Effect Of Geogebra Professional Development On Inservice Secondary Mathematics Teachers' Technology Integration Level

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Abstract

Integrating technology in education has not been and still is not an easy task. Teachers' adoption of technology in their teaching is even more problematic. The availability of technology added another challenge to educators, teachers, parents as well as students. This article is one part of an ongoing PhD thesis which is a multiple case study aiming to study in depth the effect of a GeoGebra (a free mathematics software) intervention on secondary mathematics teachers -teaching the Lebanese curriculum in English- practices regarding GeoGebra integration in their teaching. The type of the study is Design-Based Research that stresses on working closely with practitioners in collaborative and iterative manner in the real context with the aim of producing principles that add to theory and practice. Results showed increase in teachers' extent of use of GeoGebra in their teaching especially in adopting a student-centered approach.

Keywords: Technology integration, PD, in-service secondary teachers, GeoGebra, DBR.

Introduction

When new technologies appear in medical or industrial fields, we see a rush to replace obsolete tools with new ones, the staff get immediate training on their use; the adoption level is high and quick. Why does this not happen in the education field? This question is not easy to answer because a lot of factors come in the adoption and the education field is known for being slow in its rate to change.

Literature review

We can find a lot of research that have studied in details the problem of technology integration in classes in general and mathematics classes in particular. In what follows are the main findings. First, research in many countries has found that technology still plays a marginal role in mathematics classrooms and that access to technology resources, educational policies, and institutional support are insufficient conditions for ensuring effective integration of technology into teachers' everyday practice (e.g., Cox, Abbott, Webb, Blakely, Beauchamp, & Rhodes, 2004; Cuban, Kirkpatrick, & Peck, 2001; Goos & Bennison, 2008; Tondeur, van Keer, van Braak, & Valcke, 2008). Second, there is a big gap between research and practice. The ongoing challenge of understanding technology integration problems is of three folds: (a) previous research done on the integration of technology in teaching has had unrealistic expectations for technology-based reform, (b) lacks consensus on research questions and methodologies, and (c) lacks emphasize on the role of research on changes in educational practice (Shrum, 2011). Each research focused on some aspects of the integration problem such as lack of teachers training (e.g., Law, 2008; Tondeur et al., 2008) or lack of theory (Mishra & Koehler, 2006) and suggested certain solution(s) such as conducting professional development with specific characteristics, working with mentors (Kratcoski, Swan, Mazzer, 2007), working in a community-based inquiry environment (Lavicza, Hohenwarter, Jones, Lu, & Dawes, 2010), or working with a theoretical framework such as TPACK, but most of these suggestions "have crashed on the hard rocks of the classroom" (Herrington, McKenney, Reeves, & Oliver, 2007, p. 9). The problem is deeper than it seems and the teacher is at its center, since teachers' successful experiences with technology greatly influences both their continuation in using technology and other teachers' willingness to integrate technology in their classes (Ertmer & Ottenbreit, 2009), therefore teachers need to be able to actively participate in that process of technology integration (Voogt et al., 2011).Third, in most researches the methodology used is not sufficient for such a complicated multi-faceted problem resulting in a lack of impact of research in practice (Herrington, McKenney, Reeves, & Oliver, 2007). Fourth, some like Mishra and Koehler (2006) argue that the problem is the lack of a theoretical framework for technology integration, while this is true is not enough in order to inform practice. Most research used one theory leading to partial perspective of the technology integration problem. This is due to the nature of the object under study (math education) that can be viewed from different theoretical perspectives, e.g. cognitive, semiotic, social…

Summing up all of the above, this study combines working with a community of in-service mathematics teachers around GeoGebra to study its effect on technology integration trying to answer the following research questions:

1. How and to what extent does a GeoGebra intervention done cooperatively and iteratively affect in-service secondary mathematics teachers' practices regarding integrating GeoGebra in their teaching?
2. How does the participants’ background and perception of the integration barriers mediate the impact of the intervention on their practices regarding GeoGebra integration in their teaching?

Theoractical framework

The theory used was the Zone Theory that categorizes the factors affecting technology usage by teachers are categorized into three zones namely zone of proximal development (ZPD, includes skill, experience, and general pedagogical beliefs), zone of free movement (ZFM, includes access to hardware..., support, curriculum and assessment requirements, students...) and zone of promoted action (ZPA, includes pre-service education, practicum and professional development) (Goos et al., 2010). Goos argued that teachers may also construct personal ZFMs within which constraints or affordances exist as a result of their interpretation of the external environment (Goos, 2005). In order for teachers who are novice in using technology to successfully integrate technology in their classes, their zone of promoted action should be within their zone of free movement and consistent with their zone of proximal development. Putting it in perspective, if technology integration by in-service teachers is to be increased, then those teachers should be equipped with knowledge on technology that is: 1) available for them, 2) related to their curricula, and 3) consistent with their pedagogical beliefs. We have adopted in this study these three criteria but how to do that is also an important factor.

Methodology

Design Based Research (DBR) methodology in three iterations was used in this study over two stages (Figure 1). The first stage is the pre-intervention stage. This stage was dedicated to understanding the situation of integrating GeoGebra in the Lebanese curriculum, piloting the GeoGebra activities and testing the instruments. Six workshops were conducted over two years and a pilot study with two teachers. At the end of this stage four teachers (other than the ones in the pilot study) were selected as cases for the study. After selecting the participants 3 hour-workshop was conducted by the researcher with the four participants to make sure all participants acquired the basic features of the software (GeoGebra). In addition, as a group we collaborated in discussing the topics in the secondary mathematics Lebanese curriculum that could be better taught with the use of GeoGebra. We found that GeoGebra can be used in 37 different lessons of the secondary Lebanese curriculum. The second stage was the intervention stage which was made up of two iterations. In this stage collaboration was one-to-one between the researcher and each of the participants. In the first iteration, the participating teachers decided which lesson they wanted to teach with GeoGebra in accordance with their school mathematics scope and sequence. They were provided with a ready-made GeoGebra activities (made by the researcher) to be implemented in their classes. In the second iteration, teachers adapted already made GeoGebra activities and/or made their own GeoGebra activities. Three visits were conducted with each participant at his/her own school and according to his/her free time. The first visit was to prepare for the first lesson. The second visit was to evaluate the first lesson and prepare for the second lesson. Analysis of data collected from the instruments was done before starting the second iteration as required by Design Based research. The last visit was to evaluate the second lesson and give a general overview of the whole experience.

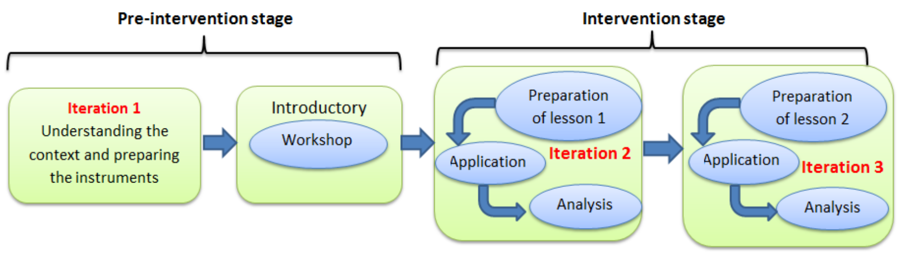

Figure 1. **The stages of the study**

Instruments

For the pre-intervention phase, three questionnaires were administered by the participating teachers: (1) Demographics questionnaire, (2) Instructional Practices in GeoGebra Questionnaire IPGQ (Form 1), (3) Barriers (grouped in zones) in Using Technology Questionnaire BUTQ (Form 1). The purpose of these questionnaires was to measure teachers' current integration practices of the GeoGebra software in their teaching and the barriers (grouped in three zones) that affect their technology integration. The questionnaires were developed by the researcher, reviewed by three professors in mathematics education and piloted for internal validity. The value of Cronbach alpha was >0.9. After conducting the first lesson, semi-structured interview parallel form was used; IPGSI (Form 2), BUTSI (Form 2); to measure the impact of the intervention on teachers' practices and to find out to what extent the zones could mediate that effect. In addition, another instrument was used to assess the GeoGebra activity itself .The instrument is Lesson Assessment Criteria semi-structured Interview (LACI) which is based on instrument by Harris, Grandgenett & Hofer (2010).

The analysis was done in general for the four participants and later individually. The general analysis looked for the general impact of the intervention and for the dynamicity of change in the extent of use in each category of the practices and its subcategories. For the impact of the intervention we were interested in the change in the extent of use of GeoGebra at the end of implementation, whereas for the dynamicity we were interested in the pattern in the extent of use of GeoGebra of change happened in between the implementation stages: 'before implementation', 'after implementation 1', and 'after implementation 2'.

Participants

In the sixth (last) workshop conducted by the researcher attendees were given the pre-intervention questionnaires mentioned above. Based on the answers, for the practice instrument, the values were 0 (never use GeoGebra), 1(sometimes use GeoGebra), and 2(most of the time use GeoGebra). The average of all the questions was calculated. An average within the range [0, 0.7[is considered low integration level, an average between [0.7, 1.3] is moderate integration level, and between]1.3, 2] a high integration level. Similarly the average for each zone was calculated in the zone questionnaire that consists of 27 questions. Based on these results, four cases were selected (Pseudonyms: Tima, Sara, Amani, and Hazem) in a way that they differ among themselves in practice level and/ or in at least one barrier level. Table 1 represents the characteristics of each participant.

Name	Age	Highest degree	Teaching experience	Practice level	ZFM	ZPA	ZPD
Aman	50-55	BS	25 years	Low	Moderat	Modera	Low
Tima	23-26	Masters	2 years	Moderate	Low	Modera	Not*
Sara	33-40	BS	7 years	Moderate	Moderat	Low	Not
Haze	41-50	Masters	31 years	High	Moderat	Not	Not

Table 1. Participants domographics, practice and zones level
****Not: the zone is not considered as a barrier to GeoGebra integration***

GeoGebra modules

The criteria used for lesson selection are based on the criteria identified by Angeli & Valanides (2009) called ICT-TPCK. The GeoGebra activities were prepared by the researcher and tested on both students and teachers. The activities were designed based on the following criteria: Each activity: 1) should be student centered, 2) can be conducted by students in a computer lab or elsewhere (classroom or at home), 3) allows student to discover the concept or theorem under study, 4) includes immediate application of the concept under study, 5) does not require prior knowledge of the software.

Each teacher selected an activity according to his/her scope and sequence, so each teacher applied a different GeoGebra activity. Table 2 shows type and place of activities applied by each teacher.

	Activity 1	Place	Activity 2	Place
Amani	Sign of quadratic polynomials	In class	Derivative	In lab
Tima	vectors	In lab	3D	In class
Hazem	Equation of a straight line	In class	Thales Theorem	In class
Sara	Translation of functions	In lab	Vectors	In lab

Table 2. The intervention activities conducted by participating teachers

Results

Stages of use of GeoGebra

The pattern of impact was the same for the extent of use of GeoGebra for lesson presentation, lesson implementation, and lesson enhancement but different for assessment. Figure 2 shows that for lesson presentation, implementation, and enhancement, in general, participants started with '*sometimes* use GeoGebra' and ended with '*most of the time'* after the second lesson. For assessment, there was a slight breakthrough from '*never use* of Geogebra in assessment' to *'sometimes use'* for each of the four participants.

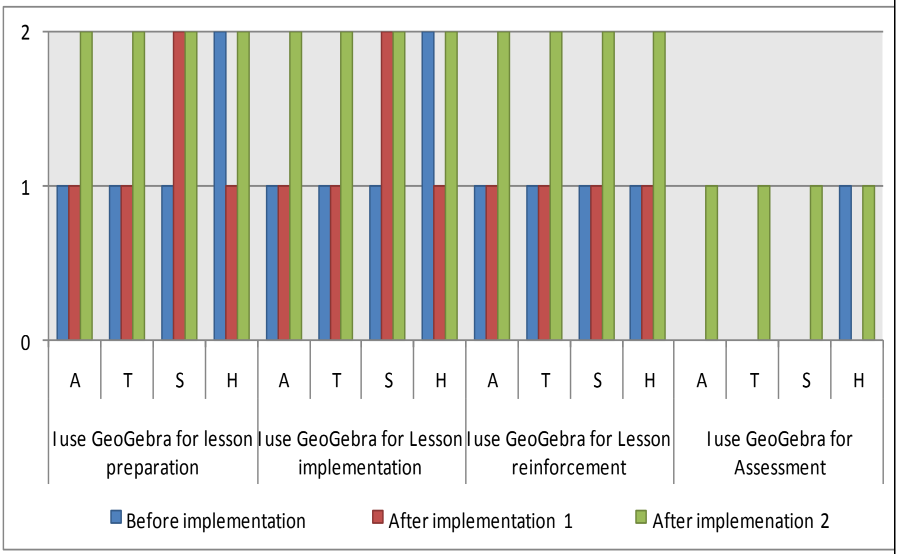

Figure 2. The extent of using GeoGebra by the participating teachers over the three stages:
Before the intervention, after implementing the first lesson , after implementing the second lesson.
0: Never; 1: sometimes; 2: Most of the time
A: Amani; T: Tima; S: Sara; H: Hazem

The increase in the use of GeoGebra is mainly due to the increase of teachers' confidence in using the software after implementing the two activities; in addition teachers sensed the importance and capabilities of GeoGebra in their teaching. The later factor was mostly due to: (a) the effectiveness of the GeoGebra activity, (b) the ease of operating the software by students, (c) the strong alignment between the activity and the curriculum, and (d) lastly the strong fit of the activity with the instructional strategies each teacher uses.

The low extent of use of GeoGebra in assessment by the participants was due to many reasons. The two most important reasons were: the Lebanese national curriculum and assessment and school assessment policies. However, teachers started making different and better test questions using GeoGebra and sometimes they gave their students extra grades on homework using GeoGebra.

Method of use

It is important to use GeoGebra, but what is more important is how to use it. In the method of use category of practices the general pattern is *no* to slight change in all categories. This cannot be explained in general but rather individually because it is related to the background of each teacher and the barriers he/she has faced. In what follows we have selected some examples.

Amani. The application part for Amani's case explains in details the increase in her extent of use of GeoGebra. That increase was not in all aspects and that is due to Amani teaching method which was balanced between teacher-oriented and student-centered but in terms of technology it was teacher-led through presenting a PowerPoint or an applet. After conducting the first activity Amani explained the method she used: "…They (students) worked in groups (in class using their own devices) using sliders (a GeoGebra tool) with me as a guide, it was followed by discussion with me." (Interview 2, November 11, 2015). The second activity was conducted in the computer lab (also for the first time); this lab was newly installed in her school. She described how the students worked the second activity:

They (the students) took the activity home (to save time) then went to computer lab filled what was empty in the worksheet and some were able to help the other students, then we had a follow up and discussion in class. (Interview 3, December 5, 2015)

Sara. Sara made a huge effort to take her students to the computer lab to apply discovery activities− something never done before−and she said: "I will take them (the students) instead of computer periods on Saturday session to introduce them to the software. They never worked with it before.” (Interview 1, October 17, 2015). Another factor was Sara belief that mathematics is only related to physics and to teach mathematics properly is to relate it either to physics concepts or to real life situations: “I see mathematics as related to physics and better to be attached or related to real life examples.” (Interview 1, October 17, 2015). What the results do not show is how the activities were applied and the change in Sara’s perception about mathematics itself. In Sara’s words:

After this experience (applying GeoGebra activity) for the first time and in a lab I will change a lot of things (in my teaching) now I have a lab for secondary. Frankly I will not use that with an LCD in the class to show students such things, there is nothing called to show (not effective) showing them is like treating them as babies not capable of applying and concluding results, when they do it, it is different even for me I felt different. (Interview 2, November 7, 2015).

Hazem. Hazem case and results are different from the previous three cases.

Hazem always use technology in general and GeoGebra in specific *‘for lesson presentation’* and sometimes for *‘students’ presentation’* and that did not change by the intervention. The increase was in *‘conducting discovery activities’* and in *‘modeling problems’*.

Hazem said in explaining how he used to use technology: “I used to do things differently, what I used to do was: students draw many cases with paper and pencil at the same time I show them on LCD then they repeat on their devices.” (Interview 2, February 11, 2016)

But for the intervention:

I gave them the activity paper to do at home and we discussed it in class…I have used GeoGebra in almost every lesson I taught but less in algebra lessons and I am asking my students to try almost all problems at home. (Interview 2, February 11, 2016)

He added: “I used GeoGebra in new way for wrapping a lesson or remember previous theorems in geometry Also.” (Interview 2, February 11, 2016)

Place of Use

Similar to application category there was *no* to slight effect of the intervention on the extent of use of GeoGebra in their classroom, computer lab, or at home (Figure 3).

This was not a surprise because to use GeoGebra in class or in the computer lab is related to availability of equipment and to the method GeoGebra was used. Three out of the four teachers tried one or both of the GeoGebra intervention lessons for the first time in the computer lab.

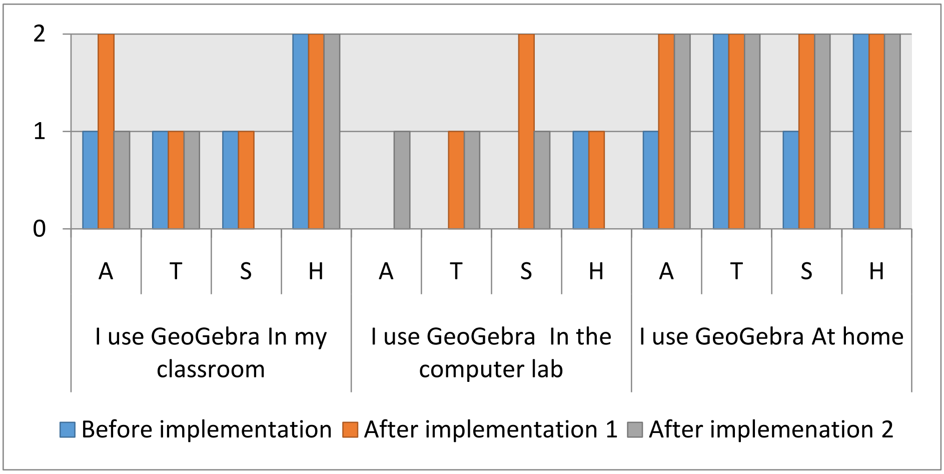

Figure 3. The place of using GeoGebra by the participating teachers over the three stages:
Before the intervention, after implementing the first lesson, after implementing the second lesson.
0: Never; 1: sometimes; 2: Most of the time
A: Amani; T: Tima; S: Sara; H: Hazem

Discussion

GeoGebra intervention done cooperatively and iteratively increased in-service secondary mathematics teachers GeoGebra usage in their practices regarding lesson presentation, lesson implementation, and lesson enhancement. This is consistent with the results of a study on the importance of professional development within the context of teachers' work (Swan, Mazzer, & Kratcoski, 2007). Similar result was found by Ertmer & Ottenbreit (2009) that teachers need positive experience with the help of experienced peers in order to increase their technology integration in their practices. This study had a minor effect on assessment which was also found by study by Hoyles & Lagrange (2010) and by Goos & Bennison (2008). The participants' background in general slowed the process of integrating GeoGbera in their teaching. The lack of updated hardware was the main barrier that mediated the impact of the intervention on their practices (Goos & Bennison, 2010). In addition, the intervention had an important effect on both the increase of use in conducting discovery activities done by students in the computer lab and on participants teaching method with technology to be more student-centered. The barriers teachers faced in application part were of two kinds the accessibility to the computer lab and students' motivation but these barriers minimally mediated the impact of the intervention (Bennison & Goos, 2010). Lastly, the intervention affected to a certain extent the use of GeoGebra at home by the participants whereas it had a minor effect of its use in the computer lab and that is due to two factors the availability of/accessibility to the computer lab and the teaching method each participant adopted in applying the activities. What moderated the impact of the intervention other than the factors related to availability and accessibility was students' motivation. When students were motivated the teacher was encouraged to repeat and the opposite also applies.

Recommendations

It seems that unlike the medical or the industrial fields, the educational field is more complex in integrating technology in terms of social and psychological factors of all the stakeholders.

In the medical field for example the instrument for measuring blood pressure is one tool that is used for all people, young or old, under-weigh or over-weight… To use this instrument or an updated version of it does not require social acceptance or/and making the medical staff believes of its importance. On the other hand, in the educational field there is no technology that fit all ages, abilities, and intelligence levels… Deciding to use any instrument in a certain class needs to pass many filters in order to be an integral part of the teaching-leaning process.

To see change in mathematics teachers’ extent of using GeoGebra in particular and technology in general it seems one day workshop is not the perfect choice according to this study. May be with such professional development teachers’ knowledge might change quickly but more have to be done in order to change their practices. How should universities prepare their pre-service teachers to be ready to use technology in their teaching most of the time? How should professional development be designed to make sure teachers’ practices are changed regarding integrating technology in teaching? May be this study answers some of these questions but more work still to needs to be done to solidify them.

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