An Empirical Study on Using E-schoolbag to Promote Deep Learning in the Primary Mathematics Course

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Abstract: It is believed that Information and Communication Technology (ICT) can promote deep learning, and E-schoolbag is widely used in primary and secondary schools in China to enhance deep learning in different subjects. There are nearly seventy students in two classes in the fifth grade of a primary school in China, and we designed quasi-experiment research to examine the use of E-schoolbag for promoting deep learning in primary school mathematics. The intervention condition was mainly the learning situation design supported by technology. Data were collected through experiments, interviews, and classroom observation. Through one month of teaching, the teaching of the experimental class and the control class were compared from the three dimensions of deep learning to draw relevant conclusions. It was found that E-schoolbag can promote deep learning in primary school mathematics, thereby optimizing the teaching situation of primary mathematics classroom and enhancing the effectiveness of teaching.

Keywords: Information technology; primary school mathematics; deep learning; E-schoolbag

Introduction

Deep learning is the way of learning for decision making and problem-solving. Through the first cognitive experience, learners reorganize new things, integrate them into the unique cognitive structure (Entwistle, 2005). Learners also find many ways to connect or transfer existing knowledge into new situations. Constructivism provides a theoretical basis for deep learning that “learning depends on the individual’s construction of the meaning, the process of constructing meaning is embedded in a specific social context” (Gergen & Davis, 1985). The significance of constructivism in information technology education is that the task-driven, visual demonstration, operational practice, cooperative learning method, and other teaching methods are used in the curriculum to make deep learning more likely to happen. According to the age of students and the laws of cognitive development. The use of information technology has the potential to enable students to establish mathematical learning methods in specific situations to promote deep learning of primary school mathematics.

E-schoolbag is not only a portable device, but also the learning platform and virtual learning environment for ICT in education, it was used to be called “E-textbook”, a comprehensive learning platform similar to a learning management system, that contains
digitized learning materials such as texts, videos, and audio clips and so on. In addition to the digitized learning materials, various tools were embedded in the E-schoolbag for facilitating teaching and learning activities such as assignment management, discussion space, collaborative tools for the group project, survey tools, tests, etc (Hui et al., 2017). The devices were connected to a wireless network, which makes it possible for creating a social environment where learners can grow together academically (Vygotsky, 1978).

The author has participated in the project titled “Using Information Technology to Promote Effective Teaching Improvement” jointly operated by Ningxia Normal University, Guyuan Experimental Primary School, and TF Enterprise Research Institute, planning course with the primary school teachers, preparing lessons, and conducting classroom observations on the teaching of elementary school mathematics. It has been found that in the current mathematics classroom in elementary school, students only learned the mathematical symbol knowledge that the class teachers hope them to master. However, that is not the essence of learning. The information technology teaching equipment used was mainly E-schoolbags in the study.

The use of E-schoolbag for promoting the deep learning of mathematics in primary schools has become a new research hotspot in recent years. However, the researches on information technology for promoting the deep learning of primary school mathematics at home and abroad basically focus on concept analysis and connotation understanding. In theoretical research such as strategy construction, empirical analysis is not in-depth (Huang, 2015). In this paper, we took "deep learning" as the focus and used E-schoolbag to design, practice, analyze and evaluate the mathematics classroom in primary school. Through the analysis of the teaching classroom observation and test results, it is verified that E-schoolbag is useful to promote the deep learning of mathematics in primary schools, thus providing a more practical reference for K-12 teachers.

Deep Learning

“Deep Learning” as an academic concept originated in the United States in the mid-20th century. The research on deep learning mainly includes two fields: machine learning and cognitive science. In this study, deep learning is a concept developed from the field of cognitive science. It is also sometimes regarded by scholars as deeper learning. The National Research Council's Committee on Defining Deeper Learning (2012) concludes that deeper learning is the process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations (i.e. transfer) by developing cognitive, interpersonal, and intrapersonal competencies (NRCC,2012). The Hewlett Foundation (2012) defines deeper learning as the skills and knowledge students will need to succeed in a world that is changing at an unprecedented pace. Deeper learning prepares students to master core academic content, think critically, and solve complex
problems, work collaboratively, communicate effectively, and learn how to learn (for example, self-directed learning). Some researchers also believe that deep learning is a new learning method for decision making and problem-solving. The type of learning that results from students’ self-directed application of critical and creative thinking, problem-solving, communication, and collaboration to deepen their understanding of key concepts in the curriculum. Deeper learning is also the outcome of those processes (Bellanca, 2014).

Combining previous scholars’ research on deep learning, the author figures that the two aspects including cognitive and non-cognitive factors these two aspects may influence deep learning, as shown in Figure 1. The cognitive factor includes relating new ideas and concepts to previous knowledge and experience, integrating their knowledge into interrelated conceptual systems, and looking for patterns and underlying principles, evaluating new ideas, and relate them to conclusions. Also, deep learning means that learners understand the process of dialogue through which knowledge is created and that they examine the logic of an argument critically. Non-cognitive factors mainly include students’ learning interest and attitude, as well as learning situations that can effectively set up for deep learning. The stimulation of learning interest is the key to successful teaching, which makes it easier for students to concentrate on the classroom and may benefit the exploration of new knowledge. Finally, it is possible to have deep learning.

Participants in this study were children aged about 11 years old. According to Piaget's staged division of students' cognitive development, they are in the specific stage of operation. At this period, the children are freed from the apparent thinking, and their cognitive structure already has an abstract concept, so it can carry out logical reasoning. But the operation is still inseparable from the support of specific things (Shi, 2013). Although compared with the first two stages, children have made some progress, their cognitive ability is still weak, and it is difficult to establish links to connect the knowledge. Because of the age characteristics of students, while using information technology to promote deep learning in primary school mathematics, educators should pay more attention to establish the connection between various teaching contents. Teachers need to combine students' cognitive development rules and use information technology to create a kind of virtual reality life scenes for enabling them to establish mathematics learning methods in vivid and specific situations, fully mobilize students' multi-sensory participation, stimulate students' enthusiasm for learning, and change students' learning attitudes. Thus, promoting deep learning of mathematics in primary school.

The construction of the learning context is an important indicator to measure the effectiveness of classroom teaching. Teachers use the skills of creating scenarios to enable students to learn effectively in the learning context. The effect of learning and the ability to transfer knowledge can better reflect the meaning of deep learning, which requires students to learn and apply abstract and complicated knowledge based on understanding, not simply through repeated memory. Studies have shown that the application of ICT can provide
certain situational support for the occurrence of deep learning (Peng, 2020). In this study, situational construction is mainly based on the E-schoolbag environment supported by information technology.

**Figure 1 Factors influencing the occurrence of deep learning**

**Research Method**

This study adopted a quasi-experimental research design. The content of this study is aimed to confirm that information technology promotes deep learning in elementary mathematics. In this study, information technology mainly refers to E-schoolbag. The process is shown in figure 2.

**Figure 2 Research process**
Research Design

Data source

Two classes in the fifth grade in GY Experimental Primary School were enrolled in the study. In the mid-term exam, the mathematics scores of the two classes were comparable, providing pre-test data for further comparative studies. GY Experimental Primary School is currently one of the province's demonstration schools for information teaching. The school fully recognizes the important role of information technology in education and teaching, and actively promote ICT application in education, increases training on information technology applications for teachers, and actively uses multimedia. The collection and analysis of the data used in this study were carried out with the consent of the school.

The framework of research design

This study is designed from the three dimensions of cognitive ability, learning interest, and learning situation in deep learning. Firstly, data from observing the classrooms of the control class and the experimental class was collected, and then we have analyzed whether the situation constructed by information technology has a certain promotion effect for students; Secondly, some students from the experimental class and the control class were randomly selected to participate in the interview. The goal of selection was to understand the students' interest in learning mathematics and to compare the influence of different pedagogics on students' interest in learning. Thirdly, tests are designed for the course content and the test scores have been analyzed with SPSS software. The scores of the experimental and control classes were compared to see if there was a significant difference between the experimental and control classes, and further to infer whether the students have achieved meaningful learning or deep learning in the classroom.

In this study, we set two classes. In the experimental class, E-schoolbag was adopted to support learning, the control class did not adopt the learning situation supported by E-schoolbag, E-schoolbags were mainly used as learning terminals for students. Besides, the teaching environment of both classes is the same, each student has the textbook, paper, and pen, and the classroom is equipped with a blackboard and an electronic whiteboard.

The data of the cognitive changes of relevant knowledge points of students was collected through tests and then we obtained the non-cognitive data affecting the occurrence of deep learning through interviews and observation.

Informational Instructional Design

In the traditional classroom, students were taught in a passive position. Their knowledge is mainly derived from the instruction of teachers. In the 21st century, the unpredictability of mathematics classrooms in primary school has also increased accordingly. Teachers need to reconsider more factors and carry out a more specific instructional design. Therefore, to optimize the effect of information technology for promoting deep learning of mathematics in primary school, it is necessary to properly handle various contents such as textbook analysis, academic analysis, creation of learning
environment, teaching strategy, and teaching process. And then we have proposed a specific teaching design plan here as following:

**Analysis of teaching materials**

This study selected the content of the “Division” in the fifth grade of the Compulsory Education Curriculum Standard Experimental Mathematics Textbook. These students who take part in our research are 10-11 years old. The textbook contains two sections including the largest common divisor and the divisor. The divisor is the direct application of the basic properties of fractions, and it is a common method to simplify fractions. Learning about fractions can not only improve the understanding of the basic nature of fractions but also lay a foundation for learning the four operations of fractions.

**Analysis of the learning situation**

Considering that our participants are fifth-grade students, teachers should pay special attention to the specific reflection of the students while teaching, and adjust the teaching plan at any time during the whole class. The case in this study chose a total of seventy students from class 3 and class 4, most of the students were motivated to learn mathematics, who could acquire knowledge from the existing knowledge and experience, the abstract thinking ability has also developed during learning, the basic knowledge is relatively solid, there is the certain ability to learn mathematics.

**Results and discussion**

**Classroom observation analysis and discussion**

Through observing the control class and experimental class, it was found that the traditional classroom and the information classroom showed significant differences in the expression forms of the teaching content, the teacher and student activities, the media application, and the teaching procedures as well as methods. In the series of traditional classroom activities featured with a lead-in by reviewing, teaching new lessen, consolidating and summarizing new courses-summary courses, the teaching content is simple, mainly based on imparting knowledge, occasionally joining discussions and questions, and rarely using information technology. Students are only passively accepting knowledge. However, in the series of informational classroom activities from Happy Review-Scenario, context lead-in, explore new knowledge, thinking expansion-consolidation to the summary, the teaching content is diversified. Teacher-student interaction and human-computer interaction are more obvious. The teacher plays the role of a leader and helper of student learning. The students are in the teaching situation constructed by information technology. Thus, their interest in learning is high, the motivation for learning is obvious, and the knowledge is acquired through group discussion and inquiry activities, which contributes to the knowledge content. Deep understanding will result in deep learning.
Interview data analysis and conclusion

Interviewee: twenty students were randomly selected from class 3 and Class 4, grade 5 of G Experimental Primary School. In this interview, 90% of the students in the experimental class reported that they like mathematics classes, because the application of various information methods enables students to actively participate in the classroom, and for some difficult knowledge point. Information technology can transform abstract mathematical symbols into visual and intuitive things, especially many animations that can show the mathematical operation process in the E-schoolbag, which makes students understand easily. Besides, the use of gadgets such as photographs and mutual evaluations increases the curiosity of students in the mathematics classroom, and the students' attention is more likely to focus on the classroom, which is conducive to student learning. 85% of the students in the controlled class say they don’t like mathematics, because mathematics knowledge is difficult, difficult to understand, and they are eager to communicate with their peers at any time to solve the problem and experience. In the context of informational teaching, the classroom tends to be transparent. Each participates, everyone is equal, and it can stimulate students' interest in mathematics.

Test data analysis and conclusion

The data was collected through two different treatments for two homogeneous samples to judge whether the results are different. Therefore, the data processing method of the paired-sample T-test in SPSS software is selected. The data is judged whether there is a significant difference in the mean of the paired population from which the sample is derived. Firstly, establish the null hypothesis $H_0: \mu_1 = \mu_2$, that is, it is assumed that there is no significant difference between the test scores of the experimental class and the controlled class. It means that the application of information technology means in the classroom does not have any influence on the student's learning. Secondly, the significance level of the hypothesis is determined to be $\alpha=0.05$. The following is an analysis of test scores:
Table 1 Paired sample statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Standard deviation</th>
<th>The standard error of the mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scores of multiple choice in experiment class</td>
<td>34.7714</td>
<td>35</td>
<td>10.47149</td>
</tr>
<tr>
<td></td>
<td>Scores of multiple-choice in controlled class</td>
<td>35.2857</td>
<td>35</td>
<td>12.13786</td>
</tr>
<tr>
<td></td>
<td>Scores of Ture or False questions in the experimental class</td>
<td>23.4286</td>
<td>35</td>
<td>6.39064</td>
</tr>
<tr>
<td>2</td>
<td>Scores of Ture or False questions in a controlled class</td>
<td>20.7143</td>
<td>35</td>
<td>6.20043</td>
</tr>
<tr>
<td></td>
<td>Scores of subjective exercises in experimental class</td>
<td>22.4286</td>
<td>35</td>
<td>4.59722</td>
</tr>
<tr>
<td>3</td>
<td>Scores of subjective exercises in a controlled class</td>
<td>15.7143</td>
<td>35</td>
<td>7.08591</td>
</tr>
<tr>
<td></td>
<td>Total score in experimental class</td>
<td>80.6286</td>
<td>35</td>
<td>16.07535</td>
</tr>
<tr>
<td>4</td>
<td>Total score in controlled class</td>
<td>71.7143</td>
<td>35</td>
<td>15.66106</td>
</tr>
</tbody>
</table>

As shown in Table 1. The average score of the experimental class multiple-choice questions is lower than the average score of the control class. The average scores of the Ture or False questions and the subjective questions in the experimental class are higher than that of the controlled class; accordingly, the average score of the experimental class is higher than the average score of the control class. It can be seen the two pairs of samples has a certain amount of change, but to determine whether the change is significant, or whether it is an essential difference, it is necessary to calculate the corresponding statics in two sets of samples.
<table>
<thead>
<tr>
<th></th>
<th>Pairwise difference</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>The standard error of the mean</th>
<th>95% confidence interval for the difference</th>
<th>Sig. (two sides)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>t</td>
<td>df</td>
</tr>
<tr>
<td>1</td>
<td>Experiment class multiple-choice score - control class multiple-choice score</td>
<td>-.51429</td>
<td>15.70008</td>
<td>2.65380</td>
<td>-5.90745</td>
<td>4.8788</td>
</tr>
<tr>
<td>2</td>
<td>Experimental class judgment score - control class judgment score</td>
<td>2.71429</td>
<td>8.34397</td>
<td>1.41039</td>
<td>-.15197</td>
<td>5.5805</td>
</tr>
<tr>
<td>3</td>
<td>The subject class score of the experimental class - the subjective subject score of the control class</td>
<td>6.71429</td>
<td>9.54424</td>
<td>1.61327</td>
<td>3.43573</td>
<td>9.9928</td>
</tr>
<tr>
<td>4</td>
<td>Experimental class total score - total score of the control class</td>
<td>8.91429</td>
<td>22.19482</td>
<td>3.75161</td>
<td>1.29010</td>
<td>16.538</td>
</tr>
</tbody>
</table>

Table 2 shows the key paired sample t-test results. The scores of multiple-choice tests in the experimental class and control class were p = 0.847 > 0.05, which means that there is no significant difference between the two. Still, the experimental class judgment scores and the control class judgment questions. The score of p=0.063>0.05, there is no significant difference between the two; the score of subjective exercise of the experimental class and that of the controlled class are p=0.000<0.05, which indicates that in the case of the significance level of 0.05, the two-sided tests worth accompanying probability value p<0.05, so the null hypothesis H0 should be eliminated and the alternative hypothesis
H1 should be accepted. Therefore, there is an obvious difference between the scores of subjective exercises of the experimental class and that of the controlled class; the total score of the experimental class and the total score of the controlled class are $p<0.05$, which indicate that in the case of a significance level of 0.05, the two-sided T-test worth accompanying probability value $p<0.05$, so reject the null hypothesis $H_0$ and accept the alternative hypothesis $H_1$. Still, there is also a significant difference between the total score of the experimental class and the total score of the controlled class.

According to the above data analysis results, in the classroom teaching with information technology, the accuracy rate of subjective question is relatively high, so that the overall performance of the class is better than the controlled class, which shows that students start their meaningful learning and generate deep learning.

**Limitations**

In the early stage of the study, although a large amount of literature was reviewed, a more comprehensive research design was carried out; the teaching classroom was analyzed and tested during the implementation process; the post-experimental data analysis was consulted by the teacher and teachers read many related books, there are still some limits which need to be further explored in the future. Firstly, the experimental samples in the empirical study relatively small, and the experiment was conducted on a tight schedule. Second, due to the limitation of manpower, material resources, and financial resources, the research only selected two classes. The effectiveness of information technology to promote deep learning in primary school mathematics needs to be tested, verified, and adjusted within a larger time and space.

**Conclusion**

Information technology is a developing concept. In the process of exploring information technology which can promote deep learning in primary school mathematics, by the observation record monthly and teaching effects evaluation on the students in class 3 and 4 in fifth grade, it was found in the primary mathematics classroom that rational application of information technology can promote students’ deep learning.

The author believes that teachers should provide students with a good learning environment, create a reasonable teaching situation, and infiltrate lead-in, new teaching consolidation, and other parts of the teaching, to help students to sort out the relationship between various contents, thus achieving the task of completing teaching aims. However, the proper use of information technology in this process will produce a good impetus.

Future research should examine the certain reference significance for the teaching of teachers teaching mathematics in primary school. The author calls on society, schools,
teachers, and parents to attach importance to the role of information technology, using information technology to promote primary school mathematics learning, and jointly construct information learning environments for students. And the final purpose is to cultivate students' interest in learning mathematics, improve the effectiveness of students' mathematics learning, and better realize the aim of deep learning.

References

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