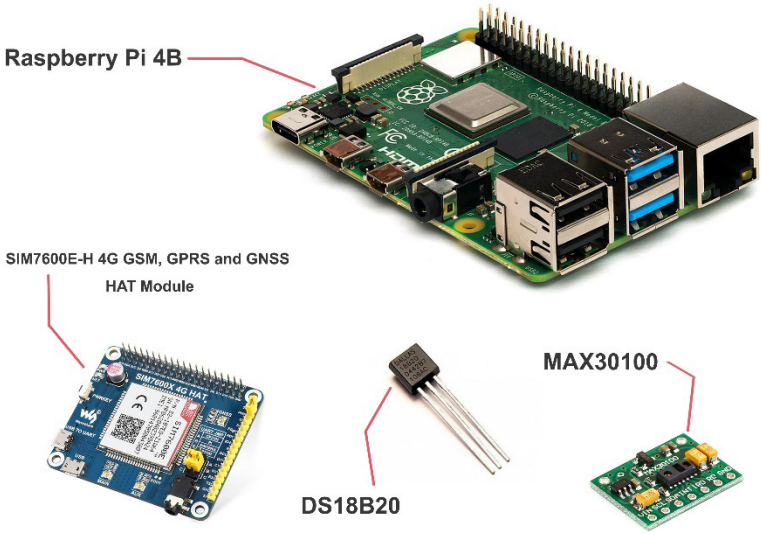

Fig. 1. Raspberry Pi 4B with SIM7600E-H 4G GSM, GPRS and GNSS HAT module, DS18B20 body temperature sensor and MAX30100 pulse oximeter

The Figure 2 shows the schematic of hardware healthcare monitoring system components used in this research paper.

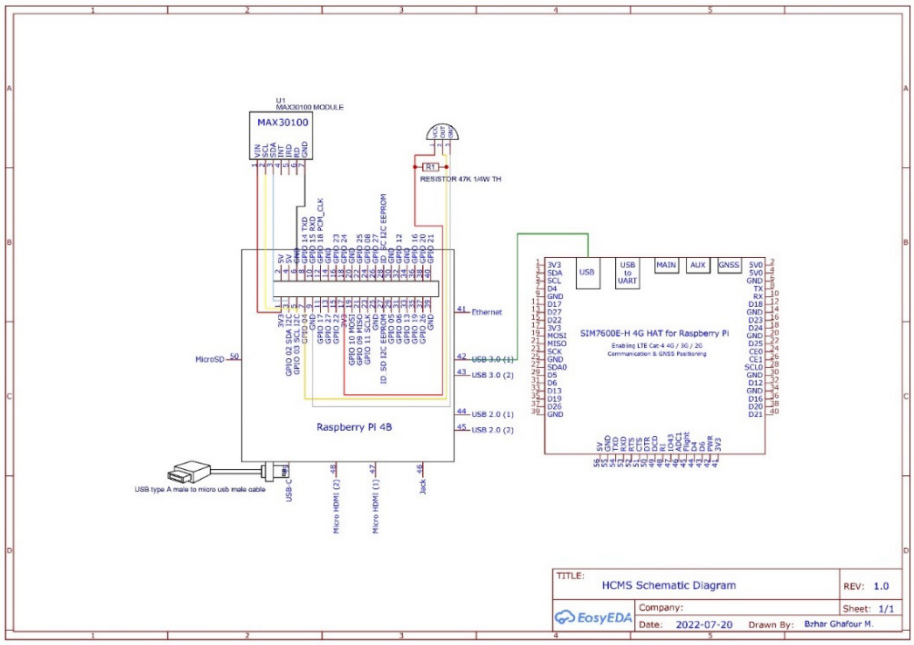

Fig. 2. System hardware component schematics

4 Software and programming language

4.1 Python programming language

Python programming language used for programming raspberry pi microcontroller to read sensors data and transmitting it to cloud storage and the library of sensors were written by python. Python could be used to construct cross-platform applications as well as Web, mobile, and scientific applications.: In general, the same Python program may be launched on Windows and Unix-like systems like Linux, BSD, and Mac OSX s [15].

4.2 Flutter and Dart

Flutter is an open-source platform that leverages Dart as its programming language to create natively built and cross-platform applications from a single codebase. Flutter and Dart were both developed by Google. In this proposed system Flutter and Dart were used to create a cross-platform mobile application (i.e., Android and iOS compatible) for displaying real-time health parameter values, alerts, and notifications for both patients and paramedics/doctors.

4.3 MySQL

MySQL is the world's most popular open-source database. Whether you are a rapidly developing online property, a technology ISV, or a huge company, MySQL can help you build high-performance, scalable database systems at a low cost. In this suggested system, MySQL was used as cloud storage to store data from various sensors and hardware after it has been processed by the microcontroller. The required information of the patient, doctors/paramedics and record of abnormal data also stored in database. The recorded data can be used to find the past information of the previous patient status.

5 Proposed system and working method

Important healthcare parameters remotely tracked in real-time and measured value presented to doctors and patients through a system-specific mobile application. The healthcare parameters are SPO2, heart rate and body temperature. The hardware configured by connecting sensors to the raspberry pi microcontroller. The 4G GSM, GPRS and GNSS HAT Module attached to the raspberry pi which was connected to the MySQL database via Wi-Fi. the raspberry pi and sensors programmed by python language for gathering, analyzing and transferring data. Each sensor was placed to specific defined location of patient's body, as the temperature sensor placed to the skin and the pulse oximeter to the fingertip. after measuring health parameters, it will compare with its normal reference range then all values are presented to the mobile application, if there is any abnormal value i.e., any value below or above normal range, an emergency alert will send to doctors/paramedics and relative of the patients via SMS notification with patient's position thus allowing doctors to make life-saving decisions without requiring patients to be present in clinics and hospitals. Figure 3 shows the flowchart of proposed system.

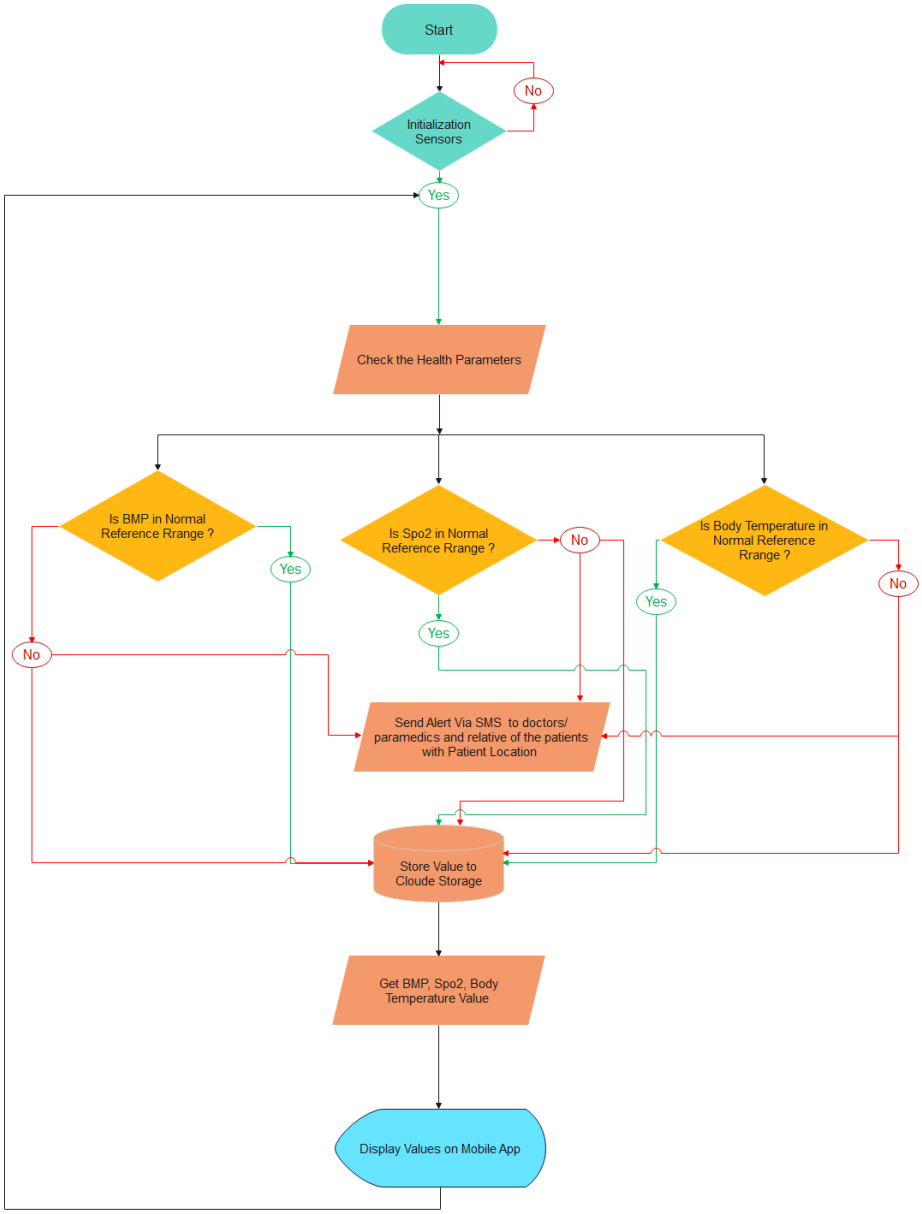

Fig. 3. IoT based smart healthcare monitoring system flow chart

The reference ranges for the involved health parameters shown in Table 1.

Table 1. Reference range of SPO2, heart rate and body temperature [16] [17] [18]

Health Parameters	Normal Reference range	Note
Spo2	95 % -100 %	90% - 94% Borderline
Heart Rate	(60 – 100) bpm	10 years and older - adults
	(70 – 190) bpm	Neonate
	(80 – 160) bpm	Infant (1 – 11) months
	(70 – 130) bpm	Children (1 – 9) years
	(40 – 60) bpm	Athletes
Body Temperature	36.4 C – 37.6 C	11 years and adults below 65 years

6 Testing and results

The hardware devices properly configured and all sensors connected to the raspberry pi microcontroller and a portable power bank used for power supply, The reference range for each health parameter was defined based on available medical resources, then after calibration of sensors data were done precisely. the data was successfully received from sensors by microcontroller, then transferred to the MySQL database server after processing and analysis.

The proposed system was then tested on 30 persons (Rest State) in two groups; healthy individuals and patients in different age and both genders. The patients were chosen from an emergency hospital. The value of Spo2, heart rate and body temperature were shown in the system specific mobile application interface in real time as shown in Figure 4. In the case of an abnormal state for each parameter, when the value was below or above the normal reference range, the system will send an SMS alert to doctors/paramedics and the patient's relative, providing information about the abnormal health parameters and the patient's position for making appropriate decisions and taking necessary measures for proper management and saving patient's life. The information about location of the patient facilitates the process of sending ambulance. Beside receiving alert notifications when a health parameter value was abnormal, clinicians can remotely monitor all recorded health parameters in real-time. Table 2 displays the data obtained from seven individuals and the Figure 4 shows the picture of an individual during collecting health parameters data by the system.

Table 2. Recorded data for SPO2, heart rate, and body temperature

#	Spo2	Heart Rate	Body Temperature
P1	99 %	81 Bmp	35.9 °C
P2	96 %	107 Bmp	36.5 °C
P3	95 %	98 Bmp	37.0 °C
P4	96 %	82 Bmp	37.2 °C
P5	98 %	79 Bmp	35.92 °C
P6	95 %	86 Bmp	36.24 °C
P7	94 %	67 Bmp	36.61 °C

Fig. 4. Testing of the proposed system

7 Conclusion

Developments in information and communication have brought about the advent of the Internet of Things (IoT). Internet of Things enables more physical sensors/devices to collect data via the internet and provides further methods of data connectivity. Nowadays IoT has affected every part of our life, including health care, smart city, transport, and many more. The health monitoring system was described in this research to offer sufficient patients' health status in real-time to the clinicians remotely. Monitoring the precise state of the patient in the absence of the doctor was developed for effective health purposes. The system collects patient information including Spo2, heart rate and body temperature, in addition to providing patient location information in emergency situation with SMS alert notification in case of presence abnormal health parameters value. The system also includes a cross platform mobile application as graphic user interface for both clinicians and patients. The physical presence of patients and clinicians may be avoided by implementing the suggested system in healthcare management, and the condition of patients with chronic diseases can be monitored remotely for effective intervention, allowing doctors to make life-saving decisions at the right time.

8 Future work

Adding more health parameters to the system based on patients need and doctors request like ECG, Blood Pressure, Respiratory Rate, Urine Output, Fetal Heart Rate and So on.

Development of the system to include a decision making for aiding doctors and paramedics in the management of patients.

9 Conflicts of interest

The authors certify that they do not have conflicting interests to mention with relation to the current research.

10 References

[1] I. S. Areni, A. Waridi, I. Amirullah, C. Yohannes, A. Lawi, and A. Bustamin, "IoT-Based of Automatic Electrical Appliance for Smart Home", Int. J. Interact. Mob. Technol., vol. 14, no. 18, pp. pp. 204–212, Nov. 2020. https://doi.org/10.3991/ijim.v14i18.15649

[2] Rout, S., Patra, S.S., Mohanty, J.R., Barik, R.K., Lenka, R.K. (2021). Energy Aware Task Consolidation in Fog Computing Environment. In: Satapathy, S., Zhang, YD., Bhateja, V., Majhi, R. (eds) Intelligent Data Engineering and Analytics. Advances in Intelligent Systems and Computing, vol 1177. Springer, Singapore. https://doi.org/10.1007/978-981-15-5679-1_19

[3] P. Valsalan, T. A. B. Baomar and A. H. O. Baabood, "IOT BASED HEALTH MONITORING SYSTEM," JCR, Volume 7 , Issue-4: 739-743, 2020, https://doi.org/10.31838/jcr.07.04.137

[4] T. Vineela, J. NagaHarini, C. Kiranmai, G. Harshitha and B. AdiLakshmi, "IoT Based Agriculture Monitoring and Smart Irrigation System Using," *International Research Journal of Engineering and Technology (IRJET) ,* vol. 5, no. 1, 2018.

[5] A. Gondalia, D. Dixit, S. Parashar, V. Raghava, A. Sengupta and V. Sarobin, "IoT-based Healthcare Monitoring System for War Soldiers using Machine Learning", Procedia Computer Science, vol. 133, pp. 1005-1013, 2018, https://doi.org/10.1016/j.procs.2018.07.075

[6] L. A. Durán-Vega, P. C. Santana-Mancilla, R. Buenrostro-Mariscal, J Contreras-Castillo, L. E. Anido-Rifón, M. A. García-Ruiz, O. A. Montesinos-López, and F. Estrada-González. 2019. "An IoT System for Remote Health Monitoring in Elderly Adults through a Wearable Device and Mobile Application" Geriatrics 4, no. 2: 34. https://doi.org/10.3390/geriatrics4020034

[7] K. S. Naik and E. Sudarshan, "SMART HEALTHCARE MONITORING SYSTEM USING RASPBERRY Pi ON IoT PLATFORM," *ARPN Journal of Engineering and Applied Sciences,* vol. 14, no. 4, 2019.

[8] A. D. Acharya and S. N. Patil, "IoT based Health Care Monitoring Kit," 2020 Fourth International Conference on Computing Methodologies and Communication (ICCMC), 2020, pp. 363-368, https://doi.org/10.1109/ICCMC48092.2020.ICCMC-00068

[9] B. Godi, S. Viswanadham, A. S. Muttipati, O. P. Samantray and S. R. Gadiraju, "E-Healthcare Monitoring System using IoT with Machine Learning Approaches," 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA), 2020, pp. 1-5, https://doi.org/10.1109/ICCSEA49143.2020.9132937

[10] K. Sangeethalakshmi, S. P. Angel, U. Preethi, S. Pavithra and V. S. Priya, "Patient health monitoring system using IoT," *Materials Today: Proceedings,* pp. 2214-7853, 2021, https://doi.org/10.1016/j.matpr.2021.06.188

[11] "Raspberry Pi Foundation," January 2021. [Online]. Available: https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-product-brief.pdf

[12] Ramesh Saha, S. Biswas, S. Sarmah, S. Karmakar and P. Das, "A Working Prototype Using DS18B20 Temperature Sensor and Arduino for Health Monitoring", SN Computer Science, vol. 2, no. 1, 2021, https://doi.org/10.1007/s42979-020-00434-2

[13] S. Rao, "IoT Enabled Wearable Device for COVID Safety and Emergencies", Int. J. Interact. Mob. Technol., vol. 15, no. 03, pp. pp. 146–154, Feb. 2021, https://doi.org/10.3991/ijim.v15i03.17815
[14] N. N. Sari, M. N. Gani, R. A. Maharani and R. Firmando, "Telemedicine for silent hypoxia: Improving the reliability and," *Indonesian Journal of Electrical Engineering and Computer Science,* vol. 22, no. 3, p. 1419~1426, 2021, http://doi.org/10.11591/ijeecs.v22.i3.pp1419-1426
[15] C. Dow, Internet of Things Programming Projects: Build modern loT solutions with the Raspberry Pi 3 and Python, Bermingham: Packt Publishing, 2018.
[16] A. Hashmi, "Forbes Health," 2022. [Online]. Available: https://www.forbes.com/health/healthy-aging/normal-heart-rate-by-age/ [Accessed 10 July 2022].
[17] Mayo Clinic, "Mayo Clinic," 2018. [Online]. Available: https://www.mayoclinic.org/symptoms/hypoxemia/basics/definition/sym-20050930 [Accessed 10 July 2022].
[18] Cleveland Clinic, "Cleveland Clinic," 2021. [Online]. Available: https://health.clevelandclinic.org/body-temperature-what-is-and-isnt-normal/ [Accessed 10 July 2022].

11 Authors

Bzhar Ghafour Mohammed is an assistant programmer at Salahaddin University, Erbil, Iraq since 2015. He got B.Sc. computer science at Salahaddin University (2014). He is currently M.Sc. student at Salahaddin University, Erbil, Iraq. His research interests are related to IoT and Intelligent Systems (E-mail: bzhar.mohammed @su.edu.krd).

Dr. Dler Salih Hasan is a lecturer at Salahaddin University, Erbil, Iraq since 1999. He got B.Sc. in Production Engineering at University of Technology – Baghdad, Iraq (1991), and he got his M.Sc. in Production Engineering at University of Technology – Baghdad, Iraq (1999). His split-site Ph.D. was in Robotics Engineering (2017 between Salahaddin University, Iraq & University of Florida, USA). He is currently Head of Computer Science & Information Technology Department at Salahaddin University, Erbil, Iraq. His research interests include robotics engineering, sensors and IoT (Email: dler.hasan@su.edu.krd).

Article submitted 2022-08-13. Resubmitted 2022-11-10. Final acceptance 2022-11-23. Final version published as submitted by the authors.

The Other Side of the Mobile World

"Mobile Mobbing"

https://doi.org/10.3991/ijim.v17i01.36219

Nalan Kazaz[1](✉), Tuncay Dilci[2], Tolga Karadas[2]
[1] AAB College, Pristina, Kosovo
[2] Sivas Cumhuriyet University, Sivas, Turkey
nalan.kazaz@universitetiaab.com

Abstract—The innovations brought by the digital age leave deep traces in the lives of individuals of all ages. With technological tools becoming an integral part of life, we are observing changes in the behaviors and reactions of individuals. Mobile technology pushes individuals to ease and drags them to loneliness in society. Individuals who withdraw into their shells are socializing on mobile platforms. The progress of science and technology from past to present has brought changes in society. Rapidly advancing technology shapes the lives of individuals in many areas. Digitalization has been efficient in the exposure of individuals to an insidious application of mobbing. In this context, the mobile world has come to the point that it threatens the living space of the individual with the content that is a design product it offers. In particular, the role of digital media in a way that interferes with every aspect of life has turned into digital despotism. In this study, which is considered a compilation, we used document analysis as a data collection tool. We obtained data by examining the documents related to the subject and handled it through descriptive analysis. In this context, while trying to examine the concept of "mobile mobbing", the other side of the digital world; we discussed digitalization, mobbing, digital violence, cyberbullying, digitalization, and its aspects on human life. As a result, we have reached a high relationship between mobile mobbing and its effect on individuals. Among these results, there are changes in their behaviors and habits, the digital world has turned into a covert mobbing tool, social media contents influence the attitudes of users through hidden messages, exerts pressure on their behavior by directing them, disturbing insults and threats, etc. are shared in communication styles, we have concluded that mobbing is experienced in a similar digital environment. In this context, we have listed suggestions and measures against mobile mobbing, with digital media users being more careful and conscious of techniques, respecting safe sharing with courtesy rules in their discourse and actions.

Keywords—mobbing, technology, digitalization, mobile mobbing, cyber bullying, digital violence

1 Introduction

Changes and developments in today's world have left various effects in all areas of life [1]. One of these changes and developments is digitalization. With the age of digitalization, many functions of individuals in society have altered. Karakas et al. (2009) defined the concept of digitalization as "substituting or renewing your existing resources with digital products to ensure the highest level of efficiency with the lowest level of physical effort".

With the effect of digitalization, individuals can do most of the things they see in real life in the virtual environment. Within the scope of this subject, Sayar (2016) emphasized that virtuality and real life are intertwined by saying that "people can fight, talk, plan, gossip, exchange ideas, be friends and even fall in love". Due to today's world conditions, changes are seen in the habits of individuals with digitalization. With various applications, individuals have had many advantages such as getting an education, visiting museums, following the agenda, and communicating. In addition to these, people can create their content and share it with other individuals through blogs, podcasts, and various digital social communication tools [4]. These sharing contents can often turn into implicit coercion.

The communication and interaction environment offered by the internet, which is an essential instrument of digitalization, pushes many fields such as education, economy, and trade to change [5]. While digital tools become widespread and virtual environments offer various opportunities to individuals, it brings many positive results; It also causes negative consequences. One of these negativities is the phenomenon of trust. It is difficult to establish trust with actions such as making eye contact or shaking hands in the digital environment [6]. Besides the problem of trust, digitalization can cause internet addiction, inefficient use of time, and communication disorder among individuals [5]. Additionally, people who are addicted to the digital age may experience emotional changes such as "irritability and unhappiness" when they cannot access the internet [7]. While such emotional changes completely influence the behavior of individuals, they turn into a mobbing perception.

1.1 The aspect of digitalization reflected on life

People use technology to meet their daily needs, and this pushes them to stick to digitalization [8]. The use of digital tools such as television, computer, and tablet in society is increasing day by day. Many people create social media accounts in virtual environments through various digital tools and spend a lot of time in these virtual environments [9]. Especially today's children enter digital platforms at an early age and spend most of their time on social media or game sites. Guvendi et al. (2019) express that "many games that reconstruct the children's world by digitizing them, while performing useful functions as a leisure time tool, to relieve fatigue and stress, can also make violence a normal behavior by containing elements of violence in their content". They drew attention to the effect of games on child psychology and the concept of mobbing, which is a version of violence. With the effect of digitalization, elderly individuals, just like other people, are sharing their every moment on social media. Of

course, these shares are a means of eliminating deprivation in the individual. For this reason, content that is an expression tool can transfer some risks to the other party. At this point, experiencing emotional changes, irritability or resentment can be seen in both young and old individuals. [11]. Seeing these moments through social media upsets them and causes some problems.

Considering all the above: The rapid spread and advancement of technology has also led to change that surrounds the lives of people of all ages. In this context, Ryan & Jones (2016) stated that the use of the telephone and internet paved the way for the development of new technologies. Due to the widespread use of digital technology, "time, space, identity, self, communication, consumption, production processes, values" are not fixed but restructured with digitalization [13]. Behaviors that reflect the characteristics of digitalization lead to the formation and change of new behavior in a positive way as well as in a negative way [14]. At this orientation stage, digital media greatly changes the behavior of individuals by influencing them. Rapidly advancing technology has brought with it the transition to the digital age known as "Digitalism". At this age, it is possible to say that some interactions are depending on the contact habits, content, and duration of individuals.

1.2 Mobbing

The word mobbing as a form of action means psychological violence, siege, collective attack, inconvenience, or distress. Mobbing, which is named with the words "bullying, emotional harassment or intimidation" applied in the workplace in Turkish, is defined as malicious attempts to force a person to quit his/her business by using unjust accusation, defamation, humiliation, and direct or indirect violence through gossip.

Mobbing exists at every stage of life, it should not be strange that it is also in digital media, which is a brand-new living space. At this point, it is not an exaggeration to argue that mobbing, which is produced by the purposeful and deliberate content of the digital world, causes increasing physical and emotional damage. It is possible to express this situation as the reflection of the results of multidimensional causality relations related to mobbing. Considering the mental disorders caused by people exposed to mobbing in general terms; "Many mental disorders may occur in connection with the way, duration and severity of mobbing. Boredom, anger, pessimism, sleep problems, depressive symptoms, anxiety symptoms, and behavioral problems can be seen. Adjustment disorders where depression, anxiety, and behavioral problems coexist, anxiety disorders such as depression, generalized anxiety, and panic disorder, somatoform disorders that express themselves with somatic symptoms (somatization, conversion, pain disorders), psychosomatic diseases in which psychological factors play a role in their emergence and course (skin diseases, hypertension, etc.) can be seen. In addition, as a kind of self-healing efforts such as alcohol, substance or drug can be turned into substance-use disorders. "Post-Traumatic Stress Disorder" is one of the most serious mental disorders that can occur due to experiences that threaten the physical integrity of the individual, it leaves him helpless and creates a sense of horror. The quality of being chronic, disrupting functionality, and creating disability are much

higher in those that occur because of traumas (such as torture, rape, war trauma) that are deliberately created by human hands. As a trauma deliberately created by human hands, "intimidation" draws attention as a remarkable and contemporary form of trauma for PTSD." [15].

1.3 Digital mobbing

Digital mobbing refers to situations that we can also call cyberbullying and that disturb and upset people through digital channels, concepts of privacy, etc. According to this definition, most of the attacks made through digital media that threaten and put at risk are expressed within the scope of mobbing.

Under normal conditions, the concept of mobbing refers to the stressful situations that disturb the individual related to the working climate in a workplace, usually towards the superior from the top. With the spread of the digital age in digital mobbing, it has started to become a threat tool by sharing personal words or visuals on mail, chat rooms, Facebook, or other social media since the 2000s. On the other hand, the content of the digital channels created can turn into an imposition or despotism, accompanied by the jargon or presentation tools they use on the target group.

This situation started with people staying at home during the COVID-19 process and accelerated with the intense use of screens as a communication channel. This situation has become even more common with people's intense follow-up of digital channels. As a result, it shows itself as a habit-based, indispensable thing for people in today's conditions. Digital bullying or digital harassment is not just something that happens in office environments or working climates but can also manifest itself in full or part-time home office work or distance learning environments, what we call hybrid work environments.

Although at the beginning of the pandemic period, the comfort of not going to the workplace and staying away from the stress of traffic seemed like an advantage, then we started to experience the disadvantages and negative aspects of this situation. One of the reasons for this is that the greatest advantage of humanity is related to the lifestyle that is maintained in real life dynamics. While meetings held with remote online applications in the home environment negatively affected the work-life balance, the efforts of individuals to talk over the phone in the name of so-called communication, unlimited and abundantly, turned into a habit and addiction after a certain period. This type of addiction can be expressed as digital life addiction, but it also brings a mobbing practice within itself.

In this study, the current situation will be examined with various views on "digital mobbing" as the other face of digitalization.

2 Method

In this section, the design of the research, the quantity of the study group, the characteristics of the data collection tool used in the research, and how to get and analyze the data are given.

2.1 Research pattern

The research will be shaped according to the document analysis method. In this context, digitalization and digital mobbing concepts will be discussed and explained and the relationship between them will be examined.

2.2 Model of the research

In this study, we preferred a compilation model to examine the relationship between digital psychology and value perception. We scanned the domestic and foreign literature on the subject. We discussed the interaction between concepts, accompanied by the information we obtained by examining various articles and theses.

2.3 Data collection

In this study, we preferred the document analysis method for data collection. "Providing data by analyzing written documents containing information about facts and events related to the subject examined within the scope of the research" is known as document analysis [16]. Document analysis is used to scan oral or written records about the past [17]. In this research, we have benefited from journals, theses, articles, various web pages, and reports related to the subject.

2.4 Analysis of data

In this research, we analyzed the information obtained as a result of document analysis through descriptive analysis. We preferred descriptive analysis, which aims to reflect our findings in an organized and interpreted way [18]. We examined and interpreted the information obtained from the documents and examined the current situation in the form of discussions and comparisons following the subject of the research.

2.5 Digital technologies and its use

When we look at the history of humanity, we can understand that there is no other time in which technology has progressed rapidly as in the last 30 years. Especially, information technologies provide the speed of this revolution. Technologies are easily accessible and have become available in every country via the internet, one of the most common of all, and is now indispensable for everyone [19].

According to the January 2020 numbers, it is known that 4.54 billion individuals are internet users in the world and more than 5.9 billion people are active phone users. It is known that this data belonging to internet users increased by 7% compared to January 2019; It was observed that there was a 2.4% increase in phone users compared to January 2019 [20]. In the light of these data, we can understand that technology is widely used in every field and is adopted by everyone today. These technologies, which develop very rapidly and become a part of our daily life without question, have become

indispensable. For example, the frequency of checking smartphones that we did not use in the early 90s is now 48 per day in Europe and 78 in Turkey. According to this result, users in Turkey control their mobile devices almost twice as much as users in Europe. According to the 'Global Mobile User Research' conducted by the consultancy company Deloitte with more than 53 thousand participants in 33 countries, mobile users in Turkey look at a mobile phone screen every 13 minutes on average [21].

As of 2020, the rate of internet usage in Turkey was 79.0% for individuals in the 16-74 age group. This rate was 75.3% the previous year. When the internet usage rate is analyzed by gender; this rate was 84.7% for men and 73.3% for women. The percentage of households with internet access is 90.7%. This rate was 88.3% in the previous year [22]

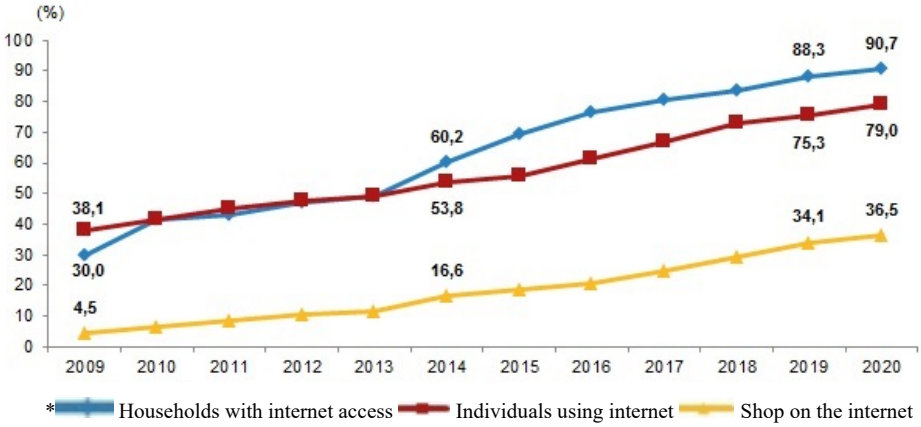

Fig. 1. Key indicators of household ICT use, 2009-2020 [22]

According to the results of the "Household Information Technologies Usage Survey", the rate of households accessing the internet via broadband was 89.9%. The rate of households accessing the Internet via broadband was 89.9% in 2020. Accordingly, 50.8% of the households accessed the Internet with a fixed broadband connection (ADSL, cable Internet, fiber, etc.), while 86.9% of them accessing the Internet with a mobile broadband connection. The rate of households with broadband Internet access was 87.9% in the previous year [22].

Table 1. Digital analysis data results (pandemic process and before)
Comparative general commentary on and before the pandemic process [21]

	Pandemic Process	**Before Pandemic Process**
Total number of participants	2.055	800
Total number of dependents	615	104
Dependency rate (%)	29,93	13,7
Participant age range	22-44	22-44
Way of contacting the participant	Facebook (social media)	Facebook (social media)
Participant	Türkiye	Türkiye

The total dependency rate of the pandemic (Covid-19) process is 29.93%, and an increase of about 116% is observed compared to before. The pre-coronavirus digital analysis data belong to a study 6 months ago, and there is a noticeable increase.

There is a dependency on digital objects with a rate of approximately 30%. This dependency situation also appears as a loss of 30% in terms of workforce and quality of life. According to all these results, there are some potential risks in terms of healthy communication and productivity.

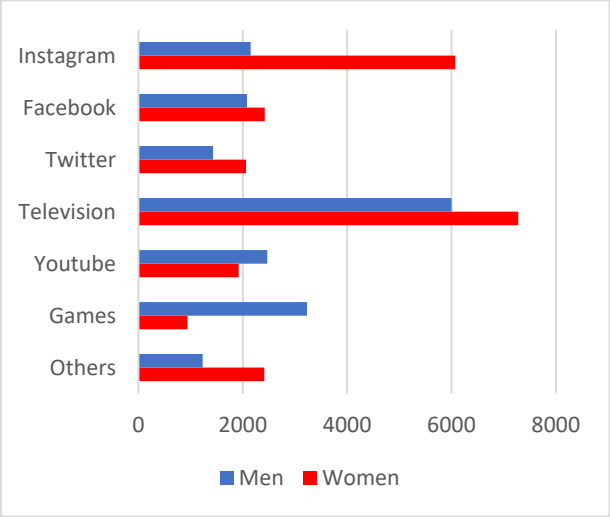

Fig. 2. Distribution of usage period on the related digital media by gender variable [21]

The duration of using television intensively by the women included in the sample is 72.77%. On the other hand, 60% of men use television contact.

In terms of minutes, while women spend a total of 109,155 minutes (95 minutes / 1 hour and 35 minutes per person) during the day, men spend 91,080 minutes (99 minutes / 1 hour and 39 minutes per person), while the theme of television stands out in digital media.

According to the research data, Instagram comes to the fore in the second place. Women are in contact on Instagram for 90,150 minutes (79 minutes/1 hour and 19 minutes per person), and men for 25,845 minutes (28 minutes per person/approximately half an hour). According to gender, women spend more time on Instagram [21].

2.6 The relationship between digital media and mobbing

The innovations brought by the digital age leave deep traces in the lives of individuals of all ages. With technological tools becoming an integral part of life, we observe changes in the behaviors and reactions of individuals. Digital psychology pushes individuals to take it easy and drags them to loneliness in society. Individuals who withdraw into their shells in society are supposedly socializing on digital

platforms. It is possible to observe behavioral changes in individuals with the effect of digital psychology. As a result of observing behavioral changes, we see that social relations of individuals weaken, problems in the family occur, a feeling of alienation from other individuals occurs, and individuals who are introverted and live on their own are common in society [23].

Everyone has started to use the Internet and digital tools in many areas [24]. The widespread use of digital tools shows that digitalization has been made in many areas. With the use of digital tools such as computers, phones, and tablets, individuals have started to take more place on social platforms.

At this point, it is possible to say that digital psychology affects the individual in every sense. Individuals who dedicate themselves to digitalization in all areas of life can lose their values and themselves. Yengin (2019) emphasized that with the widespread use of the internet, social media has become a habit in society. Damage or damage to individual-specific behaviors can lead to a change in the psychology of the person. In today's world, it can be said that there is a change not only in the behavior patterns of individuals but also in their value perceptions.

When we look at some examples of mobbing applications made through digital channels:

- Being exposed to false and false information,
- Being insensitive to calls or visual messages,
- Offending the other person by displaying passive or aggressive attitudes,
- Forcing the other person to open the camera or forcing communication by extending the talk time,
- Maintaining communication with obscene images or gossip in front of the camera,
- Being forced to speak or being exposed to a meeting during non-working hours,
- Sending e-mail contents or messages with verbal or isolating abusive language,
- To sabotage the working climate by following or observing the employees through cameras or various applications in the workplace,
- To sabotage communication by exaggerating or monitoring the information that needs to be shared,
- Accidentally or knowingly gossip about someone else in a way that is reflected in the content of digital media or disclose the image,
- To force likes on shares with colleagues and life partners or to make comments based on the number of likes,
- Giving implicit messages or forcing follow-up by using various emojis or silent message channels,
- To force a follow-up through content created in digital media or by being a member of a group,
- Making accusations of insensitivity to the call records or threatening to cut off communication,
- Presenting the content created by digital channels to followers through advertisements in the form of constant bullying,
- Bringing advertisements or sections related to any content or promotion to the screen and forcing the individual to watch,

- Forcing the individual to distance himself from his real life with a new form of identity and isolation,
- Subjecting people to content through psychological or emotional Blackmail, as well as trying to dominate the person, etc.

When the individuals who are forced by the given mobbing patterns are examined, burnout syndrome and fatigue expressions are seen much more frequently, and mental and physical diseases may increase due to high levels of stress.

The consequences of mobbing and violence caused by the unlimited use of computers and video games and not being exposed to any censorship are as follows:

- Violent games keep children's arousal at the highest level. While these children's heart rhythms increased more due to adrenaline, it was observed that these children were more prone to violence after play.
- Whether a child or an adult, violent and reflexive behavior develops negatively after encountering violent digital media.
- Intense contact with violent digital media creates an anti-social phobia personality in the individual, restricting his interaction with his environment and resulting in social isolation.
- The frequent handling of themes such as murder, terrorism, suicide, etc. in digital media transforms the tendency toward violence into a self-fulfilling prophecy by creating fear and anxiety in children and the effect of Murphy's law.
- Children who take media heroes as role models tend to apply the behaviors they identify with their heroes at the slightest opportunity to their close friends.
- Children who are heavily exposed to media violence perceive the world as a place to be feared and difficult to live in.
- In parallel with the increase in violent behavior in children who are exposed to more chronic and long-term media violence, we see that they have made the slogan "don't die, kill" a character consciousness to survive in the future with depersonalization against violence.
- In case of widespread and uncontrolled use of the Internet, bullying, sexual messages, contact with strangers, insecurity against strangers and passive personality, gambling, and meeting with harmful content may occur within the peer group.
- In the pandemic process, a new form of mobbing has occurred on people with the "Digital certificate" application. The vaccination certificate is expressed as that it will strengthen the immune system against the disease, will include information showing whether the person has the Covid-19 vaccine, if so, where and which vaccine, information about the recovery of those who have had the disease, and the immune body level, and the Covid-19 test result. Restrictions such as additional testing or quarantine will not be applied to people who have received approved Covid-19 vaccines in the EU with a certificate and 2 weeks have passed since the last dose. Vaccination certificate will be valid in all EU countries, Iceland, Liechtenstein, Norway, and Switzerland [25].

We see this digital certificate as the first stage of imposition of the new world order in the field of health. In the future, people will also experience vaccination certificates for other diseases.

2.7 Cyberbullying and children in digital media

We know that children need to be on social media to meet new people, make friends, spend their free time, communicate with their real friends in the virtual environment, wonder about what their friends are doing, and develop some attitudes and behaviors about what their friends are doing [26]. We can also infer that one of the reasons why children spend a lot of time in digital media is they are fond of digital media and games with the desire to take risks and the irresistible attraction of their desire, due to the passion for pleasure and excitement that occurs under the influence of adrenaline and dopamine hormones such as impulsive disorder and withdrawal syndrome [27]. Actions in which the serotonin hormone, which has become a habit based on the above statements, is exhibited intensely, evolve into self-violence.

Cyberbullying is sending harmful, irritating, offensive messages over instant mail, messages and network connections on the internet over the phone or computer, posting a post or image, engaging in offensive behavior through threats and blackmail. It is the process of harming an individual or a group or a personality through digital objects in relational style, creating material and moral victimization, for people who are exposed to such behaviors with internet content and those who have suffered after this exposure [28].

Many studies have shown that children exposed to cyberbullying behaviors have a decline in academic life skills and serious failures in their social lives. Most of these students, experiencing alienation from school, being away from school, difficulty in focusing, and problems in their relationships, cause injuries behind their anxiety-ridden self, turn the school into a fighting arena with their other friends and turn into many hurtful aggression behaviors, including weapons [21]. There may be serious damage to the family life of people who are exposed to cyberbullying. In this respect, it can trigger family conflicts and other problems, as well as stress and depression related to anxiety disorder.

We know that people who have the psychology of cyberbullying take advantage of the freedoms offered by the digital environment and exhibit attitudes such as imitation, disclosure, harassment, and defamation more easily. What these people think about themselves is they are inaccessible behind the screen [29]. On the other hand, cyberbullies take revenge on the people they have a problem with because they could say that they cannot say it face to face due to their gender, status, and lack of communication with people. In addition to all these, it can take on a character that evolves into digital bullying, with the possibility of hiding one's identity on social media, providing transportation, and being an unconscious internet user. Media companies have adopted an understanding of raising insecure and aggressive characters towards the future by creating traumas on children, especially with violent events shaped in visual media [21].

Negative gains obtained through digital media feed the sense of violence in children and show itself first by applying the heaviest blow to their environment, then to their families, and then to themselves. We should never forget our children who had Blue Whale syndrome and committed suicide in the past, who were victims of PUBG and ended their lives by throwing themselves from the 15th floor. For this reason, murder scenes or images staged in digital media agitate the existing situation with storifying. Then, it can turn into a behavior pattern in the future with emotional damage to the limbic system.

According to the principles outlined in Article 17 of the United Nations Convention on the Rights of the Child, "They encourage the development of appropriate guiding principles for the protection of the child against information and documents that may harm his or her well-being." This article provides the opportunity to take some measures and prevent the violence that can be applied to children or the murder of children. It is not the right approach for publishers to present content produced without taking into account the social values and traditions of the society in digital media, without paying attention to children, or to impose contradictory content on children to increase the rate of viewing or the number of clicks [21].

Perhaps the most important effect of digital media on children is the digital addiction situation, which is cyber cocaine. According to many studies conducted by Dilci 2019; children cannot develop healthy digital contact skills since they do not use digital objects healthily and appropriately, families are sufficiently conscious and incapable of digital media literacy, and teachers in the school environment cannot guide children in accordance with the requirements of the digital age.

3 Conclusions

We are facing the fastest digital cultural sociological change process in human history. The subject of this process is the human being. Human; is a bio-cultural-socio-economic-psychological entity. A social being is born only in the social environment and shaped by the conditions of the environment. It abides by the superstructure rules such as religion, morality, and law, which are socially accepted values. It fulfills the duties assigned to it by society [30].

We should look at this process of change, for which we are not ready, from a wider perspective. As adults and children, we found ourselves in a digital age where we have not yet gained consciousness and are caught unprepared. The concept of the new normal, whatever there is about the past that we used to live in, has become accepted with its magic. While society is familiar with the change like a boiled frog day by day, the content perceived as negatively yesterday has become accepted by most of the society today. For example, the threshold of violence, aggression, and similar practices in traditional life has reached an acceptable point [31]. The media has turned systematic desensitization into a social change by raising the level of acceptability against social violence and aggression that it has used over time. Unfortunately, as a violence mechanism, the presentation tools of digital media increase its field of activity day by day. The size of media content that should normally be watched by adults increases the

culture of violence in children when watched by children. By serving mediatic violence through games via computers and the internet, the child's violent behavior, which is a product of life, has turned into a more concrete and interactive. Many studies on this subject show that children who have experience in violent cartoons hit each other, talk to each other with slang words, and imitate cartoon characters, displaying a hurtful and aggressive personality toward their other friends. The media's transmission of practices that will provoke and destroy the society, such as violence, in a more interesting style and narrative style, to make competitive content interesting, opens the door to the culture of fear. While this situation brings the concept of mediatic violence to the agenda, the media need to work on productions that have more positive and constructive educational content [21].

4 Suggestions

In this section, we gave recommendations based on the data in the research.
What are the recommendations against digital mobbing?

- We must use digital channels in line with their purpose and a planned manner.
- Children's games provide data on children's world, personalities, and value judgments. Considering the mental hacking and content impositions marketed through digital objects, we should not forget that we are facing a battle that needs to be considered once again.
- The child's emotional life reaches some satisfaction through face-to-face play. In this respect, he formalizes the reflections of his own living space through play. In this way, they are emotionally relaxed. The relaxed individual will think healthier and shape their value judgments accordingly. Play is another factor that is effective in the socialization of the child. Environmental interaction is an important tool of socialization and can be gained through play. Through face-to-face and interactive games, the research proves the role of play in the treatment and has come to very definite conclusions.
- After the self-control of an individual, his environment needs to take part to prevent digital mobbing on the individual's environment.
- By defining the way and form of communication, families should create a social media culture and it should become a lived value.
- We should check what content children are exposed to and whether there is any trauma or emotional violence in this direction.
- It is necessary to have information about the socio-psychological-cultural structure of the close friend group of our child.
- In case of mobbing, professionals should support people,
- They should provide rehabilitation approaches according to the dose of emotional or physical violence,
- Whether corporate employees are working from home or the office, especially the communication problems, should be addressed in the meeting agenda, in line with

the corporate culture. In this regard, institution officials should support employees with periodic surveys, anonymous feedback forms, and team-building activities.

- Recently, we have frequently seen in social media posts that digital mobbing is done in online meetings and many people are exposed to it. For this, it is important to be sensitive about content sharing. For this reason, businesses should work diligently on the ethical scope of online meetings, especially with video. It should set a clear policy on communicating properly online. Employees should know how sanctions will be applied to unethical acts.
- Another problem experienced in digital mobbing is that although corporate managers are sensitive to the issue, sometimes employees avoid reporting these problems and harassment to their relevant departments. Fear of losing a job during the pandemic period or thinking that the problem will get worse may be the reason why these problems are not brought to the agenda of the relevant department. According to experts, only ⅓ of employees exposed to digital mobbing report this problem to their department. To prevent this situation, the officials of the institution should organize individual meetings with the employees in addition to their observation at periods and, if necessary, make team changes to prevent the conflicts from reaching the level of harassment.
- Lastly, it would be best to leave the job to justice and the legal process in mobbing issues that do not remain within the business. Experts say that in such cases, we should never be afraid and remain silent and use our legal rights in the best way possible. Regardlessly, public or private sector employees, you can call the ALO 170 line 24/7 for mobbing complaints and information.

5 References

[1] Yucel, G. and B. Adiloglu (2019), Dıgıtalızatıon - artıfıcıal ıntellıgence and accountıng expectatıons, *Muhasebe ve Finans Tarihi Araştırmaları,* vol.17, pp. 47–60, Available: https://dergipark.org.tr/tr/pub/muftad/issue/46942/589319

[2] S. Karakas, F. Rukancı, and H. Anameric, *Belge Yönetimi ve Arşiv Terimleri Sözlüğü*. Ankara: Devlet Arşivleri Genel Müdürlüğü, 2009.

[3] K. Sayar, (2016). Dijital toplum, *TRT Akad.*, *vol. 1*, no. 2, pp. 762–775, 2016, [Online]. Available: https://dergipark.org.tr/tr/pub/trta/issue/23620/252180

[4] R. C. Lefebvre and A. S. Bornkessel, (2013). Digital social networks and health, *Circulation*, vol. 127, no. 17, pp. 1829–1836, 2013, https://doi.org/10.1161/CIRCULATIONAHA.112.000897

[5] F. Altun, (2020). Teknolojik gelişmeler, dijitalleşme ve çalışmanın geleceği, in *Kelebek Etkisi Çalışma Yaşamında Değişim ve Dönüşüm*, 1., O. Bayrakcı, Ed. İstanbul: Kriter, 2020, pp. 169–190.

[6] R. Agarwal, A. K. Gupta, and R. Kraut (2008). Editorial overview —The interplay between digital and social networks," *Inf. Syst. Res.*, vol. 19, no. 3, pp. 243–252, Sep. 2008, https://doi.org/10.1287/isre.1080.0200

[7] B. Guney (2017). Dıgıtal culture transıtıon ın dıgıtal addıctıon: netlessphobıa, *e-Journal of New Media.*, vol. 1, no. 2, pp. 207–213, [Online]. Available: https://dergipark.org.tr/tr/pub/ejnm/issue/34698/383559

[8] D. Yengin, (2019). Dıgıtal addıctıon as technology addıctıon, *Turkish Online J. Des. Art Commun.*, vol. 9, no. 2, pp. 130–144, 2019, https://doi.org/10.7456/10902100/007
[9] H. Kocarslan and H. Kılınc, (2019). Consumer Perception in Digital Marketing, A Research On Shopping on the Internet," *Eur. J. Sci. Technol.*, no. 17, pp. 1263–1273, Dec. 2019, https://doi.org/10.31590/ejosat.659295
[10] B. Guvendi, G. Tekkursun Demir, and B. Keskin (2019). Digital Game Addiction and Aggression in Secondary School Students, *OPUS International Journal of Society Research*, vol. 11, no. 18, pp. 1194–1217, Jun. 2019, https://doi.org/10.26466/opus.547092
[11] S. Cataloglu (2018). Old Age, value and technology, *International Journal of Human* Studies*,* vol. 1, no. 1, pp. 27–35, 2018, https://doi.org/10.35235/uicd.434005
[12] D. Ryan and C. Jones (2016). *Understanding digital marketing: marketing strategies for engaging the digital generation*, 1st ed. London: Kogan Page.
[13] A. Ciftci and Y. Karakas (2019). In the Projection of Digital Times: Transformation of Identity, Body and Communication *AJIT-e Online Acad. J. Inf. Technol.*, vol. 10, no. 37, pp. 7–30, Apr. 2019, https://doi.org/10.5824/1309-1581.2019.2.001.x
[14] A. Yanık and M. Batu (2019). Sorunlu akıllı telefon kullanımı ve öne çıkan psikopatolojilerin sistematik gözden geçirilmesi, in *Multidisipliner Perspektiften Psikoloji*, IKSAD, 2019, pp. 135–166.
[15] Türkiye Psikiyatri Derneği (2022) Mobbing, https://psikiyatri.org.tr/halka-yonelik/15/yildirma-mobbing
[16] Z. Karatas (2015). Sosyal bilimlerde nitel araştırma yöntemleri,*Manevi Temelli Sos. Hizmet Araştırmaları Derg.*, vol. 1, no. 1, pp. 62–80, 2015.
[17] M. Kozak (2018). *Bilimsel araştırma: tasarım, yazım ve yayım teknikleri*, 4th ed. Ankara: Detay.
[18] A. Yıldırım and H. Simsek (2011). Sosyal bilimlerde nitel arastirma yöntemleri. Journal of Theory and Practice in Education. *2* (2): 113-118 Ankara. Available: http://scholar.google.com.tr/scholar?hl=tr&q=nitel+araştırma+yöntemleri&btnG=&lr=#1
[19] S. K. Guven (2008). Promises and threats of the ınformation technologies in the new world regime, *Istanbul Univ. Fac. Commun. J.*, no. 34, pp. 69–86.
[20] F. G. Yalcın (2020). 2020 Yılı Global Dijital Raporu. https://www.fundalina.com/2020-yili-global-dijital-raporu/
[21] T. Dilci (2021). *Dijitalim*. Ankara: Sonçağ Akademi.
[22] Turkish Statistical Institute (2020). Hanehalkı Bilişim Teknolojileri (BT) Kullanım Araştırması, *TURKSTAT*. https://data.tuik.gov.tr/Bulten/Index?p=Hanehalki-Bilisim-Teknolojileri-(BT)-Kullanim-Arastirmasi-2020-33679#:~:text=İnternet kullanım oranı cinsiyete göre,s%2C3 olduğu görüldü.&text=Hanelerin %90%2C7'sinin,yılda %88%2C3 idi.&text=89%2C9 oldu-,Genişbant ile İnternete erişim sağlayan hanelerin,yılında %89%2C9 oldu.
[23] T. Dilci (2015). *Dijital Diyet Zamanı*. Kayseri: Geçit Matbaacılık.
[24] F. Aydogdu (2018). Investıgatıon of dıgıtal game addıctıon of chıldren playıng dıgıtal game ın terms of varıous varıables, *Ulakbilge Sos. Bilim,* vol. 6, no. 31, pp. 1–18. https://doi.org/10.7816/ulakbilge-06-31-01
[25] European Commission (2021). EU Digital Covid Certificate, *European Commission*, 2021. https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/safe-covid-19-vaccines-europeans/eu-digital-covid-certificate_en
[26] A. A. Ceyhan (2016). Predıctors of adolescents' problematıc ınternet use levels, *Cocuk ve Genclik Ruh Saglıgı,* vol. 18, no. 2, pp. 85–94, 2016.

[27] H. Aktas and N. Yılmaz (2016). Smartphone addiction in terms of the elements of loneliness and shyness of university youth, *Int. J. Soc. Sci. Educ. Res.*, vol. 3, no. 1, pp. 85–85, Dec. https://doi.org/10.24289/ijsser.283590
[28] O. T. Arıcak, H. Kınay, and T. Tanrıkulu (2012). Siber Zorbalık Ölçeğinin İlk Psikometrik Bulguları, *Hasan Ali Yücel Eğitim Fakültesi.*, no. 17, pp. 101–114, 2012.
[29] B. Dilmac (2009). Psychological needs as a predictor of cyber bullying: a preliminary report on college students, *Educ. Sci. Theory Pract.*, vol. 9, pp. 1291–1325, 2009.
[30] T. Dilci, *Gelisim Psikolojisi*. İdeal Kültür, 2014.
[31] M. Damar (2018). Medyanın Çocuklarda Korku ve Şiddete Etkisi, Ankara, [Online]. Available: http://www.hegemvakfi.org.tr/Files/ckFiles/file/RAPORLAR/5 RAPOR 5-Sanal Alem_Medya Şiddeti.pdf#page=8

6 Authors

Nalan Kazaz, Department of Educational Sciences, Faculty of Education AAB College, Faculty of Social Sciences/ psychology department, Kosovo (https://orcid.org/0000-0001-9778-5788, nalan.kazaz@universitetiaab.com).

Tuncay Dilci, Cumhuriyet University, Faculty of Education, Department of Educational Sciences, Turkey (https://orcid.org/0000-0002-6901-5492, tdilci@cumhuriyet.edu.tr).

Tolga Karadaş, Cumhuriyet University, Faculty of Education, Department of Educational Sciences, Turkey (https://orcid.org/0000-0001-9408-5583, tlgk.38@gmail.com).

Article submitted 2022-09-18. Resubmitted 2022-10-28. Final acceptance 2022-10-29. Final version published as submitted by the authors.

Imprint

iJIM – International Journal of Interactive Mobile Technologies
http://www.i-jim.org

Indexing
International Journal of Interactive Mobile Technologies is indexed in
Elsevier Scopus, INSPEC, Ulrich, DOAJ, EBSCO, Google Scholar, and DBLP.

Publication Frequency
Bimonthly

Publisher
International Association of Online Engineering (IAOE)
Kirchengasse 10/200
A-1070 WIEN
Austria