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Message from the editor-in-chief

Malaysian Online Journal of Educational Technology (MOJET) highlights the current issues in educational technology. MOJET is an international, professional refereed journal in the interdisciplinary fields sponsored by Faculty of Education, University of Malaya. This journal serves as a platform for presenting and discussing the emerging issues on educational technology for readers who share common interests in understanding the developments of the integration of technology in education. The journal is committed to providing access to quality researches ranging from original research, theoretical articles and concept papers in educational technology.

In order to produce high quality journal, extensive effort has been put in selecting valuable researches that contribute to the journal. I would like to take this opportunity to express my appreciation to editorial board, reviewers and researchers for their valuable contributions to make this journal a reality.

Professor Dr. Saedah Siraj
January 2017
Editor in chief

Message from the editor

The Malaysian Online Journal of Educational Technology (MOJET) is aimed at using technology in online teaching and learning through diffusing information from a community of researchers and scholars. The journal is published electronically four times a year.

The journal welcomes the original and qualified researches on all aspects of educational technology. Topics may include, but not limited to: use of multimedia to improve online learning; collaborative learning in online learning environment, innovative online teaching and learning; instructional design theory and application; use of technology in instruction; instructional design theory, evaluation of instructional design, and future development of instructional technology.

As editor of the journal, it is a great pleasure to see the success of this journal publication. On behalf of the editorial team of The Malaysian Online Journal of Educational Technology (MOJET), we would like to thank to all the authors and editors for their contribution to the development of the journal.

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Assessing The Impact Of Caad Design Tool On Architectural Design Education

Rana Al-Matarneh [1], Ihsan Fethi [2]

ABSTRACT

The current concept of architectural design education in most schools of architecture in Jordan is a blend between manual and digital approaches. However, the disconnection between these two methods has resulted in the students’ failure to transfer skills learnt through traditional methods to the digital method of CAAD. The objective of this study is twofold: to first compare students’ attitudes toward using both methods and to then assess the impact of CAAD use on the quality of architectural design final product. An open-ended questionnaire was designed to measure variables related to students’ preferences toward CAAD and traditional methods. The quality of sixty graduation projects at three Jordanian universities was investigated. The results appear to support the assumption that CAAD tools are used largely as visual means and thereby cause a marked decline in design quality. These findings call for a reconsideration of the status quo and a rethinking of perhaps the entire architectural educational model.

Keywords: CAAD; architectural design education; design methodology; Jordan

INTRODUCTION

In the last few decades, revolutionary developments in the field of Information and Communication Technology (ICT) have significantly impacted everyday life. The internet, advanced illustration tools and software are obvious examples of this digital revolution that has affected the very process of teaching architectural design. Thus, the development of such digital tools over a relatively short time and their continuous advancement and refinement had, and continues to have, an inevitable major impact on many key pedagogical aspects of architectural education and curricula design.

Although CAAD was introduced into most, if not all, the architectural design departments in the Jordanian universities, but students are not allowed to use it unless they finish their first two years of the architectural education program as they must, due to their curriculum, to learn the basic hand sketching and other hand communication skills in order to apply it in their designs.

However, in the third to the fifth years they are encouraged to use both methods in design, that are the traditional and the CAAD. Although this transition is not clearly addressed, thus students are left unable to implement this blend of methods when needed. Moreover, some students are not able to employ CAAD tools in design different processes, for example, they cannot use CAAD to better understand their projects’ different components and systems, for example the structure, electro-mechanical, heating, ventilation, and air conditioning, etc. CAAD tools and software are not taught as design or analysing tools or programs, thus students are not able to analyse the environmental aspects of the site. As a consequence, students are not able to implement their learned skills in CAAD to their design projects in practical manner to deliver integrated designs.
The purpose of this research is to study number of architectural design projects for students in the last year, the fifth year, to explore and examine the role of CAAD in the design process from conceptual phases to final product as it is the case in different departments of architecture in Jordan.

This paper presents a framework to assess the impact of CAAD on the architectural design process and the quality of its product. This framework focuses on a group of indicators that were investigated: architectural program; site analysis; conceptual design development; buildability; and design presentation. This assessment may reveal certain indicators that can help educators and practitioners to understand the impact of this rapid and radical transition on the architectural design process and thus help to redirect the future of architectural education into a more adaptive and qualitative.

Definition of the Problem

The current concept of architectural design education is a blend of the traditional method of drafting on paper and the modern method of using CAAD in the design process. This paper argues that the transition to the new digital media has been vague and largely ill-defined, which causes several serious pedagogical problems. The introduction of these new tools into design teaching has been combined with a dysfunctional relationship between the tools and the intended end tasks (Yehuda, 2008). Consequently, this dysfunction has resulted in a separation between architectural design and the context of the project, specifically its sense of scale and proportion, and has led to a marked decline in the spatial quality experience and a disproportionate dependence on illustrative techniques. The inappropriate use of the digital tools and the heavy reliance on them, the lack of integration among different digital tools and, more importantly, the absence of effective coordination between theoretical courses and design projects has resulted in a relatively poorer overall architectural design product.

Aims of the Study

The aim of this study is twofold. First, this study quantitatively explores students’ preferences and attitudes toward the use of CAAD tools. Second, this study assesses the potential impact of these digital tools on the quality and creativity of architectural design final product by examining design projects. The main objectives of this paper can be summarized as follows.

- What motivates the student to use CAAD software in the design process?
- What is the importance of the role of CAAD in an architectural curriculum?
- What impacts do CAAD tools have on the overall quality of architectural design in all of its stages (conceptual, design development, presentation)?

The overall aim of the study is to examine the impact of caad design tool on Architectural design education.

Theoretical Framework

Architectural Design

Architectural design is a complex process of creating a coherent structure or system that comprises many unified elements. During the last few years, many theoreticians and practitioners have attempted to define the word "design". Archer (1964) defined it as: “A goal-directed problem-solving activity”. Others defined it as "a creative activity that involves bringing into being something new and useful that which display new physical order, organization, form, in response to function” (Alexander, 1961). However, the authors prefer the broader definition of Suh, (1989), which we believe captures essential aspects of architectural design while also accommodating other kinds of designing too. Namely: “… the creation of a synthesized solution in the form of products, processes or systems that satisfy perceived needs through mapping between the functional requirements (FRs) in the functional domain and the design parameters (DPs) of the
physical domain, through proper selection of the DPs that satisfy the FRs.”

During the last two decades, architecture has been influenced by the increasing use of digital technology—both in the process and in the final outcome of design—to meet certain functional, cultural, aesthetic, environmental, and socio-economic needs. Thus, digital technology became the mediating factor between design theory and architectural theory. Accordingly, architectural design has become engaged in the exploration of complicated forms that depend heavily on the use of sophisticated “generative” computational programs. This transformation has begun to show a significant influence on architectural design theory, concepts and approaches (Zellner, 1999). Much of the earlier basis for design methodology, such as the study of typological precedents and contextual setting, has now been replaced by emerging digital tools, such as generative modeling, animation and performance-based indicators (Zellner, 1999).

Architectural Education

The advance of the information computer technology revolution with the accompanied digital technologies has changed the traditional context of architecture as a profession and in education (Breen, 2004).

ICTs have been used in the profession over the past three decades to enhance existing practices by facilitating the production of vast quantities of drawings with high accuracy and over less time. A study prepared by Andia (2002) suggested that digital technologies have been used in architectural schools to challenge the modernizing view of architectural practice (Andia, 2002; Schenk, 2005).

Andia indicated that ICT has affected both practitioners and students in terms of their skills and the setting of educational and professional culture. Simultaneously, combining traditional design approaches with digital technology is effectively improving architectural practice. ICT has been used by schools of architecture to transform architectural imagination and architectural practical possibilities.

However, architectural schools are becoming laboratories for various digital design media, and the architectural studio itself has become a space to examine the role of computers in architectural design (i.e., Ataman and Lonnman, 1996; Bermudez and King, 2000; Ataman, 2000; Al-Qawasmi, 2004, 2005; Schenk, 2005). Students have increasing tendencies toward ICT and are becoming more skilled and involved in using various design media in their design processes, which, in turn, has affected the traditional design studio culture. Al-Qawasmi emphasized that digital media, as used in the e-studio, can bring important changes to the architectural design process but might have unintended restricting effects (Al-Qwasmi, 2005).

In contrast, Achten (2003) warned that this transformation towards digital architecture should be reconsidered whether in term of practice or education. First, digital tools could replace, the traditional design tools, such as manual sketching that often provides the necessary direct physical link between the hand and the brain. Second, digital tools has provided an alluring, easy, and inexpensive alternative to physical architectural models and has replaced them with a set of seducing graphics that are usually designed to impress the audience (juror/client).

According to Guney (2015), the disadvantage of using CAAD tools is to make the students addicted and design their projects without creativity. Salman et al. anticipated that the use of CAAD tools by students came as early as the conceptual stage in the investigation of specific formal themes (Achten, 2003). However, many educators and practitioners have called for a combination of both physical and digital design methods rather than the use of either method separately. Breen indicated that the combination of both techniques gives the designer added insights and more “real” approaches to develop, reconsider and refine any design. Breen also emphasized that the combination of both techniques should be actively incorporated in the educational curriculum to prepare the students as they move toward practice (Al-Qwasmi, 2005).

The State Of Cad Education In Architecture Schools In Jordan

CAAD has been used in Jordan since the mid-1990s. Several engineering firms and contracting
companies were interested in the potential of digital technologies as drafting and modeling tools. As an educational tool, CAAD software was installed as an introductory course for undergraduate architectural programs in 1994, but there were only a few faculty members who could teach it then. Several years later, CAAD courses became obligatory (i.e., CAAD I, CAAD II) over two semesters, typically for second-year students (Abu Ghanima, 2006). Moreover, most schools of architecture in Jordan attempted to update their curricula through software and digital technologies to bridge the gaps between design theory and practice. Since 2014, however, some schools have begun to re-think the use of digital software as an analytical, generative and constructive tool. Consequently, software such as “Revit” and “Introduction to BIM” were installed in their curricula.

Generally, schools of architecture in Jordan combine the physical method with the digital method to ensure that students enjoy the benefits of both methods. Thus, most, if not all, schools of architecture prohibit the use of CAAD tools in design for students in their first two years. Design teaching for first- and second-year studios emphasize on the importance of developing manual graphic communication skills, sketching, and the experience of making physical models. However, the current curriculum of architectural design education in most schools suffers from a lack of synchronization and integration between computer courses and design projects. The prevalent tendency at present is to treat each course as a separate entity with its own distinct particularity, which prevents the necessary coordination between theoretical and design courses and applied computer courses. Moreover, although the structure of the curricula remains relatively flexible to manage new digital technologies, integrating these technologies with design courses is highly advisable and will ensure a more holistic and creative environment and not to use this software only as drafting tools.

RESEARCH METHODOLOGY

The present study focuses on studying the impact of the CAAD use on architectural design projects in schools of architecture in the Jordanian Universities. Three universities in Jordan, namely, Al-Ahliyya Amman, Petra, and Philadelphia, were selected as the study cases. The following figure illustrates the CAAD use assessment Approach Framework that is used throughout this research.

![Figure 1. The Caad Use Assessment Approach Framework](www.mojet.net)
This study was completed in two distinct stages. This study used a case-study approach to assemble the main data through the following:

1. **Interviews and Questionnaire Surveys**

   (a) Qualitative in-depth interviews: The data used for evaluation were based on qualitative in-depth interviews that were conducted with a sample that comprised the following:
   
   - 90 fifth-year architecture students, who have acquired and developed various design skills and practices and whose studio work incorporates traditional and new architectural design methods; and
   - 60 educators from three universities in Jordan.

   (b) A paper-based questionnaire survey: an extensive survey questionnaire was completed by the 90 fifth-year students and 60 educators in the study area.

The conducted interviews and questionnaire involved open ended-questions based on collected qualitative data from the students, such as students’ preferences and attitudes toward the use of CAAD, the types of CAAD software used by students, CAAD learning methodology, proficiency level in CAAD, the frequency of using CAAD in different design phases, and the advantages of using CAAD software (table 1.).

<table>
<thead>
<tr>
<th>Main questions</th>
<th>Sub-questions</th>
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<tbody>
<tr>
<td>Part one: Questions that determine preferences and attitudes toward the use of CAD?</td>
<td>Q1. Attitudes toward the importance of CAAD compared with traditional methods</td>
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<td></td>
<td>Very Positive</td>
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<td></td>
<td>Positive</td>
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<td></td>
<td>Neutral</td>
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<td></td>
<td>Negative</td>
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<tr>
<td></td>
<td>Very Negative</td>
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<td></td>
<td>Q.2 Superiority of using CAAD over the traditional method of sketching</td>
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<tr>
<td></td>
<td>CAAD</td>
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<td></td>
<td>Traditional</td>
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<tr>
<td></td>
<td>Both</td>
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<tr>
<td></td>
<td>Others</td>
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<td></td>
<td>Q3. Type(s) of CAAD software used by students?</td>
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<tr>
<td></td>
<td>AUTOCAD</td>
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<tr>
<td></td>
<td>REVIT</td>
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<td></td>
<td>3D-MAX</td>
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<td></td>
<td>PHOTOSHOP</td>
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<td>GRASSHOPPER</td>
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<td>Q4. CAAD learning methodology?</td>
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<td></td>
<td>Self-learning</td>
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<td>Departmental courses</td>
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<td></td>
<td>Private classes</td>
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<td></td>
<td>Departmental courses + Self-learning</td>
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<tr>
<td></td>
<td>Self-learning + Private classes</td>
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<td></td>
<td>Q.5 Frequency of using CAAD in different design phases?</td>
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<td></td>
<td>Conceptual</td>
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<td></td>
<td>Schematic design</td>
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<tr>
<td></td>
<td>Design development</td>
</tr>
<tr>
<td></td>
<td>Construction drawings</td>
</tr>
</tbody>
</table>
Q6. Proficiency level in CAAD?
- Very High
- High
- Average
- Low
- Very low

Part two:
Q7. Questions on the advantages of using CAAD software compared with traditional methods?
- Accuracy
- Neatness
- Speed
- Save money
- Help to visualize end product

Part three:
Q8. Questions regarding the integration of CAAD Courses with other courses & subjects of the Architecture Curriculum?
- Structural
- Environmental
- Electrical
- Mechanical
- Heating, ventilation, and air conditioning

Note: The survey was prepared and conducted from January to June 2016.

The questionnaire comprised a number of questions with 5 different scores for each answer. The students evaluated each of the standardized answers on a 5-step scale from very high to very low (each of them had an assigned numeric value to calculate the sum for each answer). To compare the answers, each sum was divided by the number of times that a specific answer was chosen.

2. A well-structured matrix to assess the impact of CAAD use on the design projects: Sixty graduation projects in the study area were examined through the matrix that has five suggested indicators (i.e., architectural program, site analysis, concept, presentation, and buildability) to assess the architectural product quality (Table 3). The gathered data of graduation projects was important in providing evidence of the benefits that the respondents mentioned in the questionnaire survey and interview.

Assessment Criteria

Five essential criteria were chosen to assess the quality of the graduation projects with differing score weights that totalled 100. These criteria were architectural program (15 points), site analysis (15 points), architectural concept (30 points), presentation and illustration (25 points), and buildability (15 points). The criteria are basically self-explanatory, but the architectural concept criterion needs some elaboration. Section A-Table 3 shows that architectural program was subdivided into 3 main considerations: First (1), projects’ adoption to interrelated values, goals, facts, and needs of users and the surrounding community. A well-conceived program leads to a high quality design, (2) projects’ adherence to the functional relationships of the main components of the projects. Finally, (3) the projects’ adherence to standards and binding codes and regulations.

Regarding the site assessment, and as shown in section B-table 3, projects were examined according to their responsiveness to their: (1) direct urban context, (2) environmental context, i.e., climate, topography, etc.; (3) plot's shape, area and location, and finally Appropriateness of the use of CAAD to develop the overall site design.

Section C-Table 2 shows that architectural concept was subdivided into 6 main considerations. First (1), a philosophical and intellectual basis is adopted to explain the concept and conceptual development and shows how students arrived at their final solution and whether any design reference or precedent was
adopted. Second (2), aesthetic and creative considerations refer to the overall formal, spatial and sculptural aspects of the project, including proposed materials, colors, patterns and textures. Third (3), regional and cultural factors refer to how the student responded to the sense of place and whether cultural influences such as local and/or regional architectural heritage had any role in the overall design or architectural trend that was adopted. Fourth (4), environmental considerations include the student’s response to the question of sustainability, energy consumption, climatic factors, such as orientation and solar shading devices, etc. Fifth (5), the appropriateness of the adopted trend refers to what degree the design approach has succeeded in being relevant and workable with the overall function of the project. The final Sixth (6) consideration is the degree of use of the CAAD tools, including generative design software, to develop the final solution.

Architectural Presentation in section D was subdivided into 5 main considerations revolved around quality and quantity of visualization. Finally, the Buildability was assessed by measuring the role that CAAD software and courses played into delivering integrated designs, through using structural design software to provide technical details.

Table 2: Matrix of main criteria assessed for the impact of CAAD on the quality of architectural design product. (scores 1 poor to 5 high)

<table>
<thead>
<tr>
<th>A. Architectural Program [15 points]</th>
<th>[1]</th>
<th>[2]</th>
<th>[3]</th>
<th>[4]</th>
<th>[5]</th>
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</thead>
<tbody>
<tr>
<td>1. Analysis of the needs, values and main goals of the client, tentative cost analysis of the proposed project and its feasibility</td>
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<td>2. Provision of detailed inventories, required facilities, functional relationships of main components of the project.</td>
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<td>3. Compliance with local and/or international space standards and binding codes and regulations</td>
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<td>Total A</td>
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<tr>
<th>B. Site Analysis [15 points]</th>
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<th>[2]</th>
<th>[3]</th>
<th>[4]</th>
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<tbody>
<tr>
<td>1. Response to urban context, surroundings and accessibility</td>
<td></td>
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<td>2. Site layout, topography and overall landscape design</td>
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<td>3. Appropriateness of plot's shape, area and location</td>
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<td>4. Use of CAAD to develop the overall site design</td>
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<td>Total B</td>
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<tr>
<th>C. Architectural Concept [30 points]</th>
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<th>[2]</th>
<th>[3]</th>
<th>[4]</th>
<th>[5]</th>
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<tr>
<td>1. Philosophical and intellectual basis adopted to explain the architectural concept to client</td>
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<td>2. Quality of conceptual development and evolution of main design theme</td>
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<td>3. Aesthetic and artistic considerations</td>
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<td>4. Regional/cultural/environmental considerations</td>
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<td>5. Appropriateness of adopted design approach to overall function and context</td>
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<td>6. Appropriate use of digital software in generating design?</td>
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<td>Total C</td>
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<tr>
<td>1. Overall poster design theme and clarity</td>
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Findings from the Analysis

Part one, Question 1: Attitudes toward the importance of CAAD compared with traditional methods?

Figure 2 shows that the majority of respondents (85%) described their attitudes positively toward the importance of CAAD compared with traditional methods. However, 5% of the respondents were indifferent, and 10% had negative attitudes regarding the use of CAAD.

![Figure 2. Attitudes toward Using CAAD among architecture students](image)

Question 2: On the superiority of using CAAD over the traditional method of sketching, 80% of the students preferred to use CAAD media over traditional methods, whereas traditional-method users accounted for only 5% of the total (Figure 3). A great interest in CAAD was noted among all respondents. There seems to be a strong trend for architectural students to convert from traditional methods to CAAD. The dramatic increase of CAAD users suggests that there should be a serious reconsideration of the current curriculum to adapt to the new CAAD trends.
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Question 3: Type of CAD software used by students: The respondents were asked to identify the type of CAD software used in their graduation design project. Among the 60 respondents, 52 used AutoCAD, 3D-MAX and Photoshop, which are the most widely used software in education. However, the results revealed that the highest response rate was reported in Revit (7%), followed by Google Sketch-up (4.5%), ArchiCAD (4.5%), Grasshopper (2.1%), Maya (1.1%), and Vasari (1%) (Figure 4). None of the respondents used Heliotrope. Nevertheless, students employ various CAAD software to produce the best graphical representations with minimum cost, maximum functionality, and the highest quality.

Question 4: CAAD learning methodology by students: The respondents were asked to describe how they gained CAAD proficiency based on the parameters of departmental courses, self-learning, and private classes. As shown in Figure 5, 30% of the respondents stated that they gained proficiency in CAAD by self-learning first, and 25% gained their CAAD proficiency through departmental courses. This result confirms the finding when students were asked about their preferences toward CAAD. As shown in Figure 5, the majority (85%) of the respondents had positive attitudes concerning the use of CAAD, which explains the percentage of the respondents who were interested (55%) in learning CAAD either by themselves or in the department. The least number of respondents (15%) learned CAAD through private classes.
Question 5: The students were asked to specify the design method that was used in each stage/stages of the design process. Interestingly, both design methods were employed in all design stages. However, Figure 6 shows that traditional methods were used the most (80%) at the initial or conceptual stage and were utilized much less in the schematic design stage (30%). CAAD was used mostly in the phases such as in: design development, construction drawing, and the detailing and specification phases at 55%, 80% and 90%, respectively. Few respondents may use CAAD in the conceptual stage because CAAD has not replaced the traditional method of manually sketching designs. Instead, CAAD acts as an extension of manual methods with a vast potential to advance various design that previously were impossible to develop with traditional methods.

![Figure 6. Design method used in each stage](image)

Question 6: The students were asked to evaluate their proficiency level with CAAD applications. Figure 7 indicates that 90% of the respondents had high proficiency in AutoCAD, 85% had high proficiency in Photoshop, and 70% had moderate proficiency in 3-D MAX. In total, 40% and 35% of the respondents reported proficiency in Revit and Sketch-up, respectively. Moreover, 10% of the respondents used ArchiCAD, and 10% used Grasshopper. In contrast, regarding the use and performance of CAD environmental software, the results revealed that a very low response rate was reported for Heliotrope (0%), Vasari (1%) and software for lighting (3%) (Figure 7). This result can be explained by the lack of competent tutors in different CAAD areas.

![Figure 7. CAAD applications proficiency levels](image)

Part Two: Questions about the Advantages of Using CAAD Software

As shown in Figure 8, 90% of the respondents preferred to use CAAD for its various advantages, such as accuracy, neatness, speed and lower cost. Interestingly, 70-90% of the students stated that using the combination of CAAD with traditional methods typically helps them to visualize the end product better than using the CAAD method alone.
Fig. 8. Advantages of using CAAD software, traditional methods and combined methods

Moreover, majority of the respondents, of 90%, considered the quality of the projects that used CAAD to be higher than the quality of the projects that used traditional methods. However, 5% of the respondents are indifferent, and another 5% considered the design that is generated by CAAD to be of lesser quality than the design that is generated by traditional drafting (Fig. 9).

Fig. 9. Responses to Questions Pertaining to Quality of Designs Created with CAAD

As shown in Fig. 10, respondents indicated that CAAD has an important role in three central areas in the architectural curriculum, namely, design, urban design, and building technology, according to 90%, 85%, and 80% of the respondents, respectively. However, CAAD has a weak role in other areas, such as theoretical courses (45%), engineering systems (35%), and project management (25%).

Fig. 10. The Role of CAAD Course across the Curriculum of Architecture Schools

Part Three: A. Graduation Project Analyses

Fig. 11 shows that about 60% of the graduation projects demonstrated that their designers were
unaware of the projects’ needs, values, main goals and tentative cost estimate. It is interesting here to notice that the same ratio of the projects had problems with the functional relationships of the main components of the project. Finally, 55% of the projects' designs did not adhere to local or international standards.

![Figure 11. Architectural Program](image)

**B. Site Analysis**

A very interesting finding here was the low number of projects that employed CAAD or any other digital software in analyzing the site. Figure 12 indicates that only 5% to 15% of the graduation projects had used digital applications in analyzing or planning the site. This result accords with the findings in part 2, question 2, regarding the types of CAAD software. The majority of respondents were having a good command of traditional AutoCAD. Moreover, the absence of specialized software to analyze or plan the site obviously caused the wrong design decisions. About 60% of the examined projects had no or low responses to the urban context, surroundings and accessibility. Finally, 50% of the projects in the study area did not respond to the projects' given land in terms of shape, area and topography.

![Figure 12. Site Analysis](image)

**C. Architectural Concept**

As shown in Figure 12, the majority of the students showed a tendency to use CAAD even at the conceptual stage for drafting or site planning. Meanwhile, only 5% to 15% of the projects showed a tendency to use “generative” software to investigate a specific conceptual theme and its formal potential, such as Grasshopper, Maya, and Vasari. The interviews also revealed that because generative design software is not taught at the 3 schools, few students used this software by learning it on their own. Consequently, the projects were largely developed by using CAAD for drafting and illustrative goals and lacked the necessary basis to comply with the required criteria to generate rational and creative designs, with little or no attention paid to regional, cultural and environmental or artistic considerations.
D. Architectural Presentation

As shown in Figure 14, the majority (90%) of the analyzed graduation projects were mainly concentrated on the poster design theme. Regarding “3D presentation”, a higher use was reported; 85% reported that they used it in their graduation projects, whereas only 35% responded that they employed the traditional methods of physical modelling in their projects. Furthermore, the 3D presentations were delivered as seductive conceptual images that were incompatible with the 2D drawings and in some cases, with the physical models. This result means that the students are concentrating on images rather than on content, which leads to irrational and unrealistic projects. This result confirms our findings from the questionnaire survey, part 3, where most respondents indicated that CAAD would guarantee a higher quality project. Certainly, there is no integration between CAAD and other courses in the curricula.
E. Buildability

The survey revealed that no digital software was used to achieve a certain level of buildability (see Figure 15). The overwhelming majority of graduation projects lacked the necessary information regarding the structural and constructional aspects of the proposed design and with no meaningful impact on the architectural concept.

As shown in Figure 16, the evaluation of 60 graduation projects from three architectural schools in Jordan according to criteria of program, site analysis, concept, presentation and realization revealed relatively similar results for the three schools. As expected, the architectural presentation criteria consistently scored the highest; ranging from 75% to 61.3%, and the site analysis and concept criteria presented the next highest scores, ranging from 67.7% to 59.1% and from 59% to 55.1% respectively. However, the architectural program and buildability criteria had the lowest scores, in the ranges of 59.7% to 48% and 32% to 30.5% respectively. These disappointing results reinforce the notion that the overall quality of design has declined significantly due to the misuse of digital visual tools.

DISCUSSION AND CONCLUSIONS

This paper assessed the impact of CAAD tools on the design process and on the quality of the architectural end product at three schools of architecture in Jordan. The findings revealed that all three schools have almost the same architectural design educational approach that mixes traditional design methods with digital methods.

Analyses revealed that although majority of students were found to have a strong tendency to use
CAAD software programmes for its various advantages, such as: accuracy, neatness, speed and lower cost, etc.

Presently, the mode of teaching CAAD in most, if not all, of the architectural departments in Jordan does not encourage the use of CAAD in early phase of the design, just like in the conceptual stage.

The study shows that CAAD tools have not been integrated into the creation processes of the conceptual architectural design and the influence of the CAAD tools in the conceptual design phase is still very minor. Moreover, all interviewees agreed that the creation procedure has not been influenced by the adoption of digital tools (see Figure 17). At the same time, findings from the analyzed design projects showed that the presented projects are seductive graphic more than realistic architecture.

CAAD is still being considered, perceived and utilized as drafting, modelling, and rendering tool rather than as a problem-solving strategy. Simultaneously, this restricts the potential use of CAAD to develop already created designs, but not to use it as a tool to generate new design. Very few analysed projects showed the use of CAAD as medium to create an innovative form in the geometrical formation and conceptual phase. And this can be explained according to:

- A basic curricular split between architectural education and the digital world. This assures Botchway et al. (2015) findings, when he assessed the impact of CAAD Design Tools on Architectural Design Education, as he found out that CAAD is taught in isolation of other design courses in the department.

- Marginal balance between creative and technical courses.

- Split between CAAD courses and other multi- and inter-disciplinary disciplines (e.g., structural, environmental, urban courses, etc.)

- The transformation of students’ design trends from traditional methods to CAAD is still not clearly defined. And this affects students’ ability to transfer their skills that are learned through traditional methods to the more complicated CAAD method.

<table>
<thead>
<tr>
<th>Conceptual Mental Stage</th>
<th>Role of CAAD</th>
</tr>
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<tbody>
<tr>
<td>Architectural Program</td>
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<tr>
<td>Site Analysis</td>
<td></td>
</tr>
<tr>
<td>Form</td>
<td></td>
</tr>
<tr>
<td>Design development</td>
<td></td>
</tr>
<tr>
<td>Buildability/ construction</td>
<td></td>
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<tr>
<td>Architectural Presentation</td>
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</table>

Figure 17. The Role of CAAD Tools in Architectural Design Stages
Therefore, this shift in students' preferences toward CAAD systems has resulted in a dramatic change in the study context together with other various shifts in design media, design thinking and design theory.

Analyses of design projects showed that digital media has become very essential, so that other physical media, such as scale-models and sketches that address better sensible aspects of design, are excluded. 3D CAAD modelling and virtual animation in most of the analysed projects were replacing the physical model. Thus, students' designs were neither realistic nor comprehensive and there were no compatibility between the different set of drawings. Drawings are more seductive artistic and graphic rather than buildable (see Appendix A1, A2, A3). This should be resolved by integrating both: physical and digital tools in design. This integration would increase students' experience of inquiry, discovery and representation (Achten, 2003) and this leads to creativity.

Furthermore, we as educators have the responsibility to teach CAAD courses in creative way, as extension to our creative possibilities. So that, CAAD tools can be used in developing a responsible, responsive and integrated architecture that meets society needs and adhering to the surrounding environment as well.

So far, our case study confirms Schenk (2005) findings in terms of how to integrate CAAD into the drawing curriculum not the opposite. This gives another example of how students' tendency to apply visual media to any other conventional design skills need to be reconsidered (Salman et al, 2006; Breen, 2004; Schenk, 2005).

Finally, CAAD and other digital technologies shall be engaged within the architectural design in early stages so that such tools would be used to provide creative design. Moreover, digital technology should be utilized as an essential part of the new design studio culture that integrates with other design subjects and courses in the architectural education curriculum. Integrating digital technology into architectural design education curricula help to create more responsive designs in terms of: structural, environmental, urban, and other components. Thus, understanding and employing these new technologies in proper ways could afford us with more innovative, responsible, effective, and more integrated designs. Thus, we must reconsider the potential of computers and communication technology to orient the entire institutional infrastructure and pattern of behavior for better architectural education and practice. There is also a crucial need to review the national accreditation criteria for architectural education postgraduates' program curriculum to make them more adaptable to these emerging and ever-changing digital technologies.

REFERENCES


### APPENDIX A

#### Architectural Graduation Projects, Jordan

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>A1</th>
</tr>
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<tr>
<td><strong>Assessment Criteria</strong></td>
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<th>University:</th>
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<td>2015-2016</td>
<td>AAU</td>
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<th>Location:</th>
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<tbody>
<tr>
<td>25,000 m²</td>
<td>AQA- JORDANBA</td>
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</table>

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**CULTURAL CENTER IN AQABA** - Ziad Abu Naser - Supervised by Dr. Rana Matarneh

![Cultural Centre in Aqaba](image-url)
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>A2</td>
<td></td>
</tr>
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</table>

**Project Title:** Cultural centre  
**Year:** 2015-2016  
**University:** AAU  
**Built up Area:** 25,000 m²  
**Location:** AQA- JORDANBA

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**BERQESH ECO RESEARCH CENTER**

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![Images of the Berqesh Eco Research Center project, including sketches and renderings of the building design.]
**Cultural centre**

*Title:* Cultural centre  
*Year:* 2015-2016  
*University:* AAU  
*Built up Area:* 25,000 m²  
*Location:* AQA-JORDANBA
Asymptote Misconception on Graphing Functions: Does Graphing Software Resolve It?

Mehmet Fatih Öçal [1]

ABSTRACT

Graphing function is an important issue in mathematics education due to its use in various areas of mathematics and its potential roles for students to enhance learning mathematics. The use of some graphing software assists students’ learning during graphing functions. However, the display of graphs of functions that students sketched by hand may be relatively different when compared to the correct forms sketched using graphing software. The possible misleading effects of this situation brought a discussion of a misconception (asymptote misconception) on graphing functions. The purpose of this study is two-fold. First of all, this study investigated whether using graphing software (GeoGebra in this case) helps students to determine and resolve this misconception in calculus classrooms. Second, the reasons for this misconception are sought. The multiple case study was utilized in this study. University students in two calculus classrooms who received instructions with (35 students) or without GeoGebra assisted instructions (32 students) were compared according to whether they fell into this misconception on graphing basic functions (1/x, ln x, e^x). In addition, students were interviewed to reveal the reasons behind this misconception. Data were analyzed by means of descriptive and content analysis methods. The findings indicated that those who received GeoGebra assisted instruction were better in resolving it. In addition, the reasons behind this misconception were found to be teacher-based, exam-based and some other factors.

Keywords: Asymptote Misconception, GeoGebra, Graphing Functions

INTRODUCTION

Functions play a crucial role during and after the late-elementary school years. They are used in many areas of mathematics education including word problems, analytic geometry (Nachlieli & Tabach, 2012), derivatives, and integrations (Thompson, Byerley, & Hatfield, 2013). In many cases, teachers present the graph of any function to visualize it and interpret its behavior under different circumstances. Some of the functions (such as 1/x, ln x, e^x) are considered as basic ones especially after late high school education and both teachers and students can graph them on paper by rote (Hacıomeroglu & Andreasen, 2013) without wasting time.

In mathematics education, technology use is widespread in recent years. Various software, applications, and animations are used by teachers or proposed for use by mathematics educators in the classroom in order to visualize the mathematical contents (Hohenwarter, 2006) and improve students’ mathematical thinking and conceptual understanding (Özgün-Koca & Meagher, 2012). Among them, the dynamic mathematics software developed purposively for learning mathematics give students opportunities to communicate and explore the relations among mathematical concepts and reason about them (Akkaya,
Tatar, & Kağızmanlı, 2011). In addition, students can visually observe the instant effects of the changes made (e.g., the effect of changing constants of a function) while working in such environment due to their dynamic feature. GeoGebra is one of these dynamic mathematics environments. Since this software elicits the relation between the algebraic and geometric forms of mathematical concepts (Haciomeroglu & Andreasen, 2013), it can be used in different grade levels from primary school to university mathematics classrooms. Therefore, this software is a useful tool for teaching and learning the graphs of the functions and is a remedy for misunderstanding in this topic.

This paper emerged due to students’ rote memorization of graphing function. In this study, using GeoGebra in a calculus course to observe the behavior of basic functions made an inspiration for the researcher to discover a misconception for graphing functions. Studying the graph of a logarithmic function \( \ln x \) in that case on GeoGebra, a student noticed how fast the graph was approaching to y-axis as the value of \( x \) approaches to 0 by stating that “the left arm of graph is very very close y-axis just after \( x \) is smaller than -2”. He added that “the arms of this function is not as close as it is on GeoGebra in my sketches”. This situation was considered to be a new emerging misconception on graphing functions, especially for the basic ones \( \frac{1}{x}, \ln x, e^x \).

With this respect the purpose of this study is to investigate students’ misconception while sketching graphs of functions by rote, what is called in this study the asymptote misconception on graphing functions. Based on the function’s characteristics, this misconception occurs if the arms/arms of the function are approaching to any asymptotes and the arm/arms sketched are relatively far from such asymptote. That means in its operational definition that if students have problems in approaching the arms of functions to the asymptotes during the sketching process, this cognition was considered as asymptote misconception.

Since this study was related to the graphs of basic functions \( \frac{1}{x}, \ln x, e^x \), the focus was on the arms of functions approaching to the linear (horizontal and vertical) asymptotes.

**LITERATURE REVIEW**

The idea of using graphing technology in mathematics learning and teaching is widespread. In various domains of mathematics including calculus (Lauten, Graham, & Ferrini-Mundy, 1994) and representation of algebraic equations (Erbas, Ince, & Kaya, 2015), graphing technologies are widely used in mathematics classrooms. In addition, the present literature and international curricula support the use of technologies in learning mathematics (e.g., Common Core State Standards Initiative [CCSSI], 2010; Heid, Thomas, & Zbiek, 2013; National Council of Teachers of Mathematics [NCTM], 2000). For example, one of the six principles in the principles and standards for school mathematics is the technology principle indicating that “technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning” (NCTM, 2000, p. 24). Considering that “...graphing utilities facilitate the exploration of characteristics of classes of function” (NCTM, 2000, p. 27), it would be better for students to deal with the interactive or dynamic environment while investigating the behavior of the functions on the graphs sketched (Hohenwarter, 2006).

Students may have misconceptions about sketching graphs of functions. As known, the misconceptions are considered to be incorrect conceptions and many students are prone to perceiving them as correct (Koray & Bal, 2002). The main characteristics of misconceptions are that students construct alternative definitions for the concepts studied; many of them believe in them as scientific fact, and it is very hard to change such incorrect beliefs (Fisher, 1985).

Especially in mathematics education, various misconceptions related to different topics including graphing functions. For example, Clement (1985) mentioned about two types of misconceptions about graphs of functions. These are “treating the graph as a picture” and “slope-height confusion”, the latter of which is somewhat related to the present study. Similarly, Glazer (2011) emphasized that the display of graphs of functions is of great importance for interpreting them by discussing which one of creating or
interpreting a graph is more crucial. Considering these facts, students’ misconceptions might be strengthened with inappropriate use of graphs in high school and university textbooks (Kajander & Lovric, 2009), role of teachers’ pedagogical content knowledge during instructions (Rubel, 2002) and their use of inappropriate visual materials (Mudaly & Rampersad, 2010), and inconsistencies in students’ mind while they are dealing with interrelated mathematical concepts (Tall, 1990). Taking them into consideration, the traditional instructional methods and teachers’ role in teaching activities during such instructions may foster misconceptions in students’ cognitions (Marek, Cowan, & Cavallaro, 1994; Ubuz, 1999). Combination of these reasons may influence students’ understanding and become a serious obstacle to learning.

The mathematics education researchers investigated the ways of remedying or at least diminishing negative effects of emerging misconceptions (e.g., Ellis & Grinstead, 2008; Straesser, 2001). For graphing functions, studying the problems in interactive platforms including GeoGebra, Sketchpad or graphing calculators are seen as one of the effective ways of doing so (Koklu & Topcu, 2012). If teachers use graphing software (such as GeoGebra) effectively, it is possible to deal with possible arising misconceptions related to graphing functions (Heid, Thomas, & Zbiek, 2013). This is because such platforms and the effective use of graphing software provide advantages in student learning. Some of the advantages of graphing software are “representing mathematical objects from multiple perspectives, examining and/or exploring mathematical relationships in depth, experimenting with different approaches to problem solving, forming and testing conjectures and questioning and critical thinking” (Koklu & Topcu, 2012, p. 1000).

As a dynamic mathematics environment, the effect of using GeoGebra in math classrooms was investigated by many researchers (e.g., Akkaya, Tatar, & Kağızmanlı, 2011; Aydos, 2015; Carter & Ferrucci, 2009; Dikovic, 2009; Haciomeroglu & Andreasen, 2013; Hutkemri & Zakaria, 2012; Koklu & Topcu, 2012). For example, Akkaya, Tatar, and Kağızmanlı (2011) compared the effects of instruction with GeoGebra and traditional instruction for the case of teaching trigonometry. This study revealed that achievement levels of students receiving instruction with Geogebra were higher than those taught via traditional method. Similarly, Aydos (2015) studied gifted students’ conceptual understanding of limit and continuity. The study mentioned the importance of the sketching and interpreting the graph of functions for increasing the conceptual understanding of such topics. In this experimental study, the students taught with Geogebra were more successful in the test measuring the conceptual understanding of limit and continuity. In addition, Carter and Ferrucci (2009) indicated that Geogebra was a helpful tool for enhancing learning and understanding the geometry topics including sketching graphs after investigating the prospective mathematics’ teachers’ understanding of geometry by means of Geogebra. Another study was about high school students’ conceptual and procedural knowledge of functions after teaching the topic via Geogebra (Hutkemri & Zakaria, 2012). It was concluded that visual representations of the functions played a key role in improving conceptual knowledge of functions and Geogebra is a beneficial interactive environment for doing so.

Taking this suggestion into account, enhancing conceptual understanding of functions might hinder the possibility of asymptote misconception and other misconceptions related to graphs of functions. Moreover, the aid of graphing technology may diminish their negative effects. Therefore, students do not encounter further problems in understanding the relation between a function and its graph, the meaning of graphs of functions, and interpreting them.

This paper gives answers to the following questions:

1- Is there any difference in remedying students’ asymptote misconception between calculus classrooms with and without GeoGebra assisted teaching environment?

2- What are the reasons for students’ asymptote misconception while sketching graphs of basic functions?

METHODOLOGY

The present study is a qualitative case study investigating students’ asymptote misconception and its possible reasons. With the case study design, one or more cases including a person, a clique or a group of people are examined deeply within their holistic constraints (McMillan & Schumacher, 2006). Creswell (2007)
indicates that the researcher can investigate the cases studied through in-depth data collection (p. 97) with multiple data sources. With its nature, this study is a multiple case study (Yıldırım & Şimşek, 2008) investigating whether there is a difference in remedying asymptote misconception with or without GeoGebra assisted instructions. Therefore, there are two cases, first of which was the students in calculus classroom receiving GeoGebra assisted instruction. The latter one is those who did not receive GeoGebra assisted instruction in calculus lesson.

**Participants**

In order to investigate the difference in calculus classrooms with and without GeoGebra assisted instruction, the participants were selected from two calculus classrooms. Students in these classrooms were generally second graders of a public university located in the eastern part of Turkey. The convenience sampling method was utilized in order to determine the participants of the study (Yıldırım & Şimşek, 2008).

The lecturer of one chosen calculus classroom preferred to use GeoGebra in some parts of his lessons. Although he was not strictly dependent on using GeoGebra, he used it throughout the semester. He consulted the software at least once per block scheduled lesson (merging two lessons). He used this software when there was a need for visual stimulant related to content studied during the lessons. For example, he visualized the function of max-min problem or investigated the limit of function on graph. Therefore, students attained familiarity with the correct form of any given functions. On the other hand, the lecturer of the other chosen calculus classroom did not use any graphing software or physical material to show the graphs of functions. Instead, he sketched the graphs on the board by hand. In both classrooms, the lecturers did not emphasize this misconception to students. There were 35 students enrolled in the former classroom (instruction with GeoGebra aid classroom [Iw/G]); some 32 students were in the latter (control group classroom [CGC] with regular instruction implemented).

**Data Collection Procedures and Tools**

The calculus course contents included the limits of functions, derivative, integration, and their applications. All participants have taken the pre-calculus course providing knowledge for pre-requisites of the content of the calculus course. The course was given in different sections in the faculty of education in a public university. Before enrolling in the calculus course, it was assumed that students were taught several functions and their graphics including basic functions such as $\frac{1}{x}$, $\ln x$, $e^x$ during their high school education. This is because they graduated from the science and mathematics track in high schools and took nationwide university entrance exam in science and mathematics, which include tests from geometry and pre-calculus mathematics.

Both classrooms followed the same curriculum. However, the difference was that the lecturer in the former classroom utilized GeoGebra in solving questions, sketching the graphs when necessary, explaining the meaning of the graphs sketched by using properties of GeoGebra. The lecturer in the latter classroom, on the other hand, presented the same content by solving questions or sketching graphs on the board.

The data were collected from two data sources. First of all, all students were expected to sketch graphs of $\frac{1}{x}$, $\ln x$, $e^x$ on a grid paper provided and to explain how they sketched them. Secondly, three students from each calculus classrooms were interviewed about sketching the graphs, possible difficulties encountered and the reasons for asymptote misconception. For both data collection tools, expert opinion was gathered from two lecturers who had experience in teaching calculus courses.

**Data Analysis**

Both data sources were analyzed according to the content analysis method (Creswell, 2007). Descriptive analysis was also used and frequency and percentage tables were provided to enrich findings. For the first data source, two researchers classified all students’ graphs sketched under three categories by scoring them as incorrect, shape is correct (asymptote misconception), and correct. Answers indicating correct and asymptote misconception sketches were evaluated according to reference points that students
indicated. For example, for those who sketched the graph of \( \ln x \), the reference point was (1, 0) \((\ln 1 = 0)\). How fast the left arm of the function approached to y-axis was compared according to distance from y-axis to the reference point (1, 0).

For frequency table, inter-rater reliability was found to be 91%, which is inside the acceptable level (Marques & McCall, 2005). (The inter-rater reliability was calculated according to the formula “total agreement” / “total observations”) The table is presented according to final consensus over all codes. The interviews were analyzed to find the reasons for asymptote misconception. First of all, students were asked to sketch the graphs. In case they fell into asymptote misconception, they were provided with the correct forms of the graphs on GeoGebra and the interviewer emphasized how fast the arms of the functions approached to the axes. Then, the reasons that students indicated were supported with direct quotations from their statements during the interviews.

Findings

Findings related to Influence of Using GeoGebra in Remedying Asymptote Misconception

Both classrooms encountered the graphs of \( \frac{1}{x} \), \( \ln x \), and \( e^x \) during the calculus instructions. The difference was that the Iw/G observed these functions on GeoGebra software while CGC observed them on the board sketched by the lecturer. The correct forms sketched on GeoGebra are given in the following Figure 1. It was observed that the arms of the functions are rapidly approaching to the axes and asymptotes.

As well seen in Figure 1, functions approach the x- and y-axes very fast as x approaches to plus or minus infinity or 0. On the other hand, answers of students who fell into asymptote misconceptions were shown in the Figure 2, 3, and 4.
According to reference points that the students indicated (for example (1, 0) for $\ln x$ and (0,1) for $e^x$), the graphs sketched by students were not approaching to the axes as fast as the correct forms of the graphs of the functions shown in Figure 1. To give answer to the first research question, Table 1 showed the frequencies and percentages of whether students correctly sketched the graphs of given functions, fell into asymptote misconception while sketching them, or incorrectly sketched them.
Table 1. Comparison of students’ asymptote misconception on graphing functions in calculus classrooms with and without GeoGebra assisted instruction

<table>
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<tr>
<th></th>
<th>Graph of $\frac{1}{x}$</th>
<th>Graph of $\ln x$</th>
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<td>Iw/G (n=35)</td>
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<td>Incorrect</td>
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<td>8</td>
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<td></td>
<td>(11.4)**</td>
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<td>(Asymptote Misconception)</td>
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<td>Correct</td>
<td>15</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(42.9)</td>
<td>(34.4)</td>
<td>(34.3)</td>
</tr>
<tr>
<td>No Answer</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>(5.7)</td>
</tr>
</tbody>
</table>

* Frequency of students for the intended answer

** Percentage of students for the intended answer. Rounded to first decimal place.

As seen in Table 1, the percentages of students who fell into asymptote misconception are high both in Iw/G and CGC. However, the percentages of students who fell into asymptote misconception are slightly lower for all types of functions for the Iw/G group. In addition, percentages of students who correctly sketched the functions are slightly higher in Iw/G. One interesting finding is that students experienced difficulty in correctly sketching the graph of $e^x$. Highest difference was observed in the percentages of students who fell into asymptote misconception while sketching $\ln(x)$ where 13 students in Iw/G fell into asymptote misconception for this question. Comparing this finding with students in CGC, the number of students sharply increased to 17, which was more than half of all students in CGC.

These findings indicated that using GeoGebra in teaching the topic had a limited effect on resolving students’ asymptote misconception. This is because it was observed that the correct answers in the GeoGebra classroom were slightly higher than those in the other classroom. Moreover, there was a small difference between students’ answers indicating the misconception in GeoGebra and control group classrooms. It should be pointed out that students in the GeoGebra classroom achieved better scores according to the findings summarized in Table 1. Keeping in mind its limited effect, students could observe the functions on GeoGebra and correctly sketch, therefore, interpreting correctly the basic functions such as $\frac{1}{x}$, $\ln x$, and $e^x$. This limited effect could be increased over students if the lecturer emphasized the behavior of functions on arms of their graphs. The following transcript of the interview with Aylin (pseudonym) having asymptote misconception in CGC shows this situation clearly.

Interviewer : *Can you sketch the graph of $\ln(x)$? (Grid paper is provided for student)*

Aylin: *(While sketching graph). Well, first of all, I need to show the intersection point with x-axis, which is (1, 0). Because when x is equal to 1, $\ln 1$ is equal to 0. If the x goes to infinity, so does $\ln x$. And the other arm of function approaches to y-axis.*

Interviewer : *Ok. Your sketch is somewhat correct, but you have little problem on it.*

Aylin: *Umm... I think it is correct. It intersects the x-axis at point (1, 0) and is going to minus infinity when x is approaching to zero. I think it is totally correct.*

Interviewer : *Do you want to see the graph on graphing software, for example GeoGebra?*

Aylin: *I wondered about it? Yes. Please show it. (After observing the graph on GeoGebra). Umm. It is similar to my sketch. ... Hmm... Wait. It is very close to y-axis. Something like they (left arm of function and y-axis) are almost united. ... And, the left side is getting very flatty.*
This transcript showed how important it is to emphasize the behavior of functions on any graphing software when teaching the behavior of graph of functions, especially for those having asymptotes. This student could not realize the approaching behavior of the function in the first place. After analyzing the function on GeoGebra in detail, she realized her asymptote misconception.

Findings related to Possible Reasons for the Asymptote Misconception

The interviews with students continued to discuss the possible reasons for this misconception. These interviews helped the researchers to present answers for the second research question. Based on interview findings, they can be grouped under the main themes such as teacher-related, exam-related, and some other miscellaneous reasons. Table 2 presents these reasons and respective quotations from students’ explanations during the interviews.

Table 2. Reasons for asymptote misconception from students’ points of view.

<table>
<thead>
<tr>
<th>Main Categories</th>
<th>Related Reasons</th>
<th>Quotations from Interviews with Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-Related</td>
<td>Teachers’ Misconception</td>
<td>...Like us, I think they did not also realize how fast they (graphs of functions) were approaching to the axes. Most probably, they did not know it (asymptote misconception) either...</td>
</tr>
<tr>
<td></td>
<td>Time Taking</td>
<td>...Sketching the graphs with original shape similar to computer sketches takes too much time. In the paper (test applied to students for graphing functions before interviews), I tried and it took much time. I think teachers do not want to spend such much time for sketching any graph...</td>
</tr>
<tr>
<td></td>
<td>Belief that Students do not understand</td>
<td>...Maybe teachers did not want students to get confusion in mind. Instead, I mean, they are sketching them (graphs of function) roughly...</td>
</tr>
<tr>
<td></td>
<td>Not giving attention</td>
<td>...They were roughly sketching the graphs. They were not paying attention to sketch as similar to GeoGebra does...</td>
</tr>
<tr>
<td>Exam-Related</td>
<td>Nation-wide university exam</td>
<td>...we were dealing with questions instead of the details of the graphs during high school education. We needed to solve as many questions as possible. So, it was enough for us to see the graphs sketchy...</td>
</tr>
<tr>
<td></td>
<td>Regular exams</td>
<td>...Our focus was on the solution of the question (during high school education). In the practice papers and tests, we did not look whether the graph was close to axes or not. It is not useful for us to solve questions...</td>
</tr>
<tr>
<td></td>
<td>Sketching by rote</td>
<td>...Neither we nor teachers applied the basic steps on sketching graphs of function. If we knew where the function approaches as x goes to minus or plus infinity, or if we knew the shape of it roughly, we would sketch it by rote. It is a kind of hand habit...</td>
</tr>
<tr>
<td></td>
<td>Sketching based only on a few points</td>
<td>...I’m giving some value to x and defining the points that the function pass through. Then, I’m guessing what shape the graph takes...</td>
</tr>
</tbody>
</table>

According to the findings gathered from the data sources, it could be concluded that there were many possible reasons for the misconception. In general, both teachers and students ignored to sketch the graphs
as correct as GeoGebra did. Instead, they all preferred to sketch the graphs roughly. In addition, students generally referred to the high school teachers and high school education for this misconception.

Lastly, one student gave much attention to sketching the graphs correctly. The researcher asked the reason for her attention. She gave the following answer.

It is possible that teachers in high school cope with details in sketching graphs. But I will be a mathematician, I have to know them. I have to interpret the graphs. I have to know the critical points and steps of any topic in mathematics.

CONCLUSION & DISCUSSION

Based on the findings of the study, students were prone to fall into asymptote misconception. Considering students’ incorrect answers exhibiting the asymptote misconception for the functions of \( \frac{1}{x} \), \( \ln x \) and \( e^x \), it was observed that they roughly sketched them. They did not even give detailed explanations for their sketches or provide information about how to sketch the graphs. Their sketches (e.g., Figure 2, 3 and 4) gave evidence that they constructed an alternative belief and definition that the sketches of graphs of functions are correct if their displays are roughly similar (Fisher, 1985), which was a misconception. Alternative belief in this case was that sketching the graphs by rote represented the correct form for the indicated function. However, the graphs of functions were distinguished when compared to their correct forms as shown in Figure 1. The main concern for this misconception was that it may result in students’ misinterpretation of graph of function (Glazer, 2011), misleading effect of which might cause new misconceptions for further learning due to their widespread use in many areas of mathematics (Nachlieli & Tabach, 2012). Considering the NCTM (2000) technology principle, GeoGebra is a useful platform for students to study graphs of functions to diminish the misleading effect of this misconception, because it enhances students’ understanding and explorations of the functions due to its dynamic feature (Hohenwarter, 2006).

Table 1 indicated that instruction with GeoGebra in the calculus classroom had slight positive effect on students’ correct sketches of the graphs of functions and remedying this misconception. During the instructions, the focus was not on investigating the behavior of functions. For example, the lecturers did not emphasize how the arms of investigated functions (e.g., \( \ln x \)) approach to the x- and y- axes as x approaches to minus or plus infinity. However, students in the Iw/G classroom had opportunities to observe the correct form of the functions and their behaviors in a dynamic environment and explore the characteristics of functions including their graphs (NCTM, 2000). Considering the slight effect of using GeoGebra without focusing on the behavior of functions, the teachers or lecturers should beware of the presence of asymptote misconception and make an effort to resolve it with graphing software (such as Geogebra) in order not to encounter new misconceptions fostered by it in the further learning of mathematics (Heid, Thomas, & Zbiek, 2013).

Teachers’ emphases on resolving this misconception served the purpose. As an interactive platform, it is known that GeoGebra helps students to construct relations between algebraic and geometric representations of mathematical concepts (Haciomeroglu & Andreasen, 2013) and conceive the relations among them (Koklu & Topcu, 2012). In this study, it was observed during the interviews with students that focusing on this misconception by using GeoGebra provided them with better understanding of correct forms of the functions. Interviews with students who had such misconceptions (e.g., interview with Aylin) showed that emphasizing the asymptote misconception by means of GeoGebra helped them to resolve the misconception.

Students’ responses to the interview questions revealed the possible reasons for the asymptote misconception. The possible reasons in line with students’ opinions were grouped under three categories including teacher-based, exam-based and other miscellaneous reasons. These findings were supported by the Kajander and Lovric (2009) and Rubel (2002) studies. Considering the possible negative effects on analyzing and interpreting the graphs of functions for students’ further learning, teachers (or lecturers) may
pay attention to resolve the appearing misconceptions (including asymptote misconception and other possible ones related to graphing functions) on time (Heid, Thomas, & Zbiek, 2013). For example, Clement (1985) mentioned about students’ possible confusion in interpreting the correct graphs of speed-time and word problems.

Based on students’ opinions, this misconception appeared among students mainly for teacher-related reasons. Some students thought that teachers also had this misconception and applied the incorrect sketches during teaching activities. Before teaching the mathematical content in the classroom, teachers had various misconceptions and incorrect beliefs because of their past learning experiences and tended to bring them into their classroom instructional practices (Yanik, 2011). This might result in sketching the graphs by rote, which was another reason for asymptote misconception. In this case, teachers should be open to new ideas for improving their teaching skills. Considering the graphing graphs topic, using graphing software (such as GeoGebra) in classrooms may inspire teachers’ teaching methods and diminish the possibility of misconception occurrence, because both teachers and students would see the graphs of functions in the correct form.

Some students thought that although teachers were aware of this misconception, they thought that graphing function is a time-consuming activity, and did not give enough attention and sketched the graphs roughly in the classroom. This was because they had to give attention to the contents taught instead of the graphs of functions. However, it was evident that the incorrect form of graphs of functions might result in students’ misinterpretation of the graphs of functions and influence the understanding of the topic studied or topics in further learning (Carter & Ferrucci, 2009). With correct and well-organized use of graphing software (such as GeoGebra) in classrooms, the possibility of such misinterpretations could be diminished and correct cognition could be maintained due to software features enabling visualization of the functions and the dynamic environment for constructing relations between algebraic and geometric forms (Hohenwarter, 2006; Koklu & Topcu, 2012).

The nationwide university exams and grade level exams were considered to be another reason for this misconception. Students thought that their focus was on solving the questions instead of dealing with sketching the exact form of the graphs of functions. The key point was that teachers were prone to accepting their sketches indicating this misconception as correct especially in regular math exams. At this point, teachers should beware of this misconception and emphasize the correct form to students.

One interesting finding was that students experienced difficulty in sketching the graph of $e^x$ in both classrooms although they encountered it during lessons and in textbooks. In fact, one of the purposes of this study was to examine the reasons for a particular misconception (asymptote misconception). However, this finding showed that there was a need for deep investigation to study the reasons (e.g., cognitive or readiness reasons) for students’ inability to sketch this and other particular functions. This is because even university level students encountered difficulty in sketching a basic function ($e^x$ in this case).

This study specifically investigated students’ asymptote misconception on particular functions. The focus was only on students’ asymptote misconception during graphing basic functions of $\frac{1}{x}$, $\ln x$, and $e^x$. Considering that their asymptotes were either horizontal or vertical, the findings of this study were shaped accordingly. This brought a discussion on whether investigating asymptote misconception on different functions with other asymptote types may reveal new findings and implications. Therefore, the research can be extended to deeper investigation of graph-related misconceptions including the asymptote misconception for other functions with horizontal, vertical and oblique asymptotes.
REFERENCES


ABSTRACT

This study aimed at determining the impact of demographic factors on the Internet usage purposes of high school students. The population of the study consisted of students between 9th and 12th grades from the Anatolian high schools, science high schools, social sciences high schools, sports high schools and fine arts high schools in Turkey. The sample was chosen through the stratified and cluster sampling procedure. The students were chosen randomly depending on the regions of their school attendance. The sample for this research numbered 3170 students. The research was conducted in the second term of the 2014-2015 academic year. The data were obtained through online forms and the bases of participation are honesty, sincerity, and volunteerism. The data collection tool is a questionnaire and a demographic information form prepared by the researchers. Chi-square Automatic Interaction Detector (CHAID) analysis was conducted through SPSS in order to determine the demographic factors affecting the purposes of internet usage among high school students. The results of this research show that 9th grade students in Turkey mostly use the Internet to do homework while students from other grades mostly use the Internet for social networking. The male students use the Internet for playing video games more frequently in comparison with female students. Also, socioeconomic status affects the purpose of Internet usage. Hence it is suggested that teachers talking to male students might use the examples of computers and games and with female students they might relate the topics to social media.

Keywords: Internet Using Purposes, CHAID Analysis, High School Students.

INTRODUCTION

In recent years, the Internet has facilitated daily life in many aspects and it has become increasingly widespread. Internet usage has increased in areas such as: health, shopping, education, banking, transportation and personal data investigation. Mobile devices play an important role in this significant increase in Internet usage. By the first 3 months of 2015, 74% of the internet users in Turkey accessed the Internet through mobile phones or smart phones (TÜİK, 2015), an increase from 58% in 2014. Thus, it can be said that smart phones have become more prevalent for Internet access and quite a number of people living in Turkey access the Internet through PDAs.

Internet usage has increased among the entire population as well since it has the lion’s share especially among the teenagers in Turkey (TÜİK, 2013). Since today's youth is composed of digital natives, it is necessary to understand them, review their needs in education and use new pedagogical approaches (Bilgiç, Duman, & Seferoğlu, 2011). Internet has some advantages such as the variety of knowledge presentation or the speed and convenience of information access. The Internet has acquired a stronger position than other tools with these advantages (Ekiz, Bayam, & Ünal, 2003). When
this strong position of the internet is considered, it can be referred that it is one of the most important tools enabling enhancement of the digital natives’ learning capacity.

The teacher-student relationship has been reshaped as a result of Internet use in education (Akkoyunlu, 2002). To manage this relation properly and make the Internet beneficial for students, it is very important to know, understand and explain the purposes of internet use by students. By identifying the Internet use purpose correctly, communication resources can be used more effectively and student motivations can be increased. In addition, if the purposes of high school students’ Internet use are identified, this information could be used as a tool for improving education. The variables affecting Internet use among them should be determined. As a result of that study, several researches could be conducted on designing the best educational environment for the students depending on the primary purposes of their internet usage. For instance, the study by Noh et al. (2013) on Facebook indicates that Facebook could have a position in the future design of curriculum. DeWitt et al. (2013) also posit in their study on the impact of YouTube on education that YouTube could be used in the performing arts education. With the contribution of these studies, curriculum specialists, teachers and other partners could be advised based on the Internet usage purposes of the students. Therefore, it is important to examine and show the purposes of the internet usage of the high school students in Turkey.

While some researchers have studied problematic Internet usage at high school level (Derin, 2013; Gençer, 2011; Gürcan, 2010; Ha et al., 2007; Isarabkhaki & Pewnil, 2016; Kim, Nam, Oh, & Kang, 2016; Özgün, 2011; Seo, Kang, & Yom, 2009; Sinkkonen, Puhakka, & Meriläinen, 2014; Şahin, 2014; Toraman, 2013; Wang et al., 2011), other scholars examine how much time is spent on the Internet (Çevik, 2016; Kelleci, Güler, Sezer, & Gölbaşi, 2009). Although there are some studies on the Internet usage habits of high school students (Ak, 2014; Kahraman, Altun-Yalçın, & Çevik, 2011; Nachmias, Mioduser, & Shemla, 2000; Ogur, 2016; Tsai & Tsai, 2010), it is observed that the level of examining the purposes of the internet usage by these studies is not adequate. As a result, identifying the Internet usage purposes of the students and the factors affecting them carry are of utmost importance. Through this identification, methods used frequently by the students could be determined and used for improving education. As Sheikh-Abdullah (2016) states, teachers should benefit from technology to contribute to the learning environment.

When the conducted studies on the university students’ Internet usage are examined, it is observed that university students use the internet for research, doing homework, accessing information, communication/social networking and trading purposes (Akkoyunlu & Yılmaz, 2005; Atav, Akkoyunlu, & Sağlam, 2006; Li & Kirkup, 2007; Odell, Korgen, Schumacher, & Delucchi, 2000; Okay, 2010; Öztürk & Akgün, 2012; Ruzgar, 2005; Simsim, 2011; Uçak, 2007).

The findings of the literature show that the teenagers usually use the Internet for social networking and communication. However, the studies investigating the purposes of the internet usage of the high school students are quite restricted and it has been observed that there are not adequate numbers of Turkey-wide studies in terms of sampling. In this context, analyzing the purposes of Internet usage of the high school students, the relationship between these purposes and the demographic variables, and determining important factors affecting the purposes of Internet usage are the objectives of this research. This study aims at answering the following research question: “What are the demographic factors affecting internet using purposes of high school students?”

**METHODOLOGY**

**Research Design**

This research aims at determining the impact of demographic factors on the Internet using purposes of high school students. General screening model based on quantitative data is used in this study in order to identify attitudes, opinions, behaviors or characteristics of the sample (Creswell,
Survey design aims at determining the characteristics of a group. It aims at describing a condition from the past or a still present condition, as it is. The advantage of survey design is to reveal comprehensive information from quite a large sample. The research data are reported through tables which include frequencies, percentages and more (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, & Demirel, 2013; Karasar, 2014). It aims at defining the individual or object mentioned in the research as in their own conditions and as they are. There is no effort to change them (Karasar, 2014).

Population and Sample

The population of the study consists of students between 9th and 12th grades from the Anatolian high schools, science high schools, social sciences high schools, sports high schools and fine arts high schools in Turkey. Nomenclature of Territorial Units for Statistics is used for choosing the sample. Since the student ratios are determined according to the regions and types of schools, stratified sampling method was applied. In addition, since the school is chosen so as to choose the student, cluster sampling method is used too. The sample of study comprised 3170 students.

Student distribution according to demographic variables are as follows: Gender (48.5% boy, 51.5% girl), grade (43.3% 9th grade, 26.1% 10th grade, 17.2% 11th grade and 13.3% 12th grade), school type (78.6% Anatolian high school, 6.8% science high school, 3.2% social science high school, 4.6% fine arts high school, 6.8% sport high school), the educational status of the father (1.8% not graduated from any school, 27.6% primary school, 19.2% secondary school, 31.9% high school, 17.5% bachelor’s degree and 2% postgraduate); the educational status of the mother (8.7% not graduated from any school, 35.9% primary school, 19.7% secondary school, 24.9% high school, 9.3% bachelor’s degree and 1.5% postgraduate), the number of individuals in the family (14% 3 or less, 65.2% 4-5 people, 14.3% 6-7 people, 6.5% 8 or high), living with elder family members (15.8% yes, 84.2% no), living house status (22.4% rent, 75% owner, 2.6% housing), family monthly income (6.4% 800 TL or less, 16.3% 800-1000 TL, 19.1% 1001-1500 TL, 17.2% 1501-2000 TL, 12.8% 2001-2500 TL, 12.1% 2501-3000 TL, 16.2% 3001 TL or high), the daily average duration of the internet usage (16.1% less than 1 hour, 50.2% 1-2 hour, 22.1% 3-4 hour, 11.7% 5 hour or high), playing any instrument (31.2% yes, 68.8% no) and the place of the residence (9.7% dormitory, 89% with own family, 0.7% with friends, 0.6% other).

Data Collection Tools and Data Analysis

The research was conducted in the second term of the 2014-2015 academic year. The data were obtained through online forms. The data collection tool is a questionnaire and a demographic information form, prepared by the researchers to enable students to express their Internet usage purposes. To develop the questionnaire, the first step was an exploration and review of the literature. Then, identified possible internet usage purposes are sent to two domain experts, who have a Master’s degree in computer and instructional technologies. The questionnaire was finalized following recommendations of the domain experts. In accordance with the domain experts’ opinion, the Internet using purposes are determined as playing games, doing homework, surfing the Internet and joining social networks. In addition, an “other” option is presented in the questionnaire.

Chi-square Automatic Interaction Detector (CHAID) analysis was conducted via SPSS to determine demographic factors affecting high school students’ purposes in using the Internet. The dependent variable of the analysis is the Internet using purpose and independent variables were the other demographic variables.

CHAID analysis is an algorithm developed by A. Hartigan in 1975. This technique improved on the Kass (1980) studies (Linoff & Berry, 2011). CHAID as a decision tree method is used to classify the data. This analysis merges categories which do not cause statistically significant difference on the dependent variable by using chi-square analysis. Then optimal separation categories are chosen and analysis is conducted with this category.
When the sample size is big, the principle of homogeneity can be violated. Therefore, the
process of making predictions which randomly constructed a regression equation may not be realistic.
Because The regression analysis assumes that the variances for the subset of dependent variables are
homogeneous (Alpar, 2013). For this reason, splitting the whole to the sub-groups and continue
examining it becomes a more realistic approach. Thus, the homogeneity requirement can be fulfilled
(Kayri & Boysan, 2007). In addition, in a classical regression equation, the assumptions of normality,
linearity, homogeneity of variances and additivity should be provided (Tabachnik & Fidell, 2012).
Because CHAID analysis splits the population child node through a strong algorithm, the regression
equation of this analysis does not create normality, linearity, homogeneity of variances and additivity
assumption. In addition, both the continuous variable and the categorical variable can be examined by
CHAID analysis. As a result of this specification, CHAID analysis is a semi-parametric analysis (Kayri &
Boysan, 2007; Linoff & Berry, 2011).

To identify demographic factors affecting the Internet using purposes of high school students,
CHAID analysis is conducted through SPSS.

RESULTS

Results of the CHAID analysis which is used to identify demographic factors affecting the internet
using purposes of high school students are presented in the Figure 1.
Figure 1: CHAID Analysis Schema Carried Out to Identify Demographic Factors Affecting the Internet Using Purposes of High School Students
When Figure 1 is examined, it can be seen that the Internet using purposes of high school students is the dependent variable and the other demographic variables are the independent variable. Independent variables do not reveal the differences between groups, who do not take part in Figure 1.

The daily average duration of Internet use seems to be a dominant variable by having an influence on the internet using purposes of high school students when Figure 1 is examined ($\chi^2(12) = 561.659, p = 0.000$). Some 63.3% of the students who use the Internet for less than 1 hour per day, use it for doing homework. Some 37.2% of the students using the internet for 1-2 hours, 48.2% of the students using the internet for 2-4 hours and 52.3% of the students using the internet for more than 4 hours use the internet for joining social networking sites.

Gender seems to be the dominant variable affecting the internet using purposes of students who use the internet for less than 1 hour ($\chi^2(4) = 32.292, p = 0.000$). According to this result, 71.7% of female students and 53.4% of male students use the internet to do homework. When female students and male students are compared, it can be argued that female students using the Internet for less than an hour spend more time using the Internet for doing homework.

Grade variable seems to be a dominant variable influencing internet usage of male students who use internet less than an hour ($\chi^2(4) = 14.5263, p = 0.041$). According to this result, 64.1% of 9th grade male students using internet less than an hour, 45% of the other grades’ male students use internet for doing homework. Compared with other grades’ students, 9th grade male students spend more time using the Internet for doing homework.

School type variable is a dominant variable affecting the internet using purpose of female students who use Internet less than an hour ($\chi^2(4) = 23.547, p = 0.001$). According to this result, 75.3% of the students attending Anatolian high schools and fine arts high schools and 57.9% of female students attending social science high schools and sports high schools use the Internet for doing homework. Compared with female students who are attending other types of schools, female students attending Anatolian high schools and fine arts high schools spend more time using Internet for doing homework.

Monthly income variable is a dominant variable affecting Internet using purposes of male students who use the Internet for 1-2 hours ($\chi^2(4) = 38.804, p = 0.000$). While 45.9% of male students whose families earn 1000 TL or less monthly income use the internet to do homework, 31.9% of male students whose families earn higher than 1000 TL monthly income use the Internet for social networking. It can be said that monthly income affects Internet using purposes. While male students whose families have 1000 TL or less monthly income use the internet mostly to do homework, male students whose families have higher monthly income use the Internet for social networking.

Grade variable has been observed as a dominant variable having an effect on the internet using purpose of female students who use the internet for 1-2 hours ($\chi^2(8) = 42.493, p = 0.000$). While 45.5% of female students in 9th grade use the Internet to do homework, 45.8% of female students in 10th and 11th grade and 59.5% of female students continuing to 12th grade use the internet to join social networking sites. It can be said that while female students continuing to 9th grade use the Internet mostly for doing homework, female students continuing 10th grade or higher use the Internet mostly to join social networking sites. The 12th grade student ratio is statistically significantly different among the female students who use the internet to join social networking sites in comparison with 10th and 11th grade female students.

It has been observed that gender is a dominant variable affecting the internet using purposes of students who use the internet for 2-4 hours daily ($\chi^2(4)=126.361, p = 0.000$). It can be said that 62.6% of female students and 33.5% of male students use the internet to join social networking sites. Compared with
male students, female students who use the Internet for 2-4 hours spend more time using the Internet for joining social networking sites.

Mother's educational status variable is a dominant variable affecting the internet using purposes of male students who use the Internet for 2-4 hours ($\chi^2(4) = 26.840, p = 0.001$). It can be said that while male students whose mother's educational status is high school or higher use the Internet mostly to play games (36.4%); ones whose mother's educational status is lower than high school use the internet mostly to join social networking sites (41.1%).

Gender variable is a dominant variable influencing internet using purposes of the students who use the Internet more than 4 hours ($\chi^2(4)= 71.503, p = 0.000$). While 68.4% of female students in this category use the internet to join social networking sites, 36.4% of male students use the Internet to play games. Accordingly, male students using the Internet more than 4 hours daily use the internet mostly to play games; on the other hand most of the female students use the Internet for joining social networking sites.

Grade variable is a dominant variable having an effect on the internet using purpose of female students who use internet more than 4 hours ($\chi^2(4) = 14.961, p = 0.031$). It was found that 58% of female students in 9th and 12th grade using the Internet more than 4 hours, and 80.5% of female students in the 10th and 11th grade who use internet more than 4 hours use it mainly to join social network sites.

DISCUSSION

This study examined the demographic variables which best describe the internet using purposes of high school students. The daily average duration of internet usage variable is the dominant variable affecting their Internet use purpose. It has been observed that students who spend an hour or less on the Internet per day use it to do homework and the ones who spend more than an hour use the Internet to join social networking sites. This result conforms with other findings in the literature (Anunobi, 2006; Bashir, Mahmood, & Shafique, 2008; Gençer, 2011; Toraman, 2013; Yılmaz, 2012). Nachmias et al. (2000) found that high school students primarily use the internet for communication while their following purpose is obtaining information. However, this study is not an updated study since it was conducted sixteen years ago; there could be some differences today.

The 9th grade male students who spend an hour or less on the Internet use it mostly for homework. Female students, who spend an hour or less attending Anatolian high schools and fine arts high schools, use the Internet for doing homework when compared to the female students from other school types. According to these results, it can be said that the principal purpose of teenagers who use the Internet for an hour or less is to do homework. This result is similar to other results in the literature (Atav et al., 2006; Gençer, 2011; Okay, 2010). According to Tsai and Tsai (2010), male students use the Internet mostly for researching purposes whereas female students use it for communication. Although internet use was evaluated generally, the purposes of internet usage with respect to time spent on the internet was not examined. Therefore, this might explain the differences between their findings and the findings of the present study.

Students spending 1 or 2 hours daily on the Internet use it mostly to join social networking sites. It can be said that female students, who use the internet for 1 or 2 hours a day, use it to join social networking sites more than male students. Nevertheless, it can be said that male students use the internet mostly to play games in comparison with the female students when the other purposes are examined. Studies in the literature show that male students use the Internet to play games in comparison with female students (Gençer, 2011; Kahraman et al., 2011). According to Li and Kirkup (2007) whose study examined individuals aged between 18 and 25, male students use the Internet mostly to play games. In this respect, the current findings correspond with the literature.

Out of male students with a daily internet usage of 1 or 2 hours, most of the male students with monthly family income of 1000 TL or less use the Internet for doing homework whereas male students whose monthly family income exceed 1000 TL use the Internet for social networking. It can be said that Internet use is related to socioeconomic status. This result is similar to Toraman's (2013) study. According to Toraman (2013), as level of family income is higher, the level of social networking usage gets higher. Debell and
Chapman (2006) also found that Internet use increases with rising family income. The 9th grade female students with a daily Internet usage of 1 or 2 hours use the internet mostly for doing homework whereas female students in other grades use the Internet mostly to join social networking sites. As the age of the female students with a daily internet usage of 1 or 2 hours increases, they tend to use the Internet mostly for social networking. This result is similar to the Öztürk and Akgün (2012) study results. On the other hand, Tsai and Tsai (2010) state that female students use the Internet mostly for communication, while Çam and Işbulan (2012) reported that senior students show addiction to Facebook more than students from other grades. As a result, it can be argued that as the grade increases, the Internet usage for social networking also increases. Accordingly, the results obtained from this study are consistent with the results in the literature.

It has been observed that female students with a daily Internet usage of 2 to 4 hours, in comparison with the male students, use the internet mostly to join social networking sites. Gençer (2011) also indicates that students use the Internet mostly for communication. When other purposes are examined, 32.9% of male students use the Internet for playing games whereas this ratio is 2.3% among female students. Kahraman et al. (2011) indicate that 33% of male students in the study group follow online games. In addition, Ogunlade, Faith, Ogunlade, and Amosa (2015) who investigated university students stated that 84.7% of them use the Internet for social networking rather than doing homework. Thus it can be claimed that the results of this study are consistent with the other results in the literature.

Male students with a daily Internet usage of 2 to 4 hours, whose mothers’ educational status is high school or higher, use the internet mostly to play games whereas male students whose mothers’ educational status is lower than high school use the Internet mostly to join social networking sites. So it can be said that both mother’s educational status and the purpose of Internet usage is related to socioeconomic status. Debell and Chapman’s (2006) study reveals that as the education level of parents increases, internet usage among the students also increases. These results are compatible with the findings of Özgür (2016). According to this study, the mother’s education level and the Internet parenting style is related. However, there is no relation between the father’s education level and the internet parenting style. The present study suggests that mother education level impacts on the internet usage purposes of the male children using the Internet for 2-4 hours a day. It can be argued that this impact originated from the internet parenting style.

Female students with a daily Internet usage of higher than 4 hours use the Internet mostly for social networking whereas male students in this category use it for online games. Makas (2008) indicates that adolescents use the Internet most frequently for educational and social purposes and the Internet plays an important role in their life. These results are consistent with the results of Kahraman et al. (2011). In the present study, female students in the 10th and 11th grades with a daily Internet usage exceeding 4 hours use the Internet mostly for social networking sites unlike the 9th and 12th grade female students. Seo et al. (2009) showed that 52% of the students aged between 12 and 17 use the Internet for games and 14% of them use the Internet for communication. Thus the present findings are consistent with the literature.

CONCLUSION

By knowing the purposes of internet usage by the students and being able to categorize them based on particular groups with particular purposes educators will be able to provide higher quality of education to them. Since the teacher-student relationship has been transformed as a result Internet use in education (Akkoyunlu, 2002), the relationship can be reformed according to the results of this study. This study shows that the major variable affecting the purpose of Internet usage is the duration of Internet usage. A secondary significant variable is gender. The following variables important for this research are: grade, type of school, mother’s education level and the family income. Consequently, in high school, social media practices could contribute to the way the lessons are taught to the female students in the higher grades. Naimie, Siraj, Ahmed-Abuzaid, and Shagholi (2010) suggest using new teaching styles to increase student motivation.

Research by Ahmad (2014) reports that most teachers use information and communication technologies for Internet surfing, sending e-mails and preparing PowerPoint presentations. As a result, some advice on changing teaching styles should be presented to the teachers based on the findings of this research.
Teachers are advised to include computer games in the teaching environment for the male students who spent more time on the Internet. In addition, content on social media could be created for the female students. Furthermore, the teachers could be advised about the way they talk to the students and relate the topics taught. For instance, while talking to male students, teachers might use examples from computers/games and while interacting with female students, they might relate the topics to social media. Further research should look into the usage of social networking sites and computer games in education. This would ensure improving the content used in education. Other studies can be conducted on the relation between student success and the purposes of internet usage. Moreover, the purposes of the internet usage could be examined in detail through qualitative research.

REFERENCES


Secondary School Mathematics Teachers’ and Students’ Views on Computer Assisted Mathematics Instruction in Turkey: Mathematica Example

Mehmet Alper Ardiç[1], Tevfik İşleyen [2]

ABSTRACT

This study aimed at determining the secondary school mathematics teachers’ and students’ views on computer-assisted mathematics instruction (CAMI) conducted via Mathematica. Accordingly, three mathematics teachers in Adıyaman and nine 10th-grade students participated in the research. Firstly, the researchers trained the mathematics teachers in the Mathematica program, a computer algebra system (CAS) and CAMI. Then, they provided a suitable environment for teachers to practice CAMI with their students to teach quadratic functions (parabola). Case study, a qualitative research design, was utilized in the study. Semi-structured interview forms were used as data collection tools. The interview data were analyzed using descriptive and content analysis, and the codes and themes related to the topic were obtained. The findings revealed that all the teachers found CAMI implementations interesting as supported by students’ views. While all mathematics teachers wanted to benefit from CAMI in mathematics and geometry courses, most of the students asked that CAMI be used in different courses. It was found that students did not have any problems with the Mathematica used with CAMI activities. However, it was also revealed by one student and one teacher that involving CAMI constantly in the courses would hinder preparations for the university entrance exam.

Keywords: Computer-assisted instruction, computer algebra systems, mathematics instruction.

INTRODUCTION

Today information and communications technologies have been developing rapidly and new opportunities have been generated for meaningful mathematics instruction. As a result of continuous development of computer technologies, both the quality and the quantity of educational software have been increasing and the alternatives have been growing. (Ministry of National Education [MNE], 2013). According to Baki (2015), “apart from computer being used as an effective computational tool, a more important quality of it is that it can show the abstract mathematical concepts on the screen and concretize them”. This concretization will have positive effects on students’ meaningful learning. Thus, students’ process of constructing mathematical knowledge must be promoted with multi representations and materials and they must be actively engaged in Information and Communications Technologies (ICT). ICT in mathematics instruction is used not with the intent of replacing the teaching of mathematical skills with technology but the purpose is to be able to have all students reach mathematical thinking without paying regard to their skill levels. Students can solve realistic mathematics problems with effective use of ICT and they can spend the time saved from long operations on reasoning and creative thinking (MNE, 2013). Hence it is inevitable that IT in general and computer assisted mathematics instruction (CAMI) in particular will have its place in educational environments.
Computer assisted instruction (CAI) refers to an instruction offered via a computer during the teaching-learning process. In CAI, students interact with the computer and determine their weaknesses and learn from their performance; they are responsible for their learning thanks to the feedback offered, and they are more interested in the lessons via animation, graphs, sound and demonstrations (Baki, 2015). The primary goals to use a computer in mathematics instruction are to activate students’ higher order cognitive skills and enable them to create their own mathematics knowledge based on their interaction with mathematics.

Yeşilyurt (2010) conducted meta-analysis by examining 155 studies carried out in science and mathematics education fields using quantitative research methods in Turkey between 2002 and 2008. The study concluded that student academic achievement in the learning environment where CAI was used was higher at a meaningful level when compared to learning environments using the classical method.

CAI can be discussed as a system which is interconnected regarding software, hardware and teacher. Even if a computer with the best hardware features and the best qualified teacher is used, software still plays an important role as an infusive factor. If the goal is to be attained efficiently in CAI, three factors must be paid attention (Arslan, 2003). Of these three factors, the deficiencies with hardware will be eliminated in line with the activities carried out within the context of The Movement to Enhance Opportunities and Improve Technology (FATIH) project initiated by the Ministry of National Education (MNE) and Ministry of Transport in Turkey at the end of 2010. This project aims at equality of opportunity in education, improvement of technology in schools, and effective use of ICT tools in the teaching-learning process.

The Project intends to provide LCD Interactive Boards and the infrastructure of internet network in all schools, and to distribute tablet PCs to every teacher and student. It provides for in-service training for teachers to enhance effective usage of ICT equipment in the classroom teaching-learning, and to form educational e-contents in accordance with ICT-assisted teaching programs (MNE, 2013). When teachers were considered as the second factor, it was emphasized by many studies that teachers were the main factor in benefiting from CAI in learning settings (Hutkemri & Zamri, 2016; Öksüz & Ak, 2009; Seferoğlu, Akbıyık, & Bulut, 2008; Umay, 2004). On the other hand, it was stated that one of the biggest factors preventing CAMI from taking place in the classroom was teachers’ weaknesses in this subject (Ersoy, 2005; Hangül & Devrim, 2010; Kutluca & Ekici, 2010; Seferoğlu et al., 2008; Yenilmez & Karakuş, 2007). When software, the third component of the process, is considered, again the effect of teachers is viewed. Kazu and Yavuzalp (2008) conducted a study on 471 primary school teachers in Turkey. Their study concluded that although teaching software existed in the schools with CAI classrooms and educational software was developed in all fields, a considerable number of teachers (26.8%) were unaware of them and they did not examine the software in their fields (27.6%). When considered from this point of view, identifying teachers’ real opinions about CAMI transparently will be possible after they are trained about CAMI and given opportunities to implement educational software in their classes. Students’ views can be utilized as well as teachers’ views in order to bring up CAMI activities and the software treated as an infusive factor to better levels.

According to Hohenwarter and Fuchs (2004), using dynamic geometry and algebra software based on computer in mathematics instruction caused a new understanding to develop. Computer algebra systems (CAS), based on the use of symbolic expressions, and dynamic geometry software (DGS), based on geometric structures, are the two most important ones used among the software which can respond to this new understanding, which can be used to create positive teaching, learning, and classroom settings for supporting mathematics instruction and learning (Hohenwarter & Jones, 2007).

CAS was developed as software that could do symbolic computations as well as numeric computations for solving mathematical problems was obtained by expanding standardized numerical programming languages such as C, Pascal and Fortran (Aktümen, 2007). It is basically possible to divide numeric computations into two. One of them is floating point method which uses a variety of algorithms and does number based computations. In this method, the results obtained are not precise because the operations are number-based and most of the time computations are done using approximate values. Another computation method is symbolic, or algebraic computation, or computer algebra which is based on doing computation on symbols representing mathematical objects. While the term symbolic refers to expressing an answer in a closed formula or finding a symbolic approximation, the term algebraic means...
carrying out computations exactly (Davenport, Siret, & Tournier, 1993; Kabaca, 2006). Besides being an effective symbolic computation tool, another important characteristic of computer algebra systems is their ability to draw graphs at an advanced level and to visualize. Thanks to their developed abilities, CAS can do drawings in Cartesian, polar, and cylindrical coordinates.

Mathematica is one of the most developed CAS of our day and its first version was released in 1988 by Wolfram Research; since then it has been constantly improving with its more than twenty versions published by Wolfram Research. Mathematica is an expandable system which works with input-output logic, has a graphical interface, allows easy entry of graphs and gives opportunities to carry out operations on chart objects (Gülcü, 2004). Another feature of Mathematica is its Computable Document Format (CDF), an electronic document format designed to allow easy authoring of any content generated on Mathematica without having to set up a program on a computer. Thanks to the CDF player which can be downloaded free, the structures developed by the programmer can be examined and they can be manipulated within the allowed limits. Moreover, Mathematica has structures such as a slider allowing users to manipulate any mathematical and geometrical structures and this is an important feature of Mathematica which intersects with DGS.

It was revealed in the studies on the activities of computer-assisted mathematics instruction conducted through CAS that students’ conceptual understanding levels (Aksoy, 2007; Ghosh, 2003; Kabaca, 2006; Sevimli, 2013; Sevimli & Delice, 2015), problem solving skills (Aktümen, 2007; Sevimli, 2013; Tuluk, 2007), academic achievement (Aksoy, 2007; Bulut, 2009) and attitudes toward mathematics (Aksoy, 2007; Aktümen, 2007; Kabaca, 2006; Tuluk, 2007) were higher at a meaningful level when compared to students in control groups.

In the international literature review on teaching activities carried out via CAS, similar results were obtained as well. These results can be listed in the way that students learn maths better and with a deeper comprehension via CAS, that CAS encourage students’ independent learning and success, and thus increased their motivation for mathematics, that CAS enable students to deal with more difficult and realistic mathematical structures more easily in earlier periods, and that CAS can meet workplace requirements in the 21st century (Buteau, Marshall, Jarvis & Lavicza, 2010; Lavicza, 2008; Marshall, Buteau, Jarvis, & Lavicza, 2012).

Tatar, Kağızmanlı, and Akkaya (2013) conducted a study examining 126 studies on technology assisted mathematics instruction in Turkey which were published between 2000 and 2011 in terms of demographic information, key words, and methodology. Results of their study emphasized that the sampling of the most of the studies carried out in Turkey consisted of undergraduate students, and the secondary school students participated only in 11% of the studies. Similarly, in the articles examined it was found that only 8% of the research studies included secondary school students and secondary school mathematics teachers as participants, which is quite low. The key words used by the researchers in the articles were also examined; these examinations revealed that the studies published in Turkey did not include mathematics topics adequately and the research studies about the software which could be used in mathematics education were limited. On the other hand, DGS was encountered more than CAS (about 50%) among the key words and Mathematica program was not mentioned.

The literature review shows that studies on using CAS as a teaching-learning tool in Turkey are quite rare (Tatar et al., 2013), and those researches, as in the international literature, have been carried out on general mathematics (Calculus) with undergraduate participants (Buteau et al., 2010; Lavicza, 2008; Marshall et al., 2012). On the other hand, it is also seen in researches on secondary school level that CAS-based graphic calculators have been used mainly (Baki & Çelik, 2005; Pierce, Ball, & Stacey, 2009), and that computer-based applications have not been dealt with sufficiently (Pierce et al., 2009). This present study, involving secondary school mathematics teachers and students as participants, is an attempt to contribute to literature with its focus on the effects of using CAS in the teaching-learning environment.

**Aim of the Study**

The purpose of this research study is to determine the views of secondary school mathematics teachers and students, who have not had any experience about CAS and CAMI before, about CAMI activities.
which have been carried out via “Mathematica 9.0” program that they have just used for the first time. In order to examine mathematics teachers’ and students’ views about this new situation, the following was selected as the research question of the study: “What are the views of secondary school mathematics teachers and students who practiced CAMI activities via Mathematica program for the first time?”

METHOD

For the sake of revealing the present situation in the research, a detailed and in-depth perspective, without any generalization concerns, was adopted. Thus, the research study was carried out using the case study method, one of the qualitative research methods. A case study is a design that investigates a phenomenon within its real life context, discusses “how” and “why” questions in the event that the researcher has very little control over the phenomenon (Yin, 2014), and involves in-depth and detailed examination of a single case or multiple cases, settings, or other systems connected with each other (McMillan, 2000).

At the beginning of the research three secondary school mathematics teachers were given a 16-hour training on the fundamentals of CAMI, the use of Mathematica program which is a CAS, and CAMI implementation examples. Then, mathematics teachers in their suitable time taught secondary school 10th grade students graphing quadratic functions (parabola) benefiting from Mathematica program in the computer laboratories in Adıyaman University (Figure 1). The aforementioned activities lasted for five lesson hours sticking to the lesson plans prepared by the teachers themselves and curriculum. Nine CAMI activities were utilized in this process.

![Figure 1. A visual on the physical conditions of computer laboratories where the teachers practised.](image-url)

CAMI activities were designed by the researchers with the worksheets considering student gains about the topic parabola and asking opinions of eleven mathematics teachers and three mathematics educators. Moreover, during the process of preparing CAMI activities, Wolfram Demonstrations Project (2014) activities developed by the Wolfram company, a producer of Mathematica program allowing free access, were used (Figure 2).
After the mathematics teachers carried out CAMI implementations via CAS, interviews were performed with them and their three students.

Participants

The research was carried out with three mathematics teachers working in different high schools in Adıyaman city center, located in the Southeastern Anatolia Region, and 63 secondary school 10th grade students in the 2013-2014 academic year. Convenience sampling technique was used to select teachers. According to Yıldırım and Şimşek (2008), convenience samples are relatively less costly and they are practical and easy for some researchers. Convenience sampling is to select a population due to its convenient accessibility and proximity. Random sampling was used for selecting nine students whose opinions were asked. The researchers randomly chose three students from each class where the CAMI implementations were carried out.

While two mathematics teachers who participated in the study had between 10 and 15 years of teaching experience, one of the teachers had more than 20 years of teaching experience. None of the teachers received training about CAMI during their college years or teaching profession before. Three teachers had undergone training on using interactive board within the context of the FATIH project.

Data Collection and Data Analysis

Semi-structured interview forms were used to identify the secondary school mathematics teachers and students’ views. While creating the semi-structured interview form, firstly the literature about CAI and technology integration in teaching-learning environments was reviewed (Demir, 2011; Demir & Öz mantar, 2013; Leonard, 2001; Taşlibeyaz, 2010) and preliminary drafts were prepared by utilizing resources containing information on scientific research methods (McMillan & Schumacher, 2001; Yıldırım & Şimşek, 2008; Yin, 2014). Later, opinions of four mathematics instruction experts on the preliminary drafts were taken and drafts of semi-structured interview forms were created. A pilot implementation was then made to ensure validity of the mentioned draft forms and eliminate their shortcomings if any. In the pilot implementation, the draft forms were given to 11 mathematics teachers who utilized ICTs in their classes, as well as their students. The necessary modifications were made on the drafts based on the findings obtained, and the opinions of a mathematics educator and three mathematics teachers. These modifications were generally about re-ordering questions and making questions clear and comprehensible. Additionally, the final question “Is there any other opinion or recommendation you want to state regarding this issue?” was added as the last question to the draft form used in pilot interviews with students. The final version of the semi-structured interview form was therefore created.
All of the interviews were carried out one-to-one with the participants, and their voices were recorded with their permission. Those voice recordings were transcribed and analyzed through descriptive and content analysis. Data were primarily summarized and interpreted using descriptive analysis. Then, content analysis was utilized to determine the concepts and themes which were not noticed through the former analysis. The data were examined carefully during the content analysis process, and then codes and themes were identified with a holistic view. The codes obtained were presented in tables with their frequency values under the themes related to them. To assure objectivity of the study, the views of some teachers and students who helped to create the codes were cited. Then, the codes and themes were checked by the three mathematics teachers and the necessary corrections were made. The teachers were called T1, T2 and T3 while citing the data and quotations. The students of each teacher, whose opinions were taken, were given pseudonyms such as S1.2 (the second student of Teacher Number 1) and S2.3 (the third student of Teacher Number 2).

In order to achieve internal reliability and validity in the study, the collected and analyzed data were ensured consistent both internally and in terms of the theoretical framework. In this process, the researchers performed their investigations by taking into consideration how the study would be understood by an outsider. To achieve external validity and verifiability of the study, the raw data obtained during the study and the conclusions reached were analyzed comparatively, and subjected to expert analysis later. The findings and conclusions in the study were finalized after reaching agreement with relevant experts. Moreover, all the data collection tools, obtained data and field notes used in the study were stored on electronic media for re-usage in cases where necessary.

Findings and Results

The findings obtained in the research were presented under two sections as teachers’ views and students’ views.

Teachers’ Views

In this section, the findings obtained from the interviews carried out with high school mathematics teachers who implemented CAMI via Mathematica program, a CAS, were presented.

An ideal classroom environment to carry out CAMI.

The teachers who benefited from CAMI in their lessons were asked the following questions: “In your opinion, what must be the ideal classroom environment to teach mathematics and geometry courses with CAMI? What kind of materials and equipment are needed in the classroom?” Their responses to these questions were examined under the category of “Ideal classroom environment to carry out CAMI” and the codes obtained were presented in Table 1.

Table 1 An Ideal Classroom Environment for Implementing CAMI

<table>
<thead>
<tr>
<th>Code</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every student must have a computer/tablet</td>
<td>3</td>
</tr>
<tr>
<td>There must be interactive boards compatible with their tablets</td>
<td>3</td>
</tr>
<tr>
<td>There must be suitable educational software</td>
<td>3</td>
</tr>
<tr>
<td>There must be a white board</td>
<td>1</td>
</tr>
</tbody>
</table>

T2 who stated that every student was required to have a computer/tablet and also an interactive board or a reflector like a projector and a white board was needed opined the following:

First of all, every student should be provided with a computer. As students themselves will follow from them and also they will practise it, one computer per student must be provided. In addition, a projector or an interactive board and a white board can be useful.
T3 who thought that students must have a computer / tablet and added that the smart boards in the classroom environment must be compatible with this computer/tablet and also they must interact with each other shared his views on the issue and on available technological equipment:

“Students must have a computer or a tablet. If the tablets interact with the teacher’s whiteboard, they will be more efficient. ...[Tablet computers] have not reached the students yet. I have one. Even if we have them, we are unable to download every program on it. We have some problems. Right now, I cannot use the tablet effectively. Compatibility problem, I mean, I cannot use the interactive board format with them as it does not allow it.”

T1 emphasized that in addition to equipment in an ideal classroom environment where CAMI would be carried out, there must be suitable software:

“...Most importantly, software is required. Well, a program is needed. We used Mathematica but training on how to use it must be given. It must be translated into Turkish and it must be easily accessible. I mean it can be used, other software programs can be used but in addition to equipment which a student can carry out and obtain a result easily, there must be software.”

When the mathematics teachers who benefited from CAMI in their lessons were asked the following question “Is the current condition of your school suitable for the implementation of CAMI?”, all of the teachers’ (three teachers) responses were negative. It was revealed during the investigation that only one of the schools had a computer laboratory and none of them had distributed tablets to their students. The following statement of T1 who said that the school where he worked had a computer laboratory but some computer programs did not work because the computers were very old exemplifies this situation:

“Well, it is not possible to say that [current condition for CAMI] is suitable. There are smart boards and interactive boards in our classrooms but our computer laboratory is not suitable in terms of infrastructure. The computers are very old. We cannot download new programs. They need to be updated. I mean, our school needs to be renovated and modernized technologically.”

Positive sides of the courses taught by the mathematics teachers via CAMI.

When we asked the teachers who implemented CAMI in their classrooms whether there was a difference between the courses (taught with traditional/classical method) and the courses taught with CAMI, three of the teachers remarked that there were differences between them.

Then, we asked the teachers “What are the positive sides of the CAMI activities you did, what did you like about them? Can you please explain them?” and their responses to these questions were categorized under the title of “Positive effects of CAMI implementations by the teachers” and presented in Table 2.

<table>
<thead>
<tr>
<th>Code</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interesting for students</td>
<td>3</td>
</tr>
<tr>
<td>Reducing teachers’ course load</td>
<td>3</td>
</tr>
<tr>
<td>Enabling students to learn by discovery</td>
<td>2</td>
</tr>
<tr>
<td>Materializing learning at a higher level</td>
<td>1</td>
</tr>
<tr>
<td>Actualizing more concrete explanations</td>
<td>1</td>
</tr>
<tr>
<td>Increasing student participation in the course</td>
<td>1</td>
</tr>
<tr>
<td>Actualizing student-centred learning</td>
<td>1</td>
</tr>
<tr>
<td>Giving immediate feedback to the students</td>
<td>1</td>
</tr>
</tbody>
</table>

T1 who thought that due to students’ interest in computer, CAMI drew their attention and at the same time the students learned by discovery in the courses taught by CAMI and these enabled students to undergo learning at a much higher level when compared to classical teaching method shared his opinions:
“Computer is a new application which attracts more attention. A child approaches it as a game and thus it brings more benefits. Popularizing it will certainly bring more benefits.”

“For example, we taught parabola. When we teach it with classical method, we draw a figure on the board, children try to comprehend what they see on the board but a child discovers various alternatives on the computer screen by applying on his own. And I saw that there were big but positive differences between the understanding, comprehension, and comprehension level of the students who were taught with classical method and the understanding and comprehension level of the students who performed operations on the computer by themselves. I mean a student who determines the coordinate of a vertex on a computer can say it more easily but we make the other student memorize it. In other words, while one of them discovers, the other one memorizes it. This means a much bigger difference in education.”

The following opinions belong to T2 who stated that CAMI provided a student-centered learning environment which increased student participation in the course and also reduced teachers’ course load:

“As teachers, we are the presenters; we transmit information to the students. Unfortunately it is both boring and tiring for a person. We only guide or facilitate the student who has a question in computer assisted mathematics instruction. When a student gets stuck on a question, we help him. Everyone participates actively in the course. Therefore, the lesson is not very tiring. The course becomes more fun.”

Besides these opinions, T2 who stated that student participation in the course increased with CAMI implementations and thanks to the immediate feedback students received from the computer, they saw their mistakes and made comments on them support his views with the following statements:

“[Students] are engaged actively in the course. They enter numbers, draw graphs, do different things. Well, the students are involved in it so they are more instructive. At least they see their mistakes directly via computer. If he enters a wrong data and a different result appears, he tries to interpret why it came out like that.”

The following opinions belong to T3 who said that mathematical concepts would be transmitted to the students more concretely via CAMI:

“Students see things more concretely. We solve directly on the board as we want, draw a graph, we say this is the point. By saying this is $f(5)$, we write it here but it comes out by itself, we explain it much better to the students. Students understand much better.”

Negative sides of the courses taught by the mathematics teachers via CAMI.

We asked the teachers “What are the negative sides of the CAMI activities you did, what you did not like about them? If there are, can you please explain them?” and their responses to this question were categorized and discussed under the title of “Negative sides of CAMI implementations revealed by the teachers” (Table 3).

<table>
<thead>
<tr>
<th>Code</th>
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</thead>
<tbody>
<tr>
<td>Difficulty of controlling what students are interested in on a computer during the course</td>
<td>1</td>
</tr>
<tr>
<td>Students not revising their lessons</td>
<td>1</td>
</tr>
<tr>
<td>Students not being able to improve their operational ability</td>
<td>1</td>
</tr>
</tbody>
</table>
Teachers’ requirement to develop documents and materials
Hindering preparations for university entrance exam

T3 thought that he had troubles controlling what students were interested in on the computer during the courses carried out with CAMI and said they would have problems about revising their lessons after the school because students did not take notes in the traditional sense. He expressed his opinions in this excerpt:

“I sometimes cannot control what students are doing on the computer. For example, when I see them writing in their notebook, I am relieved. They will write, they will revise, they will look at their notebook. Of course if they have tablets, this problem will also be eliminated. But while I am moving around the classroom, I am suspicious of whether they are doing it or not. This is the only negative thing. It depends on a student. What I mean is that if a student wants to cheat, he can cheat while taking notes or writing in his notebook.”

T1 is worried that due to CAMI implementations, their operational ability will weaken or will not improve and expresses his worries like that:

“In computer assisted instruction, the only issue that concerns me is that a child will have the computer perform the operations and push his operational ability into the background.”

T2 stated that teachers must design materials and hardware in order to actualize CAMI implementations, and at the same time he expressed his views that the course hours must be increased in order to carry out CAMI activities and preparations for the university entrance exam collectively:

“Because our current examination system is used to solving questions and finding the options of the questions, we may need more time in this system. I mean because we can comprehend the topic much better here.”

“Time can be a problem. Second, a teacher must study his course very well. I mean, he must prepare good materials and documents so that there is no disconnection during the lesson flow. A teacher must have a command of the course, do practices, and get prepared.”

**Difficulties the teachers encountered during implementations of CAMI activities.**

We asked the teachers, “Did you or your students encounter any difficulties while using the program during the implementations of CAMI which was carried out via Mathematica program, a CAS? If you did, could you please explain them?”, and their responses to this question were categorized under the title of “Difficulties encountered during the process of CAMI” and the codes obtained were given in Table 4.

**Table 4 Difficulties Encountered During the Process of CAMI**

<table>
<thead>
<tr>
<th>Code</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have not had any difficulties.</td>
<td>2</td>
</tr>
<tr>
<td>Because Mathematica program was in English</td>
<td>1</td>
</tr>
<tr>
<td>My students did not have any problems</td>
<td>3</td>
</tr>
</tbody>
</table>

T1 stated that because the Mathematica program used during the CAMI activities was in English, he had problems developing the materials to use in the course and he expresses his views in these words:

“The biggest challenge is language. If they are translated into Turkish, if we have such an opportunity, its use will be easier and bring a lot of benefits.... Whenever I sit at a computer, I wish I knew a little English.”

On the other hand, T1 answered the question “In your opinion, did your students encounter any difficulties while using the program during the implementations of CAMI which was carried out via Mathematica program?” like this:
“I don’t think so because I have not received such feedback. I did not encounter such questions asked by my students as why it happened like that because they draw a conclusion by trying and practising on their own.”

Student Views

In this section, nine secondary school 10th grade students’ views on CAMI implementations about parabola were given.

Students’ general views on the courses carried out with CAMI.

During the interviews carried out with some students taught with CAMI, we asked them, “What do you think about the implementations carried out with CAMI?” and as a response, nine students expressed their positive views and admiration about the implementations of CAMI. They were also asked, “In your opinion, are there any differences between the mathematics course taught with CAMI and the previous courses?” and when their responses were examined, similar to the teachers’ view, all of the students stated that there were positive differences in favor of CAMI.

S1.2 stated his positive views about implementing CAMI:

“In my opinion computer assisted mathematics is a very good implementation, particularly it causes us to understand the mathematics course much better because when we learn here via computer, we learn it practically and because we see it, it is much better.”

On the other hand, after comparing classical teaching method with CAMI; S1.2 used the following expressions in favor of CAMI:

“There is a big difference between them. To me, in this course [CAMI] is much better. It is better because it is visual. Because we understand by seeing it, there is a much big difference. I think that I understand much better than other topics. To me, it is really good.”

Positive sides of CAMI revealed by the students.

We asked students, “What do you like about CAMI implementations? If there are, can you explain them?”, and their responses to this question were categorized under “Positive sides of CAMI implementations revealed by the students” as presented in Table 5.

<table>
<thead>
<tr>
<th>Code</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>The courses taught with CAMI are fun and interesting</td>
<td>8</td>
</tr>
<tr>
<td>It visualizes mathematical concepts</td>
<td>7</td>
</tr>
<tr>
<td>It uses time more efficiently</td>
<td>5</td>
</tr>
<tr>
<td>It enables learning by discovery</td>
<td>4</td>
</tr>
<tr>
<td>It makes me learn much more quickly /easily</td>
<td>3</td>
</tr>
<tr>
<td>It makes me focus on the course much better</td>
<td>3</td>
</tr>
<tr>
<td>It provides more retention</td>
<td>2</td>
</tr>
<tr>
<td>It gives immediate feedback</td>
<td>2</td>
</tr>
<tr>
<td>It enables me to learn much better</td>
<td>2</td>
</tr>
<tr>
<td>It reduces students’ workload</td>
<td>2</td>
</tr>
<tr>
<td>It reduces teachers’ workload</td>
<td>2</td>
</tr>
<tr>
<td>It deals with real life problems</td>
<td>1</td>
</tr>
</tbody>
</table>

S1.3 stated that thanks to the lessons taught with CAMI, he overcame the prejudice against the parabola topic and the lesson was fun, and his views are as follows:

“When parabola was mentioned, I opened the book and looked at it. I said to myself, “I cannot understand anything from it”, it seems very difficult and I had a
prejudice against it. But when we learned it in the laboratory, it was quite enjoyable and fun.”

S3.1 remarked that because of the visualization ability of CAMI, he understood the topics much better and he visualized the mathematical structures in his mind. In addition, S3.1 added that as he had to write less in the lesson, he saved time, and he understood it much more easily because he learned the topic by discovery, and thus it facilitated teachers’ work:

“Instead of taking notes during the lesson, we not only save time but also understand it much better due to visualizing them in our mind. Sir, the activities are better, what I mean is they are intended for discovery. To me, it is a good program because learning is easier and also the teacher explains it more easily.”

S2.2 said that he could immediately understand whether he did it correctly or wrongly as computers give immediate feedback on the operations carried out during the CAMI activities, which enabled the course hour to be used efficiently:

“When we enter the numbers on the computer, it lets us see the given distance directly, the roots of that parabola, and all of them. If we solve it, it gives feedback in seconds whether we did it correctly or not. It does not allow us to lose time, it rather enables us to gain time.”

S2.3 stated that the visuals of CAMI activities made contributions to knowledge retention and that both teachers and students got less tired during the lesson due to actualizing learning by discovery:

“It appeals to visual intelligence so it becomes permanent. Neither you nor your teacher gets tired and you discover things like that. You know, you play with \( f(x) = ax^2 + bx + c \) and you change the values of \( a \) and then you see that the arms of parabola change directions. You learn to discover. I like it very much.”

Ö3.3 who said that he could maintain his concentration for a long time in the lessons taught with CAMI when compared to the lessons taught with classical method explained his views as such:

“To speak for myself, normally in mathematics courses I could understand the course in the first ten or fifteen minutes. Then, I was miles away. But we studied nearly two and a half hour on the computer and my concentration was not broken.”

S3.2 stated that the activity (4th activity) included in CAMI activities about an owner of a farm who wanted to enclose his garden with a fence was a real-life problem and it promoted his interest in the course:

“...for example, I was not interested, well, I was a little interested but that farm question was the question that drew my attention because the things from real life made me think. For example, whenever I see a fence, that question will come to my mind and I will think about that parabola.”

**Negative sides of CAMI implementations revealed by the students.**

During the interviews conducted after the CAMI implementations with the students, they were asked, “Were there any sides of CAMI implementations which you did not like? If there are, can you explain it?” and the students’ responses were evaluated under the category of “Negative sides of CAMI implementations revealed by the students” (Table 6).

<table>
<thead>
<tr>
<th>Code</th>
<th>( f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>It did not have any negative sides</td>
<td>5</td>
</tr>
<tr>
<td>Students did extracurricular activities on computers</td>
<td>2</td>
</tr>
<tr>
<td>I had difficulty with the 4th activity</td>
<td>1</td>
</tr>
<tr>
<td>I had difficulty with the 8th and 9th activities</td>
<td>1</td>
</tr>
<tr>
<td>Looking at the computer screen for a long time tired my eyes</td>
<td>1</td>
</tr>
</tbody>
</table>
It did not include questions and answers for university entrance exam.

S1.3 stated that the CAMI implementations carried out in the classrooms did not pose any problem or trouble for him:

“It did not cause any problems to me. It was quite a nice implementation. At least we learned what we did and how we did it. For example, if it is told in a book, we see it only as a picture. But we practised it there and experienced it. In my opinion, it was quite good.”

S2.3 stated that he had difficulty in comprehending the 8th activity which required the identification of rules of quadratic functions whose graph was given on an analytical plane presented as a game to them and the 9th activity which asked them to draw a parabola passing through three points given on an analytical plane, and also added that he tended toward extracurricular activities on a computer:

“I just had difficulty with the games part; I learned what it asked quite late. There were not any other things. And also because we spent plenty of time on the computer, we discovered other fields of interest, I tried to look for the parabola graphs.”

S1.1 had difficulty in understanding the 4th activity (The Farm question) implemented throughout the CAMI:

“In calculating areas, there was a rectangular, that farm question. I had difficulty in understanding how the field got bigger and what it depended on or what it did not depend on. It was a little negative in this aspect. That’s all. But it was much better in other ways.”

S3.3 said that because he had to wear glasses, he could not look at the computer screen for a long time and thus his eyes got tired:

“Because I wear glasses, my eyes extremely hurt when I look at the computer screen for a long time. That is the only reason; I did not have any other problems.”

S2.1 said that more problems needed to be solved in the lesson so that CAMI implementations cannot hinder preparations for the university entrance exam:

“Since the examination system is based on directly solving questions, [CAMI] could be as an example, as an addition. When we look at the examination system, there are a lot of question types about that topic after all. You do not understand them unless you practise them with examples.”

Difficulties encountered by the students while using CAS.

We asked students the question about Mathematica program, a CAS, “Have you encountered any problems in using the program with the activities performed with Mathematica program, a CAS? If so, can you explain it?” and their responses were discussed under the category of “Difficulties encountered by the students while using CAS” (Table 7).

Table 7 Difficulties Encountered by the Students While Using CAS

<table>
<thead>
<tr>
<th>Code</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have not had any problems</td>
<td>9</td>
</tr>
<tr>
<td>My peers have not had any problems</td>
<td>8</td>
</tr>
<tr>
<td>One of my peer’s activity started late</td>
<td>1</td>
</tr>
</tbody>
</table>

S3.1 stated that he did not have any problems in using the Mathematica program:

“To me, there was not a difficulty because every single thing was considered like sliders, manual data entry, everything shows up when we transfer them. There was no difficulty. As it also guided us from the sheets, there was no trouble, sir. Well,
everyone could do it.”

When the students interviewed were asked whether their peers encountered any problems or not, most of them (seven people) stated that their peers did not encounter any difficulties. However, S3.3 said that the program which one of his peers was going to use for the 2nd activity started late:

“I had a friend who was sitting at the back row behind me and his second program started a little bit late but there were not any other problems.”

Students’ views about benefits of CAMI in mathematics and geometry courses.

In the interviews conducted after CAMI implementations with the students, they were asked, “Would you like to use CAMI method not only for quadratic functions (parabola) but also for the other topics of mathematics and geometry?”, and their responses were discussed under the category of “Students’ views about benefits of CAMI in other courses” with the codes presented in Table 8.

Table 8 Students’ Views About Benefits of CAMI in Other courses

<table>
<thead>
<tr>
<th>Code</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would like to learn mathematics and geometry courses with CAMI</td>
<td>9</td>
</tr>
<tr>
<td>I would like CAMI to be used in other courses</td>
<td>6</td>
</tr>
</tbody>
</table>

S1.2 answered the question which asked about the use of CAMI for other mathematics and geometry courses so:

“I also considered that, if implementation is carried out not only for one topic but also for other topics, it will be much better because we see better, and we understand better.”

The following conversation took place between the researcher and S1.1, one of the interviewees, about utilizing CAMI in mathematics and geometry courses:

“S1.1: In my opinion, it will be reasonable to use it. At least, if we skim through once at home, it becomes once; if we go to school and observe it on a computer, it becomes twice; and if we revise it, it becomes three times... For example, it is also important with geometry. To see in geometry, you have to see it to solve questions in geometry. That’s why it is very reasonable. For example, with the topics related to angles ... Computer assisted instruction can also be used with other courses.”

“Researcher: Which lessons do you mean by other courses? Can you give examples?”

“S1.1: Numerical courses. Physics is a really challenging course for me. It is the problem of all students taking numerical courses. Before learning the topic in physics, you can revise once at home and you can understand it. But, if you study it on a computer, if they teach you on computer to show what’s what, it will be reinforced more and you can solve questions better.”

CONCLUSION

When the findings obtained from mathematics teachers who carried out CAMI activities with the help of Mathematica program in their courses are examined, their positive views generally stand out. All of the teachers found CAMI implementations interesting with regard to their students. At the same time they thought that it reduced their course load. Similarly, two teachers considered that CAMI activities enabled students to learn by discovery. It can be concluded from these data that CAMI was perceived as a student-centered and activity-based teaching method. Mathematics teachers’ views about the ideal classroom environment where CAMI will be implemented seem to support this result.

All teachers emphasized that suitable software and hardware like Mathematica in the classrooms
where CAMI would be implemented would be required and also stated that every student in the class must have a computer or tablet. It can be deduced from these findings that teachers did not consider CAMI only as a presentation method but they also regarded it as a student-centered method. These results support the findings of studies where teachers’ views on computer-assisted mathematics instruction conducted via Mathematica were explored (Arıç & İşleyen, 2015; Pierce et al., 2009). These teachers’ positive views support the studies of Kaleli Yılmaz and Güven (2011) which introduced primary school mathematics teachers to Cabri, Graphic analysis, Derive, and GeoGebra programs in an in-service training program; the teachers in their study mentioned their positive views about CAMI after their classroom implementations. The current study results share similarities with the findings of studies examining the views of both mathematics teachers (Buteau et al., 2010; Lavicza, 2008; Lavicza & Papp Varga, 2010; Marshall et al., 2012) and prospective teachers (Tatar, Zengin, & Kağızmanlı, 2013) on the use of CAS and DGS in mathematics instruction.

While all of the mathematics teachers stated that the students did not have any problems during the CAMI activities carried out with CAS, one of the teachers said that he had a problem with the language of the Mathematica program. Similarly, Ersoy and Akbulut (2014) conducted a study with pre-service teachers and the results of the study in which CAS was used in the learning environment emphasized the foreign language problem. On the other hand, there are some negative sides of CAMI indicated by the teachers. The main reason could be that current university entrance exam is measuring students’ operational skills mostly. While one of the teachers said that students’ operational skills would not develop due to using CAMI continuously in mathematics courses, the other teacher emphasized that it would hinder university entrance exam preparations. This result shows parallelism with some results of the study of Çakıroğlu, Güven, and Akkan (2008) who examined mathematics teachers’ beliefs about using computers in courses.

When the views of students participating in mathematics course in an environment where CAMI was used for the first time were investigated, it was understood that all of them had positive views about this condition. This was supported by the fact that all of them wanted the CAMI method to be used in mathematics and geometry courses while six of them also wanted it to be used in other courses. While most of the students (seven people) mentioned that they liked CAMI owing to its ability to enable visualization of mathematical concepts, nearly all of the students (eight people) stated that they found the lessons taught with CAMI more enjoyable and more interesting. In addition, some of the students’ views on using time more efficiently in the courses taught with CAMI (five people), learning some topics by discovery (four people), and learning more easily (three people) are some of the findings that stand out in the research. Students’ positive views about CAMI support the results of research studies in which both DGS was used with the participation of secondary school students (Kutluca & Zengin, 2011; Reis & Özdemir, 2010) and CAS was used (Arıç & İşleyen, 2015; Taşlıbeyaz, 2010). Similar results were obtained in studies using CAS as a teaching tool and most observed positive developments in undergraduate students’ attitudes (Aksoy, 2007; Aktümen, 2007; Aktümen & Kaçar, 2008; Cildir, 2012; Kabaca, 2006; Kutzler, 2000; Tuluk, 2007; Vlachos & Kehagias, 2000).

When the findings obtained from the students were examined, as stated by their teachers, it was understood that students had no difficulties in using Mathematica, which is a CAS program. Once again, most of the students (five people) stated that there were no negative sides of implementing CAMI in mathematics courses. Two students, however, expressed that they did extra-curricular activities on the computers during CAMI, and one student said that enough problems were not solved for university entrance exam during this process. Considering the emphasis paid by the teachers on similar topics, this condition becomes prominent as factors practitioners must consider. It is clear as demonstrated by various studies (Hutkemri & Zamri, 2016; Öksüz & Ak, 2009; Seferoğlu, et al., 2008; Umay, 2004) that if mathematics teachers who are seen as fundamental actors in CAMI usage in classrooms receive the necessary in-service training, teaching activities utilizing CAS may be conducted successfully. The implementations were found interesting by students and teachers; they did not experience difficulties in using CASs like Mathematica in this process.

RECOMMENDATIONS

CAMI consists of three main components: software, hardware, and teacher (Arslan, 2003). Within the scope of the FATIH project in Turkey, it is predicted that lack of ICT in the classrooms will be overcome in the upcoming process. It is clear that there will only remain equipping teachers with CAMI knowledge and
developing or supplying software with suitable content. In this process, it is vital that teachers should be
given in-service teacher training in CAMI. Accordingly, teachers can be trained in CAS software such as
Mathematica. Moreover, in the forthcoming process, with the cooperation of education experts and
computer programmers, educational materials and e-contents in Turkish which will work on both tablets and
interactive boards without any problem can be designed and developed. Current curriculum and textbooks
can be re-designed to provide opportunities for actualization of CAMI. The research studies with teachers as
participants may continue and the failing points or positive conditions can be determined. Moreover, thanks
to such studies, teachers and students' awareness about CAMI can be raised.

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öğretmenlerinin görüşleri [Mathematics teacher views on adaptation of graphing calculators in


Students’ Performance in Geometrical Reflection Using GeoGebra

Pavethira Seloraji [1], Leong Kwan Eu [2]

ABSTRACT

Students in this era need to grasp the concept of geometry instead of memorizing formulae. This is important for them to further their knowledge in geometry. The purpose of the research was to determine whether GeoGebra software influences year one students’ performance in geometrical reflection. The research utilized an experimental research method. A total of 24 Year One students were randomly selected from an international school. The research used pre-test and post-test. The sample selected were taught and learnt by using GeoGebra software after the pre-test. Then, a post-test was given to them. A paired sample t-test was conducted and the results indicated a significant difference between pre-test and post-test. ANOVA was also conducted to test the influence of gender and ability level on student performance in geometrical reflection. The findings show a significant difference in the scores between genders. Similarly, the results also found statistically significant difference in scores among the three student ability groups. In conclusion, the study implies using GeoGebra enhances students’ performance in geometrical studies. Implementing teaching and learning geometry using GeoGebra would help students to explore the concept more in detail and help them to build and develop their geometry knowledge.

Keywords: geometry, reflection, GeoGebra software, primary mathematics

INTRODUCTION

Geometry is one of the longest-established branches of mathematics and its origins can be traced back through a wide range of cultures and civilizations. During the nineteenth and twentieth centuries, geometry, like most areas of mathematics, underwent a near cataclysmic period of growth. As a consequence, the content of geometry and its internal diversity increased almost beyond recognition (Jones, 2000).

A problem occurs when three-dimensional real-life objects are represented in a two-dimensional computer screen environment. One study by McClintock, Jiang, and July (2002) found GSP provides opportunities to have a distinct positive effect on students’ learning of three-dimensional geometry when using the sketching software. Moreover, students have difficulty moving from the three-dimensional world to a two-dimensional world. Experiences that bridge this gap will help them move from concrete to abstract examples of shapes. Reys, Lindquist, Lambdin, Smith, and Suydam (2006) feel that teachers need to emphasize the stages of concrete (manipulatives), semi-concrete (the sketching software), and the symbolic (paper and pencil). Thus, this research study was conducted to ascertain the effects of semi-concrete tools (GeoGebra) on geometry performance.

Technology is a powerful tool for engaging students in learning Mathematics. The importance of using technology in mathematics teaching has been advocated by the National Council of Teachers of Mathematics (NCTM) for many years (NCTM, 1989, 2000). One of the compelling tools that can be used is GeoGebra. GeoGebra is an interactive tool for exploring algebra and geometry. It lets the students explore the
mathematics concept. The GeoGebra user interface is flexible and can be adapted to student needs (Dogan, 2010).

Statement Of Research Problem

The literature on student performance in mathematics lesson conducted at school is important to know how effective ICT is in enhancing understanding of mathematics concepts. However, some past research shows several barriers to using ICT in the classroom. Jones (2004) found a number of barriers against ICT integration into lessons, namely: (1) lack of confidence among teachers during integration, (2) lack of access to resources, (3) lack of time for integration, (4) lack of effective training, (5) facing technical problems while the software is in use, (6) lack of personal access during lesson preparation, and (7) the age of the teachers.

Based on Ritchie (1996), schools are not yet effectively implementing instructional technologies despite the increase in the capacity of available educational technology. This study identified lack of administrative support as one of the most critical impediments to integrating instructional technology.

In addition, Dynamic Geometry Software (DGS) use in solid geometry and analytic geometry of space has been neglected. One of the main reasons for this is that two-dimensional Euclidean geometry is still more popular than three-dimensional geometry; hence students often faced difficulties in visualizing three-dimensional figures (Kosa & Karakus, 2010).

Other research studies show that many students have difficulties imagining spatially the analytic geometric task in Euclidian 3D space (E3). Blackboard drawings or handmade transparencies, mainly of questionable quality of perception, are no basis for developing an adequate spatial-geometric understanding in working on tasks of spatial analytic geometry – which does not exclude that students can solve those tasks algorithmically without spatial understanding (Schumann, 2003).

This research attempts to determine whether GeoGebra Software affects students’ performance in Mathematics lesson. The framework of the research is given in Figure 1.1.
visualizing, and computing (p. 25).

Furthermore, NCTM suggests that appropriate technology use can facilitate such applications by providing ready access to real data and information, by making the inclusion of mathematics topics useful for applications more practical (e.g., regression and recursion), and by facilitating teachers and students in handling multiple representations of mathematics topics (NCTM, 2000).

**Teaching and Learning Geometry using technology**

Karakus (2008) planned to determine possible effects of computer-based teaching on student achievement in transformation for geometry subjects. The experimental study found a significant difference in favor of the experimental group. All students in the experimental group achieved high attainment level with computer-based instruction in teaching of transformation geometry. Moreover, this difference becomes more significant and increases for successful students in the subjects of reflection and rotation. It has been observed that computer based instruction increased the experimental group success. However, there was no significant difference between experimental and control groups for low achieving students; According to Ustun and Ubuz (2005), a study comparing traditional educational environments with the dynamic learning environments (Geometer’s Sketchpad used) showed a significant difference in favor of the experimental group on the recall (permanence) test. The most important reason for this significant difference was identified as students’ explorations of geometrical shapes to see possible connections by manipulating the computer based environment.

Visualization is very important while studying geometry, especially 3D geometry. It can be difficult for students to visualize spatial figures in their mind. The nature of dynamic geometry software provides students with opportunities to learn geometric concepts and to explore and visualize geometric relationships easily. The study aimed at determining whether the three-dimensional computer supported activities designed by dynamic geometry software Cabri 3D for analytic geometry of space can help students develop a better understanding and have a positive attitude or not. Results of the study show that Cabri3D has an important potential to teach analytic geometry of space (Kosa et al., 2010).

**Difficulties in Learning Geometry**

According to Idris (2006), the lack of understanding in learning geometry often causes discouragement among students, which invariably will lead to poor performance in geometry. She claimed that some factors have been identified as causing difficulties in geometry learning; these are geometry language, visualization abilities and ineffective instruction. She also highlighted that spatial visualization has been linked with geometric achievement because geometry is visual in nature. Geometry is the study of shape and space; it requires visualizing abilities but many students cannot visualize three-dimensional objects in a two-dimensional perspective (Guven & Kosa, 2008).

Learning geometry may not be easy and a large number of students fail to develop an adequate understanding of geometry concepts, geometry reasoning and geometry problem-solving skills (Battisa, 1999; Idris, 2006).

**PURPOSE AND RESEARCH QUESTIONS**

The purpose of this research was to determine whether GeoGebra software affects students’ performance in Mathematics. The research was guided by the following research questions:

1) What are the levels of geometrical reflection among Year 1 students?
2) Is there any significant difference in the post test between genders?
3) Is there any significant difference in post-test between students’ ability?
4) Is there any significant difference between the pre-test and post-test scores?
METHODOLOGY

The research utilized the one group pre-test and post-test design. It targeted students in an international school. The research population comprised all students who are studying in Year 1 in international schools. We have used cluster sampling design in this research by selecting students from only one of the year 1 classes from the particular school. A total of 24 students were selected as the research sample. Their age group is 5-6 years old; they are of different ethnicity from Malaysia and internationally such as America, New Zealand, UK, Korea and India; different gender: 12 boys and 12 girls. The students in the class consisted of three groups namely Extension, Core and Support. Some 6 students from the Extension group are those who always achieved excellent performance in Mathematics, whereas 12 students are in the Core group which is known as an intermediate group. Lastly, the Support group students consist of 6 students who need some extra guidance in completing their tasks or sometimes they might not achieve their objectives. All the students were given a task to do in their sketchbook after Reflection was taught using GeoGebra software.

The task used in this study consists of the drawing of buildings by the student. Then, students were asked to reflect the object of the buildings they drew.

All the students, consisting of 12 girls and 12 boys were given a pre-test before being introduced to GeoGebra software. They were taught what reflection is using the traditional method and asked to draw the reflection (pre-test). After the pre-test, the students were introduced to the GeoGebra software during their ICT lesson. The students listened to the steps explained using Smart board. Three students were selected to try out the reflection. The students were exposed to the knowledge of what reflection is and how it is used in our lives and where it happens. The students then went to their own PC to complete the activity given. Then, they were given the post-test a few days later.

The pre-test and post-test results were analyzed using the SPSS software.

RESULTS

To answer the research question, “What are the levels of geometrical reflection among Year 1 students?”

![The levels of students' performance of Year 1 in pre-test and post-test](image)

*Figure 2. The comparison of pre-test and post-test results of geometrical reflection for Year 1 students*

Figure 1 shows that, in the control group Moderate and Poor have the highest percentage 38%. The students from different group such as core and support groups are mostly in the Moderate and Poor category. The students proved that they do not prefer traditional method because it could not fulfil all the requirements in drawing. The least is Excellent which is 25% only. Some students from the extension group
can adapt to traditional method.

However, in the experimental group, the highest percentage is 58% for Excellent, 42% Moderate and 0% Poor. It shows in post-test students did better than in pre-test. There is none in the category Poor which shows the students are able to learn the concept of Reflection and could carry out the task given successfully.

Table 1. Tests of Normality

<table>
<thead>
<tr>
<th>Gender</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
</tr>
<tr>
<td>Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>.351</td>
<td>12</td>
</tr>
<tr>
<td>Male</td>
<td>.153</td>
<td>12</td>
</tr>
</tbody>
</table>

* This is a lower bound of the true significance.

To fulfill the requirement of ANOVA test normality test had been conducted. Table 1 shows the results for tests of normality. Since the number of participants was below 50, Shapiro-Wilk test was used to check the normality. The p-value for male is .282 more than .05 which means the assumption of normality was not violated. Table 7 shows the tests of normality.

Table 2. Tests of Normality

<table>
<thead>
<tr>
<th>Ability</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>Df</td>
</tr>
<tr>
<td>Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support</td>
<td>.186</td>
<td>6</td>
</tr>
<tr>
<td>Core</td>
<td>.191</td>
<td>12</td>
</tr>
<tr>
<td>Extension</td>
<td>.455</td>
<td>6</td>
</tr>
</tbody>
</table>

* This is a lower bound of the true significance.

The p-value for Support is .595 which is more than .05 indicating that the data were approximately normal in distribution.

To answer the second research question of “Is there any significant difference in the post test between male and female students?”

Table 3. Descriptive Statistics Score

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>12</td>
<td>86.00</td>
<td>8.356</td>
<td>2.412</td>
<td>80.69</td>
<td>68</td>
<td>92</td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
<td>68.33</td>
<td>13.506</td>
<td>3.899</td>
<td>59.75</td>
<td>50</td>
<td>88</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>77.17</td>
<td>14.215</td>
<td>2.902</td>
<td>71.16</td>
<td>50</td>
<td>92</td>
</tr>
</tbody>
</table>

The descriptive table, Table 3, provides some very useful descriptive statistics, including the mean, standard deviation and 95% confidence intervals for the dependent variable (Score) for each separate group (Female and Male), as well as when all the groups are combined (Total). The mean score for Female is 86.00 that is higher than the male score of 68.33. The standard deviation for Female is 8.356 while the standard deviation for male is 13.506.
An independent samples t-test was conducted to determine if the mean of male group differs from that of the female group. The F test and p value of Levene’s Test for Equality of Variances was reviewed to determine if the equal variances assumptions have been met. According to Levene’s Test, the homogeneity of variance assumption of was F= 5.689, p = .001.

Based on Table 4, we see that the significance (2-tailed) value is .001. This value is less than .05. Thus, there was a statistically significant difference between the mean of male and female group on the score of geometrical reflection. An independent-samples t-test was conducted to determine the significance of difference between male and female in the geometrical reflection score. There was a significant difference in the scores for male (M = 68.33, SD = 13.506) and female (M = 86.00, SD=8.356) conditions; t(22) =3.85, p = .001.

The mean difference value of 17.667 shows that in the population from which the sample is drawn, the female students (mean score = 86.00) scored better compared to male students (mean score = 68.33). The mean value for both groups can be seen in Table 4. To answer the third research question, “Is there any significant difference in post achievement between students’ abilities?”

Table 5 Descriptive Scores

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
</tr>
<tr>
<td>Support</td>
<td>6</td>
<td>59.67</td>
<td>7.941</td>
<td>3.242</td>
<td>51.33</td>
<td>68.00</td>
<td>50</td>
</tr>
<tr>
<td>Core</td>
<td>12</td>
<td>80.17</td>
<td>11.676</td>
<td>3.371</td>
<td>72.75</td>
<td>87.59</td>
<td>54</td>
</tr>
<tr>
<td>Extension</td>
<td>6</td>
<td>88.67</td>
<td>4.320</td>
<td>1.764</td>
<td>84.13</td>
<td>93.20</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>77.17</td>
<td>14.215</td>
<td>2.902</td>
<td>71.16</td>
<td>83.17</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 5 provides some very useful descriptive statistics, including the mean, standard deviation and 95% confidence intervals for the dependent variable (Score) for each separate group (Support, Core and Extension), as well as when all groups are combined (Total). The results show that the mean for Support is 59.67, Core is 80.17 and the highest score is for the Extension group (88.67). On the other hand, the standard deviation was the highest for the Core group (11.676) followed by Support with 7.941 and Extension with 4.320.
Table 6 ANOVA Score

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2739.000</td>
<td>2</td>
<td>1369.500</td>
<td>15.070</td>
<td>.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>1908.333</td>
<td>21</td>
<td>90.873</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4647.333</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6 shows a one-way between groups analysis of variance conducted to explore the effect of GeoGebra on Geometrical Reflection. Participants were divided into three groups according to their ability (support, core and extension). There was a statistically significant difference at the $p < .05$ level in scores for three ability groups $F(2, 23) = 15.070, p < .05$. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Support group ($M = 59.67, SD = 7.941$) was significantly different from that of the Core group ($M = 80.17, SD = 11.676$) and the Extension group ($M = 88.67, SD = 4.320$).

Table 7 Multiple Comparisons

**Dependent Variable: Score Tukey HSD**

<table>
<thead>
<tr>
<th>(I) Ability</th>
<th>(J) Ability</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Core</td>
<td>-20.500*</td>
<td>4.766</td>
<td>.001</td>
<td>-32.51 -8.49</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>-29.000*</td>
<td>5.504</td>
<td>.000</td>
<td>-42.87 -15.13</td>
</tr>
<tr>
<td>Support</td>
<td>Support</td>
<td>20.500*</td>
<td>4.766</td>
<td>.001</td>
<td>8.49 32.51</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>-8.500</td>
<td>4.766</td>
<td>.199</td>
<td>-20.51 3.51</td>
</tr>
<tr>
<td>Core</td>
<td>Support</td>
<td>29.000*</td>
<td>5.504</td>
<td>.000</td>
<td>15.13 42.87</td>
</tr>
<tr>
<td></td>
<td>Core</td>
<td>8.500</td>
<td>4.766</td>
<td>.199</td>
<td>-3.51 20.51</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.

As shown in Table 7, most of the $p$-values were less than .05. For this reason, we can conclude that the Extension and Core groups were not significantly different. However, the other 2 groups were significantly different from one another. This means that the Support and Core group were significantly different. Similarly, the Support and Extension group scores were statistically significant.

To answer the last research question, “Is there any significant difference between the pre-test and post-test scores of the experimental group?”
Table 8 Paired Samples Test

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest - Posttest</td>
<td>14.8750</td>
<td>10.71493</td>
<td>2.18718</td>
<td>-19.39952 to -10.35048</td>
<td>-6.801</td>
<td>23</td>
<td>.000</td>
</tr>
</tbody>
</table>

A paired samples t-test was conducted to determine the significant difference between pre-test and post-test in using GeoGebra on students’ performance. There was significant difference in the scores for the GeoGebra group (M = -14.875, SD = 10.715), t (23) = -6.801, p = .00. These results indicate that the students performed better after using GeoGebra on Geometrical Reflection.

DISCUSSION AND CONCLUSION

The findings of the study indicate that using of GeoGebra software in teaching and learning will promote good learning outcome in geometric transformations especially in the topic of reflection. There is a significant difference between pre-test and post-test in using GeoGebra on students’ performance in the paired samples t-test conducted. The results indicate that the students did better after the interventions using Geogebra software. The students can have clear understanding of reflection by reflecting the objects in the software. Additionally, they also could explore and grasp the concept of reflection. Thus, they manage to do well in their post-test compared to their pre-test.

Moreover, the study also investigated the role of gender (male and female) on students’ performance and the results indicated a statistically significant difference. The results indicated that girls did better than boys probably because girls have high interest in exploring the software on the reflection topic. They also might link the concept well that they have learnt when they do it manually (using pencil and paper). However, boys were more focused on the software activity and showed less interest in doing reflection manually.

Furthermore, ANOVA test was also conducted to find if there is any significant difference in post achievement and ability of the students and there was a statistically significant difference at the p < .05 level in scores for three ability groups F (2, 23) = 15.070. The results meant that all the ability groups are keen to learn the topic using GeoGebra software. The software is suitable and user friendly for all the ability groups.

The findings support Ustun and Ubuz (2005); the results of their study comparing traditional educational environments with the dynamic learning environments (Geometer’s Sketchpad used) showed a significant difference in favor of the experimental group on the recall (permanence) test.

This study found a positive effect by teaching Reflection using GeoGebra Software on students’ performance in mathematics lessons. The finding supports NCTM (2000). This finding also supports the view of Doğan and İçel (2010) that GeoGebra is found to be very efficient in mathematics education and can be used effectively both in teacher training and student learning. It can be said that computers can lead to improved teaching and learning of mathematics by establishing possible benefits of software. The finding also supports the view of Dogan and Icel on effectiveness of GeoGebra as an interactive geometry system.

Based on the present research findings, both traditional method and using GeoGebra Software to teach Reflection shows positive effect. However, it can be concluded that using GeoGebra software to teach Reflection shows better results than the traditional method. The findings show none of the students at the level of Poor (do not fulfill most of the properties of reflection). The students who did not manage to do well
in pre-test, could do better in the post-test. Moreover, some students who were at the level of Moderate (fulfill partially the properties of reflection) in pre-test, could manage to improve themselves and obtain the level of Excellent (fulfill all the properties of reflection) in post-test. In overall, all the students could draw the image or the reflection of the object to satisfy the properties of Reflection with understanding of the concept in the post-test. However, using traditional method, only the Extension group students could fulfill all the properties of reflection. Core students could only score up to Moderate and some scored Poor together with the support group.

Students often have difficulties in visualizing three-dimensional figures (Kosa & Karakus, 2010); the difficulties were tackled by implementing usage of GeoGebra software in learning Reflection in this research. The children visualized the object in 2-D and 3-D very well. They could imagine the 3-D picture and mostly can draw by reflecting it.

Idris (2006) stated that the lack of understanding in learning geometry often causes discouragement among the students, which invariably will lead to poor performance in geometry. However, the study proves that GeoGebra software gave students a clear understanding on the topic of geometric transformations because the students could perform better in their post-test compared to their pre-test.

In conclusion, the students can achieve the learning objectives of geometric transformations in reflection by using GeoGebra software in learning. Research suggests that teachers should use the software in teaching and learning of geometric transformations since it is useful. For further research in future, research can be conducted by testing on a larger sample. The research also can employ a longer period of intervention. Research also can be focused on different topics in geometric transformations using GeoGebra.

REFERENCES


DRAW A PICTURE IN THE MIRROR

<table>
<thead>
<tr>
<th>Description</th>
<th>The students insert picture in this software and try to see the reflection of the picture. Then, they were asked to draw the picture on their own in their IPC topic book.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>Year 1</td>
</tr>
<tr>
<td>Age Group</td>
<td>5- 6 years old</td>
</tr>
<tr>
<td>Total Time</td>
<td>60 minutes</td>
</tr>
<tr>
<td>Standards</td>
<td><strong>Draw a Picture in the Mirror</strong></td>
</tr>
<tr>
<td></td>
<td>Create a square and see the reflection. Then, insert their favorite pictures and see the reflection in <em>GeoGebra</em>. Draw the pictures of buildings near the beach with reflection on the beach in their IPC topic book.</td>
</tr>
<tr>
<td>Geogebra Skills</td>
<td>The topic reflection is appropriate to be taught using <em>GeoGebra Software</em> where the students of this age group can see the clear picture of reflection and can understand the concept. The students will use the skills learnt earlier such as inserting pictures and constructing polygons to do this activity.</td>
</tr>
<tr>
<td>Mathematical Background</td>
<td>The students will be introduced to a new topic of reflection.</td>
</tr>
</tbody>
</table>

**Step 1**
Students will open *GeoGebra software* from the desktop.

**Step 2**
Students will click “Show or hide the axes” to make both the axes disappear. Then, they will be asked to click “Show or hide the grid” to make the grid disappear on the window as well.

**Step 3**
Students will be asked to click on the regular polygons and create a square. Then, to label the points students will choose one of the points and click “Set Label Style” to select “Name” as shown in the following Image 1. The steps will be repeated for other points also.
Step 4

Students will be asked to construct a line. Next, they will click one of the points from the square and click; click the line constructed and click “Reflect about Line”. The steps will be done for all the points like Image 2.
Step 5
The points are then connected by the segments.

Step 6
Students will continue by inserting different pictures. At this time, they just need to click the picture and followed by the line only because the option “Reflect about Line” is already selected. The students will repeat the steps by adding other pictures. The example Image 3 as below;