Educating Pre-Service Teachers in Metacognitive Activities

Nimer Baya'a[1], Wajeeh Daher[1,2], Otman Jaber[1], and Ahlam Anabousy[1]

[1]Al-Qasemi Academic College of Education, Graduate Studies, Israel, bayaan@qsm.ac.il; [2]An-Najah National University, Faculty of Educational Sciences, Palestine.

ABSTRACT

The present research examines the influence of pre-service teachers' professional development (PD) program in metacognitive skills on their practice of these skills in a mobile technologies environment. Twenty-four pre-service teachers participated in the PD program. The data was collected from the pre-service teachers' texts for activities solutions, as well as from their Edmodo discussion. We analyzed the data using the constant comparative method. The research results indicate that at the beginning, the pre-service teachers did not use such skills, but, because of the preparation, they started using these skills as learners, where this use utilized the mobile technologies. In a later phase, the pre-service teachers used these skills as teachers to encourage their students to use metacognitive skills collaboratively.

Keywords: metacognitive skills, pre-service teachers, mathematics teachers' education, mobile technologies.

INTRODUCTION

Researchers are interested in the metacognitive aspect because of its relationship with other aspects as the cognitive aspect (Gavelek & Raphael, 1985) and the social and affective aspects (Daher, Anabousy & Jabarin, 2018). Belet and Guven (2011) claim that metacognition makes students aware of their learning. This awareness supports the internalization of what one learns and makes him/her consider carefully how to solve problems posed in the classroom. These advantages of metacognition for students' learning make it necessary that teacher education colleges attempt to prepare pre-service teachers, so that they develop their knowledge of metacognition for teaching. This development is expected to develop also their perceptions of metacognition in teaching and learning. In the PD program that the present study accompanies, we intended to develop the metacognitive skills of mathematics pre-service teachers as learners and teachers of mathematics.

LITERATURE REVIEW

Researchers looked at metacognition as cognition about cognition or knowledge about knowledge (Flavell, 1976; Panaoura, Philippou & Christou, 2003). Flavell (1976) was the first to use the term 'metacognition' to refer to the individual's awareness, consideration and control of his or her own cognitive processes and strategies. Since then, a variety of definitions has been given to the term of metacognition. Du Toit and Kotze (2009) argue that the various definitions of metacognitive processes in the literature, including that of Schoenfeld (1992), emphasize the monitoring and regulation of cognitive processes. Moreover, Gavelek and Raphael (1985) argue that metacognition involves promoting effective understanding through adjusting the cognitive processes involved in the activity. Furthermore, Panaoura et al. (2003) say that it coordinates cognition, affecting it and, as a result, affecting students' academic success.

Researchers pointed out, that metacognition is comprised of two different components connected to each other. Veenman et al. (2006) argue that the most common distinction in metacognition distinguishes between metacognitive knowledge and metacognitive skills. On the one hand, Flavell (1999) defines metacognitive knowledge as the knowledge or beliefs about the factors that act and interact to affect the course and outcome of cognitive enterprises: person, the task and the strategy. On the other hand, metacognitive skills involve planning, monitoring, evaluating and regulating the processes leading to achieving goals. Davidson and Steinberg (1998) described a theoretical framework that includes the following metacognitive skills: encoding, representation, decomposition, planning, selecting strategy, monitoring, evaluating and suggesting other strategies. In the present study, we focused on metacognitive skills and utilized the previous framework to introduce metacognition to our pre-service teachers.

In addition, researchers suggested ways to encourage students to use metacognitive processes (e.g., Spiller & Ferguson, 2011). Schoenfeld (1992) describes ways for students to practice monitoring and evaluating their performance on math problems. For example, pause frequently during problem solving to ask themselves questions such as “What am I doing right now?” Spiller and Ferguson (2011) say that if we want students to use metacognitive processes, we need to encourage them to consider the nature and sequence of their own thinking processes. Chauhan and Singh (2014) say that as students become more skilled at using metacognitive strategies, they become confident and more independent as learners. In the present research, we wanted to educate mathematics pre-service teachers for using metacognitive processes, as learners and as teachers, through utilizing mobile technologies and collaborative learning.

Mobile technologies in mathematics education

Mobile technologies in general have been used in the mathematics classroom for more than a decade now. Advantages of using mobile technologies in education encourage teachers' use of these technologies, where various reasons encourage teachers to use them in their teaching (Daher & Baya'a, 2012; Ng & Nicholas, 2012). Ng and Nicholas (2012) reported that teachers are interested in mobile technologies for their professional development and because these technologies raise students' motivation to learn. In addition, these mobile technologies influence positively students’ behavior and emotions. Daher and Baya'a (2012) found that mobile technologies could be utilized as proper strategies for mathematics measurements and investigation in solving real life problems. These positive influences and utilizations of mobile technologies make us encourage our pre-service teachers to use them in their teaching. In the present research, we encouraged them to use the mobile technologies in their metacognitive processes, especially as strategies for solving real life mathematical problems.

Research question

How would mathematics pre-service teachers develop their metacognitive learning and teaching skills as a result of one-year preparation?

METHODOLOGY

Research context and participants

This PD program was held for a full academic year 2016-2017. Twenty-four pre-service teachers participated in the PD program. They were in their third academic year majoring in teaching mathematics and computer science in middle schools. Two of the authors, who were the pedagogical supervisors of these pre-service teachers, accompanied them in two middle schools in the frame of the practical training. Our preparing of the pre-service teachers in metacognitive skills was based on the work of Davidson and Steinberg (1998) (See above), with special emphasis on using mobile technologies for solution strategies. In addition, special attention was given for collaborative learning among the pre-service teachers' groups and their students. To achieve this goal, the pre-service teachers utilized the forums in Edmodo – an educational social network site, to discuss their preparation and implementation of the mathematics activities. The role of Edmodo discussions was crucial since all the disagreements, negotiation and alignment occurred in these forums. To read the detailed description of the PD phases, including the role of Edmodo discussions, see Daher, Baya'a, Jaber and Anabousy (2018).

Data collection and analysis

The data tools were the pre-service teachers' texts for the solutions of the activities that we requested them to carry out using metacognitive processes. In addition, we used the pre-service teachers' discussion texts in Edmodo forums.

To analyze the texts, we used inductive and deductive qualitative content analysis. Content analysis is a process designed to condense raw data into categories or themes based on valid inference and interpretation that use inductive reasoning. Deductive reasoning can also be used with the goal of generating concepts or variables from theory (Patton, 2002). Using the deductive reasoning we looked for themes related to the metacognitive skills from the work of Davidson and Steinberg (1998). Using the inductive reasoning, we tried to find out if additional metacognitive skills not given in the literature were described by the pre-service teachers.

FINDINGS

The findings report the participating pre-service teachers' metacognitive activity when solving authentic mathematical problems during the one-year preparation. First, they practiced using metacognitive skills, as learners, to solve an authentic mathematical problem prepared by their pedagogical supervisors. Second, they used metacognitive skills, as teachers, in the preparation of authentic mathematical activities that use mobile devices. Finally, it reports the pre-service teachers' metacognitive processes when implementing the prepared activities in the middle school with their students.

The pre-service teachers' metacognitive activity as learners

At the beginning and in the first activity, when the pre-service teachers were requested to build a plan for measuring the height of a tree, they did not mention any technological tools that would help them in measuring the tree height. They suggested using a stick, but could not elaborate on the process of the solution. While, in the following activities, for example, when given an authentic problem about a computer engineer from a village in the suburbs who was hired to work for a Hi-tech company in the city. The participating pre-service teachers were requested to help the engineer find the most efficient way to get to work. They suggested a plan that demonstrated their awareness of the metacognitive processes needed for such plan. Following is their suggestion in which they used the terms of the metacognitive processes.

Encoding of the givens – We can use Google Maps to identify the locations of the village and the city, and to measure the distance between them.

Representation of the givens – After presenting the locations on Google Maps, we prepare a table of the various measurements of the variables that could contribute to the efficiency of each way of transportation.

Decomposition of the problem – Depending on Google Maps representations, we can identify various roads of transportation.

Planning the solution strategies – After finding data about each road of transportation, we give weight for each road to determine its efficiency, and finally decide on the best road.

Selecting and implementing strategy – We will suggest to the engineer several roads that utilize Google Maps and the Mobile application "Waze". This would help provide data on each road, such as distance, time, toll payment, traffic jam, etc. These data determine the efficiency of the road. This mobile application would facilitate the obtaining of the data.

Monitoring of the plan – We advise the engineer to travel using more than one suggested road. Doing that, the engineer needs to keep collecting data, using a mobile application like "Waze", to keep calculating the efficiency.

Evaluating the solutions – To look after the measurement and compare between the efficiencies of the different roads, the engineer could register the collected data in a mobile spreadsheet. This application facilitates the evaluation of the efficiency of the transportation roads.

Suggesting other strategies or mobile applications – Finally, we advise the engineer to keep tracking of new strategies/applications that could improve the accuracy of the measurements in order to get better assessment of the efficiency of the transportation roads.

The pre-service teachers' metacognitive activity as teachers

We will describe an activity that shows the pre-service teachers' actions when preparing a metacognitive mathematical activity for their students. The whole activity occurred in Edmodo.

The activity: We want to plan an activity that encourages the use of metacognitive processes of middle school students regarding the following mathematical problem: A landowner needs to calculate the costs of tiling a wall in a building that includes the entrance to that building. Help the landowner with the calculations?

As a first step, the pre-service teachers discussed the task in Edmodo utilizing the metacognitive framework of Davidson & Steinberg (1998). Doing that, they discussed which questions they need to ask the middle school students in each phase of metacognitive processes. This discussion led them to adopt the following questions for students at each phase:

Encoding of the givens – Appropriate questions are: Which givens are present in the problem? Which givens are needed to compute the costs of tiling?

Representation of the givens – What ways do we have to represent the givens in the problem? What ways do we have to represent the givens needed to compute the costs of tiling?

Decomposition of the problem – After you represented the problem givens, how do you suggest that we decompose it?

Planning the solution strategies – How would you find the needed givens? How many ways or strategies are there? What are the differences between these strategies?

Selecting and implementing strategy – How can we implement each of the strategies that we identified? Which mobile applications can help us implement the planned strategy? What are the advantages and disadvantages of each mobile application?

Monitoring of the plan – How can we assert that the implementation of the plan is effective?

Evaluating the solutions – How can we evaluate that the implementation of the strategy is effective? How can the mobile application which we used help us in this evaluation?

Suggesting other strategies – How can we assert that the strategy which we used is more effective than other strategies? How can we assert that the mobile application which we used is more effective than other mobile applications?

The pre-service teachers' metacognitive processes when performing the prepared activity and their teaching this activity to middle school students

To ensure that they know how to guide the students' metacognitive processes, the pre-service teachers went through the whole series of metacognitive processes for solving the problem by themselves. Doing so, they suggested that the mobile applications 'Photo Ruler' and 'Smart Measure' would help them to implement their strategies. Some of them decided, in order to facilitate the implementation phase, to prepare user guides for using these applets and uploaded them to the Edmodo. In the monitoring phase, they looked at the measurements which each application gave. Evaluating the performance of each application, they found that the 'Photo Ruler' gave relative non-realistic measurements, while the 'Smart Measure' helped in calculating the scale of measurements from the same location, so they could convert the relational measurements to actual realistic ones.

The pre-service teachers pointed at the advantages of the collaborative learning to the metacognitive processes of the group regarding the solution of mathematical problems. They said that this collaborative learning contributes positively to all the metacognitive processes because every participant critically evaluates the suggestions of the rest of the participants.

The pre-service teachers worked with their students in the training school, in the Edmodo context and in the classroom context. They posed the questions which they agreed upon beforehand, and other questions that were raised as a result of the students' metacognitive processes related to the solving of the problem. The students were encouraged to manage their learning, to ask questions about this learning and to regulate it.

All the previous sequence of metacognitive processes was accompanied by reflections and discussions in Edmodo environment, which facilitated the success of these processes.

After the preparation and implementation of this activity, the pre-service teachers were required to work in groups of 4-5 members to design more activities of this type. Finally, each group of pre-service teachers was requested to choose an activity of those they designed earlier by themselves, and to implement it with a group of students.

DISCUSSION

Educating pre-service teachers for new practices has attracted the attention of educational researchers for its influence on teachers' practice as college students and as future teachers. In the present research, we wanted to examine the influence of pre-service teachers' preparation in metacognitive skills on their practice of these skills in a mobile technologies environment. The research results indicate that at the beginning, the pre-service teachers did not use such skills, but, as a result of the preparation, they started to use these skills as learners, where this use utilized the mobile technologies. In a later phase, the participating pre-service teachers used these skills as teachers to design activities and encourage their students to use metacognitive skills while performing them. These results indicate that metacognitive skills for learning and teaching could be learned and adopted by teachers, which agrees with other studies in mathematics education that examined the influence of education on teachers' knowledge and practice. For example, Agyei and Voogt (2012) found that as a result of working collaboratively to design and develop technological solutions for authentic problems they face in teaching mathematics during their in-school training, a group of pre-service teachers developed their TPACK. We should note that the roles of the mobile technologies as tools for problem solving were influenced by metacognitive questions that the pre-service teachers asked in each metacognitive phase.

To conclude, the present research demonstrated that it is possible to educate mathematics teachers to use metacognitive processes. This education would affect positively their students' use of metacognitive processes (Du Toit & Kotze, 2009), which would result in deeper cognitive processes of the students (Gavelek & Raphael, 1985). Moreover, to succeed in this education, the pre-service teachers need to solve activities that emphasize metacognitive skills, to design such activities, to implement them with students, to discuss their practices, and to reflect on the whole sequence of their metacognitive processes.

REFERENCES

Agyei, D. D. & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service mathematics teachers through collaborative design. *Australasian Journal of Educational Technology, 28*(4), 547-564.

Belet, S. D., & Güven, M. (2011). Meta-cognitive strategy usage and epistemological beliefs of primary school teacher trainees. *Educational Sciences: Theory and Practice, 11*(1), 51-57.

Chauhan, A., & Singh, N. (2014). Metacognition: A conceptual framework. International Journal of Education and Psychological Research (IJEPR), 3(3), 21-22.

Daher, W., Anabousy, A. & Jabarin, R. (2018). Metacognition, positioning and emotions in mathematical activities. *International Journal of Research in Education and Science (IJRES), 4*(1), 292-303.

Daher, W. & Baya'a, N. (2012). Characteristics of middle school students' learning actions carrying out mathematical activities with the cellular phone. *Teaching*

Mathematics and Its Applications: International Journal of the IMA, 31(3),133-152.

Daher, W., Baya'a, N., Jaber, O., & Anabousy, A. (2018). *Developing pre-service mathematics teachers' metacognitive thinking for learning and teaching with mobile technology*. Paper presented at the International Conference on Education in Mathematics, Science & Technology (ICEMST), April 28-May 1, 2018. Marmaris, Turkey.

Davidson, J. E., & Sternberg, R. J. (1998). Smart problem solving: How metacognition helps. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), The educational psychology series. Metacognition in educational theory and practice (pp. 47-68). Mahwah, NJ: Lawrence Erlbaum Associates.

Du Toit, S. & Kotze, G. (2009). Metacognitive strategies in the teaching and learning of mathematics. Pythagoras, 70, 57–67.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), The nature of intelligence (pp.231-236). Hillsdale, NJ: Erlbaum.

Flavell, J. (1999). Cognitive development: children's knowledge about the mind. Annual review of psychology, 50, 21-45.

Gavelek, J. R., Raphael, T. E. (1985), Metacognition, instruction, and questioning, In D. L. Forrest-Pressley, G. E. MacKinnon, T.G. Waller (Eds.), Metacognition, cognition, and human performance (Vol. II, pp. 103- 132), Orlando: Academic Press.

Ng, W., & Nicholas, H. (2012). A framework for sustainable mobile learning in schools. British Journal of Educational Technology, 44 (5), 695–715.

Panaoura, A., Philippou, G., & Christou, C. (2003). Young pupils' metacognitive ability in mathematics. Paper presented at the Third Conference of the European Society for Research in Mathematics Education.

Patton, M.Q. (2002). Qualitative Research and Evaluation Methods. Thousand Oaks, CA: Sage.

Schoenfeld, H. (1992). Learning to think mathematically: problem solving, metacognition and sense making in mathematics. In D. A. Grouws (Ed), Handbook of research on mathematics teaching and learning (pp. 334-368). New York: McMillan.

Spiller, D., & Ferguson, P.B. (2011). Teaching strategies to promote the development of students' learning skills. Hamilton, New Zealand: Teaching Development Unit.

Veenman, M.V.J., Van Hout-Wolters, B.H.A.M, & Afflerbach, P. (2006). Metacognition and Learning: Conceptual and Methodological Considerations. Metacognition and Learning, 1, 3-14.