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Integrating problem-based learning with ICT for developing trainee teachers' content knowledge and teaching skill

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ABSTRACT

Professional teachers can guarantee the progress and the promotion of society because fostering the development of next generation is up to them and depends on their professional knowledge which has two kinds of sources; content knowledge and teaching skill. The aim of the present research was studying the effect of integrating problem-based learning with Information and Communications Technology (ICT) on developing content knowledge and teaching skill of trainee teachers. The research design was a quasi-experimental one, and the participants were elementary education trainee teachers of Shahid Bahonar teacher training center of Hamadan, Iran. Two groups were given tests of theory and practice on teaching mathematical concepts at elementary school, and then a multivariate analysis of variance (MANOVA) was conducted to compare the pretest-posttest scores. There was a significant difference, in both multivariate and univariate analyses, in scores. The findings suggest that trainee teachers who integrate problem-based learning with ICT in solving a problem may develop more professional content knowledge and teaching skill than those who merely employ ICT.

Keywords: Information and Communication Technology (ICT), Problem-Based Learning (PBL), Content Knowledge, Teaching Skill

INTRODUCTION

Teachers' professional knowledge has two kinds of sources; content knowledge and teaching skill. Teachers usually obtain this professional knowledge in teacher training colleges; however, we should accept that, at least in Iran, the number of teachers who graduate from these colleges is very small. Moreover, trainee teachers in these colleges usually become familiar with teaching methods traditionally. Therefore, their learning may not last for a long time, and as soon as they begin their career in state schools, this will affect their students' learning negatively.

The results of TIMSS studies in 1995, 1999, and 2003 showed that Iranian students have problems with science and mathematics. In 1995, elementary school fourth graders were ranked 25 out of 26 participating countries, and in 2003 they were ranked 22 among 25 countries (Iranian Research Institute for Education 2012). One can say that one of the main reasons of this failure is the method of teaching; since a professional well-trained teacher is able to approach problems in syllabus and the like employing appropriate methods or techniques. How a teacher who either has not been trained in mathematics teaching methodology or has been trained passively can teach students mathematical concepts in an appropriate way. Therefore, employing active and involving teaching methods is not only necessary for students but also teachers themselves should be trained in the similar way. As students learn social interaction and personal thinking through active search, teachers can also learn actively and constructively through experience, since this process provides them with opportunities for obtaining modern knowledge (Aghazadeh 2009).

One of the most efficient methods for trainee teachers' effective and active learning is integration of technology in syllabus. Nowadays, there is a widespread use of Information and Communication Technology (ICT) in education, and a lot of schools around the world have been equipped with technological facilities. Thus, teachers need to exploit the considerable potential of these facilities in education. Churchill (2009) argues that ICT adds a new dimension to teaching effectiveness by enabling teachers to do things that might not be possible within the traditional classroom. Nevertheless, teachers need professional training to be able to integrate technology in the syllabus. Using modern technology alone or without considering learning theories will not be effective. Most teachers in Iran regard MS PowerPoint as the only way of using modern technology in teaching; moreover, some of them do not have sufficient familiarity with efficient use of the software and usually use it for presentation of information. Molaiinejad and Zakavati (2008) in a contrastive study showed that Iran in comparison with Japan, France, England, and Malaysia has not accomplished anything special about ICT applications in teacher training centers. Some teachers prepare slides with long texts in them for teaching a lesson and conceive of using modern technology in their classes. This way of teaching not only does not facilitate the students' comprehension but also it will have nothing for them but boredom and surface learning. In fact, this is the same traditional method in a new form. Mesrabadi (2011) did not find a significant difference between experimental group employing PowerPoint for information presentation and control group. Furthermore, the results showed that PowerPoint use has no significant effect on any of cognitive factors in retention of a subject matter, text comprehension, and information use ability.

Based on what was mentioned above, first, for teachers to be able to integrate ICT in teaching they need an intensive course on the pedagogical use of ICT for a certain subject (Baylor & Ritchie 2002). Teacher-trainers should illustrate, both in practice and in theory, how technology is used in teaching so that this may provide them a direct experience. Second, teachers should be aware that introducing ICT tools in teaching not only changes the use of tools in teaching but also what we teach and how we teach, which is an important and often overlooked aspect of many ICT integration interventions (Harris et al. 2009). Therefore, trainee teachers need to be able to use ICT tools in their classrooms creatively, purposefully, and effectively. Graham et al. (2009) state that teaching ICT skills alone does not serve pre-service teachers well, because they learn how to operate ICT-related tools without being able to use them effectively to promote students' learning. To be an ICT-integrating teacher means going beyond ICT skills, and developing an understanding of the complex relationships between pedagogy, content, and ICT (Hughes 2005).

In fact, without a scientific basis, nobody can claim that using modern educational technology is effective. Resta (2002) states that educational experts of UNESCO have confirmed if teachers do not experience a model of technology application in their classes, the possibility of using new ICT equipment in an efficient way would be remote. Problem-based learning, as an active method, in which trainee teachers are involved in learning by solving problems and reflecting on their own experiences can be a proper alternative for integration with ICT. Jimoyiannis (2010) argues that true learning in the 21st century requires students being able to use ICT, not only for enhancing the memorization of facts, but also for problem solving in real world settings. Koehler and Mishra (2005) recommended that involving teachers in collaborative authentic problem solving tasks with ICT is an effective way to learn about ICT and ICT integration processes and to develop Technological Pedagogical Content Knowledge (TPACK), which they called 'learning technology by design'. The idea of Pedagogical Content Knowledge (PCK) was first described by Shulman

(1986) and TPACK builds on those core ideas through the inclusion of technology. Koehler and Mishra have done extensive work in constructing the TPACK framework. Koehler, Mishra, and Yahya (2007) proposed that teachers should work collaboratively in Design Teams (DTs) to develop TPACK by designing an ICT solution for a pedagogical problem.

In sum, the low ability of elementary education trainee teachers in teaching mathematical concepts and the need for learning computer applications in teaching led us to conduct a study on these problems. To achieve this goal, being aware of trainee teachers' familiarity with computer, we integrated problem-based learning method with ICT applications.

Operational definitions of the key concepts

Problem-based learning: Problem-based learning (PBL) is an approach that encourages active learning through the creation of environments and tasks informed by social-constructivist learning theory. It is an alternative to traditional instructional approaches (Barrett & Moore 2011).This instructional method helps learners to be independent, so that they are able to continue their learning and to solve their problems in their entire life. In this study, problem-based learning is defined as a student-centered learning technique in which trainee teachers are involved in solving a problem.

Information and Communication Technology (ICT): In this study, what we intend to say by ICT application is regulating, organizing, manipulating, and displaying data using computer tools such as MS PowerPoint. As students are very much interested in working with ICT tools, and these tools have high capabilities, then they can be used as mediation for enhancing their intellectual abilities. Promoting creative thinking is also an important goal of education which will be achieved through engaging students in imaginative and intellectual activities, making and designing visual arts and technology, and the development of ideas (Learning and Teaching Scotland 2004).

Content knowledge: **"**Content knowledge is teachers' knowledge about the subject matter to be learned or taught" (Koehler and Mishra 2009). In this study, it is knowledge of mathematics learning theories that trainee teachers obtain during teacher training.

Teaching Skill: Teaching skill can be defined as "discrete and coherent activities by teachers which foster pupil learning" (Kyriacou 2007, p. 4). In this study, this can be defined as skills that trainee teachers need to acquire for teaching elementary mathematical concepts as soon as they begin their teaching as a career at elementary schools.

Following are the results of some studies related to integrating ICT and PBL. Integrating ICT and PBL is a technique through which students while using technology are engaged in learning. Howard, et al. (2000) found that after a group of teachers received training in employing constructivist teaching strategies, they were also trained in using technology; as a result, they developed a more constructivist view toward education. Alayyar, Fisser, and Voogt (2012) used the TPACK framework to prepare pre-service science teachers at the Public Authority of Applied Education and Training in Kuwait for ICT integration in education. Pre-service teachers worked in groups to design an ICT solution for a problem they faced during training at school. Pre-service teachers were divided into two groups. The first group was trained by experts of ICT, pedagogy, and content. The second group had access to an online portal with different tutorials and examples, with opportunities to meet with different experts whenever they wanted. The findings showed that the online support condition reported a higher increase in the participants' technological knowledge, technological pedagogical knowledge, and their attitude toward ICT as a tool for instruction and productivity, and ICT enjoyment. According to another study, the teachers believed that integrating technology with PBL not only is continually used but also integrating it with curriculum motivates the students and helps them to achieve lifelong skill (Kirkwood 2000).

In Gülseçen and Kubat's (2006) study, at the beginning, the students had concerns about the use of computers. The purpose was that, using MS PowerPoint, they design slideshows to teach students. After taking a test of computer skill, they were placed in two groups of technophobes and non-technophobes. Different topics were chosen for them, and they were involved in the project through PBL and presented the results of their work using ICT. In this study, it was revealed that the motivational role of ICT in learning is very high. These pre-service teachers learned how to use ICT by being involved in PBL project and their interest grew. In Singapore, the trainee teachers participated in a study to integrate ICT in teaching and learning. The main purpose was helping trainee teachers to establish a relationship between content, teaching knowledge, and technology through planning a real lesson. They were actively involved in the lesson planning project and experienced using PBL and ICT in planning their lesson. The results showed that trainee teachers gained a good understanding of teaching knowledge about PBL. They learned about independence and responsibility; their critical thinking and creative thinking was enhanced; the use of media like video and animation made learning more interesting for them; it also became obvious that the integration of technology in curriculum can help individuals with different learning styles (So and Kim 2009). Lin and Lai (2011) studied the impact of PBL and ICT in learning natural sciences on improving key skills (technology, meta-cognition, creativity) of third grade students of elementary school. In this study, the control group received education based on the traditional ICT model and the experimental group received education based on PBL and ICT model. Results showed that creativity progressed in both groups; technology skills were better in experimental group than the control group, and it was only the meta-cognition self-evaluation aspect that was significantly increased in experimental group. In a plan that Walker et al. (2011) implemented for professional development of teachers, they found that increase in teachers' knowledge, experience, and confidence was related to technology use and its integration with PBL. In another study, Ellis and Kedler (2012) found that the integration of ICT and problem-based learning helps students gain a good understanding of PBL, helps them in learning, and increases their collaboration and cooperation.

A Proposed model for integrating PBL and ICT for content knowledge and teaching skill enhancement

In order to find an optimal model for the purposes of this study, TPACK framework was selected. The research carried out by So and Kim (2009) was based on this framework. In this model, ICT and PBL were integrated into core subjects, and course syllabus had been planned with the help of them. However, there were only three elements of ICT, PBL, and content in this model that was partial and did not specify the steps of the activity and the dimensions of knowledge; therefore, in the proposed model in Figure 1, it was decided that the steps of implementation be included in accordance with PBL, content knowledge dimensions, and teaching skill derived from the dimensions of teacher's knowledge during teacher training program.

In general, the basic structure of the model was formed when the trainee teachers' weaknesses in teaching and their interest in working with computers was observed. Thus, in the educational material design and development, the trainee teachers were told to present teaching a mathematical concept cooperatively through PowerPoint slideshows. For example, they were told to prepare slides to facilitate discovering the formula for the area of rectangle in the semi-visualization step. There are two dimensions of content knowledge and teaching skill in this model, and the teacher trainer poses some problems to strengthen both of them. By involving trainee teachers in solving a problem, the teacher trainer wants them to discuss it, to gather information about it , and to draw up a plan and present it using ICT tools they are familiar with. Next, each group is required to explain the way they solved the problem and to analyze the steps in solving the problem. The aforementioned steps cause the students to go back and reflect on their thinking styles. Another advantage in this step is that trainee teachers, after encountering various problems whether being solved or not, learn to review the problem-solving process from beginning to end and investigate the causes of their success or failure in solving the problem. The final step in this model is evaluation in which the teacher-trainer, for being ensured about students' learning, provides new opportunities for the students to use what they have learned. These opportunities can be provided either in content knowledge dimension or in teaching skill dimension. During implementation, the teacher-trainer as a facilitator provides appropriate feedback.

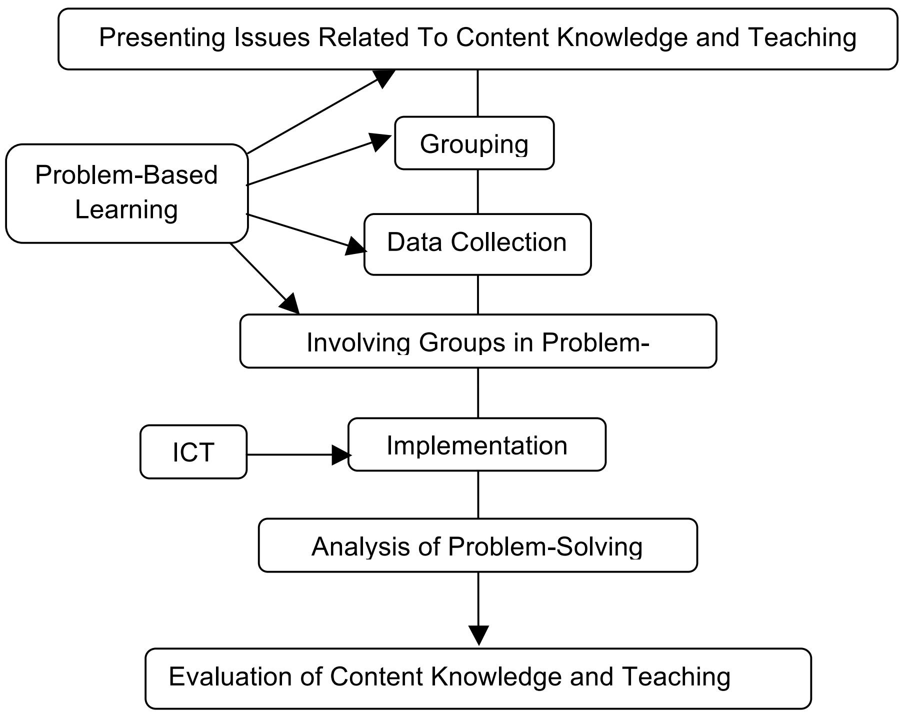

Figure 1*: A proposed model for integrating problem-solving learning and ICT*

The objective of the study was to find whether we can develop content knowledge and teaching skill of trainee teachers in teaching mathematical concepts of elementary school by an integration of PBL and ICT application. Koehler and Mishra (2005) emphasized that teacher education programs needs to develop students' TPACK to enable pre-service teachers to use ICT successfully in their daily practices after graduation. Many studies report that pre-service teachers are unable to use or integrate ICT in their own teaching practices (Chen 2008; Palak & Walls 2009). Two major research questions were investigated: Is the integration of PBL and ICT application effective for enhancing trainee teachers' content knowledge? Is the integration of PBL and ICT application effective for enhancing trainee teachers' teaching skill?

Research hypotheses

- Integrating problem-based learning and ICT application has a positive effect on enhancing student teachers' content knowledge.

- Integrating problem-based learning and ICT application has a positive effect on enhancing student teachers' teaching skill.

METHODOLOGY

This is a quasi-experimental study. The independent variable was the integration of ICT and problem-based learning, and the dependent variables were trainee teachers' content knowledge and teaching skill. Independent variable had two levels. In the first level were the experimental group who were trained by integrating PBL and ICT, and in the second level were control group who were trained by ICT alone.

Participants

All trainee teachers of Shahid Bahonar teacher training center of Hamadan, Iran, were selected as the research population in 2011 academic year. Among them, two groups of female elementary education trainee teachers, at 19-21 age level, were selected as available sample that 25 participants were placed in the experimental group and 24 participants were placed in the control group randomly (They were not aware that they were participating in a research project). All participants had almost the necessary skills to use computers, and they received education for methods of teaching mathematical concepts by the same instructor.

Materials

The test instruments employed in this study were researcher-made, theoretical part of which was used for testing the first hypothesis and its practical part for testing the second hypothesis. The purpose of the questions in theoretical part was to measure participants' content knowledge of elementary level mathematical concepts in pretest and posttest. The total score was based on a scale of 0 to 20 (See Appendix 1). And the purpose of practical part was to evaluate participants' skill in teaching elementary level mathematical concepts through a performance checklist in pretest and posttest (See Appendix 2). After observing their practical teaching, the checklist was completed, and the calculated total score was modified to fit a scale of 0 to 20.

Validity and reliability of the tests

To measure the validity of the test and the checklist, content validity form was used, and appropriate items were selected by experts in mathematics teaching methods. To measure reliability of the test, using Pearson product-moment correlation coefficient, the test-retest method was used in a period of two weeks. Preliminary analyses were performed to ensure no violations of the assumptions of normality, linearity and homoscedasticity. There was a strong positive correlation between scores of teaching skill test, $r = .94$, $n = 49$, $p < .01$, with high levels of pre-test scores associated with higher levels of score in the post-test. There was also a strong positive correlation between scores of content knowledge tests, $r = .93$, $n = 49$, $p < .01$.

Procedure

In the previous semester before the project, students in both groups had already passed courses in 'Mathematics Teaching Methodology' and 'Methods and Techniques of Teaching'. But weaknesses were observed in content knowledge and skills for teaching mathematical concepts among the groups. The trainee teachers were placed in control and experimental groups randomly. First, content knowledge test was performed in each group in similar conditions and in a 90 minute session. During this time, they answered essay questions. But they needed more time for the practical test. In the practical test, each of the trainee teachers spent 10 minutes for teaching mathematical concepts. Their teaching was observed by the teacher-trainer then the teaching skills evaluation checklist was completed. It should be noted that the concepts chosen for practical teaching were similar in the control and experimental groups, and it was held in the same condition. After the content knowledge essay-type tests were scored by the teacher-trainer, the teaching skill scores in the checklist were calculated and modified on a scale of 0 to 20; finally, the data obtained was analyzed. Before implementing the method in the two groups, important mathematical concepts in elementary school (multiplication, addition, subtraction, area of square, rectangular, parallelogram, triangle, rhombus, and trapezoid shapes; the perimeter of geometric shapes, addition, subtraction, and multiplication of fraction) had been selected. After consulting with the instructor of 'Mathematics Teaching Methodology', four important concepts (subtraction by borrowing, area of the parallelogram, perimeter of trapezoid, multiplying a fraction by a number and a number by a fraction) were selected. In control group, to teach participants the methodology of teaching these concepts, some PowerPoint slideshows were generated by the teacher-trainer in which they were taught the methodology of teaching the concepts in a step by step approach through animation and using the capabilities of this software within two weeks (4 sessions). Also through the slideshows, the trainee teachers were taught how to teach these concepts using problem solving and discovery learning methods. In the experimental group, the steps which were explained in the model (Figure 1) had been followed. First, the four concepts were introduced, and a problem was raised on each one. For example, they were told to prepare PowerPoint slideshows for teaching the area of parallelogram by means of which elementary school students can themselves discover the formula for calculation of its area. After collecting information and devising their plan based on problem solving and discovery learning methods, they were required to carry out the plan in MS PowerPoint. One condition for slideshows was that they use the existing effects in PowerPoint purposefully for transferring concepts. For example, they had to use entrance animations for addition and exit animations for subtraction. Using other effects, they could demonstrate perimeter and area of different shapes. In fact, the issue they were dealing with was how they can design a dynamic presentation by means of which students are enabled to discover concepts. Therefore, it was necessary to use methods of problem solving and discovery learning. In fact, the trainee teachers were involved in the problem, and they were required to develop a program through which get their students involved in the problem. The trainee teachers were divided in groups or teams and started collecting information. They consulted 'Mathematics Teaching Methodology' to find out more about methods of teaching these concepts. Moreover, they discussed whether they should present the concepts in problem solving or discovery learning method, then, they recorded the results on paper. Finally, they devised a set of plans and based on them made a problem-based program in PowerPoint to teach the concepts. The process lasted for two weeks (4 sessions). At the end of experimentation, both content knowledge and teaching skill post-tests were performed, and the same procedure as pre-test was adopted.

A 2 × 2 multivariate analysis of variance (MANOVA) was conducted to compare the scores. MANOVA is a statistical test procedure for comparing multivariate means of several groups. It is used when there are two or more dependent variables. It helps to answer : 1. do changes in the independent variable(s) have significant effects on the dependent variables; 2. what are the interactions among the dependent variables and 3. among the independent variables. The significance level adopted for this study was set at $\alpha < .05$, and for all statistical calculations, version 18.0 of SPSS software was used.

RESULTS

Trainee teachers in both groups successfully completed the pre-tests. Table 1 contains their mean scores for content knowledge and teaching skill tests. The mean scores indicate that differences between the control and experimental groups in the mean performance of these tests were not large enough to be significant.

Table 1: *Descriptive statistics for content knowledge and teaching skill pre-test scores*

	Group	M	SD	N
Pre. Content Knowledge	Integration (Exp.)	15.42	1.53	25
	ICT alone (Con.)	14.43	1.32	24
	Total	14.93	1.50	49
Pre. Teaching Skill	Integration (Exp.)	14.80	1.60	25
	ICT alone (Con.)	14.07	1.20	24
	Total	14.44	1.45	49

A one-way between-groups MANOVA was performed to investigate problem-based learning alone and problem-based learning integrated with ICT differences in teachers' content knowledge and teaching skill. Two dependent variables were used: content knowledge and teaching skill. The independent variable was group with two levels of control and experimental. Preliminary assumption testing was conducted to check for normality, univariate and multivariate outliers, linearity, multicollinearioty and singularity, homogeneity of variance-covariance matrices, and Levene's test of equality of error variances, with no serious violations noted. In pre-test section, there was not a statistically significant difference between the control and experimental groups on the combined dependent variables, F (2, 46) = 2.93, p = .063; Wilks' Lambda = .88; partial eta squared = .11. When the results for the dependent variables were considered separately, the only difference to reach statistical significance, using a Benferroni adjusted alpha level of .025, was content knowledge, F (1, 47) = 5.72, p = .021, partial eta squared = .10. An inspection of the mean scores indicated that the experimental group reported slightly higher scores of content knowledge (M = 15.42, SD = .28) than control group (M = 14.43, SD = .29); however, the experimental group's mean score of teaching skill (M = 14.80, SD = .28) was not so much different from that of control group (M = 14.07, SD = .29). This indicates that, in the pre-test section, the groups were not significantly different in their mean scores of teaching skill; however, the mean score of content knowledge for the experimental group was significantly different from control group. The value of partial eta squared in this case is .10, which according to generally accepted criteria is considered a medium effect size. This represents 10 percent of the variance in content knowledge scores explained by groups.

Table 2: *Descriptive statistics for content knowledge and teaching skill post-test scores*

	Group	M	SD	N
Post. Content Knowledge	Integration (Exp.)	18.04	1.45	25
	ICT alone (Con.)	16.00	1.31	24
	Total	17.04	1.71	49
Post. Teaching Skill	Integration (Exp.)	17.50	1.62	25
	ICT alone (Con.)	15.81	1.24	24
	Total	16.67	1.66	49

Trainee teachers in both groups were given the post-tests. The descriptive statistics (Table 2) indicate that, in the post-tests, there were consistent differences in the mean performance of the control and experimental groups on content knowledge and teaching skill tests.

A one-way between-groups MANOVA was performed to investigate problem-based learning alone and problem-based learning integrated with ICT differences in teachers' content knowledge and teaching skill. Two dependent variables were used: content knowledge and teaching skill. The independent variable was group with two levels of control and experimental. Preliminary assumption testing was conducted to check for normality, univariate and multivariate outliers, linearity, multicollinearioty and singularity, homogeneity of variance-covariance matrices, and Levene's test of equality of error variances, with no serious violations noted. In post-test section, there was a statistically significant difference between the control and experimental groups on the combined dependent variables, F (2, 46) = 13.75, p = .000; Wilks' Lambda = .62; partial eta squared = .37. When the results for the dependent variables were considered separately, the differences to reach statistical significance, using a Benferroni adjusted alpha level of .025, were content knowledge, F (1, 47) = 26.33, p = .000, partial eta squared = .35, and teaching skill, F (1, 47) = 16.65, p = .000, partial eta squared = .26. An inspection of the mean scores indicated that the experimental group reported higher scores of content knowledge (M = 18.04, SD = .27) than control group (M = 16.00, SD = .28); moreover, the experimental group's scores of teaching skill (M = 17.50, SD = .28) were also highly different from those of control group (M = 15.81, SD = .29). This indicates that, in the post-test section, the groups were significantly different in their mean scores of content knowledge and teaching skill. The values of partial eta squared in this case are .35 and .26 respectively for the scores of content knowledge and teaching skill, which according to generally accepted criteria is considered a large effect size. These represent 35 and 26 percent of the variances in the scores of content knowledge and teaching skill explained by groups.

DISCUSSION

The theory of constructivism led us to infer that the integration of ICT and problem-based learning would be very effective in enhancing student teachers' content knowledge and teaching skill.

The results of this study were in substantial agreement with those of Gülseçen and Kubat (2006), So and Kim (2009), Howard et al. (2000); Kirkwood (2000), Lin and Lai (2011), and Walker et al. (2011). Findings showed that the integration of problem-based learning and ICT is effective in enhancing content knowledge and teaching skill of trainee teachers. In fact, the results proved the hypotheses and showed that it would be better to use active methods in teaching and integrate problem-based learning with ICT to develop trainee teachers' content knowledge and teaching skill so that we might achieve our desired results. The results also revealed that using ICT alone without a strong support cannot lead us to success. New learning theories that believe in the active role of learners in the learning process can be helpful in this regard and help us in ICT use in the curriculum. ICT can be integrated into the curriculum in various forms, and in its implementation efficient techniques such as problem-based learning can be used to bring the desired result. One more thing that distinguished this study from similar studies was that it was performed on trainee teachers using a proposed model for the first time, and the results showed that this model will help researchers and teachers to integrate easily problem-based learning with ICT in their curriculum and evaluate it.

The integration of problem-based learning and ICT in this study had some advantages. It led the students-teachers to learn better the mathematical concepts of elementary schools and apply them better in practice; some of the students who were less interested in classroom activities could play a more active role in the classroom by this integration, since working with computers was pleasant to them. Problem-based learning also involved trainee teachers in problem solving as a result of which they could learn mathematical concepts and methods of teaching them better. Students in the experimental group during the procedure had a good feeling and were being fully engaged to show a proper method of teaching mathematical concepts, and they were discussing and receiving feedback from the teacher-trainer. In interviews with the researcher, they described the learning environment desirable and pleasant and offered to use this method in other classes, too. They expressed their satisfaction, and commented that many of their problems had been solved during the procedure and had gained a deep understanding of mathematical concepts in elementary level. Another advantage of integrating ICT and problem-based learning was that trainee teachers became familiar with practical applications of computers in education, and this may lead to using this method properly in their classes in the future.

One possible explanation is that the key to success in this model of integration is both computer technology for its capabilities and attractions and problem-based learning for engaging students in the learning process.

Implications

Considering the results of this research, we can put forward the following suggestions. In the curriculum content of the teacher training centers, a course under the title of “Methods of using ICT in teaching different courses” should be provided so that trainee teachers become familiar with criteria for using ICT in teaching. In the teaching methodologies content of the teacher training centers (methods of teaching math, science, etc.), ICT-based teaching methods should also be provided. Training courses should be held for teacher trainers to become familiar with appropriate use of ICT. New theories and their applications in classroom should be taught to trainee teachers. Teacher trainers should apply the integration of ICT and problem-based learning to the development of trainee teachers’ content knowledge and teaching skill. Teacher trainers should make trainee teachers familiar with ICT, learning theories, and active methods then require them to be involved in appropriate integrated activities. Teacher trainers should teach trainee teachers effective teaching techniques through involving them in practical situations. Teacher trainers should involve trainee teachers in problem solving and teach them how to learn and how to teach in order to enhance their teaching skill through different forms of using ICT. While involving trainee teachers in problem solving, teacher trainers should always give them feedback and facilitate learning. In order to enhance teachers’ skill in using ICT tools, the education ministry should adopt motivating policies so that teachers try hard to develop their knowledge, skill and attitudes. As teacher training centers have a significant role in educating skillful teachers, the education ministry should pay special attention to these centers and create conditions for effective implementation of these techniques through holding in-service education for teacher-trainers and providing necessary infrastructure.

Further research

In this research, MS PowerPoint, for its capabilities in teaching mathematical concepts, was used for integrating problem-based learning with ICT. It is recommended that integration of ICT and problem-based learning be replicated in web-based environment. Authors are recommended conducting this study with other hypotheses and larger groups of students and trainee teachers. In this study, a comparison has not been drawn between problem-based learning on the one hand and learning by its integration with ICT on the other hand. It is suggested that future researchers compare the use of problem-based learning and integration of problem-based learning with ICT.

Limitations

The sample size was small because there were only two groups Elementary Education available in the teacher-training center. Moreover, number of sessions implementing the project was limited. In addition, only Elementary Education trainee teachers were taking part in the study which to some degree one can say that the sample was not representative.

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APPENDIXES

Appendix 1: Content knowledge test questions

1. How can you use discovery learning and problem solving methods in teaching mathematical concepts? Explain. (2 marks)

2. Explain the difference between the three steps of visualized, semi-visualized and abstract teaching. (1.5 points)

3. In visualization steps, what teaching materials do you use to teach multiplication? (1 point)

4. Through an example, explain the way you teach subtraction by borrowing in visualized, semi-visualized and abstract steps. (1.5 points)

5. Explain how you teach area of rectangle using discovery learning method. (2 marks)

6. How can you teach parallelogram area with the help of area of the rectangle? (2 marks)

7. Explain how you teach area of parallelogram using discovery learning method. (2 marks)

8. Explain how you teach area of trapezoid using discovery learning method. (2 marks)

9. How can you help students to apply knowledge of area and perimeter in real-life situations? (2 marks)

10. Using a discovery learning method, how can you teach multiplying a number by a fraction? (2 marks)

11. Using a discovery learning method, how can you teach multiplying a fraction by a number? (2 marks)   Total: 20 marks

Appendix 2: Teaching skill evaluation checklist

N	Evaluation Criteria	Excellent (5)	Above Average (4)	Average (3)	Below Average (2)	Extremely Poor (1)
1	Evaluation of prerequisites for learning before teaching the concept					
2	Observing the sequences and hierarchy in teaching the concepts					
3	Using appropriate methods to motivate the learners					
4	Following the steps of teaching mathematics concepts					
5	Teaching the concept using active methods					
6	Getting students involved in discovery and problem solving					
7	Using appropriate learning activities to help learners apply their knowledge in real-life situations					
8	Using technology and appropriate teaching materials for efficient learning					
9	Teaching the mathematical concept using appropriate methods					
10	Using appropriate methods to assess students' learning					
11	Being skillful in teaching the mathematical concept					
Sum						
Total						

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