Research Article

Investigation of Teaching in the Technological Environment in terms of Orchestration in the Mathematics Teaching Process

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Abstract: The aim of this research is to examine the mental processes of a mathematics teacher including the instrumental action schemes related to the selection of tools and the use of these tools in the technological environment during the teaching process. In this research, it is aimed to examine in depth the awareness of a secondary school mathematics teacher about the mental and behavioral processes of the instrumental orchestration choices used in the process of integrating technology into the lecture and the instrumentalization and instrumentation processes that occur with the instrumented action schemes in the instrumental genesis during the lesson preparation and lesson experiences. In the study, qualitative research methods were used. This study was designed as a case study, one of the qualitative research designs, in which the indicators of Instrumental Theory can be observed in the best way and the process of the case can be examined in the best way. In addition, since this study requires an in-depth examination of the participant in every aspect, the single-case study was considered as the most appropriate design. In this study, a female teacher working in a public secondary school during the 2020 – 2021 academic year was chosen as the participant. The selection criteria of this teacher were determined by knowing the changed curriculum, having taken courses with technology-supported mathematics teaching course content throughout her university education, her perspective and willingness to assist the course content in these technology-supported courses, her perspective on technology during her teaching life, and finally her thoughts about her views on technology. In order to provide data diversity and to get full answers to the research questions, semi-structured interview, document analysis and non-participant observation were used as data collection tools in the study. The research results and findings were concluded by considering the teacher's schemes, instrumentation processes and instrumental orchestration elements in arranging the technological teaching environment.

Keywords: Instrumental formation, Orchestration, Mathematics teaching

1. Introduction

Technology has a very important place in the changing and developing world order. Technology, which has settled in all areas of life, has also become a whole with the field of education. Due to the worldwide Covid-19 pandemic, the alternative of remote education is not on the agenda. For this reason, the use of technology has become an indispensable element of education. In this respect, developments in technology have also been effective on mathematics education. Especially in the last thirty years, the use of various technological tools in the teaching of mathematics has become widespread. (Akkoç, 2008).

Teachers have an important role in the successful adaptation of technology to the teaching process. The concept of technology here includes the use of digital technological means (smart board, tablet, computer, various teaching aids, etc.) as well as being used to refer to continuing the distance education process from a digital environment. However, teachers have insufficient experience in the use of technology in the distance education process for teaching and learning and may encounter some difficulties due to this situation (Drijvers, 2012). In order to help teachers in the remote realization of mathematics teaching in a technological environment, it is important to know a lot more about the new teaching techniques with technology integration that have emerged in remote learning environments. (Drijvers, Doorman, Boon, Reed & Gravemeijer, 2010).

Adapting technology to the classroom environment is not an easy situation. However, technology has become a necessity for studying mathematics in today's conditions. Computers provide easy implementation of teaching applications by directing technical calculations. But this contribution of technology is possible only if the teacher properly organizes the materials in the classroom. In this regard, the teacher's role is to regulate interaction with the computer environment. The teacher encourages students to use technology (Guin & Trouche, 1998). In mathematics education, the teacher's classroom activities are expected to support the student's learning. That is why the instrumental orchestration approach stands out due to the fact that it is an approach that studies the teacher's purposeful and systematic arrangement of tools in the learning environment (Drijvers, 2012; Drijvers, Doorman, Boon, Reed & Gravemeijer, 2010; Tabach, 2013; Trouche, 2004).

The teacher who regulates the educational environment is expected to help students realize their technological mental formation in terms of using technology and integrating technology with the mathematics lesson before creating new mental processes that combine technology and mathematics, and consciously guide

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the process of distance education. It is important to understand the reasons for the orchestration choices of the mathematics teacher by making sense of the instrumentalization and instrumentation processes in terms of cognitive processes regarding the mathematics teachers who provide technology integration. Considering these situations, the research problem of this study is: “What are the mental processes of a mathematics teacher in the process of teaching that include the choice of tools in a technological environment and the instrumented action schemes related to the use of these tools?

1.1. Instrumental Theory

Mathematics teachers may experience many difficulties in the distance education process, which includes the use of technological tools and resources in teaching environments. (Drijvers, 2012). For this reason, the need to understand the actions of the mathematics teacher who teaches mathematics in a teaching environment combined with technology has emerged. (Tabach, 2013). Since an in-depth understanding of the learning processes of students with other important inputs and outputs of teaching is also one of the main challenges of mathematics education research, it is necessary to study different theoretical perspectives in order to better understand this situation. (Drijvers, Godino, Font, Trouche, 2013). As in this study, instrumental theory is one of the most important theoretical frameworks that can help to understand and make sense of these learning processes in a mathematics teaching environment integrated with technology.

In order to understand the concept of instrument, it is necessary to understand the two basic components it contains. The external component of the instrument is related to the tool, while the psychological component includes the user's usage scheme for the tool (Verillon & Rabardel 1995). A tool is a man-made object intended to be transformed into an instrument by appropriate instrumental activities (Verillon, 1995). It is known that there is a mental structure that must necessarily be present for the formation of the instrument. This condition is called scheme. In addition, a scheme consists of a set of behaviors, rules of action and conceptual components made for the use of a tool that can be developed with new experiences in the usage (Drijvers, Godino, Font & Trouche, 2013). The usage scheme, on the other hand, includes a systematic structure structured in the mind to use the tool to complete a special task (for example, a mathematical problem) (Verillon & Rabardel, 1995). The instrumental genesis, which is the process of creating these schemes, consists of a two-part. One of these parts is instrumentation and the other is instrumentalization. The formation of schemes in instrumentalization occurs with the use of the tool. Instrumentalization deals with the detection and development of components of instruments. Learning the functions and features of the instrument during the conversion to the instrument; understanding of misuse take place in this process. Instrumentation, on the other hand, is focused on the action to be achieved. Instrumentation covers the emergence and development of individual schemes of use and actions with the instrument. (Köse, 2015). The instrumental genesis process according to Trouche (2004) is shown in Figure 1.

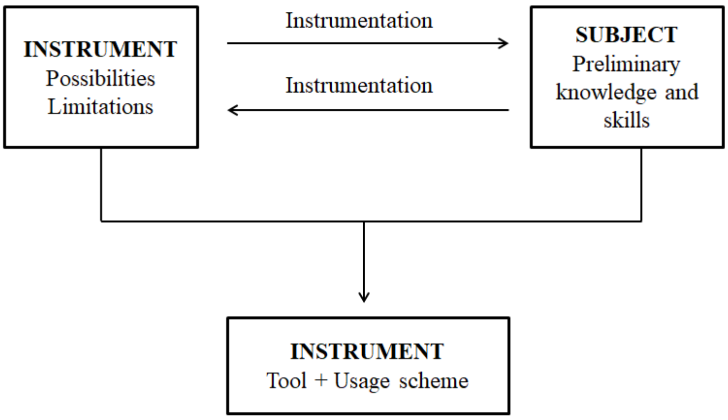

Figure 1. Components of Instrumental Formation (adopted from Trouche, 2004)

1.2. Instrumental Orchestration

The learning processes in technology-supported classrooms are realized by the teachers managing (orchestrating) the use of technological tools (instruments) within the teaching tasks (Drijvers & Trouche, 2008). Trouche (2003) used the concept of instrumental orchestration to better explain the practices of teachers in this process. Instrumental orchestration is the deliberate and systematic organization of various tools suitable for learning environments by teachers for a certain mathematical achievement in a way that will support students' instrumental genesis. (Trouche, 2003). Orchestration emphasizes the importance of instruments in the development of mathematical activity and states that it is the teacher's responsibility to ensure the use of these instruments in harmony with each other (Denizli, 2018). Trouche (2004) defines two main components in instrumental orchestration, and calls them the first stage “didactic structure” and the second stage “modes of use of didactic structures”. Didactic structuring is the decision of the teacher in organizing the learning environments of the students individually or in groups and determining the learning tools. The modes of use of didactic structures, which are the second stage of the orchestration process, include determining the aims of the activities and the points that are considered important for the students in the learning process in a way that will benefit from the didactic arrangement created by the teacher. The types of instrumental orchestration are shown in Table 1 (Kozaklı,2015).

Table 1. Instrumental Orchestration Types (Kozaklı, 2015)

Orchestration Types	Didactic structure	Didactic use
Tech-demo (Drijvers, Doorman, Boon, Reed & Gravemeijer, 2010)	Structure with a main screen in the center, including the entire classroom	For the use of the tool, the teacher explains the technical details of the tool.
Explain-screen (Drijvers, Doorman, Boon, Reed & Gravemeijer, 2010)	Structure with a main screen in the center, including the entire classroom	The teacher makes technical and mathematical explanations to the class on the main computer screen.
Connect-between-screen-and-board (Drijvers, Doorman, Boon, Reed & Gravemeijer, 2010)	Structure with a main screen in the center, including the entire classroom	The teacher connects with the representations on the screen for representations of mathematical objects that have appeared on the board or book.
Screen-discuss (Drijvers, Doorman, Boon, Reed & Gravemeijer, 2010)	Structure with a main screen in the center, including the entire classroom	It includes a class discussion attended by the entire class about what is happening on the main computer screen in order to improve the instrumental formation of all individuals in the class.
Catch and show (Drijvers, Doorman, Boon, Reed & Gravemeijer, 2010)	Structure with a main screen in the center, including the entire classroom	In addition to the aforementioned features, the teacher provides access to student work in the technological environment during extra lesson preparation.
Student-at-work (Trouche, 2004)	Structure with a main screen in the center, including the entire classroom	Technology is in a student, who prepares all other students in the class for discussion.
Work and walk (Drijvers, 2012)	Structure where students work individually or in pairs with computers	The teacher walks among the working students, monitors the students' progress and provides guidance when needed.
Technology-non-use (Tabach, 2011)	Structure with a main screen in the center, including the entire classroom	Technology exists in the teaching environment, but the teacher does not prefer to use this technology.
Discuss-technology-without-technology (Tabach, 2013)	Structure where all students have laptops or mobile computers	In environments where continuous technology is not available, it is provided with laptops or mobile computers that can be carried between classes.

The instrumental orchestration approach does not recommend the use of fixed types of orchestration (Tabach, 2013). However, various studies on the orchestration roof have focused on the identification of orchestration types in an environment that provides technologically rich learning opportunities (Drijvers et al 2010; Drijvers, 2012; Şay, Kozaklı & Akkoç, 2013; Tabach, 2004; Trouche, 2013). Considering the studies conducted on technology-supported mathematics education in Turkey, a very small number of teacher-sized studies have been observed from the perspective of the instrumental theory. Therefore, in order to find a solution to the technology integration problem, in this study, two different technology-supported learning environments prepared by a teacher were examined in terms of instrumental orchestration and the resulting types of instrumental orchestration were tried to be determined.

1.3. Research Problems and Sub-problems

The research aims to examine the mental processes of a mathematics teacher in the process of distance education, including the tool choices she makes in a technological environment and the instrumental action schemes related to the use of these tools. In the context of this purpose, answers to the following problems were sought:

1. In which situations and for what purposes does a mathematics teacher use technology in mathematics teaching?

2. Which types of orchestration does a mathematics teacher use in teaching mathematics using technology?

2. Method

As the design of the research, qualitative research method was preferred in order to closely monitor, describe and interpret the events and phenomena in the examined situation. (Çepni, 2005; Yıldırım & Şimşek, 2011). In addition, since this study is a study that requires an in-depth examination of the participant in every aspect, the single-case study was considered as the most appropriate design.

2.1. Participants

This study was conducted during the 2020 – 2021 academic year in a public middle school with a female teacher with 12 year of experience in the Ministry of National Education. Although this teacher was not exposed to using technology much during his undergraduate education, she tended to use technological tools in her teaching life. This was determined by the teacher's tendency to use technological tools in the distance education process in the lessons, observation of the researcher and interviews with the teacher. During these interviews, the teacher's beliefs about technology and whether she was willing to use technology were determined, and the teacher who would be the main data source of the research was determined.

2.2. Data Collection Tools

Data of the present study was collected by structured interviews, semi-structured interviews, non-participant observation, lesson plans and video recordings. Structured and semi-structured interviews were used in two stages within the scope of the study. The relationship between the data collection tools used in the study and the research questions is shown in Table 2.

Table 2. The Relations between Research Questions and Data Collection Tools

Research questions	Data Collection Tools
1. In which situations and for what purposes does the mathematics teacher use technology in teaching mathematics?	Semi-structured Interview Structured Interview Investigative observer (non-participant observation) Lesson Plans
2. What types of orchestration does a mathematics teacher use in teaching mathematics using technology?	Lesson Plans Semi-structured Interview (before and after lecture) Researcher observation (non-participant observation) video recordings

2.3. Data Analysis

In the analysis of the data, the data obtained by qualitative research methods were analyzed using the descriptive analysis technique. In order to determine the types of orchestration used by the participant teacher, the researcher analyzed the lesson plans that the participant teacher prepared before the lecture, with the help of document analysis in line with the criteria given in Table 1. The researcher has determined the types of orchestration that are added during the teacher's classroom experiences due to the inputs in the environment.

The researcher left the participant teacher independent of what methods and techniques she will use for teaching by using technology in the distance education environment, how she will plan the lessons and how / to what degree / for how long she will integrate technology into her teaching process in order not to affect the orchestration choices. Firstly, a semi-structured interview was conducted before the lecture in order to learn the teacher's relationship with technology both in her daily life and during her twelve-year mathematics teaching experience. In this interview; it was aimed to determine the point of view of the participating teacher against technology-integrated mathematics teaching in a technological environment.

2.4. Validity, Reliability and Ethics

In order to ensure the validity of the research, the data were examined in depth with the purposeful sampling method. The findings obtained were supported by the studies found in the literature. In this way, it was aimed to ensure validity. In order to ensure the reliability of the study, the data analysis process was carried out objectively. The researcher did not give any guidance to the participating teacher. In this way, the researcher's influence on the teacher was not in question. From an ethical point of view, the volunteerism of the participating teacher was taken as the basis. She has been informed that the course records will not be shared with anyone and her name will be kept confidential.

3. Findings and Comments

The findings obtained from the research are presented in four parts. Firstly; in which situations and for what purposes the participant teacher uses technology in teaching mathematics is given. In another title; it is discussed which orchestration types the mathematics teacher uses in teaching using technology in mathematics teaching. In the third title, how and to what extent the integration of technology in the teaching-learning life affects the teacher's integration of technology into the distance education process in mathematics teaching. Finally, the awareness of the mathematics teacher of her own orchestration choices are discussed.

3.1. The views of the Mathematics Teacher on the Use of Technology in Mathematics Teaching

The participant mathematics teacher had a very positive perspective towards technology. She expressed that technology has made her professional life much easier. She stated that she used technology in many parts of her life and she was satisfied with all of these uses. One exemple of the participant teacher’s expressions in this purpose in given below:

> *“I use technology at many stages of my life. I use it for shopping online, paying my bills, on social media platforms, preparing for classes in terms of my profession, even for preparing written ones. I think technology has made my life easier.”*

The Mathematics Teacher expressed her point of view towards technological software in his daily life as follows:

> *“My level of interest in software in daily life is an intermediate level. Actually, I was staying a little further away because of my belief in the difficulty of using it. But since we switched to distance education due to the COVID-19 pandemic, our need for technology and technological tools has increased. This need has also generated interest. As my interest grew, I started to like it. I realized that it made my lectures even more fun and easy.’’*

In the light of the structured and semi-structured interviews, it was seen that the mathematics teacher has been teaching in the secondary school part of the national education body for twelve years. She has twelve years of active teaching experience and has stated that she has been using technology more intensively and actively in the last three years of her teaching life. She expressed this situation as follows:

> *“I have started using technological tools and software more in my professional life for the last 3 years. Along with the distance learning process, I can say that my belief in the amount and necessity of use has increased. Perhaps this process, which began with the COVID-19 pandemic, can be partially settled in our lives with changing and developing educational policies. Therefore, it is necessary that we and our ideas adapt to teaching with technology.’’*

Analyses have shown that the teacher wanted to use the integration of technological software more in geometry subjects. He expresses this situation with the following words:

> *“I need mathematical software more in geometry subjects. Because for students, concepts such as geometry, geometric bodies, their drawings, elements remain abstract. Visualizing these with drawings is important for students to concretize the situation and better understand it.’’*

The analyses revealed that another purpose of the teacher's desire to integrate technology into the lesson in a distance learning environment is caused by her opinions about the constructivist approach. Indeed, she expressed that the student could actively participate in the lesson in the constructivist approach, which she thought as the basis of mathematics teaching.

Analyses of the lesson recording have also shown that the participating mathematics teacher preferred GeoGebra software, EBA portal and z book as tools to teach the achievements related to polygons in a technological environment. The teacher showed the students examples of how to draw polygons through GeoGebra. After showing the naming of polygons created via this software, she watched a video about the basic elements of polygons from the Eba portal and then explained the basic elements of the polygons. Later, the polygon creation game, which is a game similar to the GeoGebra software on the EBA portal, was played with the students and she asked the students to create the drawings of the desired polygons on the virtual dashboard. Then she opened the z book and asked the students to solve the questions in the book.

3.2. Types of Orchestration Used by the Mathematics Teacher in the Preparation Process for the Lesson

In this section, the orchestration choices that the mathematics teacher consciously or unconsciously created was examined in the lesson plan in which she prepared. The analyses were realized throughout the data obtained by the semi-structured interview conducted before the lecture and the lesson plan prepared by the teacher before the study.

Analyses of the lesson plans of the mathematics teacher have shown that she had also benefited from technology integration and the technological environment before the covid-19 pandemic process. However, it is also seen from the following words that the teacher did not include technological tools in the lecture process as much as in this period:

> *"In the period before I started the distance education process, I was using the smart boards in my lectures. The idea of getting support from technology has always been close to me. That's why I tried to learn something about software such as GeoGebra, Cabri, Maple, which I did not have the opportunity to learn in detail in my undergraduate education, with my own efforts. One of these softwares I prefer to use is GeoGebra. Especially for the last 3 years, I have tried to use this math software frequently in my professional life. But since we started the distance education process, I can say that such mathematical software and technological tools have made my job much easier in my teaching. I can say that I realized that I did not tend to use technological tools much before the distance education process.''*

Analyses of the student and teacher activities in lesson plans show that the teacher prefered to use one of the technological tools, especially math software programs. This situation was based on the techniques-demo, explain-screen and catch-and-show orchestration types. Firstly, because the teacher made explanations to the class by defining polygons technically and mathematically on the main computer screen, the screen-explain orchestration has been compared to the type of orchestration. Next, the teacher provided access to the student's work in the technological environment during the preparation of additional lessons, as well as the previously mentioned polygon features. For this reason, it is thought to be a catch-show orchestration type.

3.3. The Orchestration Choices Applied by the Teacher during the Lectures

The teacher used the technique-demo, screen-explain, capture-and-show and screen-discuss orchestration types that he preferred in the lesson plan. First, a dialogue with tech-demo orchestration was used:

> *Teacher: Friends, this program you see is a geometry program. Its name is GeoGebra. I can use this program for many purposes. Let's take a look at an example from what we've seen before. Tell me, which geometry subject do you remember?*
>
> *Student: There were triangles.*
>
> *Teacher: Okay, let's draw a triangle. For this, we can select the polygon tab from the following tab and draw a triangle according to the number of vertices. Then let's measure the edge lengths from this tab to this tab, they all turned out to be 5 cm. Thanks to this program, I can create the polygon I want, and I can see the shapes that I have difficulty in visualizing. Now, guys, for our new topic, let's see a little more about what's going on in this software, and then I'll tell you the steps, and you'll do it. You see there are tabs on the software. When we click on each tab, we can make different drawings or make measurements.*

Then, the explain-screen orchestration type was used. The teacher presented information about GeoGebra software from her own screen. She explained the aspects of this software that benefit from using mathematical knowledge. Then, with the catch-and-show orchestration, the teacher provided access to the students' work in the technological environment with extra activities she prepared in addition to the previously mentioned features.

Even if the teacher taught the topic with examples on the screen, especially when synthetizing the topic, she felt the need to summarize the topic there by turning on her camera and writing on a regular board. She preferred to show the examples on the screen and write the explanations on the normal board. In this case, unlike the course processes described in the plan, she used the-link-between-the-screen-and-the-board-during the lecture orchestration. She used this orchestration effectively in the final process.

Analyses have shown that there were three types of orchestration that the teacher especially preferred in the teaching process. These types of orchestration were tech-demo, screen-explain, catch-and-show orchestration types. As a result, she used the technical-demo orchestration to involve the students in the process about the software they had never seen. On the other hand, screen-explain orchestration was used as a liberating type of orchestration by the teacher due to its easy availability with screen sharing in it. The teacher used these two types of orchestration more intensively due to the fact that she had an interest in technology-integrated teaching. Then, as a result of two hours of technology-integrated teaching, she expressed that she would prefer more types of orchestration in the lesson plans she had prepared for the second group of students, as well as watching her own lecture video and being able to make her own self-criticism. In addition, although the teacher did not mention in her plan that the students were very motivated by GeoGebra software, she preferred the screen-discussion orchestration type in the teaching environment during the teaching process.

3.4. Awareness of Mathematics Teacher's Own Orchestration Choices

The lesson plans prepared by the mathematics teacher for mathematics teaching provided important information about the teacher's own orchestration choices. Considering the lesson plan prepared by the teacher for the 5th grade polygons acquisition before the study, she preferred to add technology to the lecture plans due to her positive attitude on the use of technology in the classroom environment, her tendency to technology and her knowledge of GeoGebra software. During her twelve-year active teaching, she also organized a technology-integrated mathematics course for many students. She expressed this situation in the following words:

> *'"During my education faculty period, my GeoGebra learning from technology-integrated software did not occur at sufficient. But during my teaching process, especially when I was teaching at the Science and Art Center, I thought that I had to improve myself in terms of technology. I also had to catch up with the conditions of the developing world in terms of education. In this sense, I increased my little knowledge by researching myself. With the transition to distance education during the Covid -19 pandemic process, technology has become fully involved in education. Thanks to the work I have done, I have had no difficulty in integrating technology into the lecture processes.*

These expressions of the teacher show that the teacher did not have any difficulties in integrating technology into the distance education process. For this reason, while the teacher was planning the lesson, she planned the process mostly through the technological tool. During the study process, as she experienced the hardware knowledge of technological tools and the features of GeoGebra software during the course processes, she realized her own formations in the course and her positive attitude towards technology increased even more. The mathematics teacher expressed that she could integrate even more technological tools into the teaching process with the awareness of what she could do with technology. After watching her own lecture video, she expressed herself as follows:

> *"It's a very different thing to watch myself lecture. But believe me, it was very effective in terms of self-assessment. This is so beautiful. I had planned the technology to explain the subject and solve the question. I was very happy to see that I was able to implement this plan. I also noticed that lecture with the help of a technological software increases the motivation of students to the lesson."*

Analyses have shown that there was a high awareness of the orchestration choices made by the teacher at the time when she was watching the video recordings of her lecture process. It has been determined that the other moment where she had awareness on this subject was when students expressed their lecture experiences. On the other hand, her awareness during the preparation of the lesson plan was analysed to be less than the awareness in other experiences.

4. Discussion, Conclusion, and Recommendations

In this study, instrumented action schemes related to the tool choices made by a secondary school mathematics teacher in the technological environment and mental processes including instrumented action schemes related to the use of these tools have been examined.

The study first examined the instrumental formation of the participating teacher to reveal the teacher's views on the relationship of technology and technology with mathematics in everyday life to learn the causes of mental and social processes resulting from technology-integrated learning experiences. In the preliminary interview conducted before the teaching processes, the participant mathematics teacher was observed to be willing to take advantage of the technology. The participating teacher preferred GeoGebra software as a tool in the course planning process. The tool-instrument interrelation during the teacher's lesson planning period, the GeoGebra software which was a previously known and used tool, formed an example of the purposefully used tool for a task (Verillon & Andreucci, 2006). It is thought that the user's previously formed schemes were used in the appropriate task. In the use of GeoGebra during teacher's lectures, the tools of the software had been transformed to perform certain mental based tasks and so instruments. Drijvers et al. (2013) described the transformation from tool to instrument as follows: "As long as it is not known what the letters are for, while the pen is a useless tool for writing, as you learn to write, it becomes much more than a drawing tool and becomes a special tool for writing. With developing skills, it becomes an instrument for writing." Otherwise, the tool in the environment remains an aimless object. The most important part of the instrumental genesis is the mental structures used in the integration of technology; because it is this structure that is in the manager position behind the process from the integration to the implementation, management and evaluation phases. It was interpreted that as the participantteacher had previously taught maths course with technology integration throughout her teaching life, some schemes about the software she used during the course, had been already formed. Usage schemes are mostly related to the effective and serial use of the tools in the environment (GeoGebra software and the tools of the software) and the application of shortcuts by the user, the user's understanding and self-shaping of the limitations and possibilities of the vehicle.

The teacher had studied intensively with traditional medhods for twelve years with an active teaching life, but had incorporated technology into her teaching, especially in the last three years of her career. As mentioned in the literature, there is no significant difference between the instrumental formation process taking place with a single student or a class full of students, therefore, it is very important for the teacher to know what kind of student community they are working with and to organize the teaching environment accordingly. (Hoyles et al. 2004) This situation indicates that the teacher usually made choices according to her technological knowledge instead of making orchestration selection according to all inputs of the teaching environment. Drijvers et al. (2013) in their work with teachers for the use of technology mentioned as a result, teachers will not be able to completely replace the paper-book that is regularly used in the classroom. These choices are usually about types of content that can get technology out of the environment when there is a shortage of technological reasons. The participating teacher did not have any problems during the period in which the technology was in the classroom environment. For this reason, the teacher preferred the type of screen-explain orchestration. It was observed that the teacher preferred orchestration types where technology is more central considering the types of orchestrations she prefered during the process. It is specified that the most important element to help learners develop instrumental action schemes is the ability of teachers to create meaningful mathematical discussion environments in the classroom and to support students to participate in these discussions (Rivera, 2007). In the present study, in the technology-integrated teaching of a mathematical concept, the screen-explain orchestration types was used by the participant teacher who justified her teaching to help the students fully understand the subject and make the right sense of their mental representations.

In the plan prepared by the teacher, it was concluded that the type of orchestration she selected and applied in the course teachings was intense. Screen-discuss, the correct usage times of student-on-work types had increased. As conclusion of the findings the participating teacher would prefer work-and-walk orchestration type if her students had tools such as computers and tablets. This indicates that the teacher attributed the disruptions in technology integration to external reasons.

Concerning the teacher's awareness of her own instrumental formation; it can be concluded that there was a parallelism between the awareness of the teacher in the teaching experience and the realization of the instrumental genesis process. In other words, it can be said that instrumental genesis deepens with increasing awareness, and awareness increases with existing instrumental genesis.

When the literature is examined, studies related to the field of instrumental genesis and orchestration are limited. One of these studies, Özdemir-Erdoğan, Dur and Özkale conducted a study on technology-supported mathematics teaching environments from the perspective of instrumental orchestration. According to the findings obtained in their study, instrumental orchestration does not contain much diversity for teachers. Teachers could not go beyond using one or two types of orchestration that they adopted instead of the orchestral variety. In the present study it has also been concluded that more technical notation and screen description orchestrations were observed. As a result of our study, more than two types of orchestration were observed. Denizli (2018) conducted a study on the use of dynamic geometry software in the teaching of transformation geometry from the point of view of instrumental theory. As a result of the study, it was observed that there was a positive increase in the technical and conceptual dimension of instrumental genesis in parallel with the increase in the teacher's technology-integrated course experience. Also the teacher's experience in aspects outweigh the traditional teacher-centered widely used orchestrations; student-centered, some orchestration rarely used, some were never used. In the other dimension of the research, while the teacher's awareness about her orchestration was examined, some schemes were formed consciously, and for some, awareness was gained by watching her lesson’s video recordings. In particular, the use of lesson video recordings to raise awareness of the teacher and the increase in awareness have shown parallelismes with our study and the study conducted by Denizli (2018). At the same time, in the study of Manoucherhri (1999), it was revealed that teachers do not have enough mastery of technology as a reason why they do not want to integrate technology into their lessons. In parallel with this result, it can be considered that the reason why some technological tools and software that are observed to be preferred were not preferred was that the participant teacher did not master these tools and software. Other points that affected the teacher’s choice of tools were technological facilities, classroom availability and students' technological knowledge.

In future studies, activities using different software on different mathematical topics may be included to reveal instrumental genesis process by converting tools into instruments. The limitation of the study was that the study was conducted with a single teacher. Studies including more participants would contribute to clarify the use of tools in the teaching and the effects of this use to the learnings.

Undergraduate students' Van Hiele geometric thinking test levels were concentrated on levels 1 and 2. In the study conducted by Akay and Kurtuluş (2017) with prospective teachers, participants' Van Hiele geometric thinking test levels were concentrated on at the 1st level. Similarly, in the study conducted by Özsoy et al. (2004) with high school students, participants' geometric thinking levels remained at the 2nd and 3rd levels. On the other hand, while no participants were found at level 0 in Özsoy et al.'s study, 21.6% of the participants in this study and 10.9% of the participants in Akay and Kurtuluş's (2017) study were found to be at level 0. Similarly, Duatepe-Paksu's (2013) study revealed that prospective primary school teachers have low geometric thinking levels. Duatepe Paksu's (2013) study showed that the prospective teachers' readiness for geometry is insufficient.

Undergraduate students are expected to demonstrate the level 3 thinking characteristics of Van Hiele geometric thinking levels to succeed in geometry and calculus courses due to their age and readiness and to comprehend geometric proof (Teppo, 1991). In addition, although Van De Walle (2016) emphasized that the students who acquired the level 3 thinking characteristics were to obtain axiomatic systems, the product of thinking, by reasoning, this study showed that the percentage of students at the 3rd level and above was relatively low (14.5%). This study revealed that while undergraduate students should be at level 3 and above regarding Van Hiele's geometric thinking levels in terms of readiness and education, most students had low geometric thinking levels. Although this finding is inconsistent, it has shown that it is compatible with the findings of many studies in the literature (Akay & Kurtuluş, 2017; Duatepe-Paksu, 2013; Oral & İlhan, 2012). For example, Oral and Ilhan's (2012) research revealed that most prospective elementary/secondary mathematics teachers could not reach the desired level of geometric thinking as in this study. On the other hand, some studies in the literature have shown that especially prospective mathematics teachers and prospective primary school teachers are at the expected level in terms of Van Hiele thinking levels, that is, at least 3rd level and above (Gür & Kobak-Demir, 2017; Osmanoğlu, 2019). Only 14.5% of the students could participate in the formal deduction level or the most advanced stage (rigor) in this study. In this respect, the findings in this study are not consistent with the findings obtained in other studies (Gür & Kobak-Demir, 2017; Osmanoğlu, 2019). Considering the content of undergraduate-level mathematics courses, having low levels in terms of formal deduction in these courses may be associated with their low performances regarding their inadequacy in Van Hiele geometric thinking levels. Osmanoğlu (2019) listed reasons why prospective teachers are not at the desired level regarding geometric thinking levels, such as having incomplete knowledge about the properties of geometric shapes, making faulty associations about geometric shapes, not being able to reach generalizations, not being able to reason about geometric proofs, and not being able to make logical inferences.

The findings of this study showed that university students most preferred learning styles were converger (47.3%), assimilator (23.6%), divergent (14.6%), and accommodator (14.2%). The learning styles preferred by undergraduate students in this study are consistent with the findings of many studies in the literature. For example, Pektaş and Bilgici's (2019) research revealed that prospective mathematics teachers mostly preferred the assimilator learning style. Çelik and Gündüz's (2016) study also revealed that prospective elementary mathematics teachers mostly use assimilator learning styles. Similarly, Altun and Yılmaz's (2016) research showed that prospective elementary mathematics teachers most frequently used assimilator, divergent, converger, and accommodator learning styles. Altun and Yılmaz (2019) revealed that mathematics teachers preferred converger and assimilator learning styles. Peker's (2005) research showed that prospective elementary mathematics teachers mostly had assimilator, converger, divergent, and accommodator styles. The reason why undergraduate students generally prefer the assimilator and converger learning styles can be related to their high school graduation from the field of numeracy. Abstract conceptualization and systematization are at the forefront for students who prefer the assimilator and converger learning styles. For this reason, students studying in departments related to STEM in our country prefer to learn with abstraction and conceptualization rather than concrete experience and active learning (Altun & Yılmaz, 2016).

These studies showed a statistically significant difference between the mean scores of university students' VHGTT performances according to their learning styles. This finding is compatible with the findings of many studies in the literature (Altun & Yılmaz, 2016, Peker, 2005; 2009). For example, Altun and Yılmaz's (2016) research revealed a relationship between prospective elementary mathematics teachers' achievement levels in derivatives and their learning styles. On the other hand, some studies in the literature show that students' mathematical performances, proof schemes, and attitudes do not differ according to learning styles (Çelik & Gündüz, 2016; Peker & Dede, 2005; Pektaş & Bilgici, 2019). In this respect, this finding of the study is not consistent with the findings of the studies mentioned above.

Regarding their VHGTT performances, there is a statistically significant difference between the mean scores of university students in this study, especially in favoring students with the assimilator and converger learning styles. While the students with the highest average in VHGTT have a converger learning style, those with a divergent learning style have the lowest VHGTT performances. This finding can be explained by the nature of students' learning styles. In particular, the fact that converger learners have the highest mean score can be associated with their advanced use of deductive reasoning, logical analysis, problem-solving, and decision-making skills during learning (Guven, 2004). Similarly, learners with converger and assimilator learning styles are expected to be at the level of inference/formal deduction since they focus heavily on abstract conceptualization. On the other hand, learning styles based on practice and discovery are preferred rather than deductive reasoning since concrete experience is at the forefront of learning in the divergent and accommodator learning styles (Ekici, 2016; Güven, 2004). The statistically higher performance of participants with converger and assimilator learning styles can be associated with mathematics teachers in our country generally teaching following converger and assimilator learning styles (Peker, Mirasyedioğlu, & Yalın, 2003). Similarly, Peker's (2005; 2009) studies have shown that participants who are converger and assimilator learners have higher mathematics achievement and significantly lower mathematics anxiety than participants who use other learning styles. In Altun and Yılmaz's (2016) study, prospective mathematics teachers' derivative achievement test scores with a converger learning style are higher than students with divergent and assimilator learning styles. Pektaş and Bilgici (2019) revealed that prospective mathematics teachers who use the analytical proof scheme mostly prefer the assimilator and converger learning styles. In addition, this study also showed that undergraduate students with assimilator and converger learning styles outperformed students using other learning styles regarding geometric proof and reasoning about Van Hiele geometric test. This situation may enable us to conclude that students who prefer assimilator and converger learning styles are more likely to use mathematical proof and reasoning skills.

Another finding of this study is that there was no statistically significant relationship between undergraduate students' learning styles and their Van Hiele geometric thinking levels. Özsoy et al. (2004) did not find a statistically significant relationship between learning styles and Van Hiele's geometric thinking levels in their study with high school students. In this respect, this finding supports the study of Özsoy et al. (2004). Since the research findings reveal that the performances in the Van Hiele geometric thinking test are low, especially for divergent and accommodator learners, it may be beneficial to design suitable learning environments for students with these learning styles. Since concrete experience and reflective observation or active experience are at the forefront of the divergent and accommodator learning styles, these students prefer to do research and learn by doing and living (Altun & Yılmaz, 2016; Ekici, 2013). Therefore, it may be appropriate to design concrete experience-based learning environments to improve the reasoning of proof skills in mathematics and geometry, especially for students who prefer divergent and accommodator learning styles. Similarly, it may be beneficial to design learning environments for proving and proof methods starting from middle school, especially in geometry, to ensure students' readiness for mathematics courses at the undergraduate level. In further studies, students' Van Hiele geometric thinking levels in geometry learning environments, designed for various learning styles, can be examined in depth with studies that use qualitative and quantitative patterns together.

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