IJERE International Journal of Educational Research Review

International Journal of Educational Research Review

Do Mathematics Teachers' Preferences on Teaching Methods and Materials Change in Online Education? Case of Probability

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Article History:
Received 18.01.2023
Received in revised form 23.06.2023
Accepted
Available online 01.07.2023

This study examines changes in the methods and materials used by middle school mathematics teachers in teaching probability content during the transition from face-to-face to online education and difficulties in terms of teaching methods and materials used in this process. 35 middle school mathematics teachers' lesson plans for both face-to-face and online classrooms were analyzed according to their content, and the reason for the changes in teaching practices of the teachers was evaluated through interviews. Findings of the study revealed that the use of lecture-based and demo & practice methods increased with the transition from face-to-face to online education in probability teaching. It has been also determined that the situations that limit the use of different teaching methods are the low motivation of the students and the difficulties of the teachers in the classroom management process. In addition, the use of concrete manipulatives has been replaced by videos and other digital teaching tools with the transition from face-to-face to online education in probability teaching. Other reflections of compulsory transitions to online education on teaching practice were discussed in terms of teaching the subject of probability and within the framework of in-service teachers' training.

Keywords: Mathematics teacher, online education, probability, teaching methods, teaching materials

INTRODUCTION

Probability, which is one of the main concepts and study areas of mathematics, is used in the decision-making process by mathematizing uncertain situations in real life (Batanero et al., 2016; Brijlall, 2014; Gürbüz, 2010; Sharma, 2006). Probability is also a learning area which students encounter in their mathematics courses at the K-12 level in different countries. It is important for the conceptual understanding of probability that students study models, compare objects and consider different sequences of probability related to experiments, observation, outcomes, and cases and their possible outcomes. It is frequently stated in the relevant literature that students encounter various difficulties in the statistical thinking, intuition and reasoning processes (Makar & Rubin, 2018; Sriraman & Chernoff, 2018). With the emergence of the Covid 19 pandemic, the teaching of probability, like all other mathematics subjects, has been carried out in hybrid or fully online environments in many countries. Teaching mathematics subjects and concepts which have an abstract nature in online education creates new experiences for both the teacher and the student. In particular, the middle-school period requires the transition from concrete to abstract for mathematical learning so students in a physically more limited communication environment might not grasp mathematical concepts efficiently. It is important to determine how teachers manage the online education process, especially in mathematics subjects which require more material or object use such as probability. This is because, in the teaching of probability, the use of various materials and objects such as coins, a wheel divided into equal parts and balls of different colors provides effective teaching. For example, experiments can be done by using various materials and objects (dice, wheel and so on) in teaching the acquisitions related to determining the possible situations of an event or showing that the probability value is between 0 and 1 (including 0 and 1). So for permanent learning, students are given the opportunity to experiment, see the results and discuss the process.

Research conducted into this will both reveal the experiences of teachers in the new environment and reflect the technological pedagogical competencies needed in online education environments. Because of the reflections of current teaching practices, mathematics teachers can better understand their role in online classrooms (Baran, Correia & Thompson, 2011; Sevimli, 2023). In addition, information about the online teaching process and the technological/pedagogical aspect of online teaching will be offered in this study and thus awareness of the possible limitations of online teaching will be shown.

The teaching of probability, which is encountered for the first time in the 8th grade level of middle school in the Turkish mathematics curriculum, was delivered online with the outbreak of the Covid-19 pandemic and

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continued online until 2021. In the current study, the motivation which this change provided for the teaching environment due to the effect of the pandemic on teaching practice, the teaching of probability was examined. The research questions addressed in the study are as follows: (1) Which teaching methods and teaching materials did mathematics teachers prefer to use during the teaching of probability online compared with face-to-face education? (2) What difficulties did mathematics teachers encounter during the teaching of probability online compared with face-to-face teaching in terms of the teaching methods? and (3) What difficulties did mathematics teachers have during the teaching of probability online compared with face-to-face education in terms of the teaching materials?

RELATED LITERATURE

In this section, online learning environments (OLEs) and their potential benefits and limitations are explained and then the relevant literature on the concept of probability is reviewed.

Online Learning Environments

Information technology has, in general, undergone a significant evolution in the last three decades, which has led to changes in education and training practices. Important innovations such as OLEs have emerged to exploit technological innovations and thus explore ways to improve educational programs (Dhakal & Sharma, 2016; Mueller & Strohmeier, 2011; Trenholm et al., 2011). OLEs refer to all categories of technology-enhanced learning systems and include each sub-category of learning systems: adaptive learning environments, blended learning systems, digital libraries, distance learning systems, e-learning services and online courses (Dhakal & Sharma, 2016; Mueller & Strohmeier, 2011). For defining OLEs, it has been emphasized that these environments share some basic features (Dillernbourg, Schneider & Synteta, 2002). According to these features, OLEs are a designed information space. This information space is a social space because educational interactions occur in the environment and space is transformed into places. As multidimensional representations of information are possible, online space is explicitly represented in online learning environments. Students, on the other hand, are not only active in these learning environments, but also play a role in the construction of the online space. OLEs also integrate heterogeneous technologies and multiple pedagogical approaches (Dhakal & Sharma, 2016).

With the widespread use of online or hybrid teaching models, OLEs have started to replace face-to-face classes. Offering more flexible and comfortable learning experiences, opening channels for synchronous and asynchronous communication and interaction, allowing for greater collaboration and interaction with peers, providing access to learning resources in various forms, and promoting authentic and embedded learning are some of the benefits of OLEs (Albrahim, 2020; Dhakal & Sharma, 2016; Fermín-González, 2019; Mueller & Strohmeier, 2011; Sevimli, 2023; Trenholm et al., 2011). Furthermore, it has been stated that OLEs have the potential to support access to classes for learners who cannot attend face-to-face classroom environments due to socio-economic, academic or health problems (Bell & Federman, 2013; Dhakal & Sharma, 2016). In addition to the advantages of OLEs over face-to-face classes, some limitations can also arise in these environments (Albrahim, 2020; Dumford & Miller, 2018; Palloff & Pratt, 2013; Trenholm et al., 2011). Palloff and Pratt (2013) said that OLEs cannot replace face-to-face instruction and that there is no single online teaching and learning format suitable for both teachers and students. There is also less collaborative learning, student/teacher interaction and effective teaching practices in OLEs compared with traditional face-to-face environments (Dumford & Miller, 2018). In addition, teachers face difficulties because of the changes and conditions involved and can feel uncomfortable dealing with technology-enriched classes and related topics (Trenholm et al., 2011). Teachers may not know how to maintain their identity and qualifications and might not be able to predict what the demographics of the students might be, how they will meet the demands of the discipline, what kind of training they will need, how they will be successful, how they will evaluate the learning outcomes and how they will cope with the feelings of stress and frustration while transitioning to OLEs. These problems and the lack of online proficiency could deter teachers from teaching online (Albrahim, 2020; Palloff & Pratt, 2013; Trenholm et al., 2011). To eliminate such disadvantages of teaching in OLEs, teachers, students and administrators should be taught about the pedagogical, administrative, technological and technical aspects of online learning (Borba, Chiari & Almeida, 2018; Palloff & Pratt, 2013).

The Potential Benefits and Limitations of OLEs

The potential benefits and limitations of OLEs can differ depending on the discipline and subject to be taught. For example, mathematics subjects require more teaching methods or techniques such as problem solving, question/answer, demonstration and inquiry-based learning (Jaworski, 2006; Van de Walle et al., 2013). For

this reason, it is important that these methods can be used in OLEs. It has also been stated that the use of multiple sources and representations is important for learning mathematics concepts (Van de Walle et al., 2013), and that OLEs offer significant advantages in this respect (Albrahim, 2020; Dhakal & Sharma, 2016; Fermín-González, 2019; Trenholm et al., 2011). The review of the relevant literature showed that many studies have been conducted on education through OLEs in the field of mathematics and in other disciplines (Borba et al., 2018; DePriter, 2013; Dhakal & Sharma, 2016; Dumford & Miller, 2018; Karal et al., 2015; Lu, 2011; Steinbronn & Merideth, 2008). In one of the studies conducted in the field of mathematics education, DePriter (2013) examined whether an object-based teaching strategy or a constructivist-based teaching strategy led to higher achievement scores for higher-education students learning mathematics online. The study used an experimental research design and the findings showed that there was no statistically significant difference in achievement scores between the groups and that both teaching strategies were applicable in the online mathematics classroom. Lu (2011) evaluated the mathematics learning experience in OLEs from a communication perspective and reported that the use of different softwares in OLEs improved communication. Karal et al. (2015) investigated the experiences of two teachers in online mathematics teaching with pen-based technology and found that the use of a digital pen in online mathematics classes was highly beneficial in terms of pedagogy and interaction and suggested that it is necessary to use a digital pen in online mathematics classes to simultaneously display the steps of the problem-solving process.

In addition to these studies, many national studies have explored teachers' experiences in teaching mathematics through OLEs and their views on these experiences (Acar & Peker, 2022; Akşan-Kılıçaslan, Tuğaç & Eryılmaz-Toksoy, 2022; Özdemir-Baki & Çelik, 2021). Akşan-Kılıçaslan, Tuğaç and Eryılmaz-Toksoy (2022) examined the platforms and digital tools which elementary mathematics teachers used in online learning environments during the pandemic and found that ZOOM was the most used platform by teachers and that Z-Book was the most preferred teaching technology. It has been shown that teachers use digital tools mostly to provide effective learning. Teachers' expectations from online platforms and digital tools, in addition to accessibility and the activeness of students, have been summarized as being easy to use, adaptable to every subject, offering various materials, attracting attention, being free, having a language option, and having high image and sound quality. Özdemir-Baki and Çelik (2021) investigated what problems elementary mathematics teachers faced with distance education for the first time during the Covid-19 pandemic and what they did in the subsequent term to resolve them. The findings showed that teachers experienced difficulties in teaching online due to instructional issues (student, teacher and mathematical), technology (applications and internet) and external factors (school administration and parents). To overcome these difficulties, it has been observed that teachers take precautions such as following and using technology, eliminating the lack of documents/materials, ensuring the active participation of students, using lesson time effectively and increasing communication methods. Acar and Peker (2022) explored the opinions of mathematics teachers who conducted their lessons with synchronous distance education applications during the period of the epidemic and found that the teachers found synchronous distance education advantageous in terms of technology use, physical factors, health and time. On the other hand, it has also been reported that synchronous distance education has disadvantages such as lessons being tiring for teachers, technological equipment and infrastructure problems, teachers' working hours being over-extended, lack of communication and interaction, indifference and incomplete learning. It has also been found that most mathematics teachers prefer the face-to-face education model to the mixed model in which face-to-face education and distance education come together. In evaluating the usefulness of OLEs for teaching mathematics, it is useful to consider this in a subject-specific manner. More concrete materials or manipulative elements are used in the teaching of some mathematics subjects, and one of these subjects is probability.

Teaching Probability

One of the most obvious reflections of mathematics in daily life is the subject of probability. Individuals can make decisions based on the results of observations in their social environment and some events which depend on chance by referring to the subject of probability (Sharma, 2015; Woolfson 2012, as cited in Sharma, 2015). In its simplest form, probability is defined as the act of predicting what will happen in the future and is a tool which helps to develop several skills such as independent thinking and probability-based thinking (Batanero et al., 2016; Brijlall, 2014; Sharma, 2006). Developing these skills is among the aims of mathematics (Batanero et al., 2016; Gürbüz, 2010). Probability is therefore an important part of the mathematics curriculum; it begins in primary school and continues at secondary and higher education levels (Abramovich & Nikitin, 2017;

Batanero et al., 2016; Cai et al., 2020). In the middle-school mathematics curriculum in Turkey, probability is one of five learning areas and is only taught in 8th grade. With probability teaching at this grade, students are expected to identify possible situations of an event and events with different probabilities, examine events with equal probability, understand that the probability value is between 0 and 1 (including 0 and 1), and calculate the probabilities of simple events (MoNE, 2018).

Studies which have focused on the difficulties experienced in learning probability have addressed these difficulties from epistemological, psychological and pedagogical dimensions (Gürbüz, 2010). From an epistemological point of view, students are stated to have difficulties since probability questions require abstract and proportional reasoning and involve complex calculations (Batanero et al., 2016; Cai et al., 2020; Garfield & Ahlgren, 1988). From a psychological point of view, it has been pointed out that it is not easy to teach the subject of probability because of the negative attitudes of students, encountering the subject of probability at an early age and establishing incorrect connections between daily experimental knowledge and scientific knowledge (Fischbein & Schnarch, 1997; Hawkins & Kapadia, 1984). In addition, pedagogical reasons such as teacher-centered classroom environments, deficiencies in teachers' pedagogical content knowledge, the limited use of teaching materials or the abstractness of the materials used can cause students to have misconceptions about probability or learning difficulties (Garfield & Ahlgren, 1988; Hawkins & Kapadia, 1984). Today, as a result of the development and spread of technology, technology has been integrated into educational approaches and methods, and studies of the teaching of probability have been conducted in this direction (Abramovich & Nikitin, 2017; Cai et al., 2020; Koparan, 2021). In one of these studies, Abramovich and Nikitin (2017) shared teaching ideas about using widely available computer applications (Spreadsheet, the Geometer's Sketchpad and Wolfram Alpha) to teach probability theory topics. The proposed use of computing is intended to achieve at least two goals: making complex mathematical ideas more accessible and emphasizing the importance of empirical evidence as a tool for conceptual development in mathematics for all student populations. Cai et al. (2020) investigated the effect of probability learning in mathematics on the learning outcomes and attitudes of middle-school students using augmented reality-based learning applications. Three augmented reality apps (such as a coin flip app) were designed to help students to understand and learn abstract concepts in probability and statistics. Experimental results showed that these augmented reality-based learning applications can help students to achieve higher learning outcomes while learning mathematics. In addition, since the learning process became fun for the students, the attitudes of the students towards the applications were positive.

Koparan (2021) examined the effects of game and simulation-based learning environments on the conceptual knowledge and attitudes of pre-service teachers about probability. The findings showed that the concept test scores of the pre-service teachers in these environments differed statistically and significantly compared with the traditional environment. In line with these results, it was suggested that teachers and pre-service teachers should adopt and use games and simulations as part of their methods for teaching probability. The studies in the related literature have generally focused on the learning outcomes of students regarding probability after an experimental intervention, but no studies have yet investigated the methods and instructional technologies used by teachers in teaching probability concepts. It is therefore important to explore the preferred methods and teaching resources in OLEs, especially in online education, in order to determine the professional development needs of teachers. Owing to the reflections on the current teaching practices, mathematics teachers can better understand their role in online classrooms (Baran et al., 2013; Borba et al., 2018).

METHOD

Research Design

In the current study, a comparative case study design, one of the qualitative research methods, was used to determine and interpret the teaching practices of mathematics teachers in probability content in different learning environments. In comparative case studies, the reflection of a phenomenon in different environments is examined using multiple methods, interpretations are made as a result of complex reasoning and researchers seek to explain in an holistic manner the reality in the environments where the case occurs (Creswell, 2014; Yin, 2012). The case in this study was teaching practice and it was investigated in terms of teaching materials and teaching methods. The phenomenon which makes the case comparative was teachers' practices in face-to-face and in online education.

Participants

The participants in the study were 35 mathematics teachers working in a city in the Central Black Sea Region of Turkey. The participants were recruited by the criterion sampling method, which is one of the purposive sampling methods (Cohen et al., 2007). One of these criteria was that the participants gave lectures on specified dates. The same 35 middle-school mathematics teachers who taught probability to 8th graders face-to-face in the spring semester of 2018-2019 academic term and online in the spring semester of 2019-2020 academic term were selected as participants. At the beginning of the study, a higher number of teachers (68 teachers) volunteered to participate but some of them were excluded from the study because they had not taught at the same level (8th grade) in both online and face-to-face learning environments. In this sense, the selection of participants was completed after their teaching processes had been checked and was restricted to teachers who fulfilled the defined criteria. The reason for choosing the 8th grade as a level was that the subject of probability is covered only at this level in the middle-school mathematics curriculum in Turkey. Eight of the teachers participating in the study were in cooperation with the university where the researchers worked within the scope of the teacher training protocol, and the other participants were reached through professional mathematics development societies. Thirteen of the participants were male and 22 were female and their period of service varied between six and nineteen years.

The students who are introduced to the subject of probability for the first time in the 8th grade are in the final year of secondary-school education, which lasts for four years in the Turkish education system. At the end of this grade level, students take national exams and are placed in high schools according to their success in these exams. In the Turkish education system, textbooks are available free to students during all compulsory education. In addition, EBA, Turkey's official education portal, provides free service to both students and teachers in the online education process with its various features and thousands of contents.

Data Collection and Analysis

For collecting appropriate data for this study, the document analysis and interview techniques were used. To understand the teaching practices of mathematics teachers in the two different teaching environments, daily lesson plans were first subjected to document analysis, specifically the lesson plans prepared by each participant for the teaching of probability in the spring semester of 2018-2019 and the 2019-2020 academic terms. Four lesson plans were used by each participant for each academic term, so a total of 280 lesson plans were evaluated ([number of academic terms] x [number of participants] x [number of lesson plans for each participant] = 2x35x4=280). In case the pre-prepared lesson plans might not reflect the current teaching process, the participants were asked to create lesson plans summarizing their teaching and the same template lesson plans were sent to the same participants in both semesters. The teachers were requested to summarize which teaching methods they used in the template lesson plan, and which materials were used and how they were used. After the lesson plans had been collected, in order to obtain the opinions of the participants about the teaching processes, semi-structured online interviews were conducted with the participants to determine their experiences and difficulties in the teaching process. The following two questions were included in the interview form used during the interviews: (1) During the transition from face-to-face classes to OLEs, did you experience any difficulties in terms of the teaching methods you used while carrying out the lesson plans? (2) During the transition from face-to-face classes to OLEs, did you have any difficulties in terms of the teaching materials you used while carrying out the lesson plans? To give the participants the opportunity to respond to these two questions in more detail citing their reasons, sub-questions were also directed to the participants during the interviews.

The data obtained from the lesson plans prepared by the teachers were evaluated using the content analysis method. Content analysis is a technique that allows researchers to indirectly examine human behavior by analysing individuals' communications (Fraenkel, Wallen & Hyun, 2011). This analysis technique is a systematic and replicable method in which categories and themes suitable for the aim of the study are developed to reach the concepts and relationships which can explain the collected data. Using conceptual analysis among the types of content analysis, the frequency of the most frequently represented category types in lesson plans and interviews was evaluated. Since the concept of probability is suitable for use with different teaching methods and teaching materials, the lesson plans developed by the teachers in this study were examined under the themes of method and material.

Table 1. Lesson Plan Content Classification Framework

Theme 1: Teaching Method		**Theme 2: Teaching Material**	
Category	***Content***	***Category***	***Content***
Lecture-based	Explaining and teaching the subject to the students in an order based on a plan	*Written materials*	Textbook, supplementary resources or other printed visual materials
Demonstration and Practice	Showing the student how to do a job and then asking them to do the same job	*Concrete manipulatives*	Physical objects and models such as dice, money, wheel, ball, playing cards
Case Study	Examining and discussing a real-life or fictional event with students in a classroom setting to support learning	*Digital tools*	Web 2.0 tools, mobile applications, digital learning objects
Role-playing	Playing/animating or dramatizing particular situations and events for various teaching and learning purposes	*Video*	An educational video or audio content from EBA (Turkey's official education portal) or other web resources
Project-based	This is a method in which students gain knowledge and skills by engaging in complex problem situations for an extended time to find a solution	*Software*	Software or electronic resources used to model, analyse or calculate different datasets

There are various classifications used by different researchers in terms of both teaching methods and teaching materials (Gözütok, 2020; Savaş, 2007; Yanpar-Yelken, 2015). In the present study, the teaching methods and materials used in mathematics teaching were taken into account, so the classification was made based on the more frequently encountered categories identified in the document review, together with the studies in the related literature. The contents considered in the classification process and the categories and themes created by these contents are presented in Table 1. In this table, under the theme of 'teaching method', the categories of lecture, demonstration and practice, case study, role-playing, and project-based were determined. For the theme of 'teaching material', a classification was made according to the categories of written materials, concrete manipulatives, digital tools, video and software. In teaching the subject of probability, since more than one lesson plan of each participant in each instructional environment was analysed and more than one teaching method and/or material was referred to in each lesson plan, the contents were primarily evaluated according to their frequencies. Then the percentage equivalents of these frequencies were determined for OLEs and face-to-face classes. The interview recordings were transcribed and then the transcripts were returned to the participants for them to verify their responses before conducting the content analysis. After the approval of the participants had been obtained, the conceptual analysis was carried out. In this process, teaching methods and materials were listed descriptively under the categories of the current potential and limitations of the OLEs, and direct quotations from significant participant opinions were given.

Validity and Reliability

This research study was based on the qualitative research approach; credibility was taken into account to ensure validity, and confirmability was considered to ensure reliability. To increase the quality of the findings by ensuring credibility and confirmability, several frequently used strategies such as "long-term participation and continuous observation, depth-oriented data collection, triangulation, rich and dense description, consensus among coders" are recommended (Creswell, 2014). To ensure the credibility of this study, data were collected using two data collection tools (lesson plan and interview). The purpose was to acquire data from

multiple sources for the same research question, taking into account both document analysis and participants' views. The researchers, who conducted the teaching practice course given in teacher training programs in Turkey before and after the pandemic, therefore had the opportunity to observe the same teachers in both face-to-face and online education. Observation notes were made to confirm whether the methods and materials that the participants stated in the lesson plan and the materials which they used in their classroom practice were compatible; these notes confirmed the accuracy of the data in the lesson plan. The credibility of the study was ensured by describing the data collection and analysis process in detail and presenting the findings of the study using direct examples. To validate categorization, the classification framework created by making use of the relevant literature was used, and some lesson plans were coded independently by two evaluators to increase reliability in the coding process. The compliance rates of fourteen randomly selected lesson plans which were re-coded using the lesson plan content classification framework with the coding of the researchers were 87% and 90% respectively.

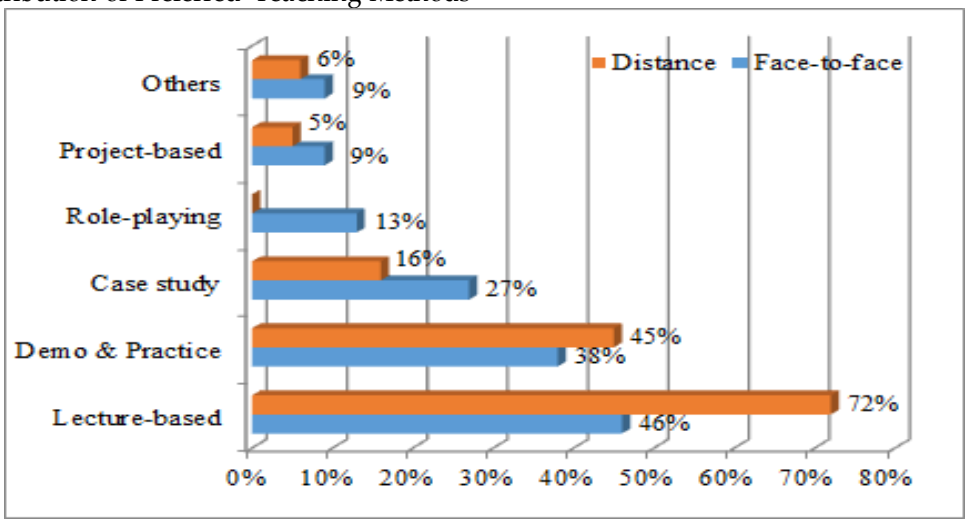
FINDINGS

The findings of the study are presented under the headings of methods and materials used in the teaching process, which are the themes of the research, and the relevant interview findings are also given under these headings. Thus, both the preferences of the participants in their teaching practices and their difficulties while carrying out the lesson plan were evaluated together.

Preferred Teaching Methods in Learning Environments

The teaching methods used by the teachers during the teaching of probability in face-to-face and OLEs were determined and the findings are presented in Figure 1. Since more than one type of teaching method is referred to in each lesson plan, the total percentage of preference for all methods can exceed 100%. Lecture-based teaching and demonstration were found to be the most frequently used teaching methods in face-to-face education. In addition, both methods were preferred by at least one-third of the teachers; 27% of the teachers discussed everyday life problems involving probability in face-to-face classes with a case study. It was observed that the role-playing and project-based learning methods were relatively less preferred in face-to-face classes. It was found that lecture-based teaching was used predominantly (72%) in OLEs, followed by the demonstration method (45%).

Figure 1. Distribution of Preferred Teaching Methods



Case studies and project-based teaching methods were preferred to a limited extent in distance education. When the teaching methods used were compared according to the teaching environment, it was observed that the two most frequently used methods in both face-to-face and online education were lecture-based teaching and demonstration, both of which methods were used more frequently in OLEs. With the transition from face-to-face classes to OLEs, the tendency toward lecture-based teaching had increased whereas the frequency of the use of case studies, role-playing and project-based teaching methods had decreased significantly. Methods such as scenario or game-based learning in the 'Others' category were included in face-to-face teaching at a rate of 9% and in online education at a rate of 6%. Interviews were used to determine the factors affecting the teaching method preferences of the participants. Table 2 summarizes the difficulties which emerged in terms of the methods used in teaching probability with the transition from face-to-face to OLEs. The teachers cited low motivation in terms of participating in collaborative learning (30 teachers) and difficulty in classroom

management in student-centered education (16 teachers) as reasons for not being able to use alternative teaching methods in their OLEs. For example, P3 pointed out that the case study and role-playing methods used in teaching the subject of probability in face-to-face classes require student performance and stated that it is difficult to effectively manage this performance in front of the screen in OLEs.

Table 2. Participants' Views on the Difficulty of Using Teaching Methods in Online Education

Frequently Cited Difficulties	*Participants*	*Quotation*
Low motivation	All participants except P14, P19, P28, P30 and P33	'Case study method coordination and student participation motivations are unfortunately not the same in online classes, so I proceed with the question-answer technique and use more direct teaching strategies.' (P8)
Difficulty in classroom management	P1, P2, P3, P6, P9, P11, P13, P14, P15, P22, P23, P26, P27, P28, P33, P34.	'In online education, the opportunity for students to work with a group and compare their solutions is very limited because it is very difficult to manage this in the online classroom.' (P3)
Exam-oriented study	P4, P5, P8, P11, P12, P16, P19, P25, P30, P33, P34	'Since students at this level compete with their peers in the high-school entrance exam, the methods and contents that will prepare them for the exam come to the fore. In order to fill the gap in distance education by solving as many questions as possible, I proceed a little more teacher-centered.' (P25)

In terms of the disadvantages of OLEs and teaching methods, eleven participants drew attention to the fact that paying more attention to drill-kill problems to eliminate the deficiencies while studying for national exams limits the use of contemporary teaching methods. It has been stated that teachers use the question/answer technique more in order to eliminate the deficiencies in learning subjects in online education, which leads to lecture-based teaching. P25 had revised her teaching method preference from project-based to lecture-based teaching with the transition from face-to-face to online education and attributed the reason for this change to classroom micro-culture. P25 stated that the assessment-evaluation process cannot be carried out effectively in OLEs, so she had used the question/answer technique more to achieve an average level in probability learning outcomes. Six of the participants stated that they used the demonstration and practice method more frequently to turn the disadvantage of OLEs into an advantage in terms of interaction. The advantage of OLEs is that many participants can experience digital tools on their personal computers at the same time.

Preferred Teaching Materials in Learning Environments

The materials used by the participants in teaching the subject of probability in face-to-face classes and OLEs were determined from the analysis of the lesson plans and the findings are presented in Figure 2. Since more than one type of teaching material is mentioned in each lesson plan, the total percentage of preference for all methods can exceed 100%. It was found that concrete and written materials were used more frequently in face-to-face classes. In the lesson plans in face-to-face classes, money or dice were used as concrete materials to show the probability of a simple event, marbles or colored balls were used for the possible situations of an event, and a spinning wheel was used for the calculation of the probability value. It was found that software and video-supported content were less preferred in face-to-face classes.

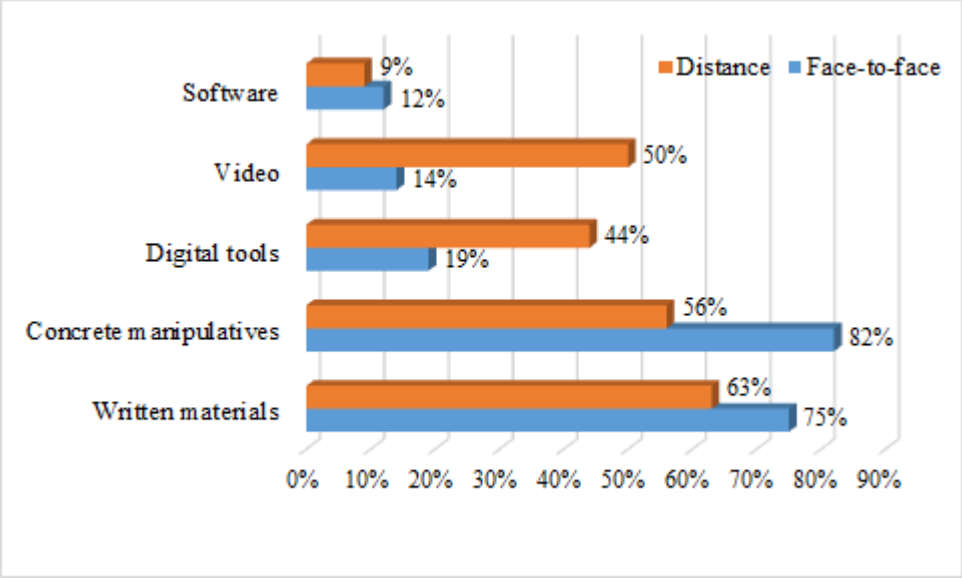


Figure 2. Distribution of Preferred Teaching Materials

Although the frequency of use was different, written and concrete materials were frequently used in OLEs, similar to face-to-face classes. Unlike face-to-face classes, it was found that video and digital tools were more frequently included in the lesson plans for OLEs. When the two teaching environments are compared in terms of the resources used, the most striking change was seen in concrete manipulatives and video resources. With the transition from face-to-face classes to OLEs, the use of concrete materials decreased by 25% whereas the use of video increased significantly (by 36%). It was observed that the use of digital tools in OLEs increased by 25% compared with face-to-face classes. Examples of the materials presented in Figure 3 are cited from the lesson plan of P18.

Figure 3. P18's Instructional Video and Digital Tool Examples in the Lesson Plan

EBA Video Example *Digital Tools Example*

In the online classroom, the participant used the instructional videos on Turkey's official education portal (EBA) and a digital tool (https://wordwall.net/tr/resource/8386579/olas%C4%B1l%C4%B1k). When the preferences for using instructional materials were evaluated holistically, more instructional materials were used in lesson plans in OLEs. In this sense, it was observed that averages of two different teaching materials were used in each lesson plan in face-to-face classes and approximately three different teaching materials in OLEs.

Semi-structured interviews were conducted to determine the possible difficulties of the participants in terms of using teaching materials during the transition from face-to-face to OLEs, and the significant findings are presented in Table 3. Nearly half of the participants (17 participants) stated that they needed professional development courses which would improve their technological-pedagogical content knowledge. For example, P12 replaced the concrete manipulatives with videos and e-books in lesson plans in online classrooms. However, he stated that he did not have enough knowledge about how these contents can overcome the technical (for example, finding programs compatible with mobile devices) and pedagogical (for example, the evaluation of teaching activities) difficulties that arise in the simultaneous execution of these contents. Thirteen of the participants, who accessed different digital resources through individual effort, stated that these

resources were not completely compatible with the program objectives and student levels. For example, P30 stated that an online teaching platform or other digital resources with ready-to-use activity examples and lesson plans are necessary, and this is also important for synchronization between teachers. Although there was a consensus on the view that the use of digital tools is an advantage for students to perform simultaneous activities in OLEs, ten participants stated that they needed digital tools in the Turkish language.

Table 3. Participants' Views on the Difficulty of Using Teaching Materials in Online Education

Frequently Cited Difficulties	***Participants***	***Quotation***
Low TPACK	P1, P4, P5, P7, P9, P10, P11, P12, P14, P17, P23, P26, P27, P29, P30 P33, P34	'Concrete materials are difficult to use with students in online classes. While I frequently use written resources such as tests and supplementary books in face-to-face classes, I used electronic versions of the same textbooks in online classes. I have resorted to instructional videos to improve the proportional reasoning of the students and to help them visualize probability.' (P12)
Limited digital tools	P2, P6, P11, P13, P19, P20, P21, P25, P28, P30, P31, P32, P35	'There are many websites for teaching probability, but these digital resources contain general practice. The preparation of digital content compatible with program objectives will facilitate teachers' access to the right content. I used materials such as dice and money, which I used in face-to-face classes, with students in online classes.' (P30)
Language problem	P3, P8, P10, P14, P15, P16, P18, P22, P24, P32	'With the transition to online education, I searched for digital tools that I can use in OLEs. There are many resources, but they are in English. Explaining these contents to students in Turkish requires serious preparation. However, students loved some of the digital tools I used.' (P18)

CONCLUSION and DISCUSSION

The purpose of this study was to understand the teaching practices of mathematics teachers in teaching probability in the different learning environments and to determine what difficulties they experienced in terms of teaching methods and materials used in this process. The findings showed that the most frequently used methods in both face-to-face and OLEs were lecture-based teaching and demonstration and practice. The findings regarding the teaching methods showed that the diversity in teaching method preferences decreased with the transition to OLEs, and lecture-based teaching and demonstration and practice methods were used more frequently in OLEs. The reason for this change in teaching practice could be related to the decrease in the preference for some methods in which students are more active (such as role-playing and case study) in OLEs. Also, because of the nature of the online education process, there may be differences in the teaching practices of the instructors (Albrahim, 2020).

It was found that the tendency towards teacher-centered lecture-based teaching increased as a result of the decrease in the preference for teaching methods in which group work is carried out, projects are prepared and discussions on case studies are carried out. Findings supporting this inference were also obtained from the interviews. The teachers stated that students had low motivation in terms of participating in activities, and thus they preferred to use methods in which the students were more active, citing the difficulties in the management of group work in OLEs. It is clear that it will be difficult to realize the potential of effective social communication and alternative teaching methods in face-to-face classes with the same potential in online education. However, this does not justify the use of completely teacher-centered teaching methods in OLEs because it is in the hands of teachers to increase communication and interaction in OLEs. As a matter of fact, Vlachopoulos and Makri (2019) reviewed the literature in the field to highlight strategies for improving communication and interaction in OLEs and concluded that teacher/student interaction, peer interaction and

student/content interaction can be achieved with the use of educational communication media such as conferencing tools, e-mail, discussion forums, social networks, web conferences and online meetings. In addition, using different software in OLEs, establishing chat rooms for group work and organizing forums for discussion can be a way to increase communication (Lu, 2011). In the current study, it was observed that some teachers took innovative steps to increase students' participation in activities, especially with the demonstration and practice method, by using digital tools. It is thought that similar initiatives could be undertaken for use in other teaching methods, such as the effective use of web resources for project-based learning.

When the results of the study are evaluated in terms of teaching materials, it was determined that the physical materials such as textbooks and concrete manipulatives used in face-to-face education were used less in online education and that digital teaching tools and auxiliary videos were used instead. The dynamics in environments where the courses are offered completely or partially online are different from the face-to-face classroom environment (Barrett, 2010). OLEs provide more flexible and comfortable learning experiences, they open channels for synchronous and asynchronous communication and interaction, allow for greater collaboration and interaction with peers, provide access to learning resources in various forms, encourage authentic and embedded learning, and welcome and support access to classes. It is expected that the teaching methods and materials used in OLEs (Albrahim, 2020; Bell & Federman, 2013; Trenholm et al., 2011) will differ compared with face-to-face classes. However, although there were differences in their rates, it was observed that the participants preferred and predominantly used similar methods and materials in both teaching environments. The lack of expected differentiation in the methods and materials used can be explained by the fact that teachers' technological content knowledge and online technology practices are limited. In the interview findings, about half of the teachers referred to the TPACK framework to explain their deficiencies in OLEs. In this sense, there has been an important demand for digital resources compatible with program objectives to reach teachers within the context of in-service training. Teachers have volunteered to participate in innovations which can make them more interactive in OLEs and increase student motivation. Teachers must have technological and pedagogical competencies in order to provide effective teaching in OLEs (Albrahim, 2020; Fermín-González, 2019; Palloff & Pratt, 2013; Sevimli, 2023; Vlachopoulos & Makri, 2019).

An important finding is that the participants who realized their shortcomings about which digital resources will be more useful for probability teaching and how these resources can be used more effectively in classroom practice wanted to attend professional development courses. Teachers' demand for in-service training on online education processes, for which they were caught unprepared by the suddenness of the Covid-19 pandemic, might increase the variety of teaching methods and materials to be used in OLEs. In a similar study, Sevimli (2020) reported that teachers who participated in in-service training on the use of online technology in teaching statistics concepts were able to integrate technology into their lesson plans effectively. It is therefore thought that learning about a number of Web 2.0 tools specific to mathematics learning areas will help them to integrate digital technologies into their lessons effectively. The finding that software was used less in teaching probability in both face-to-face and OLEs could be related to the fact that these resources require individual installation for each computer and are not sufficient to provide synchronization in OLEs. On the other hand, as web-supported and flexible counterparts of the software are already available in the Web 2.0 tools in OLEs, the participants might not have preferred the Web 1.0 tools.

The findings showed that although the teachers used more diverse teaching methods in face-to-face education, multiple sources were preferred more frequently by the teachers in online education. In terms of teaching methods, the lecture-based and demonstration and practice methods were preferred more frequently with the transition from face-to-face education to online education, whilst the use of case study and role-playing methods decreased. The data obtained from the interviews showed that the factors limiting the variety of teaching methods in online classrooms were low student motivation and classroom management difficulties in the collaborative learning process. As far as the teaching materials are concerned, videos and other digital teaching tools in OLEs have replaced the concrete manipulatives that are frequently used in face-to-face classes. The results also showed that as a result of individual efforts, teachers learn about digital content compatible with OLEs; however, these contents often do not match with program objectives.

The sudden and compulsory transformation from face-to-face education to online education may have required teachers to develop individual didactic approaches. However, given that online education and online teaching approaches will continue to be parts of the education system in the future, it is recommended that

teachers have access to professional development courses which will increase their pedagogical and technological competencies in this new teaching environment. It is believed that in this way, teachers will increase their knowledge in choosing updated and compatible digital content. On the other hand, the teachers who participated in the study claimed that the existing digital resources on the subject of probability at the middle-school level were insufficient in terms of compatibility with the program. This claim can be verified through further research, and instructional design studies could be carried out to develop online teaching platforms which can be compatible with international curriculums.

Declarations

Conflict of Interest

No potential conflicts of interest were disclosed by the author(s) with respect to the research, authorship, or publication of this article.

Ethics Approval

The formal ethics approval was granted by the Social and Human Sciences Research and Publication Ethics Committee of Tokat Gaziosmanpasa University. We conducted the study in accordance with the Helsinki Declaration in 1975.

Funding

No specific grant was given to this research by funding organizations in the public, commercial, or not-for-profit sectors.

Research and Publication Ethics Statement

The study was approved by the research team's university ethics committee of the Tokat Gaziosmanpasa University (Approval Number/ID: 03/2021/13118. Hereby, we as the authors consciously assure that for the manuscript " Do Mathematics Teachers' Preferences on Teaching Methods and Materials Change in Online Education? Case of Probability" the following is fulfilled:

- This material is the authors' own original work, which has not been previously published elsewhere.
- The paper reflects the authors' own research and analysis in a truthful and complete manner.
- The results are appropriately placed in the context of prior and existing research.
- All sources used are properly disclosed.

Contribution Rates of Authors to the Article

The first author has collected the data and he has conceived and designed the analysis, he has also contributed to the data collection tools. The second author has been involved in drafting the manuscript and she has discussed the results and commented on the manuscript. The authors wrote the paper together. The authors provide an equal contribution to this work.

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