

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/326102530>

# In-Service Mathematics Teachers' Integration of ICT as Innovative Practice

Article in *International Journal of Research in Education and Science* · July 2018

DOI: 10.21890/ijres.428945

CITATIONS

5

READS

184

3 authors:



**Wajeeh Daher**

An-Najah National University

130 PUBLICATIONS 403 CITATIONS

[SEE PROFILE](#)



**Nimer Baya'a**

Al-Qasemi Academic College of Education

44 PUBLICATIONS 187 CITATIONS

[SEE PROFILE](#)



**Rawan Anabousi**

Tel Aviv University

5 PUBLICATIONS 6 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



function transformations [View project](#)



Learning mathematics with mobile phones [View project](#)



ISSN: 2148-9955

## International Journal of Research in Education and Science (IJRES)

[www.ijres.net](http://www.ijres.net)

### In-Service Mathematics Teachers' Integration of ICT as Innovative Practice

Wajeeh Daher<sup>1,2</sup>, Nimer Baya'a<sup>1</sup>, Rawan Anabousy<sup>1</sup>

<sup>1</sup>Al-Qasemic Academic College of Education

<sup>2</sup>An-Najah National University

#### To cite this article:

Daher, W., Baya'a, N., & Anabousy, R. (2018). In-service mathematics teachers' integration of ICT as innovative practice. *International Journal of Research in Education and Science (IJRES)*, 4(2), 534-543. DOI:10.21890/ijres.428945

This article may be used for research, teaching, and private study purposes.

Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

Authors alone are responsible for the contents of their articles. The journal owns the copyright of the articles.

The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of the research material.

## In-Service Mathematics Teachers' Integration of ICT as Innovative Practice

Wajeeh Daher, Nimer Baya'a, Rawan Anabousy

---

### Article Info

#### Article History

Received:  
19 July 2017

Accepted:  
27 February 2018

---

#### Keywords

In-service teachers  
Professional development school  
Integration of ICT  
Mathematics teachers  
Innovation diffusion model (IDM)

---

### Abstract

The Professional Development School (PDS) can serve as a catalyst for the professional development of mathematics pre-service as well as in-service teachers. In the present research, we describe lower-secondary in-service mathematics teachers' development of ICT integration in their teaching. This is done through the Innovation Diffusion Model of Rogers, which consists of five stages: knowledge of an innovation, (2) forming an attitude toward the innovation, (3) taking a decision to adopt or reject, (4) implementation of the innovation, and (5) confirmation of the decision by affirming or rejecting it. In the present research, ICT integration in mathematics teaching is considered as an innovation candidate for adoption by mathematics in-service teachers, where this adoption is facilitated by a community of inquiry consisting of in-service teachers, pre-service teachers and researchers. Five in-service middle school mathematics teachers participated in the present research. We used two data collecting tools: observations and semi-structured interviews to collect data about different issues related to the integration of ICT in the lessons of the participating in-service teachers. The categories of the innovation diffusion model were used to analyze the participants' adoption of ICT for their teaching before and after our intervention through the implementation of the PDS model for the period of one academic year. The research findings indicate that the participating in-service mathematics teachers' attitudes and beliefs regarding the benefits of ICT for mathematics teaching were positive at the beginning of the experiment as well as at its end. At the same time, teachers' knowledge and experience of using ICT tools in mathematics teaching improved, which contributed positively to the confirmation of their decision to adopt these tools for their classrooms. Specifically, the research results indicate that the PDS can support the in-service mathematics teachers in their adoption of new innovations, specifically when this innovation is practiced by the pre-service teachers in the training school.

---

### Introduction

Researchers point at ICT integration in mathematics education as supporting teachers in their instruction and supporting students in their explorations of scientific relations. So, it should be the goal of teachers' colleges to develop pre-service teachers' integration of ICT in their teaching. This role has extended in the frame of the PDS model of pre-service teachers' preparation to developing also the mentoring in-service teachers' integration of ICT in their teaching. In the present research we try to understand the development of ICT integration of five in-service mentoring mathematics teachers who accompanied our 18 third year pre-service teachers majoring in teaching mathematics and computer science in the middle school.

### ICT Use in Teaching Mathematics and Obstacles Hindering This Use

In general, Different studies described the benefits of integrating ICT in Education for students (as contributing to the production of knowledge and students' interaction) and teachers (as promoting new pedagogical practices and enhancing teaching). More specifically, Becta's (2003) clarifies the contribution of ICT to students' production of knowledge, saying that ICT causes students not only to receive information, but also to provide information themselves. This could be considered an indicator that ICT supports constructivist pedagogy, where students use technology to explore and reach the understanding of mathematical concepts, which specifically

enhances students' understanding of basic concepts (Kreijns, Vermeulen, Kirschner, van Buuren, Van Acker, 2013). Becta (2003) also points at the contribution of ICT to students' interaction, saying that ICT enhances and encourages the interaction between students, as well as between students and the technology itself. ICT also contributes to teachers' instruction, as Kreijns et al. (2013) claim that ICT can enable, promote, and reinforce the use of new pedagogical practices that correspond with the educational demands of the twenty-first-century knowledge society. In addition, ICT, when combined with authentic activities can contribute to students' positive emotions (Daher, 2011), as well as beliefs about the nature of mathematics (Daher, 2013).

In spite of the ICT benefits described above, teachers are often reluctant to use Information and Communication Technology (ICT) (Kreijns et al., 2013). Keong, Horani and Daniel (2005) and Jones (2004) identified different barriers to ICT integration: (1) lack of confidence of teachers in using technology; (2) lack of time in the school schedule for projects involving ICT; (3) insufficient teacher training opportunities for ICT projects; (4) inadequate technical support and lack of resources at the school for these projects; (5) lack of teachers' knowledge about ways to integrate ICT to enhance the curriculum; (6) difficulty in integrating and using different ICT tools in a single lesson; (7) unavailability of resources at home for the students to access the necessary educational materials and (8) the age of the teachers, where older teachers are reluctant to use new digital technologies. These barriers explain why teachers could be reluctant to adopt ICT as an innovation in their teaching, and thus, should be taken into consideration when studying teachers' adoption of such innovations. In the present research, we take these barriers into consideration to study five in-service mathematics teachers' adoption of ICT as an innovation in the mathematics classroom. This adoption of ICT as an innovation could be considered as part of the in-service teachers' professional development in ICT.

### **Teachers' Professional Development in ICT**

The integration of ICT has been a key component of the agenda of teachers' professional development, where this agenda is influenced by three elements overlapping with each other to facilitate the use of ICT within schools (Mumtaz, 2000). These elements are: institutions, resources, and teachers, where the main barrier preventing the implementation of technology in education is teachers' confidence, beliefs and attitudes towards the role of technology, and towards the ability of successfully implementing it within schools (Magen-Nagar & Peled, 2013; Thomas & Palmer, 2014). Thus, it is important to examine teachers' beliefs towards the integration of ICT in their teaching as a first step towards leading them to integrate ICT in the classroom. As supervisors of mathematics pre-service teachers in the training schools, we consider it our role to encourage the integration of ICT in teaching among the mentoring mathematics teachers in the training schools. This role is founded on our conviction that ICT contributes to students' production of mathematical knowledge through supporting them in their mathematical investigations (Kreijns et al., 2013). This role is further based on the comment made by Jaworski and Huang (2014), depending on studies that have explored the relationship between professional development programmes and student performance in mathematics, that an effective professional development programme should include the following characteristics: (I) alignment with shared goals (school, district and state) and assessment; (II) focusing on core content and modelling of teaching strategies for the content; (III) inclusion of opportunities for active learning of new teaching strategies; (IV) provision of opportunities for collaboration among teachers; and (V) inclusion of embedded follow-up and continuous feedback.

As described above, we attempt to encourage in-service mathematics teachers to integrate ICT tools in their mathematics classrooms. In the present research, we try to examine the consequences of one such attempt. We do that utilizing the innovation diffusion model developed by Rogers (2003). In more detail, this examination looks at the development of five mentoring mathematics teachers' beliefs and behaviors regarding the integration of ICT in their teaching in a professional development school (PDS). For us, a PDS is a school in which pre-service teachers, their school mentors and their college supervisors try to professionally develop together (Amer, & Abu Jaber, 2012). Amer and Abu Jaber (ibid) define the partnership among the three communities above as an opportunity for simultaneous professional development of pre-service teachers, college educators as well as school in-service teachers. The ultimate goal of this professional development is improving students' learning in the different aspects: academic, social, cultural and emotional achievement. Furthermore, PDS model considers teaching as a practical reflective profession that combines theory and practice. Specifically for the experiment that we report, our image of PDS utilizes the framework of community of inquiry of Jaworski (2005), where teachers and researchers/didacticians collaborate to develop professionally.

### **Community of Inquiry for Professional Development**

Lave and Wenger (1991) consider knowledge as participation in the practice or activity of the community, and not as the individual consciousness of the participants. Nardi (1996) claims that to understand the participant knowledge we need to look not at the individual, nor the environment, but at the interaction between the two. The learning in the community could be looked at as co-learning inquiry (Jaworski, 2008). This co-learning inquiry means that people engage together in knowledge building through inquiry. This view of knowledge as developing in the community describes the processes through which knowledge develops: engagement, imagination and alignment (Wenger, 1998).

Jaworski (2008) argues that the terms participation, belonging, engagement and alignment all point towards the situatedness of activity and, as a result, the situatedness of the growth of knowledge in practice. Joworski (ibid) emphasizes that the three previous processes mean that in a community of inquiry, the participants are not satisfied with the desirable state. Instead, they approach their practice with a questioning attitude, with the goal to start to explore alternatives through wondering and asking questions about what else is possible, without the intention to change everything overnight. In our case, the alternative was utilizing digital tools in mathematics teaching. The participating in-service teachers questioned their teaching behaviours as compared with the pre-service teachers' behaviours; those behaviours that were informed by their supervisors' beliefs about ICT tools' roles in mathematics education as well as their advice regarding the utilization of digital tools in the mathematics classroom in the training school. In the present research, we intend to study the in-service teachers' utilization of digital tools in the mathematics classroom through the innovation diffusion model.

### **Innovation Diffusion Model**

Innovation diffusion is the process by which innovation is communicated among the members of a social system through certain channels over time (Rogers, 2003). Moreover, the innovation-decision process is an activity in which information is sought and processed. In this activity, an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation (Sahin, 2006). Moreover, according to Rogers (2003), the innovation diffusion process passes over time through five stages (1) knowledge of an innovation, (2) forming an attitude toward the innovation, (3) taking a decision to adopt or reject, (4) implementation of the new idea, and (5) confirmation of the decision by affirming or rejecting it. In the present research, we intend to examine, using Rogers' model of innovation diffusion, the development of ICT integration by in-service mathematics teachers working in a PDS.

The innovation diffusion model was used by various researchers to study various aspects of educational innovations. We are interested here in using this model in technology integration in education. One such studies is that of Parisot (1995) who studied the adoption and diffusion of technology as an instructional tool by the faculty members of a public community college. The study results indicated that technology can be a catalyst for faculty to reflect upon their practice and can encourage a learner-centered teaching methodology. More recently, Buc and Divjak (2015) used the innovation diffusion model to study the the diffusion of e-learning in higher education. Moreover, Carey (2015) sought to explore factors associated with the adoption process of badges in higher education. The innovation diffusion model utilizes several educational constructs in which mathematics education researchers have been studying in frame of their study of mathematics teachers' practices and professional development. These constructs include teachers' beliefs and decisions.

### **Teachers' Beliefs and Decisions**

Schoenfeld (1998) links teachers' decisions to their beliefs by arguing that teachers' knowledge, goals and beliefs influence their decision-making in the mathematics classroom. Moreover, teachers' beliefs have mutual relationship with their interactions with their students (Richardson, 1996; Voss, Kleickmann, Kunter & Hachfeld, 2011). Specifically, Barkatsas and Malone (2005) found that teachers' beliefs impact their practices. On the other hand, several researchers claim that beliefs are but one aspect that influence teachers' practice including their interaction with their students. Other aspects are teachers' knowledge and attitudes (Remillard & Bryans, 2004; Schoenfeld, 2008).

Hannula, Op't Eynde, Schlöglmann and Wedege (2007) describe factors of mathematics teachers' beliefs as agreed upon by Rösken, Pehkonen, Hannula, Kaasila and Laine (2007), as well as by Diego-Mantecón,

Andrews and Op't Eynde (2007): Beliefs about mathematics (e.g. difficulty, enjoyment), beliefs about the self (e.g., goal orientations, relevance, self-efficacy), and beliefs about the classroom context (e.g. teacher's role).

As to teachers' decisions, teachers' decision-making and lesson-practice are interrelated (Bosse & Törner, 2013; Hobbs, 2012). Researchers have attempted to characterize the factors that affect teachers' decisions to use technology in their teaching, and how these decisions affect their practice. For example, Daher and Baya'a (2014) studied teachers' decisions to use mobile learning in the mathematics classroom, and found that different factors have an impact on teachers' decisions regarding the use of mobile learning in the mathematical lessons. The factors include the teacher's history of using technologies in teaching; the teacher's perceptions of using technologies in teaching; the school community, including the principal and the coordinating teacher; rules regulating the use of technologies in teaching mathematics; and division of labor regarding this use, as who should prepare the learning activities needed to be used for learning mathematics with the mobile phone.

### **Research Rationale and Goals**

The present research intends to examine lower-secondary in-service mathematics teachers' development of ICT integration in their teaching, where this integration is considered as an innovation candidate for adoption by mathematics in-service teachers, where this adoption is facilitated by a community of inquiry consisting of in-service teachers, pre-service teachers and researchers. This is done through the Innovation Diffusion Model of Rogers. This research is reporting an additional experiment of us that aimed at developing in-service and pre-service teachers' integration of ICT in mathematics education.

In a previous research (Daher, Baya'a, Anabousy & Anabousy, 2017), we tried to understand and analyse pre-service teachers' acceptance of ICT tools using the technology acceptance model of (Davis, 1989). In another previous research, we used the activity theory lens to understand teachers' decisions to use technology in the mathematics classroom (Daher & Baya'a, 2014). Our aim in using different theoretical framework to understand and analyse pre-service and in-service teachers' integration, as well as the development of this integration, is to try to understand this integration from different points of view. This would add to our knowledge and to the literature regarding mathematics teachers' integration of ICT in their teaching. The current theoretical model that we utilize in the present research has not been utilized intensively in mathematics education, which points at the need to take advantage of it to understand mathematics teachers' practice regarding technology integration in their teaching. Our use of the innovation model fits the issue that we study, teachers' technology use, for ICT integration could be considered an educational innovation.

### **Research Methodology**

In the present research, we report the development of the integration of ICT by five lower-secondary in-service mathematics teachers in a practical training school, because of their mentoring of our mathematics pre-service teachers according to the PDS model during one academic year.

### **Participants**

The five in-service mentoring mathematics teachers accompanied our 18 pre-service teachers who were in their third academic year majoring in teaching mathematics and computer science in intermediate schools. All of the mentoring teachers had a Bachelor degree in mathematics and a teaching certificate, with at least 10 years of seniority in teaching. The teachers had some experience in teaching mathematics using technology. Two of them were part of an experiment led by a courseware development company for a whole year. Their feedback about this experiment was mostly negative, for they claimed that it had destructive effect on their students' formal procedural knowledge in mathematics. It was a challenge for us to persuade these teachers to agree once more to get involved in a new experiment in teaching mathematics with technology.

### **Research Process and Intervention Method**

In the preparation of our pre-service teachers, these pre-service teachers are required, in their third year of study, to integrate ICT in their practice as trainees in the training schools. In this integration, they are requested to use various ICT tools and technological pedagogical models which they were introduced to and discussed in the

didactics courses. Examples of such tools and models include: Videos and presentations; digital worksheets and games; spreadsheets, applets and GeoGebra; applications of cellular phones; Wiki, Google Docs and Sites; and social networking sites such as Facebook. The mentoring teachers were encouraged by the pre-service teachers' supervisors to use the same ICT tools in their teaching of mathematics. Moreover, our pre-service teachers are trained specifically to use visual dynamic tools to investigate with their students questions that encourage higher order cognitive skills, such as: 'Would the three perpendiculars in a triangle meet at the same point? If so, what could you say about the location of that point?' They would help their students phrase conjectures and discuss using mathematical reasoning the correctness and justification of these conjectures. The mentoring teachers are encouraged to use the visual dynamic tools by themselves in order to encourage their students' conjecturing and justification of mathematical relations.

To encourage the in-service teachers to integrate technology, the following support and preparation phases were employed: watching and analysing video clips of past-years pre-service teachers performances during integrating technology in their mathematics teaching, preparing ICT-based mathematics lessons together with the pre-service teachers, watching the present pre-service teachers teach ICT-based mathematics lessons, teach together with the pre-service teachers ICT-based mathematics lessons, teach with the support of pre-service teachers ICT-based mathematics lessons, and finally teach by themselves ICT-based mathematics lessons on their own. After each of these phases, the supervisors met the specific teacher and had a talk with her regarding her experience of that phase. Sometimes, this meeting included also the pre-service teacher/s who were present at that phase, as for example when the pre-service teacher taught the lesson and the teacher watched this teaching.

### **Data Collecting Tools**

We used two collecting tools: semi-structured interviews and observations to collect data about different issues related to the integration of ICT in the lessons of the participating in-service teachers. In more detail, we used semi-structured interviews to collect data about the participating in-service teachers' knowledge, experiences and beliefs regarding the ICT integration in mathematics teaching at the beginning and end of the academic year. These interviews included questions, such as: "What knowledge you have of technological tools?", "What ICT tools do you know that could be beneficial in teaching mathematics?", "How do/would you use these tools in your teaching of mathematics?", "What experiences do have of integrating ICT in teaching mathematics?", "What obstacles do you tackle when you try to use ICT in teaching mathematics?", and "What are your attitudes toward integrating ICT in teaching mathematics? Explain these attitudes." At the same time, we used observations to assess the actual integration of ICT in the in-service teachers' lessons. These observations were performed throughout the academic year, especially towards its end.

### **Data Analysis**

To analyze the data, 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 is used to generate concepts or variables from theory (Patton, 2002). In the present research we used, in the deductive reasoning, the theoretical framework of the innovation diffusion model (Rogers, 2003) in order to categorize the in-service teachers' beliefs and practices of the integration of ICT into mathematics teaching. Doing so, we identified factors that could affect the innovation diffusion in each stage regarding the in-service teachers' use of ICT in teaching mathematics. These stages were: knowledge (when the participants learned about ICT use in mathematics teaching), persuasion (when they were persuaded of the value of ICT use in mathematics teaching), decision (when they decided to adopt ICT use), implementation (when actually integrating ICT in the classroom), and confirmation (when the integration was affirmed).

### **Findings**

We present the in-service teachers' knowledge, experience, obstacles and beliefs at the beginning of the academic year, then the other stages and afterwards we present again their knowledge, experience, obstacles and beliefs at the end of the academic year.

### **Teachers' Knowledge, Experience, Obstacles and Beliefs at the Beginning of the Academic Year**

At the beginning of the initiative, we, as supervisors of pre-service teachers in a PDS, faced some difficulties and obstacles convincing the mentoring teachers to integrate technology in mathematics teaching. One reason for the existence of these difficulties is the moderate knowledge possessed by the participating teachers in ICT. In more detail, the participating teachers reported that generally they were acquainted with some Office programs, like Word and PowerPoint, and with the Internet. The difficulties and obstacles were due also to the little experience of the participating teachers in integrating ICT in their mathematics teaching. For example one teacher reported using ICT infrequently for one year, while another teacher reported using only PowerPoint presentations and sometimes online games.

Together with the moderate knowledge in ICT and the little experience of the participating teachers in integrating ICT in their mathematics teaching, they were confronting different types of obstacles that discouraged them from integrating ICT in the classroom. These obstacles were of the types: Logistic obstacles (Insufficient infrastructure, students' density in the classroom, insufficient number of lessons), technology knowledge obstacles (fear to use technological tools), and technological pedagogical content knowledge obstacles (need for pedagogical support in integrating technology in the specific mathematical topics).

In spite of the participating teachers' little experience in integrating ICT in their teaching and the obstacles that they confronted and discouraged them to integrate ICT in the classroom, the participating teachers had positive beliefs about the ICT integration in mathematics teaching. These positive beliefs were expressed through talking about the advantages of ICT integration in mathematics teaching: Advantages related to the learning materials (Connecting mathematics with real life phenomena, embodiment and visualization of mathematical concepts, manipulation of the mathematical objects), advantages related to the learner (contribution to the learner's cognitive skills, contribution to the learner's technical skills, contribution to the learner's imagination skills, bridging the gap between students, bridging the gap between students and the teacher), and advantages related to the teacher (providing tools that assist the instruction, contribution to the material coverage, explaining the content).

These mentoring teachers' beliefs about the use of technology in the mathematics classroom were probably due to the general atmosphere regarding the importance of technology in education. This general atmosphere consisted in the atmosphere across schools, as well as in the school itself. The mentoring teachers' beliefs were also due to their preparation as pre-service teachers, where this preparation includes at least two courses in ICT integration in teaching. In spite of the participating teachers' positive beliefs, they were reluctant to integrate technology in mathematics education due, as mentioned before, to their little experience to do so and to the obstacles of different types that they were confronting in doing so.

### **Persuasion, Decision and Adoption**

The five participating in-service teachers agreed to mentor the pre-service teachers in their attempt to integrate ICT in their teaching. Nevertheless, they were afraid to integrate by themselves ICT in their teaching. We guaranteed the collaboration of our pre-service teachers with them and promised to accompany them in their integration of ICT in their teaching. This made them more convinced to accompany our pre-service teachers in their integration of ICT in mathematics teaching; what resulted in their decision to participate in the experiment. In the interview, the mentoring teachers emphasised the importance of the support given by the pre-service teachers' supervisors to the mentoring teachers and to the pre-service teachers. They said that this support gave them confidence to practise using ICT tools in their teaching of mathematics. Overall, it could be said that all the participating teachers adopted our initiative; i.e. using ICT in mathematics teaching, but in different levels.

### **Implementation: Knowledge, Experience and Obstacles**

The mentoring teachers reported that their experience of accompanying the pre-service teachers in integrating technology in teaching mathematics added to their knowledge regarding technology itself, as well as its integration, and encouraged them themselves to integrate technology into their own teaching. This accompanying, they said, made their integration of technology into their own teaching easier and enjoyable. More specifically, three domains of pre-service teachers' assistance were pointed at by the mentoring teachers: technical assistance (for example helping in drawing functions using GeoGebra), technological pedagogical content assistance (for example helping in building technological pedagogical models using GeoGebra for



teaching specific mathematical topics), and affective assistance (for example showing understanding for the difficulties which the mentoring teachers encounter). In addition, the mentoring teachers' experiences also included tackling logistic and technical obstacles while integrating technology in their teaching, but they looked at these obstacles as a natural part of engaging with ICT in teaching.

### **Confirmation: In-Service Teachers' Beliefs and Intentions at the End of the Academic Year**

At the end of the experiment, the mentoring teachers had the same positive beliefs about integrating technology in the mathematics classroom, but now these beliefs seemed to be founded on their experiences and not only on their previous studies and the general atmosphere regarding the importance of ICT in education, especially in mathematics education. Moreover, the mentoring teachers became more knowledgeable regarding what to do with ICT in the mathematics lessons.

Regarding their intentions to use ICT in their teaching, the mentoring teachers expressed their intention to integrate ICT in their future teaching of mathematics, but as an additional tool in the mathematics classroom, and not all the time. For example one mentoring teacher said that GeoGebra is best for students to investigate mathematical relations, but the pencil and paper are needed for the students to assimilate and improve their procedural and formal mathematical skills.

## **Discussion**

The in-service mathematics teachers who participated in the research had at the beginning positive beliefs about the contribution of digital tools to mathematics teaching. Furthermore, being part of a PDS, these participating teachers substantiated with classroom-evidence their starting beliefs regarding the integration of technology in the mathematics classroom. The pre-service teachers' initiatives and experiences in teaching mathematics with ICT constituted the first phase of this evidence witnessed by the in-service teachers, but soon the evidence came from the in-service teachers' own experiences of integrating ICT in their mathematics teaching. The development of the in-service mathematics teachers' beliefs and practices regarding the integration of ICT in their teaching would probably not have happened without the PDS, for it helped create a community of teaching professionals that encouraged certain teaching behaviors (including integrating ICT in mathematics teaching and learning) and substantiated beliefs regarding these behaviours (Jaworski, 2008). The PDS was optimal for the in-service teachers to substantiate their positive beliefs about the integration of ICT in their teaching. This is due to the fact that in this context, it is possible for the in-service teachers to experiment teaching behaviors, and thus decide whether to adopt these behaviors or not. It could be claimed that the PDS in which the in-service teachers, the pre-service teachers and the researchers were part of, was effective due to the characteristics of the PDS that included appropriate context (as supporting professional development and the changes it is intended to bring about), appropriate content (as sharpening the participants' classroom skills), and appropriate process (as supporting interaction among the participants) (Harwell, 2003). Furthermore, this PDS was effective for it included the factor of shared vision among all the participants in the PDS which is needed for the success of the PDS (Lynch-Davis, Salinas, Crocker & Mawhinney, 2015). This shared vision was there from the beginning, but the practices of the PDS strengthened it.

This positive influence of the PDS on the educational scene is described by researchers; for example by Cave and Brown (2010) regarding the positive influence on students' achievement, and by Boote (2014) regarding the positive influence on mathematics pre-service teachers' emerging pedagogical content knowledge. The present research found that the PDS has also positive influence on mathematics in-service teachers' practices; specifically on their adoption of new innovation - the practice of ICT integration in mathematics teaching. It should be emphasized that the PDS paved the way to the successful work of a community of inquiry that had the goal of advancing the utilization of digital tools in the mathematics classroom.

The theory of the community of inquiry or practice (Wenger, 1998), utilized above to explain the PDS effect on the participating in-service teachers' utilization of ICT tools in their classrooms, could be further utilized to connect the concept of identity to the concept of practice. In the present research, the in-service teachers were part of a community of practice, where the identity of the in-service teachers moved towards closing the gap between the actual identity and that designated by the researchers through experimenting with the pre-service teachers. It seems that the identity of the in-service teachers reached equilibrium, regarding their use of ICT in their teaching of mathematics. This equilibrium was between their actual identity before the experiment and that designated by the researchers. Closing the gap or reaching an equilibrium between the actual and the designated

identity of teachers indicates that the in-service teachers underwent professional development; in other words learning (Sfard & Prusak, 2005).

## Conclusions and Recommendations

The PDS could serve as a platform for social learning in a community of inquiry with the goal of utilizing digital tools for teaching, in our case mathematics teaching. This social learning has assumptions that differ from those made in the common theoretical frameworks of teachers' competencies and professional development (Bosse & Törner, 2015). Programmes of professional development of mathematics teachers that emphasise the utilization of ICT tools in the mathematics classrooms can benefit when following this model of social learning in a community of inquiry in which researchers, in-service teachers and pre-service teachers learn together to find the best ways for utilizing digital tools in the mathematics classroom. Future research could study the relationship between pre-service teachers' adoption of digital tools for mathematics teaching and their mentoring in-service teachers' adoption of these tools for this teaching. Such research could be qualitative or quantitative or combined.

## References

- Amer, A., & Abu Jaber, S. (2012). Professional Development Schools (PDSS) as a teacher training reform in two Arab teacher training colleges in Israel. *Jamea'a*, 16, 1-20.
- Barkatsas, A., & Malone, J. (2005). A typology of mathematics teachers' beliefs about teaching and learning mathematics and instructional practice. *Mathematics Education Research Journal*, 17(2), 69-90.
- Becta. (2003). *What the research says about using ICT in Maths*. UK: Becta ICT Research.
- Boote, S.K. (2014). Who's Tutoring Who? Reflections from a Field-Based Elementary Mathematics Methods Course. *Florida Association of Teacher Educators Journal*, 1(14), 1-21.
- Bosse, M., & Törner, G. (2013). Out-of-field Teaching Mathematics Teachers and the Ambivalent Role of Beliefs – A First Report from Interviews. In M. S. Hannula, P. Portaankorva-Koivisto, A. Laine, & L. Näveri (Eds.), *Proceedings of the MAVI-18 Conference: Current state of research on mathematical beliefs* (pp. 341–355). Helsinki, Finland.
- Bosse, M., & Törner, G. (2015). Teachers' professional development in terms of identity development – a shift in perspective on mathematics teachers' learning. In K. Krainer & N. Vondrova (eds.), *Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education (CERME9)* (pp. 2769-2775). Prague, Czech Republic: ERME.
- Buc, S., & Divjak, B. (2015). *Innovation diffusion model in higher education: Case study of e-learning diffusion*. Paper presented at International Association for Development of the Information Society. Retrieved from <http://proxy.lib.odu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED562467&site=ehost-live&scope=site>
- Cave, A., & Brown, C. W. (2010). When learning is at stake: Exploration of the role of teacher training and professional development schools on elementary students' math achievement. *National Forum of Teacher Education Journal*, 20(3), 1-21.
- Daher, W. (2011). Learning mathematics in the mobile phone environment: students' emotions. *Journal of interactive learning research*, 22 (3), 357-378.
- Daher, W. (2013). Cognitive, Meta-Cognitive, Affective, Social and Behavioral Aspects of Mobile Mathematics Learning. *The electronic Journal of Mathematics and Technology*, 7 (5), 364-38.
- Daher, W. & Baya'a, N. (2014). In-service and Pre-service Middle School Mathematics Teachers' Attitudes and Decisions Regarding Teaching Mathematics Using Mobile Phones. *International Journal of Interactive Mobile Technologies (iJIM)*, 8 (4), 4-13.
- Daher, W., Baya'a, W., Anabousy, A., & Anabousy, R. (2017). Pre-service teachers' preparation as a catalyst for the acceptance of digital tools for teaching mathematics and science. In G. Aldon & J. Trgalova (ed.), *Proceedings of the 13th International Conference on Technology in Mathematics Teaching – ICTMT 13* (pp. 232-240). Lyon, France: Ens de Lyon.
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), 319-339.
- Diego-Mantecón, J., Andrews, P., & Op't Eynde, P. (2007). Refining the mathematics-related beliefs questionnaire (MRBQ). In D. Pitta-Pantazi & G. Philippou (Eds.), *Proceedings of the fifth congress of the European Society for Research in Mathematics Education, CERME 5* (pp. 229-238). Larnaca, Cyprus: ERME.

- Hannula, M., Op't Eynde, P., Schlöglmann, W., & Wedege, T. (2007). Working group 2: Affect and mathematical thinking. In D. Pitta-Pantazi & G. Philippou (Eds.), *Proceedings of the fifth congress of the European Society for Research in Mathematics Education, CERME 5* (pp. 202-208). Larnaca, Cyprus: ERME.
- Harwell, S.H. (2003). *Teacher Professional Development: It's Not an Event, It's a Process*. Waco, Texas: CORd.
- Hobbs, L. (2012) Teaching 'out-of-field' as a boundary-crossing event: factors shaping teacher identity. *International journal of science and mathematics education, 11*(2), 271–297
- Jaworski, B. (2005). Learning communities in mathematics: Creating an inquiry community between teachers and didacticians. In R. Barwell and A. Noyes (Eds.), *Research in Mathematics Education: Papers of the British Society for Research into Learning Mathematics*, Vol. 7 (pp. 101-119). London: BSRLM
- Jaworski, B. (2008). Building and sustaining inquiry communities in mathematics teaching development In K. Krainer & T. Wood (Eds.), *Participants in Mathematics Teacher Education* (pp. 309-330). Rotterdam: Sense Publishers.
- Jaworski, B., & Huang, R. (2014). Teachers and didacticians: Key stakeholders in the processes of developing mathematics teaching. *ZDM, 46*(2), 173–188
- Jones, A. (2004). *A Review of the Research Literature on Barriers to the Uptake of ICT by Teachers*. UK: Becta.
- Keong, C. Horani, S. & Daniel, J. (2005). A Study on the Use of ICT in Mathematics Teaching. *Malaysian Online Journal of Instructional Technology (MOJIT)*, 2(3), 43-51.
- Kreijns, K., Vermeulen, M., Kirschner, P. A., van Buuren, H., Van Acker, F. (2013). Adopting the integrative model of behavior prediction to explain teachers' willingness to use ICT: A perspective for research on teachers' ICT usage in pedagogical practices. *Technology, Pedagogy and Education. 22* (1), 55-71.
- Lynch-Davis, K., Salinas, T. M., Crocker, D., & Mawhinney, K. J. (2015). The Necessity of Shared Vision to Achieve Coherence: Lessons Learned in the Appalachian Mathematics Partnership. In *STEM Education: Concepts, Methodologies, Tools, and Applications* (pp. 101-111). Hershey, PA: IGI Global.
- Magen-Nagar, N. & Peled, B. (2013). Characteristics of Israeli school teachers in computer-based learning environments. *Journal of Educators Online, 10* (1), 1-34.
- Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. *Journal of Information Technology for Teacher Education, 9*(3), 319–342. Ball, D. L. (1990). Prospective elementary and secondary teachers' understanding of division. *Journal for Research in Mathematics Education, 21*(2), 132-144.
- Op't Eynde, P., De Corte E., & Verschaffel, L. (2002). Framing students' mathematics-related beliefs: a quest for conceptual clarity and a comprehensive categorization. In G.C. Leder, E. Pehkonen & Törner, G. (eds.), *Beliefs: a hidden variable in mathematics education* (pp. 13–36). Dordrecht: Kluwer.
- Rogers, E.M. (2003). *Diffusion of innovations (5th ed.)*. New York: Free Press.
- Parisot, A. H. (1995). *Technology and teaching: The adoption and diffusion of technological innovations by a community college faculty* (Doctoral dissertation). Montana State University, 1995). ProQuest DigitalDissertations. (UMI No. AAT 9542260).
- Remillard, J. & Bryans, M. (2004). Orientation toward mathematics curriculum materials. *Journal for Research in Mathematics Education, 35*, 352-388.
- Richardson, V. (1996). The role of attitude and beliefs in learning to teach. In J. Sikula, T. Buttery, & E. Guyton (Eds.), *Handbook of research on teacher education* (2nd ed., pp. 102–119). New York, NY: Macmillan
- Rogers, E.M. (2003). *Diffusion of innovations (5th ed.)*. New York: Free Press.
- Rösken, B., Pehkonen, E., Hannula, M. S., Kaasila, R. & Laine, A. (2007). Dimensions of students' view of themselves as learners of mathematics. In D. Pitta-Pantazi & G. Philippou (Eds.), *Proceedings of the fifth congress of the European Society for Research in Mathematics Education, CERME 5* (pp. 349-353). Larnaca, Cyprus: ERME.
- Sahin, I. (2006). Detailed review of Rogers' diffusion of innovations theory and educational technology-related studies based on Rogers' theory. *The Turkish Online Journal of Educational Technology, 5*(2), 14–23.
- Schoenfeld, A. H. (1998). Toward a theory of Teaching-In-Context. *Issues in Education, 4* (1), 1-94.
- Schoenfeld, A. H. (2008). On modeling teachers' in-the-moment decision making. *Journal for research in mathematics education, 14*, 45-96.
- Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher 34*(4), 14-22.
- Thomas, M. O. J., & Palmer, J. (2014). Teaching with digital technology: Obstacles and opportunities. In A. Clark-Wilson, O. Robutti & N. Sinclair (Eds.), *The Mathematics Teacher in the Digital Era: An International Perspective on Technology Focused Professional Development* (pp. 71-89). Dordrecht: Springer.

- Voss, T., Kleickmann, T., Kunter, M., & Hachfeld, A. (2011). Mathematics Teachers Beliefs. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (eds.), *Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers* (pp. 235–257). New York: Springer.
- Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, U.K.: Cambridge University Press.

---

### Author Information

---

**Wajeeh Daher**

An-Najah National University, Nablus, Palestine  
& Al-Qasemi Academic College of Education, Baqa  
Israel  
Contact e-mail: [wajeehdaher@gmail.com](mailto:wajeehdaher@gmail.com)

**Nimer Baya'a**

Al-Qasemi Academic College of Education, Baqa  
Israel

**Rawan Anabousy**

Al-Qasemi Academic College of Education, Baqa  
Israel

---