Pre-Service Teachers' Perceptions on Implementing Geogebra Software in Mathematics Teaching and Learning

Abstract

There is a gap between the traditional pre-service math teachers' education and the current more innovative math teaching methods through new Information Technology integration. We experimentally introduced the Geogebra software in the pre-service math teachers' curriculum frame to bridge this gap. The purpose of this study is to examine PSTs' perceptions of their teaching and learning experience with Geogebra. Three Geogebra courses were conducted throughout three semesters. The research sample involved (80) secondary-school pre-service teachers from one Israeli Arab teacher training college. The research data are collected through surveys based on (9) questionnaires administered during the course. The data were analyzed by measures of central tendency, variability, and the variance and the standard deviation.. Four of Geogebra (21) tools were perceived as complicated and challenging. The main conclusion, considering the low difficulty ratings for workshop activities, is that the Geogebra course is appropriate for enriching the teaching and learning processes of future secondary school math teachers.

Keywords word: Education Software, Geogebra, Mathematics Education, Pre-service Teachers.
Subject classification codes: 97C70, 97D40, 97P10

Introduction

This study attempts to bridge the gap between traditional methods of math education and more innovative math teaching methods through technological integration in pre-service math teachers' curriculum and field experience using Geogebra software.

The study is part of a research that aims to analyze the math teachers' professional development process through the introduction and practice of digital technology tools concerning Geogebra.

Innovative educational technology applied in teaching mathematics is a very active research field. A vast literature on this subject provides numerous theories, methodologies, and interpretations related to how new technologies aid mathematics teaching.

As lecturers instructing workshops and special projects in the Mathematics educational area at the Teachers' Training, we introduced my pre-service students to the Geogebra software program because it contains useful applications that help the user to solve problems in Math and associated subjects. We had found that regardless of the intense exposure of todays' younger generation to various aspects of digital and computer technology, several of our students who train to become Math teachers have lacked the knowledge and skills to make efficient and relevant use of the program, let alone the ability to integrate this program in their teaching plans and impart the required skills to their future pupils.

Considering the situation, we chose to focus on the PSTs' ability to acquire and assimilate the usage of innovative educational technologies within the framework of workshops which combine an introduction to pedagogy and technology. Furthermore, we have studied the ways these PSTs adopt new knowledge that enables them to acquire both the insights and the skills required for current, innovative technologies, and to what extent they choose to integrate the newly acquired knowledge in their personal project of developing lesson plans, as an integral part of the educational material they will teach as future Math teachers in the Israeli Arabic educational system.

The program which we have chosen, Geogebra, is a complex program that requires previous experience in computer technology and intellectual openness, the willingness to "think outside the box" – to try various approaches to problems and seek solutions in different ways than the standard, traditional ones.

Literature Review

Questions about benefit expectations of digital tool integration in mathematics instruction are nothing new. (Burrill et al., 2002) reviewed the monitoring of handheld graphic technology – 43 in all – which were used congruent to math instruction and came to the conclusion that these handheld devices could meaningfully assist students better understanding complex mathematical concepts. Since the majority of studies used qualitative methods, finding do not express any significant effects. (Ellington 2003, 2006) reviewed 54 studies that indicated a small improvement in students' ability to compute and solve mathematical problems. (Dynarski et al., 2007) and (Campuzano et al., 2009) conducted two large-scale experimental studies which concluded that the use of digital tools in 9th-grade algebra courses provided insignificant results. These studies that yielded different degrees of quantitative evidence provide mixed conclusions regarding the influence of digital tools use on mathematics.

Other studies provide information documenting the technological effects on mathematics instruction according to effect rate described by (Drijvers et al., 2016): 46 computer technology studies teaching mathematics in a K-12 classroom setting reported no less than 85 conclusive effect rates. Research findings revealed that positive effects in primary education were greater compared to those found in secondary education. Study effect rates were also more pronounced when the constructivist approach was used in teaching and when non-standardized tests were utilized. (Rakes et al., 2010) reported an astounding 109 effect rates. Interventions were sub-categorized into Technology Tools or Technology Programs. Interventions which placed their focus on the understanding of concepts provided a doubled effect rate than interventions that focused on procedural understanding. These findings suggest that technology was particularly useful at achieving conceptual objectives over procedural goals. It was confirmed how short period interventions could make a significant positive effect. (Cheung and Slavin 2013) in their third study realized 74 effect rates for K12 math classes. The authors concluded, “Educational technology is making a modest difference in learning mathematics.

Finally, studies based on a larger sample were lesser than those found in small-scale studies. The emerging picture indicates that technological usage in mathematics education influences a positive although modest effect. Although applying ingenious educational intervention usually has fruitful and positive results, these studies provide no overwhelming evidence that technological tools for mathematics education are highly beneficial. Thus, the existing literature presents various studies of inconsistent results, while investigators interpretations appear ambiguous. An OECD study showed a negative association between actual math performance and computer usage in math classes providing little to no evidence of any positive effect on student achievement (OECD, 2015). Most studies reviews referring to experimental and quantitative studies make no differentiation between the educational The Implementation of Geogebra Program into Pre-Service Mathematics Teachers Training in Israel 18 level, type of technology, nor the technology mode that was integrated into teaching, or in certain occasions, they refer to other educational factors that might have influenced the outcome. Therefore, these studies do provide insight but do not provide any detailed reports of case studies, which found that technology has a major impact on the outcome. In summary, these review studies provide an overview that helps to examine the relevance of student achievement from using technology, but do not examine why this might be the case and to what extent. To answer the question of why, we will discuss one crucial conditional factor, namely, the influence and impact of the teacher who ultimately introduces innovative educational teaching methodology.

Dynamic Geometry Software

Dynamic Geometry Software (SGD) is used as a generic term for a type of software, which basically relies on the construction and analysis of geometric problems (Strafier, 2002). Three primary functions are usually present in these computer algebraic systems and worksheets: drag mode, custom tools, and traces or locus of objects (Graumann et al., 1996).

Dynamic Geometry Software generally provides these primary math objects: points, segments, lines, circles, vectors, and conic sections. Besides, it may (a) make analytical geometry by use of a coordinate system and (b) it works with graphics in a mathematical function whereby y-coordinate is a calculated expression.

- **Using Geogebra (Dynamic Mathematics Software)**

Dynamic mathematics software is designed to combine specific features of the indirect calorimetry dynamic software, computer algebra systems, and spreadsheets in a single software package.

Geogebra is an example of such dynamic mathematics software (Hohenwarter, 2008). Insofar as Geogebra, different representations of the same mathematical object connect dynamically, give users the freedom of back and forth movement, thus making the relations between the representations more easily comprehensible (Özgün-Koca et al., 2010). Every time a representation is modified, all the remaining objects are adjusted to maintain the relationships between different objects. New objects can be created either by using the dynamic geometric tools or algebraic keyboard inputs.

There are two main types of educational software used for teaching mathematics.

The first is a dynamic geometry program (SGD) that allows users to create and dynamically modify Euclidean constructions. Properties and relationships between objects used in a geometric construction are maintained by manipulation of an object while modifying the dependent objects accordingly. Some SGDs also provide essential algebraic functions that show the equations of lines or conic sections, as well as other mathematical expressions that usually the user can directly modify.

The second significant type is computer algebra systems (CAS) that perform algebra, analytic geometry, and calculus functions. When students use geometric object equations, a computer algebra system can decide their position and display their graphic representations. Geogebra software attempts to combine these two types of software. Geometry, algebra, and calculus are treated equally. The software offers two representations of each object: the numeric, algebraic component displays, are used to coordinate an explicit or implied equation; a parametric equation, while the geometric component assembly shows the corresponding solution (Hohenwarter, 2006b).

This new connection, the bi-directional dynamics between the multiple representations of the objects, widens mathematics teaching to new possibilities for implementing dynamic software, which is a critical teaching aid feature, as the promotion of mathematical understanding of concepts was a difficult task in the past.

- ## Electronic-learning Principles in Geogebra

The Geogebra user interface design also promotes learning enhancement, considering the principles of learning established by (Clark and Mayer 2003): Multimedia Principle, Contiguity Principle, Principle of Coherence.

Initially, Geogebra was designed to enable students to discover mathematical concepts through their exploration, but since its introduction, it also proved to be a handy tool suitable to create a teacher's teaching materials.

- ## Necessary Core Competencies

Teachers who want to use Geogebra to create educational materials must acquire a specific array of necessary technical skills, including software for word processing or presentations. Although the knowledge of primary Geogebra usage is essential, the experiences of teachers' workshops throughout the world indicate that the main problems relating to creating teaching materials for secondary level mathematics often stem from teachers' lousy experience in using computers (Fuchs and Hohenwaters, 2005): File handling: core competencies relating to management and organization of files and folders.
Image file handling: basic knowledge of using images to improve instruction materials text- processing software: competency required to use word processing to create educational materials.
Internet Accessibility: competency necessary to deploy not paper-based instruction materials.

- ## Instruction Materials

Geogebra supports static educational material creation, i.e., brochures, worksheets, exams, and presentations that can be printed out and distributed.
Geogebra facilitates these following options: Printing construction model, Printing protocol construction, Export graphs to the clipboard, Export the drawing pad as an image, Interactive teaching materials
Geogebra also allows the creation of virtual educational materials called dynamic worksheets and applets (Hohenwarter, 2007a; Hohenwarter, 2006b), known as virtual mathletes or manipulated applets.
Such interactive materials can be used on computers or via the Internet and require a browser/computer (or mobile) installed software application.

- ## Teaching math with Geogebra

Since Geogebra combines easy usage and construction characteristics of DGS and CAS, it gives a broad range of possibilities for mathematics teaching.
Consequently, Geogebra may be used for presentation, create instruction material, such as notes or interactive (shared) worksheets (Hohenwarter 2005; Fuchs and Hohenwarter, 2005).
As a tool for presentation, it can be used for: Static displays and Dynamic visualizations.

- **Why Geogebra?**

The research related to the effective integration of Geogebra in the classroom shows several reasons for selecting it. The choice of Geogebra will make it an essential element of Math teachers' technological professional development, as it includes: Open Source, Effective SGD, Dynamic Mathematics Software, Multiple Representations, Bi-directional Connection, Designed for Students, Virtual Manipulation, Platforms Independence, International Community of Users (including Arab languages countries).

The Ministry of Education in Israel, Secondary High School Supervisors and Teachers Associations, already adopt Geogebra as their preferred software. Everyone agrees that it is imperative to use digital tools in math education. The impact of the use of the tools is higher in primary education than in secondary education. Adopting digital tools affects both teachers' professional development and PSTs as methods of collaboration and communication change. The use of Digital tools for secondary school math teaching in Israel began in the 1990s. Teachers in the field always look for the best adaptable software available. Geogebra (Geogebra) is a dynamic software integrating most of the functions, tools, and modules needed for teaching maths in secondary schools.

Research Questions

This study seeks to answer the following questions:

- What are the Perceptions of the participating PSTs about Geogebra?
- What are the main challenges for Pre-service teachers when using Geogebra as a teaching assistive tool to teach math, as perceived by PSTs?
- What are the most challenging tools of Geogebra?

Participants

All the 80 (eighty) participants were students on their way to becoming qualified teachers of Mathematics at a college specializes in teachers' education and qualification. The participants were all between 19-22 years of age. Both male and female students were included. All students were Arab students who lived in the northern part of Israel.

Methods

The investigation consists of six surveys based on questionnaires, content analysis, a report card and descriptive statistics were used to gauge pre-service teachers' perceptions toward the software during a Geogebra workshop.

All these instruments where distributed during workshops organized in the College as Teaching/Learning activities.

First: survey is based on two questionnaires:

(Questions on PSTs expectations and questions for content analysis).

Introductory questionnaire on PSTs

We made a short questionnaire in order to investigate the PSTs expectations toward Geogebra. This questionnaire was distributed at the beginning of the initial training course. PSTs' answers the essential attribute they expect to obtain by mastering Geogebra software. The question "What is the most important characteristic that dynamic geometry software must have?" was answered in three different major categories: Language, Vision, and Guidance for users.

Second: questionnaire for content analysis:

The participants were also asked to determine the properties of Geogebra and the essential purpose of its use. The researchers categorized the PSTs answers in the introduction of the first questionnaire to find their frequencies. As too many categories were elicited, we decided to use only the first five categories relating to each question since they represent the major categories found.

An additional tool used for this purpose was a report card filled out by each PSTs workshop team. The report card contained a list of the difficulties they encountered in the given assignment.

Second survey is based on three questionnaires. Descriptive statistics obtained the PSTs perceptions toward Geogebra.

The survey tool employed to measure pre-service teachers' views was modified by authors from Preiner (2008), ranging from 1 (Very difficult) to 5 (Very easy). The survey had five parts: 1) Characteristic of Geogebra 2) Basic geometry construction 3) Angle, transformation and insert images 4) Coordinates and equation and 5) Functions and export images. All questionnaires were coded to enable tracing data of each participant while preserving confidentiality. Cronbach's alpha values were found to be way above 0.7, the acceptable threshold suggested by Pallant (2004). The questionnaire was given at the end of the Introductory Teaching/ Learning Workshop and was related to Geogebra tools.

Survey I: Characteristic of Geogebra.

Survey II: Basic geometry construction was given at the end of Workshop I and was related to activities and tools of Geogebra.

Survey III: Angle, transformation and insert images was based on questions and was given at the end of Workshop II and related to activities and tools of Geogebra.

Survey IV: is based on equations and was given at the end of Workshop III and had to do with activities and tools of Geogebra.

Survey V is based on functions and images export was given at the end of Workshop IV and also related to activities and tools of Geogebra.

Procedure

Geogebra Course

During the academic years 2016-2017 and 2017-2018, we conducted and assessed three Geogebra courses to identify difficulties and obstacles that may arise at the introduction of dynamic mathematics software programs such as Geogebra. The Course was designed in order to help the participating PSTs achieve the following objectives:

Continuing sessions in these workshops started with either an informative input or discussion of the previous day's homework. The central part of each session comprises four activities designed to help participants obtain the necessary skills for independent use of Geogebra at the closing of each Workshop, homework was assigned.

The workshops were:

- Introduction to Geogebra Workshop.
- Workshop I: basic geometric.
- Workshop II: angles, transformations, and images' insert.
- Workshop III: Equations.
- Workshop IV: functions and images export.

Implementation

The structure and content of the Workshop consisted of four full workshops as follows:

Workshop I: Basic geometric constructions: In this Workshop, pre-service teachers learned to create basic geometry using Geogebra. In addition, pre-service teachers were introduced to a dynamic geometry tool selected for certain characteristics that facilitate the construction of:

Activity 1: Line Bisector with Geogebra.

Activity 2: Square.

Activity 3: Circumscribed Circle of a Triangle.

Activity 4: Equilateral Triangle.

Workshop II: The angle, transformations and pictures:

In this Workshop, pre-service teachers learned how to display the angle-Geogebra corner, apply the transformation of objects available, insert a picture in a Geogebra graphics window and use it to enhance the dynamic figures:

Activity 1: Parallelogram with Angles.

Activity 2: Drawing Tool for Symmetric Figures.

Activity 3: Inserting a Background Image.

Activity 4: Rotation of a Polygon.

Workshop III: Coordinates and equations:

In this Workshop, pre-service teachers learned about the algebra window and input fields in Geogebra. Also, pre-service teachers learned how to enter coordinates and mathematical equations to construct objects using algebraic presentation:

Activity 1: Coordinates of Points.

Activity 2: Linear Equations.

Activity 3: Slope Triangle.

Activity 4: Quadratic Equations.

Workshop IV: Functions and Export of images

In this Workshop, pre-service teachers learned how to handle functions using Geogebra, exploring the concepts of calculus, the Export of static images construct by the pre-service teachers, and ways to incorporate these images into the text-processing software to produce teaching materials for students.

Activity 1: Polynomials Functions

Activity 2: Library of Functions

Activity 3: Tangent and Slope Function

Activity 4: Export of Static Pictures

Results

- **Short Questionnaires' Results**

A series of questionnaires were utilized to understand the most essential attribute, according to the PSTs, for the Geogebra software. PSTs were asked their opinion regarding: 1) Language Attribute 2) Visual Attribute 3) Users' Guide Attribute 4) Most essential property overall 5) Most essential purpose overall.

- **Most essential language property**

Responses to this question revealed that the majority of PSTs believed that the program being in the users' native language is the most essential language property (54.8%) followed by language that is appropriate for the curriculum (19.4%). 9% of users believed that the most essential language property is to be a language used all around the world. 5.2% of PSTs believed it was most important for the language to be well translated, and 5.1% stated that it was most essential for the language to be clear and understandable.

- **Most essential visual attribute**

According to the majority of PSTs, the most important visual property was screen clarity and readability (29%). Use of the display area was rated as most essential by 18.9% of PSTs. Bright colors and visual integrity was most important for 15.6% of the population, while interesting and attractive imagery was most important for 12.4%. Lively colors were rated as most important by 8.7% of the PSTs.

- **Most essential users' guide attribute**

24.2% of the PSTs said the user manual being detailed was most important. Likewise, 24.2% said that the manual having a detailed explanation of how to use Geogebra in the help menu was most important. 17.4% of the PSTs said that the manual having a number of examples was most important. Being clear and understandable was rated as most essential by 6.9% of the population and 5.8% of PSTs said the manual being accessible and user friendly was most important.

- **Most essential property overall**

35.4% of PSTs rated ease of use as the most important overall property of Geogebra 16.9% voted that the program having additional tools, such as spreadsheets and a computer algebra system, was the most essential. 16.8% said the most important property was that the program still allowed the computer to run fast. 12.3% said the most essential feature is the ability to calculate and draw, while 6.8% stated that its applicability for geometry and proofs was most important.

- **Functions**

39.1% of PSTs said the most important function of such software is to present the subject matter in the lesson. 16.4% said it was to give students materials to study at home. 13.5% of PSTs concluded that it was to make applications and to reinforce previously taught lessons. 12.5% voted that the ability to do self-study was the most important purpose. 6.1% stated that the essential purpose was to facilitate the learning process.

Overall, the essential attribute, according to pre-service teachers, are: being in the users' native language, screen clarity and readability, and a detailed user manual or help menu. Nevertheless, the researchers acknowledge that some of these attributes are directly related to users' competencies with computers. Therefore, software suited to computer competencies is considered preferable. The findings indicated that PSTs prefer more precise and easier to understand software. PSTs regard easy usage as the essential property of Geogebra and that they prefer using Geogebra to make presentations in their lessons. The second most crucial property found was the program's attractive additional tools.

- **PSTs Evaluation of Geogebra Workshops**

The researchers analyzed the survey questionnaires by workshops. The findings show that PST's perceptions of Geogebra features were moderate (M = 3.58). Their perceptions of the program's features and tools introduced Workshop I presented the highest mean score (3.92). In Workshop II, the tools introduced, the angle, transformation, and picture inserts were received a mean rating of 3.82. The tools introduced in Workshop III, coordinates, and equations, were perceived by PSTs at a moderate level

(M=3.62). The tools introduced in Workshop IV, used to solve functions and to export images, were also perceived at a moderate level with a mean of 3.63.

Table 1. The overall mean of teachers' perceptions of GeoGebra workshops

Item	M	SD
Characteristic of Geogebra	3.58	0.486
Workshop I	3.92	0.695
Workshop II	3.82	0.738
Workshop III	3.62	0.625
Workshop IV	3.63	0.642

- **PSTs Evaluation of Geogebra Features and Tools**

PSTs' ratings of Geogebra characteristics in the workshops were collected, and the mean ratings were found. Items that had the highest mean score were: 1) the Grid (M=3.71) 2) Point Capturing (M=3.73) 3) Labeling Objects (M=3.7) and 4) Creating a point on an object (3.71). The remaining 11 items' mean scores were between 3.12 and 3.69. The overall mean rating of GeoGebra's characteristics (15 total) was 3.53; thus, PSTs perceived the tools and features of Geogebra to be user friendly.

- **PSTs evaluation of features and tools introduced Workshop I**

The findings indicate that the activities in Workshop were of moderate level. The mean score of 11 items was relatively high (3.85). The 'Move' feature was rated the highest with a mean score of 4.17. 'Segment through two points' was also rated very high (M=4.13). The two items with the lowest mean scores were 'Move drawing pad' (M=3.03) and 'Square of a Segment' (3.37).

- **PSTs' perceptions of features and tools introduced in Workshop II**

The 17 tools were received an overall mean score of 3.78. The perception of items ranged from mean scores of 3.53 to 4.17. The tools and activities rated as most accessible were Move (M=4.17) and Polygon (M=4.07), followed by the features that enable one to intersect two objects (3.83) and to draw a line through two points (M=3.79). Parallelogram and angles (M=3.53) and background image and an axis of symmetry (M=3.53) were the features that received the lowest mean scores of the tools introduced in Workshop II.

- **PSTs' perceptions of features and tools introduced in Workshop III**

The overall mean score of the 17 features and tools introduced in Workshop III was 3.58 ranging from mean scores of 3.13 (Vertex feature) to 4.0 (Move feature). Several features received mean scores that were fairly high, such as 'Polygon' (M=3.93), 'Intersect two objects' (M=3.90), and 'Perpendicular line' (M=3.83).

- **PSTs' perceptions of features and tools introduced in Workshop IV**

The mean score of the 13 features and tools introduced in Workshop IV was 3.59 and ranged from mean scores of 3.25 (Extreme tool) to 4.24 (New Point tool). Following the 'New Point' tool, the tool to create a perpendicular line was found most accessible by the PSTs (M=3.93) followed next by the tool to insert pictures (M=3.72).

- **Difficulty Levels of Geogebra tools**

More than 25 dynamic geometry tools were introduced within the framework of the Introduction to Technology Course: Geogebra. At first, the trainer presented an analysis of 21 "classic" tools that were presented at an early stage of the Geogebra course. Participating PSTs' difficulty level rating of all tools used in the technology workshops were marked on a scale of 0 ('very easy') to 5 ('complicated').

Geogebra tools were classified into one of three difficulty level groups: 'easy to use,' 'medium,' and 'difficult to use.' The critical value for 'easy to use' tools was set at easy = 0.99, which yielded an interval width of 0.51 between the most accessible tool rating and the threshold for this group. 4 of the 21 tools fell into this category, or 20.05% of the tools. The critical value for 'medium difficulty' was set at medium = 1.35, which yielded an interval width of .35. 10 of the 21 tools were categorized as 'medium', which is 46.42% of the tools. The critical value for 'difficult to use' was set at difficult = 1.71, which yielded an interval width of .35. 7 of the 21 tools fell into this category, which was 33.53% of the total.

In Workshop I, 11 tools were introduced. Three fell into the 'easy to use' category; six were classified in the 'middle' category and two were categorized under 'difficult to use.' None of the tools introduced were reused. Six new tools were introduced in Workshop II and seven tools were reintroduced. Of the six new tools, one was classified as 'easy to use', three as 'middle' and two as 'difficult to use'. All seven of the tools that were reintroduced in Workshop II were categorized by PSTs as easy to use. Three new tools were introduced in Workshop III, all of which were classified as difficult to use. However, of the eight tools that were reintroduced in Workshop III, all were classified by PSTs as easy to use. Only one new tool was introduced in Workshop IV, which was categorized as 'Middle.' 5 tools were reintroduced in Workshop IV, which were all determined to be easy to use.

The use of the introduced Geogebra tools, grouped according to their specific difficulty level, was analyzed for common characteristics to identify factors that make them 'easy to use' or 'difficult to use.' Summation of the typical 21 Geogebra tools' characteristics yielded complexity criteria that could be applied to these tools, as well as to other dynamic geometry software programs. The objective of this analysis was to enable the more effective introduction of such tools by considering their difficulty level and overcome common difficulties in using them. In order to summarize and analyze the complexity of tools' characteristics, descriptions of the 21 introduced Geogebra tools were examined to establish and verify the typical characteristics of tools that were rated to fit the same difficulty level group. The following tools-related information was documented to identify common characteristics within each difficulty level group: Number of actions needed, Determination of whether or not the action's order is relevant for successful use of the tool, The number of existing objects that must be applied, The number of types of objects involved, Determination of the need for specific keyboard input to use the given tool, and Determination of whether or not the given tool is the default option; if, when the Geogebra program starts, the default tool icon appears on the toolbar.

- **Complexity criteria of dynamic geometry tools**

GeoGebra tools were given a complexity rating of 1 to 5, which reflects the difficulty of the characteristics of said tools. Criteria were based on initial difficulty level rating as well as on analysis of Geogebra tools. Three tools were given a complexity rating of 1: 1) New Point 2) The segment between two points and 3) The line through two points. Five tools were given a complexity rating of 2: 1) Move 2) Zoom in/Zoom out 3) Move the drawing pad 4) Slope 5) Line bisector. Five tools were given a complexity rating of 3: 1) Polygon 2) Mirror object at line 3) Angle 4) Show/hide object 5) Circle with the center through point. Four tools were given a complexity rating of 4: 1) Parallel line 2) Intersect two objects 3) Tangents 4) Perpendicular line. Finally, four tools were given a complexity rating of 5: 1) Slider 2) Insert text 3) Insert image and 4) Rotate the object around the point by an angle.

- **Analysis of different components of the Introduction to Technology Course: Geogebra Workshops components**

This section focuses on different components of the evaluated Introduction to Technology Course, such as algebraic input, commands, and Geogebra features and their potential impact on the difficulty ratings of the workshop activities and the use of Geogebra tools. The study also includes an examination of the effect of external variables, such as age or computer skills of the participants, on the initial process of dynamic mathematics software. The student's reports are summarized, and the collected data is added to the data gathered from other sources.

- **Algebraic input and commands rating**

Unlike simple dynamic geometry software, besides the use of a wide range of pre-defined commands, the Geogebra program also supports inputs of algebraic expressions. Workshops III and IV were designed to introduce the algebra section and familiarize participants with the input fields and software extensions. The participating PSTs were asked to rate the difficulty level of workshop activities and home exercises on a scale of 0 'very easy' to 5' very difficult'. As algebraic input and commands were rated as more complicated activities than simple dynamic geometry activities, mean difficulty ratings of activities from the first two and last two introduction workshops were also examined.

The average difficulty rating of the relevant home exercises was also checked. Since the home exercises, including algebraic sections, were rated at higher difficulty level than real dynamic geometry exercises, the average time spent by the participants working on these tasks was also taken into account.

Table 2. Analysis of the different components of the Introduction to Technology course.

Tool	Complexity	Complexity Group	Difficulty Level Group
Easy			
1. New point	1	Easy	Easy
2.Move	2	Easy	Easy
3. The segment between two points	1	Easy	Easy
4. The line through two points	1	Easy	Medium

	5. Zoom in/Zoom out	2	Easy	Medium
	6. Move the drawing pad	2	Easy	Medium
	7. Slope	2	Easy	Difficult
	8. Line bisector	2	Easy	Difficult
Medium				
	9. Parallel line	4	Middle	Medium
	10. Polygon	3	Middle	Medium
	11. Intersect two objects	4	Middle	Medium
	12. Mirror object at line	3	Middle	Medium
	13. Angle	3	Middle	Medium
	14. Tangents	4	Middle	Medium
	15. Show/hide object	3	Middle	Medium
	16. Circle with the center through point	3	Middle	Easy
	17. Perpendicular line	4	Middle	Difficult
Difficult				
	18. Slider	5	Difficult	Difficult
	19. Insert text	5	Difficult	Difficult
	20. Insert image	5	Difficult	Difficult
	21. Rotate object around point by angle	5	Difficult	Difficult

- **Geogebra features rating**

The participants rated 11 introduced Geogebra features on a scale of 0 'very easy' to 5' very difficult'. These Geogebra features can be accessed and applied in the following ways:

Changing settings by using the menu bar, Access the Context menu to activate objects Features

And Use the Attribute menu to change the attribute of the objects.

The 11 features were organized into the three difficulty groups. The Easy Group (range of .68 – 1.20) consisted of the following features: 1) Grid 2) Navigation bar 3) Construction protocol and 4) Properties dialog. All of these tools can be accessed by the Menu Bar (although Properties dialog can be accessed by either the Menu Bar or Context Menu. The Middle Group (range of 1.21 to 1.62) consisted of the following tools: 1) Point capturing 2) Trace on 3) Rename 4) Label types. Point capturing is accessed by the Menu Bar; Trace On and Rename are accessed by the Context Menu and Label Types is accessed by the Properties Dialog. The Difficult Group (range of 1.63-2.05) is made up of: 1) Background Image 2) Redefine and 3) Auxiliary objects. Background Image is accessed by the Properties Dialog; Redefine is accessed by the Context Menu; and Auxiliary Objects is accessed by the Properties Dialog.

- **Menu bar features**

Geogebra menu bar comprises of seven items that each of them can be directly selected due to a sub-menu enabling access to certain features and setting change.

- **Navigation bar features**

This information is essential for using Geogebra by mobile phones, but it challenges the analysis of the workshop context. The Navigation-bar features also include Construction Protocol and Context Menu features.

- **Dialog Properties features**

The dialog Properties of GeoGebra can be accessed in three different ways: selecting the target feature from either the Edit menu or the Context menu or double-clicking on an object in Move mode.

Discussion

- **PSTs Expectations and Perceptions of Geogebra Tool**

PSTs emphasized the potential benefits of Geogebra, compared to other programs due to "the range" and "ease of use" factors. They expect for Geogebra, which they perceive as better teaching-aid software, to provide students with various options to approach a problem and arrive at logical, evidence-based conclusions (Hull and Brovey, 2004). The PST participants also pointed out that the 'drag mode' or 'dynamic property of shapes' in the software and the visualization of particular geometry concepts as beneficial features.

PSTs and teachers who readily use technology and embrace new teaching methods are more likely to incorporate these methods into their routine than teachers who initially experience difficulties (Mously et al., 2003). These initial difficulties could be related to language, computer skills, lack of guidance, etc.

Introduction to Technology Course surveys: Findings concerning the PSTs' perceptions of Geogebra features were moderate. Most PSTs felt that Geogebra software is user-friendly and relatively easily understood and explored. Similar comments were recorded in (Green & Robinson's 2009) study. However, some PSTs expressed difficulties in following commands adding dynamic text; they said that they needed more time to learn the proper command for each activity.

The Study Instrument here has an Observation Form developed by the researchers would be used in further research (academic and field level) Pedagogies. Besides, pedagogy courses without the integration of technology and the use of mobile phones are no longer relevant for pre-service teachers.

Regarding a methodology/pedagogy course as part of teachers college curricula – after leading such course in the department training future math teachers, I am convinced that such course cannot be efficient without the integration of digital teaching technologies focused on mathematic investigation. In this context, the introduction of new materials relates more to the availability of competent lecturers rather than to the abilities of the teachers' or students' needs.

Finally, the emphasis on the usage of cellphones derives from the fact that a vast ratio of the current population, children, students, and teachers alike possess such instruments and use them regularly. Thus, this accessible available resource can be used to connect Math, which is considered a distant, abstract subject to every day's reality.

- **Difficulties in Basic Geometry**

The findings of this study indicate that PSTs' perceptions of features and tools taught in the Course were highly positive. Preiner (2008) reported that these types of workshops tend to be more comfortable for the students and the findings of this study are consistent to his. Although all the respondents in this study were new users of Geogebra, the activities in these workshops presented them with no serious problem.

- **Difficulties in using Geogebra tools Angle and Transformation**

(*Preiner* 2008) stated that Activity1, angle transformation, was the easiest in this Workshop compared to the other four activities introduced; the findings of his study are consistent with those of this study.

- **Difficulties in using Geogebra tools on Coordinate and Equation**

The findings relating to PSTs' perceptions of the features, tools, and commands in this Workshop were moderate.

Workshop III activities were perceived as the most difficult. Most findings were consistent with those of Preiner (2008). One problem that caused difficulty in this Workshop was the PSTs lack of knowledge concerning basic commands such as the command that enables inserting text, and the command enabling calculation of the gradient. The PSTs claimed that the command for text insert was too complicated. This feedback was also mentioned in (Preiner's 2008) study, indicating that the activities in this Workshop were complex and challenging for the participants.

- **Difficulty observed in Workshop in activating Present and Solve Function and Perform Image Export**

The findings relating to this Workshop, although considered as moderate, were inconsistent with those of (Preiner (2008), which indicated that activities in a similar workshop were very natural. In the Workshop relevant to this study, some activities ranked a high mean score, probably because the tools used in the Workshop were introduced early. However, some PSTs commented that they needed more time to master the new command introduced in this Workshop.

- **Addressing Operational Questions**

Are the design, content, and difficulty levels appropriate for secondary school PSTs? Considering the low difficulty ratings for workshop activities, the difficulty level of the Course seemed to be appropriate for future secondary school Math teachers. The results clearly show that most of the participants enjoyed the Course, as it included tools that could be used for various mathematics concepts. Although the homework assignments were challenging to some PSTs, the overall impression is that most participants were not overwhelmed and managed to master, to a degree, the use of Geogebra at home. Furthermore, the combination of different teaching methods and hands-on activities seemed to appeal to the participants and provided the necessary variety to keep them focused and motivated.

- *How do PSTs experience using Geogebra software, and what feedback do they give regarding its usability?*

The overall feedback of the PSTs regarding Geogebra software is complimentary; they also enjoyed being introduced to innovative technology and defined it as an easy, intuitive, user-friendly, and helpful in teaching mathematics in secondary schools. They liked the software's adaptability and versatility, especially the ability to create engaging activities and interesting instructional content for their students.

- *Do PSTs subjectively rate Geogebra dynamic geometry tools to be of different difficulty levels when they are introduced in a workshop?*

Although the average difficulty ratings of dynamic geometry tools on the day of their introduction did not exceed 1.8 for any of the tools, which is within the lower half of the provided scale from 0 ('very easy') to 5 ('very difficult'), there were differences relating to the complexity and use of specific tools. Nevertheless, reusing the tools in another workshop, in addition to an extra practice that made them more familiar with the software, led to decreased difficulty ratings. Regardless of the participant's initial difficulty rating, in their second rating, they marked the Geogebra tools as "easy to us."

Conclusion

The findings of the first study revealed that mathematics PSTs have a priori positive attitude towards the use of Geogebra. The discussions enabled the researchers to conclude that mathematics, which is an abstract subject, requires students and teachers to collaborate, imagine, and think in areas of geometry and transformations. The use of technology will expose students (and PSTs) to learning without pre-set boundaries, and promote student-centered learning where the teacher acts as an enabler or facilitator.

Geogebra software is expected to help mathematics PSTs diversify their teaching methods to facilitate students' understanding of mathematic concepts. Geogebra software encourages teachers to integrate technology as a tool enabling students to exploit and expand their mathematic learning potential. Geogebra Software update major versions every year, but some of the challenges affronted by the PST's during the course remain. The challenges encountered in the study are similar to the difficulties presented in previous research (Hohenwarter, 2006a; 2006b; Hohenwarter and Jones, 2007; Hohenwarter, and Lavicza, 2007 Hohenwarter and Preiner, 2007a, 2007b; Hohenwarter and Preiner, 2008).

The Geogebra Core software developers add a series of Geogebra apps for Mobile Phones and Tablets to translate the math learning to a wide platform.(see final conclusion and recommendations) Indeed the wide use of Geogebra Apps for teaching and learning emphasize the need of a robust platform like GeoGebra Desktop for develop GeoGebra "applets and workbooks."

Acknowledgment

Authors of this article declare that there is no conflict of interest whatsoever. The authors also feel obliged to point out that this research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Authors of this article are solely self-funded.

References

Burrill, G., Allison, J., Breaux, G., Kastberg, S., Leatham, K., & Sanchez, W. (2002). Handheld graphing technology at the secondary level: Research findings and implications for classroom practice. Dallas, TX: Texas Instruments Corp.

Campuzano, L., Dynarski, M., Agodini, R., & Rall, K. (2009). *Effectiveness of reading and mathematics software products: Findings from two student cohorts—Executive summary.* (NCEE 2009- 4042)Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Cheung, A. C. K. & Slavin, R. E. (2013). The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis. *Educational Research Review*, 9, 88-113.

Clark, A., Triggs, V., & Nielson, W. (2014). Cooperating teacher participation in teacher education: a review of the literature. *Review of Educational Research*, 84(2), 163—202.

Drijvers, P., (2016). *Evidence for benefit? Reviewing empirical research on the use of digital tools in mathematics education*. Utrecht Repository.

Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N., & Campuzano, L. (2007). *Effectiveness of reading and mathematics software products: Findings from the first student cohort.* Report to Congress. Publication NCEE 2007-4005. Washington, DC: U.S. Department of Education.

Edwards, J.-A., and Jones, K. (2006). Linking geometry and algebra with GeoGebra. *Mathematics Teaching*, 194:28.

Ellington, A. J. (2003). A meta-analysis of the effects of calculators on students' achievement and attitude levels in precollege mathematics classes. *Journal for Research in Mathematics Education*, 34(5), 433-463.

Ellington, A. J. (2006). The effects of non-CAS graphing calculators on student achievement and attitude levels in mathematics: A meta-analysis. *School Science and Mathematics*, 106(1), 16- 26.

Fuchs, K., and Hohenwarter, M. (2005). Combination of dynamic geometry, algebra, and calculus in the software system GeoGebra. *Computer Algebra Systems and Dynamic Geometry Systems in Mathematics Teaching* pages 128 - 133.

Graumann, G., Holzl, R., Krainer, K., Neubrand, M., and Struve, H. (1996). Tendenzen der Geometriedidaktik der letzten 20 Jahre. *Journal fur Mathematikdidaktik*, 17(3/4):163 — 237.

Hohenwarter, J., M. Hohenwarter and Z. Lavicza, 2008. *Introducing dynamic mathematics software to secondary school pre-service teachers: The case of Geogebra.*

Hohenwarter, M. and K. Jones, 2007. *Ways of linking geometry and algebra: The case of Geogebra. Proceedings of the British Society for Research into Learning Mathematics,* (BSRLM' 07), pp: 126-131.

Hohenwarter, M., 2004. *Bidirectional dynamic geometry and algebra with Geogebra*.

OECD. (2015). *Students, computers, and learning. Making the connection*. Paris: OECD Publishing. http://www.oecd.org/edu/students-computers-and-learning-9789264239555-en.htm

Özgün-Koca, S. A., Meagher, M., & Edwards, M. T. (2010). Pre-service teachers' emerging TPACK in a technology-rich methods class. *The Mathematics Educator*, 19(2), 10-20.

Pallant, J., 2004. SPSS Survival Manual: *A Step by Step Guide to Data Analysis Using SPSS for Windows. 1st Edition.* Open University Press, ISBN- 10: 0073013307.

Preiner, J., 2008. *Introducing dynamic mathematics software to mathematics pre-service teachers: The case of Geogebra.* PhD Thesis, University of Salzburg Austria.

Rakes, C., Valentine, J., McGatha, M., & Ronau, R. (2010). Methods of instructional improvement in algebra: a systematic review and meta-analysis. *Review of Educational Research.*

Strafier, R., (2002). Research on dynamic geometry software (DGS) - An introduction. ZDM. *The International Journal on Mathematics Education*, 34(3):65.