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Original Article

Effects of a Personalized Reading Software Program on the Development of Language Learners' Reading Comprehension

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Abstract

The current study explored the effects of a personalized reading software program designed based on language learners' learning style on the development of their reading comprehension. Forty Iranian K-9 students were selected through convenience sampling and were assigned into control (n=20) and experimental (n=20) groups. Both groups' entry level of English reading proficiency was assessed by reading paper of Cambridge A2 Key exam. Reading was taught to both groups for 10 sessions using a researcher-developed software program. The experimental group used the reading software designed based on users' cognitive profile (visual, auditory and kinesthetic) with customized instructional scenarios. The control group used a version of the same software that did not include any user-tailored teaching materials. Both groups took part in reading paper of A2 Key again at the end of the experiment. The data were analyzed using One-way Analysis of Covariance (ANCOVA). The results revealed a significant difference between participants' reading comprehension at the end of the experiment in favor of the experimental group. The finding highlighted the role of learners' diversity in the success of computer-assisted learning environments, and has certain implications for software developers and language pedagogues.

Keywords

personalized software; language; learners; reading comprehension

Introduction

Some Overspread use of technology has had an immense impact on people's personal, social, and professional life in the last few decades. In particular, technology has transformed the meaning of key elements of education such as teacher, learner and instructional content and has opened myriad opportunities for personalized and life-long learning.

Computer-assisted learning environments help teachers change and adapt the content according to their students' needs and preferences; therefore, learning has become more interactive, personalized, and meaningful in recent years. The application of technology has substantially transformed instructional practices and has made teaching more effective and productive in terms of advancement and achievement [1]. Computers are now viewed as an essential instructional instrument in the classes of the 21st century in which teachers have convenient access to multiple instructional resources, are sufficiently prepared, and have more freedom in implementing the curriculum [2].

As a result of advancements in technology, teachers and learners' literacy undergoes radical changes as well. One of the advantages of using computers for learners is that they are provided with individualized instruction and become able to adjust their own learning

process to the instructional content. To achieve this aim, there should be thorough consideration of learners' needs and diversity in the process of designing software to match the content to their wants, interests, and preferences. As Raschio [3] stated, the potential of computer-assisted learning is realized only after software authors begin providing material that is both self-paced and tailored to students' individual needs and preferences. Ubiquitous presence of technology and mobile devices among the nation has paved the path for such an opportunity and thus demands instructional designers to more critically pay attention to students' choice of learning media.

One of the main issues of designing educational software is considering the individual differences and people's interests for using them. For computer-supported learning environments to be effective, merely giving students access to computers for reasonable amounts of time is not sufficient; their learning strategies and styles must also be understood and exercises should be provided that are conducive to their particular cognitive style [3]. Personalized environments can adapt to students' educational demands [4] by identifying learner modality and offering content based on different scenarios and learner-based evaluation. It can store teacher and students' knowledge about the educational content and the educational strategies and avail this collection of knowledge in the appropriate time [5]. This type of instruction promotes student engagement and understanding of key concepts; and frees teachers from their routine tasks while providing them with more time to adapt the role of instructional coaches and mentors for their students [6].

Research on the implementation of personalized instruction is indicative of its positive and constructive impact on learning achievement and motivation in mainstream education [7] in general and language education in particular [8]. Within foreign language learning domain, most work has focused on teaching vocabulary with personalized instruction and research on receptive skills is still in need of further attention. The aim of the current study thus was to design a reading software program that can differentiate and categorize English as a Foreign Language (EFL) learners based on their learning style; and then provide them with customized instructional materials following the detection/prescription model. The study aims to answer the following question:

Does a personalized reading program designed based on language learners' learning style have any significant effect on the development of their reading comprehension?

Review of Related Literature

- *Personalized learning*

In with the advent of learner-centered approached in the second half of the 20th century, more attention has been paid to learners and their learning preferences in mainstream education. Individual differences in terms of social, cognitive, and affective domains were recognized and researched in the framework of differential psychology that is "concerned with understanding those characteristics that make individuals dissimilar to each other, exploring how and why such differences occur" [9]. The rationale behind considering individuals' personal and situational needs in instructional design and practice can be explained by the fact that learning efficiency is guaranteed when education is responsibly flexible and does not follow the premise "one-size fits all".

Personalized learning is the "instruction in which the pace of learning and the instructional approach are optimized for the needs of each learner. Learning objectives, instructional approaches, and instructional content (and its sequencing) may all vary based on learner needs" [10]. Following a learner-centered paradigm, personalized learning prepares the ground for learners' more engagement in learning where the teacher is the facilitator of the learning process in contrast to a teacher-fronted approach [11] where the teacher decides for everyone's learning through organizing and managing the instruction.

Through personalized instruction the learners would be provided with learning scenarios that fit their needs and wants based on their learning preferences and contexts [12].

The advancement of technologies has greatly contributed to making more personalized learning environments such as personalized websites or mobile apps. In this way the system conforms to the learners and their learning preferences rather than the learners adjusting themselves to the system [13]. Students benefit more from self-adapting learning systems where they have control over their pace of learning, the input to be processed and the activities to be done [14]. The implementation of technology to launch personalized learning environments would "provide a platform to access myriad engaging learning content, resources, and learning opportunities needed to meet each student's needs everywhere at any time" [15]. This enables students to select those methods of online instruction that are more appropriate to their own particular learning styles [16]. This personalized and tailored instruction may utilize one of the following approaches: personalization of the content, based on learners' preferences, educational background and experience, personalization of the delivery and form of the learning content, and full personalization, that is composed of the combination of the above approaches [17].

There are five levels of personalized learning: name-recognized, self-described, segmented, cognitive-based, and whole-person-based [18]. In name-recognized personalization the identity of the suers is acknowledged by the system. In self-described personalization the learners are capable of describing their preferences by completing gate-keeping forms or surveys. Segmental personalization divides the user based on their similarities and common shared interest. Cognitive-based personalization delivers instructional content to learners based on their cognitive attributes and profiles. The whole person personalization provides a dynamic and smart learning environment where the system collects data from the learners in the process of learning and adapt the contents to the learners based on sophisticated algorithms. From level one to level five the technology sophistication increases and more complicated programming is required.

Some studies have developed personalized applications with varying levels of technology complexity with the aim of examining the impact of these enlivenments on learning gains. Hwang, Kuo, Yin and Chuang [19], for instance, developed an adaptive learning system to assist users to learn in a real-world, authentic environment by generating several individualized learning paths based on the learning status of each student and the relationships between learning targets. Similarly, Lin, Yeh, Hung, and Chang [20] developed a personalized creativity learning system that could offer personalized learning paths for optimizing the level of creativity. The result of their study showed that personalized learning paths were effective in improving students' creativity scores. Furthermore, they showed that incorporating personalized learning and game-based learning into a creative learning program could enhance learners' motivation and learning aims.

In a recent study, Alarmi et al. [21] reviewed the literature to provide an overview of personalized learning theory, technology, practices, and studies of implementing technology models to support personalized learning. The results are indicative of three technological models that support personalized learning within blended learning environments in higher education, an increase in personalized learning implementation in higher education with the support of the referenced technology models and platforms, and a lack of data-driven and independent research studies that investigate the effectiveness and impact of the personalized learning and technology models on student learning.

Within this framework, some studies have focused on developing personalized environments based on learning style to provide users with learning objectives, content, and activities that best suit their learning needs and preferences.

- *Personalized learning and learning styles*

One of the widely researched attributes of human being is learning styles or "an individual's preferred way of processing information and of dealing with other people" [22]. As in traditional classes it is very difficult to address all learners' learning style, researchers have shown interest in examining the way technology-based personalized learning environments can fulfill the needs of learners with different learning styles.

Zapalska and Brozik [23] recognized several teaching strategies for online instruction taking VAK learning styles into account. Their first suggestion was to deliver content in a variety of formats such as audio narration with a PowerPoint presentation, as well as a written transcription of the audio. Another recommendation of their study was to encourage active collaboration between students, with both individual and group activities. Zajac [16] explored the possibility of offering methods for personalizing the delivery of course content in a virtual learning environment. It is put forward that a learning styles questionnaire should be incorporated into the online course, so that students can assess their own personal learning style and then choose from a variety of course delivery methods in accordance to their individualized learning style.

Bachari, Abelwahed and El Adnani [24] examined teaching strategies that were matched with learner's personality using the Myers-Briggs Type Indicator (MBTI) tools. They developed an adaptive learning management system by considering learner's preferences and profiles according to the results of learning styles questionnaire that was fine-tuned during the course of the interaction using the Bayesian model. The result of the experiment conducted to evaluate the performance of this approach showed that the system was effective in improving the learning achievement. In another study, Yang, Hwang, & Yang [25] offered an adaptive learning system developed by using both learning styles and cognitive styles to modify the user interface and learning content for individual students. The results of the study illustrated that the proposed system could improve the learning achievements of the students. Additionally, it was found that the students' cognitive load was significantly declined and their belief of learning gains was augmented.

In a recent study Horváth [26] examined the impact of 3D VR platforms as personalized educational environments on learning efficiency. The learners' learning style was assessed based on Kolb's model. The results indicated that the 3D spaces have a high potential for personalizing VR education and would lead to better test performance in comparison to traditional teaching. Also, Martin, Dominic, and Francis [27] developed a system that classified the learners based on the time they spent on learning content of different types. The learning style based on VARK model (Visual, Auditory, Read/Write and Kinesthetic) was used to classify the learners. The system classified the learners and recommended the learning objects based on their learning preferences. No follow-up experimental study, however, was performed to examine the effectiveness of the system on learning gains.

- *Personalized language learning with technology*

Individual differences are viewed to be a part of language learners' characteristics that can predetermine a successful language learning experience [28]. By the ubiquitous presence of technology in everyone's lives, probing into the issue of personalized language learning environments with technology has attracted the attention of the researchers. The reason lies in the fact that the benefit of personalized instruction would be amplified in computer assisted language learning (CALL) environments as technological systems let the users achieve the most efficient learning in the least time [29]. In this framework, "personalization is not only about new ways of distributing learning resources, but also about finding ways to understand the skills, resources and interests of the learner outside the classroom" [30].

Despite a rather strong theoretical underpinning for the application of personalized systems in language learning and teaching, a few empirical studies are available on the

effectiveness of such systems on learning gains. Chen and Chung [29] for instance, developed a personalized mobile English vocabulary learning system based on Item Response Theory and learning memory cycle. The system was implemented on personal digital assistant (PDA) for personalized English vocabulary learning among English teaching majors in a university in Taiwan. The results showed that the personalized system promoted learning performances and interests. In another study, Petersen and Markiewicz [30] developed the PALLAS system that provided language learners with real life language learning scenarios by giving them personalized and contextualized access to learning resources. The system was mobile based and could be integrated into a Content Management System. The system was evaluated by three teachers and the results showed that the teachers agreed that PALLAS increased the flexibility of learning for the students and it was a suitable means of providing personalized learning. Jung and Graf [31] made a cognitive-based personalized web-based vocabulary learning framework utilizing word association games for teaching English as a foreign language. The system had a personalized engine that tailored the words to the current level of learners' vocabulary knowledge. Su, Yu, Su, and Lee [32] presented the design and experimental results of a cloud-based personalized recursive dialogue game system for computer-assisted language learning. A real cloud-based system was implemented and the experimental results demonstrate promising outcomes and the effectiveness of the approach.

As the review of literature shows, the development of personalized systems for teaching reading English as a Foreign language is scarce. Xu, Wijekumar, Ramirez, Hu, and Irey [33] reviewed a number of intelligent tutoring systems (ITSs) designed for teaching reading among K-12 students. The result of examining 19 studies on the theme showed that ITSs produced a larger effect size on reading comprehension when compared to traditional instruction but a small effect size when compared to human tutoring. However, no such research is available to examine these learning conditions in the context of second or foreign language learning.

Due to scarcity of research on the impact of personalized CALL environments on EFL learners' development of reading comprehension, the current study aims at probing into the effectiveness of a personalized software program designed based on learning styles of EFL learners on the development of their reading comprehension. As for computer assisted language learning (CALL), it should be noted that a careful observation of individual differences to assess human computer interaction would help language experts and educationists understand the performance and behavior of language learners in technology-based learning environments better to design personalized instructional content [34]. Admittedly, this leads to a more effective CALL environment that is capable of taking into consideration the language learners' diverse needs.

Method

- Participants

Forty K-9 female students participated in this study. They were selected based on convenience sampling (CS) from all K-9 female students who were studying in district 16 of Tehran in the academic year 2019-2020. There were eight K-9 classes in the school, two classes were selected as the sample and they were divided into experimental (n=20) and control (n=20) groups using simple random sampling. The study utilized a pretest-posttest control group design.

The participants spoke Persian as their native language and English was regarded as a foreign language for them. They attended English class once a week and each session lasted for 90 minutes. All students attended the same public school and their entry-level reading proficiency was checked prior to the study. 2.2. Instruments

A2 Key: To assess participants' English reading comprehension, reading paper of A2 Key (Key English Test) was used. A2 Key is a test among Cambridge English Qualifications, a group of examinations developed by Cambridge ESOL at Cambridge University.

Table1. Reading tasks of A2 key [35]

Part	Number of Questions	Task Type	What do candidates have to do?
1	6	3-option multiple choice	Read six short real-world texts for the main message.
2	7	3-option multiple matching	Read seven questions and three short texts on the same topic, then match the questions to the texts.
3	5	3-option multiple choice	Read one long text for detailed understanding and main ideas.
4	6	3-option multiple-choice cloze	Read a factual and choose the correct text vocabulary items to complete the gaps.
5	6	Open cloze	Complete gaps in an email (and sometimes the reply too) using one word.

There are seven tests from pre-A1 to C2 clustered in three proficiency levels (basic, independent, proficient) based on Common European Framework of Reference (CEFR). A2 Key is the third test of level 'basic' above pre-A1 and A1 and below B1 (Preliminary English). This test assesses candidates' proficiency of English communication in simple situations.

A2 Key is made up of four papers including reading, writing, listening, and speaking. For the purpose of this study, the reading paper was used. This paper has five parts and 30 questions. Details of A2 Key reading paper are provided in Table 1 [35].

The reliability coefficients of A2 Key for pretest and posttest were estimated to be .72 and .84 respectively.

VAK learning style questionnaire: VAK learning style questionnaire was used to assess the participants' learning style and portray their cognitive profile [36]. The scale has 30 items that assess individuals' preferred way of absorbing information and perceiving the outside world. The scale has three learning modalities (often identified by the acronym VAK): Visual Modality, Auditory Modality, and Kinesthetic Modality.

Each item of the scale has three options: A, B, and C by the help of which the respondents' learning style is determined:

- If the respondent chooses mostly A's, s/he has visual learning style.
- If the respondent chooses B's, s/he has an auditory learning style.
- If the respondent chooses C's, s/he has a kinesthetic learning style.

The software: The main instrument for carrying out this research was a software program for teaching reading skill designed based on learner's cognitive profile.

In the process of logging into the software, the students were asked to answer the VAK learning style questionnaire by selecting the option(s) that best described their learning preferences. Then the participants fall into one of three categories or types of cognitive modes known as visual, auditory and kinesthetic based on their answers. When the learner's preferred style of learning was identified, the individual was directed to one of the three instructional scenarios/teaching contents that matched their learning preferences in the software.

Scenario A, visual style: As a visual learning style has a preference for seen or observed things, including pictures, diagrams, demonstrations, displays, etc., the reading passages were integrated with pictures and displays. In other words, while reading the passage, the users were able to activate the hyperlinks to displays and pictures within the text.

Scenario B, auditory style: An auditory style has a preference for the transfer of information through listening to the spoken word, of self or others, of sounds and noises. Thus, the reading

passages were integrated with pronunciation of words (American accent), read-aloud of the texts, and background music.

Scenario C, kinesthetic style: Someone with a kinesthetic learning style has a preference for physical experience, motion, and doing. The reading passages were integrated with gif representations or animations that included motions and movements of the concepts. Pushing the keyboard, clicking, and acting out were among the tasks required to be done.

The software consisted of six short passages revolving around the topics of the textbook Prospect 3 [37]. The flowchart of the program is shown in Fig. 1.

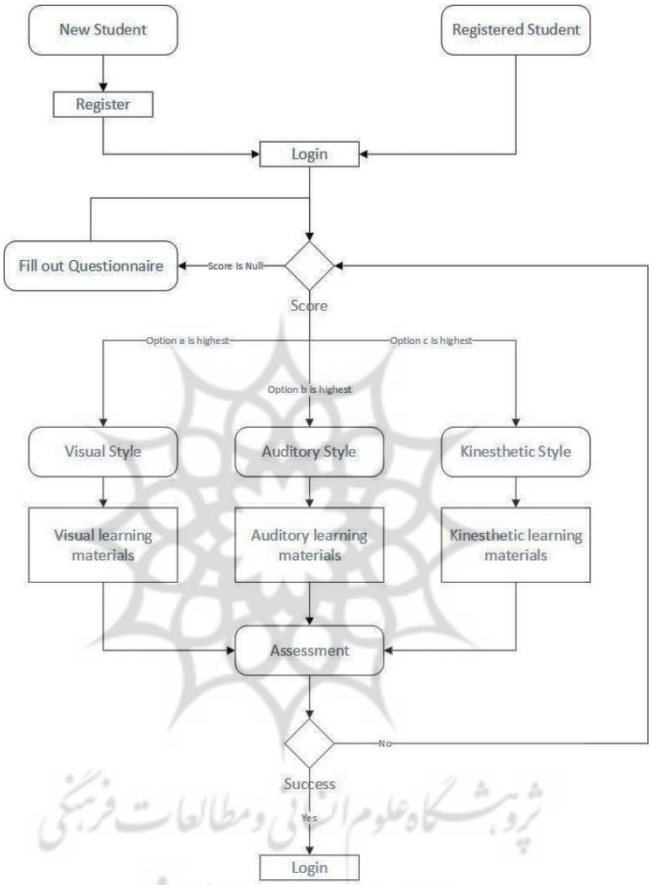

Figure1. The flowchart of the personalized software program

For the control group, another version of the software was developed with the same format and the same reading passages and questions but without the VAK learning style questionnaire as the gatekeeping. Thus, no specific scenario for teaching the texts was determined. The combination of displays, music, animations, and motions were used for each reading passage.

Procedure

- Software development

In order to develop the software first the linguistic content was prepared and then the software was designed by the developer.

Preparing the linguistic content: Appropriate reading texts were chosen and their difficulty levels were checked with two language teachers. Additional materials including pictures, animations, music, and sounds were also provided.

Designing the software: Software development methodology was incremental and the following phases were followed for designing each feature of the software.

Requirements: The flowchart of the program was developed and given to the software developer along with the list of the requirements.

Design: The software developer designed the feature(s) based on the requirements.

Implementation and testing: The software developer implemented the frontend of the software using HTML5, CSS, Bootstrap, and JavaScript. The backend was implemented by PHP. For managing the data SQL language was used.

Verification: The feature was checked by the researchers for the appropriacy of technical and pedagogical issues. Some issues were discussed with the software developer and resolved based on the researchers' suggestions. Ultimately, the feature was verified.

The software was both desktop- and mobile-based.

- The experiment

After selecting the participants and organizing them into control and experimental groups, all participants took part in A2 Key reading paper. Then the reading instruction was delivered based on the design of the study to both experimental and control groups.

The students of the experimental group were first introduced to the software and how it worked. Then they were asked to register and log into the program. Based on the results of the gatekeeping assessment of their learning styles, they were divided into three groups: visual, auditory, and kinesthetic learners. The teacher explained to the learners how different individuals learn concepts and skills in diverse ways and encouraged them to become familiar with their own style of learning and implement it while reading other texts.

The teacher provided the students of the control group with the second version of the software that did not observe any individual differences based on the cognitive profile of the leaners. Reading was taught to the whole class with the same materials and procedure.

After 10 sessions of teaching, both groups' reading proficiency was reassessed with A2 Key. The data were inserted into IBM SPSS 25 for further analysis.

- Results and findings

To compare the means of both groups' post-test scores of A2 Key reading paper, One-way Analysis of Covariate (ANCOVA) was employed. In this study, ANCOVA was preferred to neutralize the differences observed in A2 Key pretest scores of the control (mean=13.7, SD=4.48) and experimental groups (mean=12.64, SD=4.79).

Some preliminary assumptions were examined before going further with main ANCOVA analysis [38].

- ANCOVA Assumptions

The assumptions of reliability of the covariates, normality, linearity, homogeneity of variances, homogeneity of regression slopes, and equality of error variances underlie ANCOVA. The results of testing these assumptions are as follows:

Reliability of covariate: As Cronbach alpha coefficient of A2 Key pre-test was .72, this assumption was met.

Multivariate normality: To check for normality, Kolmogorov-Smirnov and Shapiro-Wilk statistic were used. The results of normality tests are shown in Table 2. As the results suggest, normality has not been violated (p=.01).

Table2. Tests of normality

		Kolmogorov-Smirnov			**Shapiro-Wilk**		
	Group	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**

A2 Key	Control	.204	20	.028	.909	20	.061
	Experimental	.111	20	.200	.981	20	.950

Linearity: To check the assumption of linearity, the linear relationship between the dependent variable and the covariate for all groups was examined (Fig. 2).

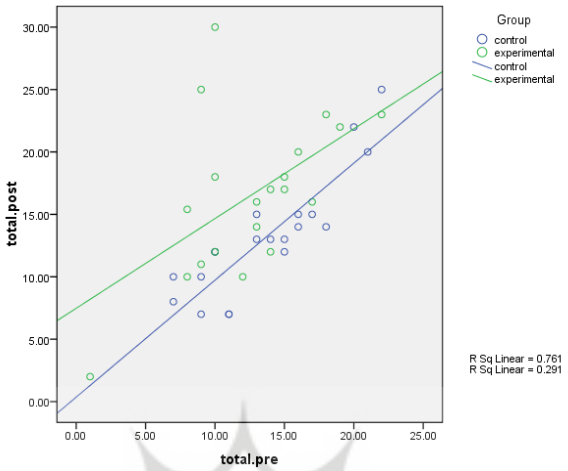

Figure2. The linear relationship between the dependent variable and the covariate

As Fig. 2 illustrates, there is a linear relationship between the dependent variable (post-test) and covariate (pre-test) for two groups due to the fact that the slope of two lines is quite similar. Therefore, the linearity assumption was fulfilled.

Measurement of Covariate: The researcher measured the covariate prior to the intended treatment, so this assumption was met, too.

Homogeneity of Regression Slope: As it is shown in Table 3, the significant value for the interaction of independent variable and covariate (group and pre-test respectively) is 0.467>.05, therefore, the assumption of homogeneity of regression slope was not violated.

Table3. Tests of between subjects effects to check homogeneityof regression

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	670.622	3	223.541	12.496	.000
Intercept	63.713	1	63.713	3.562	.067
Group	52.538	1	52.538	2.937	.095
Total pre-test	553.944	1	553.944	30.965	.000
Group * total post-test	9.647	1	9.647	.539	**.467**
Error	644.009	36	17.889		
Total	10177.160	40			
Corrected Total	1314.631	39			

Equality of error variance: The Levene's test of equality of error variances was used to examine whether the error variance of the dependent variable was equal across groups. As the value for the error variances was not significant (F=3.495, p= 0.069>.05) it can be concluded that this assumption was also satisfied.

As all assumptions underlying ANCOVA were met, ANCOVA was carried out.

-ANCOVA

The result of ANCOVA is reported in Table 4. As Table 4 shows, the result of Tests of Between-Subjects Effects is significant [F (1, 37) =10.00; p=0.003; partial eta squared=0.213] indicating that the performance of subjects in two groups was statistically different after the treatment. Moreover, Partial Eta Squared (0.213) shows that 21 percent of the variance in the dependent variable was explained by the independent variable. Based on Cohen's guideline [39], this value indicates a strong effect for the intervention.

Table4. The result of ANCOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	660.975	2	330.487	18.707	.000	.503
Intercept	68.912	1	68.912	3.901	.056	.095
Total pre-test	547.406	1	547.406	30.986	.000	.456
Group	176.761	1	176.761	10.005	**.003***	.213
Error	653.656	37	17.666			
Total	10177.160	40				
Corrected Total	1314.631	39				

Examining the descriptive statistics showed that experimental group outperformed (Mean=16.57, SD=6.3) the control group (Mean=13.20, SD=4.8) in A2 Key posttest.

Table5. Descriptive Statistics of A2 Key Post-test across groups

Group	Mean	SD
Control	13.200	4.818
Experimental	16.570	6.323

- Discussion

As the results of this research illustrates, integrating a personalized educational software program designed according to EFL learners' learning style can have a significant effect on the development of their reading comprehension.

The finding is first and foremost in agreement with theoretical underpinnings of second language acquisition that considering language learners' differences in the instruction can impact teaching and learning outcome. Since language learners are not homogeneous, the levels of linguistic competence to which they reach are also diverse. Among individual differences, this study addressed learner's learning styles that deal with individuals' preferred way of information processing, that is, perceiving, conceptualizing, organizing, and recalling information [40]. Considering these factors in instruction leads to improvement in the quality of language learning as learners' engagement in cognitive activities is influenced by the way their preferred ways of learning are appropriately addressed. In particular, literature shows that considering language learners' learning style during teaching and learning can contribute to deeper and more effective learning since, as shown in this study, imagers learn best from pictorial presentation, while verbalizers are superior when text processing is involved [41].

Further, when teaching methods and formats of presenting the materials are consistent with learners' learning styles, both student's learning performance and attitudes towards

learning are boosted. Involving students in learning environments in which they have the chance to pursue the learning process according to their own learning style can significantly influence information processing and thereby the results of learning [42].

The findings of this study corroborate the results of other works on the benefit of personalized instructions [43] implying that when the instruction format and the learner's learning styles are consistent with each other, acquiring knowledge is more enjoyable and the learner's attitude and motivation are positively affected. The personalized learning environments can create a uniquely joyful learning atmosphere tailored to the needs and wants of every individual and thus reduce the fears and insecurities the students may feel while they experience learning new concepts. Furthermore, as technology behavior of learners is highly related to learners' diversity, particularly their cognitive style [44], their learning is promoted within this context.

The finding also shows that when students' learning style in reading instruction is addressed, processing of information is optimum. Several studies have referred to the fact that incorporating the needs of language learners in reading instruction is a must in developing instructional materials. The reason lies in the fact that individual cognitive differences among students mean that no single instructional method of teaching reading skills is suitable for the range of cognitive styles. Increased comprehension of a given knowledge set, i.e., a text, and increased satisfaction with technology use have been found to be mutually reinforcing to a certain extent [45]. Further, the presentation of reading activities in the customized computer learning environments can bring about more understanding of the text and more positive attitudes towards reading tasks [46].

The study supports the proposition that computer-based learning environments are more influential when students' needs are met and observed in design process. This promotes learning because through the incorporation of technology, learners can obtain responsible and self-directed behaviors. Research suggests that instructors need to learn a different set of teaching skills, particularly, for teaching online [47], so they can fit the design and presentation of the materials to students' needs and wants. Any reading software program along with the accompanying instructions must be adaptive to learners' cognitive styles so as to increase both the efficiency and the satisfaction of the learning experience.

Conclusions

By the advancement of technology in recent years, particularly in the domain of artificial intelligence, personalized software programs have attracted the attention of researchers of different subject matters. Although there is empirical evidence to support the effectiveness of personalized applications in certain areas of language education such as vocabulary and grammar [31], the role of these types of learning environments in the development of language receptive skills is not yet fully addressed. To fill this gap, the current study investigated the effect of a personalized reading program designed based on EFL learners' learning style on the development of their reading comprehension. In order to achieve this aim, 40 Iranian language learners were asked to participate in the research. They took part in a mobile-based reading instruction course in which they worked on a reading program designed based on their cognitive profile. In agreement with a few research done on the effectiveness of intelligent tutoring systems (ITSs) on reading comprehension [33], the findings of the study showed a significant difference in the performance of the experimental and control groups with respect to the development of their reading comprehension.

Based on available literature, educational technology applications have positive but small effect on the development of reading skills [48] and personalized technology-enhanced environments can increase this effect size. The results of the study emphasize the pivotal role of learner-tailored instructional materials in learning and the importance of considering teaching and learning principles in designing CALL materials and

environments as personalization of the instruction is not only about how learning resources are distributed, but also how different ways are formed to understand the knowledge, skills, and interests of the learners [30].

Suggestions for further research: This study can be done on other age ranges of students, on both genders and on greater number of participants to increase the validity of the findings. Also, various tools for collecting data can be employed including interviews and observations in order to provide deeper insights into the qualitative data. Due to scarcity of research on personalized software programs for teaching language macro and micro skills, it is suggested that CALL specialists design such programs and probed into their effectiveness in learning outcome. Last but not least, future studies can address other cognitive styles such as holist – analyst or reflective-impulsive using neuroscience-based research tools such as electroencephalogram (EEG) or eye-tracking technology. This further helps to investigate and estimate the amount of attention students pay to different parts of a text on their computers or mobile phones when their learning preferences are observed in designing such learning environments.

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Original Article

The study of the facilities for virtual instruction of mathematics in Elementary school (A case study of mathsframe.co.uk)

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Abstract

The importance of mathematics is common knowledge, and teachers have always been concerned with teaching this subject correctly and efficiently. For this reason, teaching mathematics should be given special attention, and even the base and frameworks should be provided for online teaching of this subject. This study aims to introduce mathsframe.co.uk as a platform for online teaching of mathematics. The present study tried to turn the challenges facing online mathematics teaching into opportunities for better instruction. The method of research was descriptive and a case study (in-depth). The facilities and games of the website were divided into categories of Most popular free mathematics games, Tablet friendly games, Word problems, Using a calculator, Money, Sorting and classifying, National curriculum, Addition and subtraction, Fractions, decimals and percentages, Measuring and time, Partitioning, place value and rounding, Latest mathematics games, Multiplication and division, Ordering, comparing and reading numbers, Geometry, Statistics and ITPs. There are games and options in these categories which are suitable to teach and exercise subjects like money, reading and working with different types of charts, numbers divisible to a certain number and prime numbers, decimals, measuring angles, numbers axis, exercising and learning different math operations, multiplication table, comparing numbers, showing the number of shapes and categories, counting numbers, place value chart, measuring volume, ratio, possibility, fraction, the method of transferring numbers in technical addition and subtraction, symmetry, measuring mass and temperature, coordinates, clock, working with a ruler, volume and perimeter.

Many math instruction games and options complementary to teachers' teaching are free, and there is no need for signing up, entering information or paying a fee; but a basic knowledge of English is required for teaching or exercising elements of the categories.

Keywords

teaching facilities, online teaching, math subject, elementary, math frame

Introduction

Humanity has always been learning and acquiring wisdom throughout his life, and education has also benefited from technology development. Education has come step by step aligned with technologies and improved by it. Consequently, learning is one of the primary needs of humanity. One with no understanding of these changes in today's advanced society where information is changing and advancing is considered an unstable being lacking behind the society. Furthermore, society cannot provide for everyone's need of education because of population growth; thus, it is necessary to find a strategy to provide education for all at the least cost possible (Aghakasiri & Fazelian, 2006).

Distance education is a suitable answer for this need. However, online teaching through the internet or digital learning is a new industry in distance education technology; hence educational centers and institutions strive to provide instructions with a standard structure fit to our country as soon as possible (Shahbeigi & Nazari, 2012).

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Mathematics is considered to be one of the pervasive problematic subjects among students. In addition to being a crippling problem in school, incompetency in mathematics has destructive effects on adulthood's daily life (Lerner, 1926). Individuals with incompetency in mathematics often suffer from anxiety and depression due to their failure in academic achievement. There is a two-way relation between these problems and academic achievement, which means that failing in academic achievement increases emotional and behavioural disorders. Moreover, these problems increase the possibility of failure in acquiring academic achievement (Ghaedi & Hemmati alamdarlou, 2016).

Mathematics is essential because it teaches thinking processes, reasoning and problem-solving. The importance of this matter is higher in elementary school as it is a foundation and basis for education in the future.

It is necessary to provide a basis and situation so that meaningful learning (understanding and insight) occurs. This goal is achieved through making connections and relations between concepts and methods in teaching mathematics so that the opportunity to foster the skill of generalizing is provided (Najafikhah et al., 2012). Particular attention should be dedicated to mathematics instruction, and the basis and framework for teaching math online must be provided during the covid-19 pandemic.

Using computer-assisted teaching is a kind of intervention to improve learning mathematics in students. When a computer is used to deliver educational curriculum material, it is called computer-assisted teaching (Seif, 2009). Computer-assisted teaching is an exciting and motivating method as it provides learning fit to learning strategy and needs of individual students, immediate corrective feedback, and it also delivers content step by step, enabling teachers to follow students' learning graphs and draw their progress chart (Verts et al., 2007).

The combination of text, visual images and sound for presenting and teaching words causes objective and authentic learning and definition of words, improvement in students' short term and long term memory, learning, memorizing and remembering words in individuals with learning insufficiency and reinforcement of visual imagination ability of students and high-quality learning in students (Motamedi et al., 2013).

Considering the benefits and opportunities that computer-assisted and virtual teaching provides us, teachers must use them besides their instruction or as a framework for their teaching. This study tried to provide several approaches to virtual teaching of mathematics and some frameworks for this matter.

Significance of the study

Social The educational situation in Iran and the world has changed due to the covid-19 pandemic. The education department has diverted its focus from in-person teaching to online teaching in this situation. This approach is achieved by using new technologies in education and getting help from the competency of teachers in this matter (Gholami andarati & others, 2021). Lack of connection between class and non-educational time of students has been one of the problems of teaching mathematics in recent years among teachers; Teachers perform all of their educational activities during class and have no access to students outside the classroom to track their teaching-learning process; while successful and active teachers are always in search of novel ways to make use of students' free time to motivate them; For this reason, special attention has been given to using information technology and smartphones, educational websites and communication software (Teimouri, 2017).

Considering the spread of covid-19 and the opportunity for distance and virtual teaching, preparing frameworks and a basis for virtual education becomes critical. In the meantime, the most crucial point is to familiarize teachers with these contexts and strategies to improve their teaching. The importance of math is common knowledge because it teaches the process of thinking, reasoning and problem-solving. Furthermore, teaching math correctly and efficiently

has always been one of the teachers' concerns; this issue becomes more apparent in elementary school, which forms the basis of education for the coming years.
Nevertheless, the question is why despite the evident importance of mathematics to teachers, and after one year is passed since the breakout of covid-19, there is no sign of improvement in teachers' teaching and students' academic achievement in this math? Naturally, part of the issue is that the frameworks and facilities of virtual teaching are not adequate or teachers' lack knowledge on virtual teaching methods, but the most crucial part is that most of the research on this field and information and teachings delivered to teachers for enriching and improving their teaching is merely theoretical. They are not applicable, and neither suitable to the facilities and current frameworks of virtual teaching and thus will not have the required efficiency. Consequently, we tried to introduce one of the virtual math instruction platforms, which will be a notable help in practically improving math instruction.

Literature review

Reliable inquiries related to the topic of this study were few; however, results of inquiries relatively related to this field are given as follows:

Gholami andarati et al. (2021) assessed the view of teachers toward virtual teaching of math subjects in elementary in three levels of knowledge, comprehension and application. Gathered data were analyzed through a T-test, and results showed that virtual teaching has a meaningful effect on three levels of knowledge, comprehension and application of math subjects.

Zeinivandnejad's study (2019) called "Accrediting tools using theories of activities and item and response for assessing students' comprehension of virtual warm-ups in learning mathematics" assessed students' motivation to work with virtual warm-ups as tools in learning mathematics. A validated tool was prepared to measure students' motivation to use virtual warm-ups.

"Rasch-Andrich Rating Scale model" based on the item response theory was used to investigate psychometric aspects of tools such as acceptability of the index, learner's ability, suitability and one-dimensionality. This tool can be used to find factors indicating students' understanding of virtual warm-ups in math class. Additionally, we can assess the relationship between structures of this questionnaire using this tool, which will produce models related to students' motivation in using virtual warm-ups that broaden the threshold of knowledge in this area and improve the quality of teaching and learning process of mathematics.

The findings of Teimouri's research (2018) imply a notable increase in the amount of learning and academic progress of students under the study in a way that the average score of the students before implementing this design and employing novel methods in teaching (using social media and creating groups on Telegram for class participants) was 06/12 which had increased to 25/15. Statistical charts also confirm that employing this method in teaching math subjects increases students' learning ability with an assurance of 4/94 percent.

In Osareh et al.'s inquiry titled "Study of the effect of computer-assisted math teaching on the attitude of 9th-grade female students toward mathematics," Cronbach's alpha coefficient of 0/85 was gained. Initially, both control and experimental groups gave a pretest of attitude toward mathematics. The educational variable (computer-assisted instruction of mathematics) was conducted for 16 weeks on the experimental group afterwards, and then a post-test was conducted on both groups. Analyzing covariance results showed that computer-assisted instruction of mathematics had improved the attitude of 9th-grade students toward this subject. Thus the findings of the study imply that a significant relationship is present between computer-assisted instruction of mathematics and students' attitude towards this subject.

Analyzing the data taken from Ghaedi et al. research (2016) titled "effectiveness of computer-assisted teaching of working memory on the mathematical performance of students with mathematical incompetency" through analyzing the covariance indicated that the mean

score of mathematical performance and its subscales (the aspect of operation and application of mathematics) in the experimental group increased significantly, however, this instruction did not have a significant impact on the aspect of mathematical concepts. The findings indicated the effect of teaching working memory of computer-assisted teaching on students' mathematical performance with mathematics incompetency.

In the study of Motamedi et al. (2011) titled "Comparison of the effectiveness of three methods of direct, computer-assisted and combination education on reducing the problems of students with math disorders," 20 students diagnosed with math disorder through clinical interview, Wechsler intelligence test and standardized test were selected voluntarily. Then these students were randomly placed in 4 groups of 5. Three experimental groups each received 12 sessions of their special instruction in three 45 minutes' sessions every week. The control group continued the regular education they received in the center to cure particular learning disorders. All four groups were given a pretest and post-test, and the data were analyzed with variance analysis. The results of this research showed that the three methods of direct, computer-assisted and combination education were (p=0/05) effective in reducing mathematical disorders of the students. Accordingly, it is concluded that using direct, computer-assisted and combination teaching methods can be more effective in reducing

Purpose of the study

Main purpose:

- The facilities of virtual teaching of mathematics in elementary school

Subsidiary purpose

- Presenting an online framework as a solution to improve virtual teaching of mathematics in elementary school

Methodology

The purpose of the present study is to study the facilities of virtual teaching of math in elementary: a case study of the mathsframe.co.uk website. Thus, the research method is descriptive-qualitative and case study (in-depth). Moreover, all the data were gathered through direct observation of the earlier website. In-depth research is studying a case or a unit and exploring it deeply. In fact, in this type of research, different aspects of a phenomenon are examined, and while describing its features and characteristics, the cause or causes of some of its actions and reactions are analyzed. In in-depth research, the researcher, makes his hypotheses and gathers information about it. To do this, the researcher uses all interviewing methods, observing, questionnaires and studying libraries. Then the researcher analyzes and forms a conclusion. An important point to consider in case studies is that the results of such studies can be generalized to a statistical population with some commonalities.

Findings

In general, mathsframe.co.uk is ideal for the gamification of mathematics instruction. The capabilities and facilities that this website offers to the users are based on teaching elementary math lessons through different online games.

In addition to providing a suitable environment for students to practice and repeat math, teachers can use this site to teach the topic with the necessary explanations by recording their screen and sending it to the class group. In Figure 1, the capabilities and facilities of this site are shown.

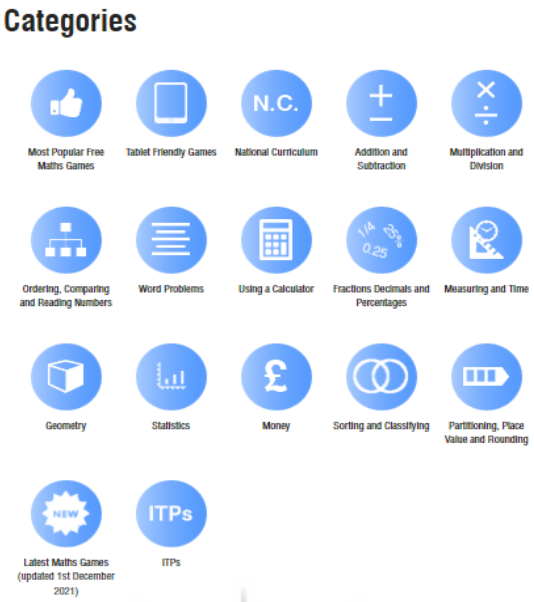

Figure 1. Facilities and capabilities of mathsframe.co.uk as a framework for virtual teaching of math in elementary

Each category is introduced below:

Most popular free mathematics games: In this section, there are online games that one can enjoy math playing them! These games are suitable for elementary and younger ages as well. The student uses many mathematical actions unintentionally while playing the games. Students practice and exercise mathematics while playing these games, and also they get to know different functions of mathematics and have a new attitude toward this subject.

Tablet-friendly games: this category has online and free tablet-friendly games. These games also help students practice and repeat mathematics in an exciting and new environment.

Word problems: In this section, definitions and concepts of mathematics are explained by games based on problem-solving. Concepts such as divisibility, proportion, and mathematical operations are introduced through problems so that students can solve problems and play games by mastering the definitions of these concepts. These games are primarily based on math equations; thus are suitable to lay the foundations for this subject in elementary. Some of these games are free and only require an internet connection, while to get access to some of the other games, the user has to sign up on the website and give his information along with a yearly subscription fee to use the facilities.

Using a calculator: This section is ideal for sharing one's class on an interactive whiteboard. Moreover, children can use it separately to trace and fix their calculation mistakes.

Money: In this section, students are introduced to adding and subtracting amounts of money and comparing their value in online games such as cash registers and salespeople. While providing an attractive environment, these games help add and subtract money in students' daily lives and their mental calculations. Most of the games in this section require a fee.

Sorting and classifying: In this section of the games, students try to classify geometric shapes and numbers based on their characteristics, such as divisibility into a number or regularity, right

angles, and other topics related to mathematics. Some games are free but to play, having a basic knowledge of English is necessary.

National curriculum: This section consists of five options: year 2 programme of study, year 3, 4, 5 and 6. In each part, different online games are categorized into separate groups. For example, number and place value, addition and subtraction, multiplication and division, fractions, measures, properties of shapes, position, direction and motion and statistics are in the year 2 programme. Furthermore, each option has different online games in the area of the group title. For instance, the games that are presented in number and place value of year 2 follow these goals: the student should be able to start counting from zero, recognize the place value of each digit in a number, compare numbers from 0 to 100 and use appropriate numbers, write numbers in letters and digits. Games become more complex from year to year, and students can use them based on their age and lesson subject.

Addition and subtraction: There are a variety of games in that students learn addition and subtraction in an exciting and new environment and improve their mental calculations. These games are designed so that the students can learn the addition and subtraction of different numbers by earning or losing scores while playing games. Most of the games of this section require a fee.

Fractions, decimals and percentages: There are games and facilities in this section that are ideal for students to practice and repeat and teachers to teach these topics. Students must calculate the percentages and fractions of the numbers correctly during the games to advance to the next stage. These facilities require a basic knowledge of English and paying a fee.

Measuring and time: Games specific to time and clock practice are mainly based on recognizing or defining time from the clock. Measuring time, volume, weight, temperature, angle, area and line length with the right tools is one of the free features that teachers can use in their teaching.

Partitioning, place value and rounding: In this section, there are games to compare the position of numbers on the axis and their amount and rounding two-digit and three-digit numbers, which provides an excellent opportunity to practice in this area. Most games in this section require a fee.

Latest mathematics games: There are many new games suitable for various math topics in this section. Register and enter personal information and pay a yearly subscription fee to access them.

Multiplication and division: in this section, students face multiplication and division questions in the exciting environment of the game, and if their answer is correct, they can pass to the other stage of the game. Most of the games in this section require a fee.

Ordering, comparing and reading numbers: the games designed for this section help students to compare numbers such as decimals and fractions, place the numbers on the numbers axis, and recognize digits of the numbers from their written form of them. To get access to more games, paying a fee is required.

Geometry: There are games in this section that require the student to find the coordinates of a point according to the information obtained, measure an angle with a conveyor, or obtain an

angle based on the information to get to the next stage of the game, Categorize geometric shapes according to the required properties, calculate the perimeter and area of the shapes, and draw the symmetry of the shapes correctly. Most of the games in this section are free.

Statistics: The exercises and games in this section include getting to know and reading charts such as bar, circular and linear, answering questions about the chart, obtaining the mean or numbers of a sample from the mean, and probability exercises. Most of the games in this section are free but require a basic knowledge of English or using an online dictionary.

ITPs: These features have been refurbished to work in all modern browsers and devices without installing flash. All games and facilities in this section are free and are a suitable environment for teaching. Tutorials for reading and working with different types of charts, divisible numbers to one and prime numbers, decimal numbers, angle measurement, number axis, practice and training of various mathematical operations, multiplication table, number comparison, counting numbers, showing the number of shapes and categories, spatial table value, measurement of volume, ratio, fractions, probability, how numbers are transmitted in addition and subtraction, symmetry, measurement of weight and temperature, coordinates, hours, ruler, environment and area are all features of this section.

Discussion and conclusion

This study aimed to study the facilities of virtual mathematics instruction in elementary school: a case study of mathsframe.co.uk. The results of the data description showed that such platforms could provide an excellent opportunity to make virtual teaching objective and attractive; in a way that students can learn math topics and problems while playing fun online games instead of practicing it traditionally on paper. This method will change students' attitude towards maths as a dull and rigid subject and solve a concern of teachers, which is to explain math to students in a meaningful way. In addition, by connecting mathematics with games, which is attractive to students, it is possible to deepen the learning and persistence of the material.

The findings of the present study are in line with the findings of these researches: Gholami andarati et al. (2021), Zeinivandnejad (2019), Teimouri (2018), Osareh et al. (2018), Ghaedi et al. (2016) and Motamedi et al. (2012); Thus we can elaborate on the findings above that this website is ideal for gamification of mathematics. This website's features and facilities are based on teaching elementary mathematics lessons with different online games. In addition to providing a suitable environment for students to practice and repeat math, Mathsframe.co.uk can also be used by teachers to teach the topic and the necessary explanations by recording their screen and sending it to their virtual classes.

The facilities and games of the website were divided into categories of Most popular free mathematics games, Tablet friendly games, Word problems, Using a calculator, Money, Sorting and classifying, National curriculum, Addition and subtraction, Fractions decimals and percentages, Measuring and time, Partitioning, place value and rounding, Latest mathematics games, Multiplication and division, Ordering, comparing and reading numbers, Geometry, Statistics and ITPs. There are games and options in these categories which are suitable to teach and exercise subjects like money, reading charts and working with different types of charts, numbers divisible to a certain number and prime numbers, decimals, measuring angles, numbers axis, exercising and learning different math operations, multiplication table, comparing numbers, showing the number of shapes and categories, counting numbers, place value chart, measuring volume, ratio, possibility, fraction, the method of transferring numbers in technical addition and subtraction, symmetry, measuring mass and temperature, coordinates, clock, working with a ruler, volume and perimeter.

Many math instruction games and facilities complementary to teachers' teaching are free and do

not require registration, entering one's information or paying a fee. However, a basic knowledge of English or using an online dictionary or Google translate is needed for teaching or practicing games of the categories. Although some domestic software and website provide these facilities in a more narrow domain, it is suggested to design and offer domestic sample websites or national and free software or with small fee modelling the games and facilities of this website and make them accessible to teachers and students to facilitate the virtual education of courses and to witness the improvement of teachers' teaching and the academic progress of our students.

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