Integration of Digital Games in Blended Learning for Elementary School's Geometry Subject

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Submission date: 24-Sep-2021 07:30AM (UTC+0700)
Submission ID: 1656015380
File name: Integration_DG_BL.pdf (144.73K)
Word count: 3131
Character count: 18251

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Introduction

Mathematics education aims to provide pupils with logical, critical, and creative thinking skills. Mathematics learning is supposed to develop students' curiosity and interest in mathematics so that they can believe in and appreciate the use of mathematics in everyday life [1]. The National Council of Teachers of Mathematics [2] contend that problem-solving, reasoning and proof, communication, connections, and representation skills can all be used to develop mathematical competence. According to some mathematicians and educators, the ultimate purpose of studying mathematics is to develop an adaptive capacity, namely the ability to apply information flexibly and creatively in a variety of settings [3]. However, existing mathematics learning practices are insufficient to assist the accomplishment of this ultimate aim.

Activities in today's mathematics classrooms tend to be informative. The teacher first discusses a theory, definition, formula, or theorem, followed by explanations of problems and the solutions. After that, the teacher assigns certain tasks to students, in worksheets or student handbooks and asks them to complete them in accordance with the processes that have been explained by the teacher earlier [4]–[6]. Because such learning process is continually repeated, mathematics is regarded as a dull, abstract, and uninteresting subject [7]–[9]. Students that learn in this manner are merely instructed to memorize formulae and processes, think mechanically, or follow pre-existing processes, preventing their thinking capability from developing correctly [5]. As a result, pupils are unable to grasp the principles they have learnt and are unable to solve issues with comprehension. Students also struggle when confronted with problems that have not been taught by the teacher or non-routine problems [6].

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Blended learning (BL) can be used as an alternative to achieve the objectives of mathematics learning. BL integrates online learning with face-to-face learning [10]. BL may be implemented in regular classrooms without the use of technology. The teacher uses the lecture technique to convey the subject in class, which is followed by class discussion, group discussion, or individual work. BL that is conducted online aims to encourage interaction between students and teachers, as well as between students and the content being studied. Outside of the classroom, online learning can be done independently [11] by integrating technology into the learning process. Learning activities, assignments, or exams are transferred to a website or Learning Management System [12]. The availability of technology facilitates communication among classmates through online discussion and collaborative activities in problem-solving, both within and outside the classroom [13]–[16]. Technology can also help students perform tasks individually as well as in groups because students do not always rely on the teacher as a single source of information [17].

Several studies show that BL can improve learning outcomes and student satisfaction [18]–[20]. BL also improves memory of knowledge, learning skills and science process skills [21], [22]; while developing independence in learning [23]. Innovative online learning can help students reach their learning goals more effectively. Innovations in online learning might take the shape of user-friendliness, interactivity, and interest [24]. As a result, the adoption of BL in mathematics learning must provide innovations that are consistent with mathematics characteristics and can overcome barriers to learning mathematics.

With the BL technique, digital games may be employed as innovations in geometry learning. Digital games can be incorporated into online learning to provide an enjoyable learning environment and promote students' excitement, attention, and involvement in learning [4], [25], [26]. Digital games have the ability to provide a positive learning environment and are well-suited to the study of complicated topics [27]. Color palettes in digital games are appealing, motion is integrated, and concepts are clearly shown. As a result, games may be utilized to overcome boredom in mathematics learning and promote student involvement in learning, resulting in increased student knowledge of the material being studied.

The benefits of BL have been extensively researched. Similarly, the favorable influence of adopting digital games in learning has been widely studied. However, no research on the incorporation of digital games into BL has been discovered. As a result, the purpose of this research is to discuss

the use of BL in combination with digital games for geometry learning in primary schools. The volume of space is the content studied utilizing the BL technique. This topic was especially chosen since research demonstrates that learning geometry, especially the volume of space, necessitates the capacity to recall formulae and perform problem-solving techniques. The findings of this study are anticipated to give an overview of the phases of learning space as well as strategies for developing students' thinking abilities. Furthermore, this research will show the barriers to BL adoption and how to overcome them.

Discussion

The Implementation of BL and Digital Games

There are four models of BL, namely rotation model, flex model, self-blend model, and enriched-virtual model. Rotation model falls into four categories, that are (a) station-rotation model, (b) lab-rotation model, (c) flipped classroom model, and (d) individual-rotation model [28]. Each model requires distinct phases of learning. For studying the volume of space, lab-rotation model (LRM) was employed. The LRM model provide students with the opportunity to learn in computer laboratories online as well as in face-to-face classrooms [11], [22]. In face-to-face learning, the teacher reinforces students' grasp of the content covered in the computer laboratory and addresses issues that were not addressed or were poorly comprehended during online learning. The implementation of LRM in studying the volume of space can be divided into four steps. Figure 1 depicts student activities at each step.

Face-to-face learning	Online learning	Face-to-face learning	Online learning
•Put forward apperception	•Observe a learning video •Discuss the observation results in groups •Make an inference or a temporary conclusion	•Communicate the temporary conclusion •Compare and contrast perceptions •Confirm the temporary conclusion	•- Use digital games to solve the problem

Figure 1. Stages of LRM when studying the volume of space

At the first stage, students study face-to-face in a classroom. The teacher goes through the ideas or attributes of the examined space. Following that, the teacher presents everyday problems relating to the material. This exercise seeks to expose students to the content to be studied while also motivating them by demonstrating the benefits of learning the volume of space. Students will be interested in learning a material if it

is useful for their life. Next, the instructor communicates the objectives, learning phases, and activities to be performed so that students can manage their time and use their preferred learning strategy. After that, the teacher states that there will be a game-based competition at the end of the class to motivate pupils to pay attention and participate actively in the process [29]. Before ending the first stage of learning, the teacher divides the students into several groups for the second stage of activity.

The second stage of learning is carried out online in a computer laboratory. Students in groups watch a video about the concept and process of finding the volume formula for a space. At this stage students explore the material through observing, questioning, collecting information from the video. Next, students communicate the results of their observations and understandings to group members. Students can confirm their findings with learning resources available on the internet. Discussion activities are facilitated by a worksheet containing questions that direct the process of constructing concepts and formulas for volume of space. This prevents students from simply receiving information passively. The worksheet also contains some problems of space's volume. Students are expected to address the problems in their own unique way. As a result, students comprehend the purpose of problem-solving processes rather than just imitating them. Group learning requires students to assist one another and to take responsibility for group learning activities. [4]. In the second stage, the teacher observes student activities and assists groups that are having trouble running a computer or comprehending worksheet tasks.

The third stage of learning takes place in the classroom, face-to-face, utilizing a teacher-led discussion style. The discussion session begins with one of the groups presenting their results or worksheet responses. Other groups respond by giving suggestions or asking questions. Students refine their results with one another during class discussions. This assignment allows students to convey the outcomes of their research and comprehension. At the end of the course, the teacher summarizes the conversation and confirms the ideas, formulae, and techniques for finding the volume of space.

The fourth step of learning takes place online in a computer lab. Students learn problem-solving skills by playing digital games. Presenting issues in the form of games improves students' passion for problem solving and causes them to lose track of time [29], [30]. The playing environment stimulates students to answer questions, to desire to keep studying, to not be drowsy or bored [29]. Students' curiosity and passion for finishing each level of learning are piqued by digital games. Students are also taught to

work under a time constraint through the use of digital games. Students compete to win the game in the fourth level of learning. Students or players who properly answer problems receive a reward in the form of points. The winner is the one who has the most points. The game's competitive character pushes students to attempt to answer the questions accurately [4].

The games can be played in groups or alone. The group competition takes place in a computer lab. There are two competing groups on each computer. Group competitions enable students to collaborate in understanding and solving the problems. As a result, each group member knows the problem and how to address it, making it less likely for pupils to plagiarize their peers' responses [4]. Individual competitions might be held at home or at a different location. An Android phone may be used to access the games. Each student is assigned a random opponent to answer the tasks. Individual competition allows students to answer problems anywhere and at any time. Students can play these games as many times as they need to until they truly learn how to solve the problems.

How to Overcome BL Problems

LRM is carried out in a variety of learning environments and through a variety of activities. For one activity, students study in class, while for another, they study in a computer lab. Students can avoid boredom by exposing themselves to a range of learning atmospheres and activities. Since learning mathematics in computer laboratories is novel in primary school, it becomes engaging. Through laboratory learning, students' interest, excitement, and involvement in learning develop significantly. Unfortunately, not every primary school has a computer lab. In fact, few schools can afford to equip laptop computers for online instruction in the classroom. To get around this, instructors and students can utilize android phones in place of PCs. Mobile phones are utilized to view educational films and to play digital games. Because practically every student's parent owns an android phone, this option is quite feasible. If the student's parents do not own an android phone, the school can give a number of smartphones for online study.

Online learning necessitates the availability of digital resources such as learning videos and digital games, which must be provided by the teacher. However, not all instructors are equipped with the knowledge and abilities required to develop digital media. To meet the need for instructional videos and digital games, instructors might use free or exchanged material created by others on the internet. Unfortunately, others' learning videos

and digital games may not always suit teachers' needs. The distinction may be found in the substance or material, how it is presented, the type and level of the problems, and so on. Therefore, digital material should be created by the teachers themselves. One solution is to enlist the assistance of colleagues who are experts in digital media producing techniques. It would be much better if teachers continue to expand their knowledge and talents in creating digital media.

Another barrier to incorporating games into math classes is the misapplication of the idea of play. In addition to their numerous benefits, games in learning have certain drawbacks. Games can divert students' attention away from their learning objectives. As a result, games must be appropriately handled. Teachers must be able to guarantee that game-learning activities are relevant to the learning objectives. Instructions or game rules must be thoroughly stated so that students do not misuse the game or fail to answer the tasks presented. Sometimes, pupils who are very passionate about playing a game do not pay attention to the teacher's explanation, and as a result, they do not benefit from the game. This can lead to frustration and losing interest in continuing the game [4].

Conclusion

LRM is one of the potential ways for determining the volume of space. Online LRM allows students to construct knowledge or concepts. The concept construction process is carried out through observation, questioning, and digging up information with the help of learning videos. To practice problem-solving skills, digital games are integrated with online learning. Digital games create a pleasant learning environment and boost students' interest and tenacity in problem-solving. In face-to-face learning, students communicate interpretations or temporary conclusions that have been constructed. Following that, pupils affirm the provisional conclusion with the teacher's explanations and encouragement. Confirmation produces a meaningful concept rather than mindless memorization. Computer laboratories and digital media are required for the integration of LRM and digital games. The supply of a laptop or an android mobile phone can replace the requirement for a computer laboratory, allowing learning to continue.

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