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Mathematics education faculty members' perceptions of barriers to distance education: Q-method analysis

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ABSTRACT

As a result of the great earthquake disaster in Turkey, mathematics education in universities was reorganized as distance education after the pandemic period. This article aims to identify the barriers to distance education practices in higher education. In line with the aim of this study; Q methodology was used to help determine the perceptions and perspectives of faculty members regarding the barriers to distance education in the process of teaching mathematics in higher education. Q methodology aims to reveal the internal frame of reference of individuals through their preferences. According to the findings of the study, participants identified barriers under 3 factors. These 3 factors, in order of weight, represent student, curriculum and technology barriers. In general, it was seen that the 4 factors revealed by the methodology in the study yielded results compatible with the literature. However, it was determined that the barriers arising from the teacher did not carry a factor load in the study. Another unique result was the identification of barriers arising from the nature of mathematics. It was understood that there are unique obstacles specific to the field of mathematics due to pedagogy and curriculum. In this respect, investigating the barriers to field-specific extended education will provide more accurate findings. In this study, which was conducted with Q methodology and supported by qualitative data, the identified barriers to distance education were consistent with the general literature. Q methodology reveals that it is a compatible tool for various research in similar situations.

Keywords: Barriers to distance education, mathematics education, Q methodology.

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INTRODUCTION

"Coronavirus (COVID-19)" has been one of the most searched terms on the internet since 2020. The year 2020 was an extremely difficult time for the whole world due to the massive COVID-19 pandemic outbreak (Spinelli et al., 2020). The critical situation that started with the pandemic also affected educational settings and brought many unexpected challenges for educators and students around the world (Dhawan, 2020; Eradze et al., 2021; Muthuprasad et al., 2021). Unexpectedly, this pandemic has significantly affected our living conditions and changed the usual order (Spinelli et al., 2020). During the pandemic, another topic that was very much on the agenda regarding education was distance education. However, we can say that the whole world has left it behind these days. However, while distance education has almost lost its attractiveness on the agenda, unfortunately, in Turkey, distance education has regained its place on the agenda, especially in higher education. The reason for this was the earthquake that occurred in Turkey in February 2023, which had a devastating impact on 10 major provinces of Turkey and Syria and caused a lot of loss of life. It resulted in the loss of about 50,000 people. In order to address the need for shelter for the many homeless people, policymakers identified student dormitories as the first alternative and turned higher education into distance learning. All stakeholders, including policymakers, educators, parents and students, have had to keep up with its many uncertainties, it is now necessary to respond quickly to teaching, learning and online collaboration through different online learning platforms and tools.

Challenges, barriers and potential concerns arise when it comes to shifting all teaching and learning to the online mode. As a result, there is an urgent need for educators to adopt new teaching methods (Harsha and Bai, 2020; Junus et al., 2021). E-Learning is often linked or used interchangeably with Technology Enhanced Learning [TEL], distance, online or virtual learning environments (Guri-Rosenblit, 2006) and has been mostly researched in the context of schools and higher education. E-learning, on the other hand, facilitates the potential for distance interaction between students and experienced teachers/academics (Wang et al., 2009). Learning content is delivered remotely through an electronic solution (Bates, 2005) and includes technology-based learning systems; digital collaboration and virtual classrooms. E-learning is transforming the map of both global education and corporate training (Bell et al., 2004). The ubiquitous accessibility afforded by e-learning has attracted the interest of researchers in various cultures and contexts (Lin, 2010); many researchers glorify e-learning over traditional learning due to the blending of synchronous and asynchronous structures (Zengin et al., 2011).

Despite this rhetoric, the long-term adoption, diffusion and utilization of e-learning solutions has been far less successful than originally envisioned (Bell et al., 2004). Failure rates in implementation and unstable statistics in student assessment pose a risk to long-term use by higher education institutions. A complex combination of barriers limiting the long-term success of e-learning solutions has research potential. This paradox between increasing public demand and failed implementation/acceptance has led researchers and practitioners to focus on e-learning implementation failure barriers (Lee et al., 2009). While extensive work has been done to understand e-learning implementation barriers (Kwofie and Henten, 2011), limited work has been done to clarify the boundaries of this understanding in the field of mathematics education.

The starting point of this article is to highlight the barriers to e-learning applications in higher education. In addition, determining the situation of these obstacles in mathematics education is the focus. With the increasing need for online technology-supported teaching and learning, teachers and students face some barriers and challenges. These challenges are categorized under the headings of teacher and student roles, curriculum, classroom activities, assessment, and student welfare (Reimers and Schleicher, 2020; Hodges et al., 2020; Kapasia et al., 2020; Zalat et al., 2021; Engzell et al., 2021). The research was developed by taking the barriers expressed in the literature as a milestone and taking into account the specific barriers in the distance education process in the field of mathematics education in addition to the barriers expressed in the literature.

This study aims to investigate the barriers to distance education among faculty members who teach university mathematics education courses. The study includes their general tendencies towards barriers to distance education, how their general ideas are clustered, and identifying similar and distinctive features among the clusters with Q methodology. In addition, differences and similarities were tried to be determined in terms of the barriers defined in the literature specific to mathematics education. In this respect, it was aimed to reveal the barriers to distance learning specific to mathematics education. The findings obtained from this study provide a different and unique method to determine the barriers to distance education. It will help to advance our understanding of the barriers to e-learning integration of all higher education courses that have suddenly transformed into distance learning with the earthquake disaster that suddenly developed after the COVID-19 pandemic.

With COVID-19, mathematics education in Turkish Universities was organized and maintained as online learning as it was all over the world. At a time when there was a complete normalization, an incredible disaster (earthquake) occurred and courses were organized as online learning at all university education levels. Considering the previous experiences, it was thought that the study would bring a different perspective to the literature with its relationship with the barriers encountered by the faculty members in the process of online mathematics teaching, both the field norms and the barriers expressed in the literature, and the q method in the process of revealing the existing barriers, which is a different perspective than the known standard tests in terms of revealing how the participants are gathered under a factor load towards these barriers.

Barriers to technology integration in education

Ertmer (1999) proposed a framework detailing first and second-order barriers to technology integration in education. The first-order barrier includes some external factors that may constrain classroom technology integration, such as lack of adequate access, time, training and institutional support. These factors are external to teachers. Second-order barriers were also added, which are more teacher-specific, including teachers' beliefs in pedagogy, beliefs in technology integration, and teachers' willingness to change (Tsai and Chai, 2012). These are seen as teachers' personal beliefs that can promote or hinder the implementation of technology integration in classrooms. In summary, instructors face three barriers in classroom technology implementation; the first barrier is technology integration (extrinsic barrier), the second barrier is teachers' personal beliefs (intrinsic barrier) and the third barrier is design thinking.

Ertmer (1999) categorized the barriers into two categories: internal and external. The first-order barrier to technology integration in classrooms is external; both pre-service and in-service teachers may face first-order barriers in resources such as available technology, adequate training, planning time and relevant administrative support (Ertmer, 1999; Lin et al., 2014). Teachers' technological skills directly influence the effectiveness and quality of online teaching (Danchikov et al., 2021). Teachers also stated that lack of access to the internet and devices is a serious barrier to e-learning implementation (Almanthari et al., 2020). Moreover, teachers do not have enough experience in a fully online learning environment (Lase et al., 2021). In modern education, students' technological skills are important in acquiring learning resources (Rasheed et al., 2020; Danchikov et al., 2021). In this regard, the critical importance of infrastructure and accessibility has been highlighted (Almanthari et al., 2020). The second-order barrier is intrinsic and includes factors such as teachers' personal beliefs about technology integration, willingness to change, and teachers' pedagogical beliefs (Ertmer, 1999; Tsai and Chai, 2012). In contrast to traditional classrooms without technology implementation, teachers may be dealing with numerous changes in teaching methods, assessment and management styles (Kerr, 1996). It has been suggested that second-order barriers may be more likely to hinder classroom technology integration because they deeply affect teachers' personal beliefs (Dede, 1998; Ertmer, 1999). Extensive research on teachers' beliefs and conceptions of the technology-enriched learning environment (Ellis et al., 2006; González, 2010; Sherman and Howard, 2012; Schweighofer and Ebner, 2015; Svihla et al., 2015; Saxena, 2017; Durff and Carter, 2019) has indicated that they are more challenging to overcome than other barriers.

It has been observed that educators are not adequately prepared for the transition to the online teaching environment (Rahiem, 2020). Dhawan (2020) stated that educators will need to find new ways to provide meaningful learning and engage students in the online environment. Tsai and Chai (2012) articulated the design of instructional strategies as a third-order barrier and emphasized the possibilities of achieving successful technology integration once the first and second-order barriers are overcome. As teachers have sufficient technology with adequate pedagogical beliefs, they may face third-order barriers, which as the need to redesign learning materials to meet the needs of different learners in a fully online environment. Design thinking skills in education help foster creativity, collaboration and problem-solving skills (Caruso, 2011; Scheer et al., 2012; Watson, 2015; Henriksen et al., 2017; Lambert et al., 2021; Nguyen et al., 2021). Teachers need design thinking skills to overcome the potential challenges of online teaching (Vallis and Redmond, 2021). Muthuprasad et al. (2021) stated that the key factor of a successful online course is interaction, and continuous meaningful activities will help students to participate in online courses. It is known that another alternative to do this is to mobilize collaboration. In this respect, design thinking skill was defined as a third-order disability.

Apart from this, Chen et al. (2022) articulated classroom management barriers for online teaching; they examined potential barriers to teachers' use of mobile devices in classrooms. They added that teachers find it difficult to engage and sustain students' attention when using mobile devices to participate in online lessons. Ghateolbahra and Samimi (2021) noted that teachers need to put in extra effort when dealing with online classroom management to ensure meaningful learning. In a fully online teaching environment, classroom management becomes another important factor that influences the effectiveness of online teaching and learning. Constant monitoring of student practice and effective feedback are also important in an online learning environment (Prilop et al., 2021).

In distance education, mathematics teachers in higher education face the obstacles of fully online teaching and course redesign. Teachers need to find appropriate ways of expression in online style and through the use of different modalities to enrich teaching or course materials. Teaching materials (readings, videos, exercises, etc.) become an influential factor as students spend more time at home reading and reviewing course materials on their own (Rapanta et al., 2020). Moreover, the use of various online platforms or the fear of being monopolized by certain platforms can affect the quality of online education and training altogether. Different platforms offer different interactions between various parties (Kennedy, 2020). Another interesting type of challenge that emerged from the researcher's experiences and the exchange of ideas with colleagues was the redesign of mathematics education for skills-based courses.

METHOD

In line with the purpose of this study, Q methodology was utilized to help identify the perceptions and perspectives of distance education students regarding the barriers to distance education in the process of teaching mathematics in higher education. Q methodology, developed by Stephenson (1935), aims to reveal the internal frame of reference of individuals through their preferences (such as human subjectivity) (Stenner and Watts, 2012). By adopting the depth and richness of qualitative data (post-sequencing semi-structured interviews) and the objective rigor of quantitative data (factor analysis), Q methodology provided an opportunity to examine tutors' subjective views on barriers in distance education. In Q methodological studies, participants are presented with a set of statements covering possible opinions on the topic. Typically, participants are asked to rank these statements from least important to most important, depending on their preferences and reflecting their subjective world (Stenner and Watts, 2012). Therefore, in the present study, the Q methodology was used to develop an understanding of tutors' subjective thoughts about barriers in distance education.

Participants

The study group of this research consists of 13 faculty members working in the department of mathematics education in Turkish universities who switched to online teaching due to the earthquake in the spring semester of the 2022-2023 academic year. In studies conducted with Q methodology, different subgroups are produced in line with the participants' unique social perspectives (Moser and Baulcomb, 2020). According to Watts and Stenner (2005), in studies conducted with Q methodology, there is no need for a large group of participants since participants' views on an item can be combined or separated under many factors (groups). While determining the participants, faculty members from the Department of Mathematics Education in Marmara, the geographical region with the highest number of universities in Turkey, were selected and contacted to collect data about the study. A lottery was drawn among 96 faculty members who agreed. Data were collected face-to-face and online from 13 faculty members determined as a result of the draw.

Discourse space and Q statements

The first step in Q methodology is to create a collection of statements of opinion about the targeted topic, known as a concourse. This collection of statements about a phenomenon is called a Q set (Stephenson, 1978). Brown et al. (1999) stated that the statements used to develop a domain of expression in Q methodology can be collected through a variety of methods, including extensive literature reviews and researchers' personal experiences and existing knowledge.

From a total of more than 300 articles on E-learning implementation barriers, 135 barriers were identified through data-driven qualitative content analysis. A comprehensive summary of e-learning barriers was presented by Andersson and Grönlund (2009) who reviewed 60 articles and thematically categorized the barriers into four conceptual categories: Technological, Course-related, Individual and Context-related problems. Analyzing 259 articles and identifying 104 barriers, Ali, Uppal and Gulliver (2017) found that most of the barriers expressed in their study fit the framework of Andersson and Grönlund (2009). In addition to these, it was examined directly in mathematics education (Almanthari, Maulina and Bruce, 2020) and studies conducted in related fields (Chen, Siu-Yung Jong and Tsai, 2022; Rahiem, 2020; Sherman and Howard, 2012; Assareh and Bidokht, 2011). In order to create a structure in line with the literature, it was deemed appropriate to structure the model into the categories of Technological, Individual (teacher), Pedagogical (content) and student barriers. The model expressed here is in line with the TIPEC model in Ali, Uppal and Gulliver's (2017) study. In the current study, 135 statements were generated from the perspective of these recommended methods. After the compilation of the statements, a Q set with a smaller number of statements was developed by taking into account the recommendations of Brown, Baltrinic, and Jencius (2019), with the methods of highlighting the determinant statements. Finally, a comprehensive Q set of 50 statements was elicited (see Table 2 for the full list).

During the data collection process, after the participants answered personal demographic information questions, they were first reminded to reflect on their distance education experiences after COVID-19 and the earthquake disaster. Afterward, participants were instructed to categorize the 50 Q statements on enabling processes shown in Table 2 into three groups: least agree, neutral and most agree. In the next stage of the data collection process, the participants made more detailed decisions based on the choices they had made in the previous stage, leading to the main ranking. As shown in Figure 1, participants ranked the statements along a continuum of seven categories ranging from least agree (-4) to most agree (+4). The middle category in the distribution was used to place statements where participants felt 'neutral' or 'undecided'.

As the second step of the data collection phase, in addition to providing their qualitative comments on the statements they rated under least agree (-4) or most agree (+4), participants were given the opportunity to provide additional comments on any of the 50 statements. Q methodology studies can be complex for participants as they require a comprehensive process; therefore, participants were offered the opportunity to receive additional support from the researchers throughout this process.

As the last step of the data collection phase, interviews were conducted with two participants who strongly represented the views that were divided into factors and groups by the Q method. These interviews aimed to explore their reasons for selecting the discriminative items in depth. In this context, the participants were asked the following four questions:

Do you find distance education useful for mathematics education? Why?
Why do you agree the most?
Why do you agree the least?
How do you foresee distance education in mathematics education in the future?

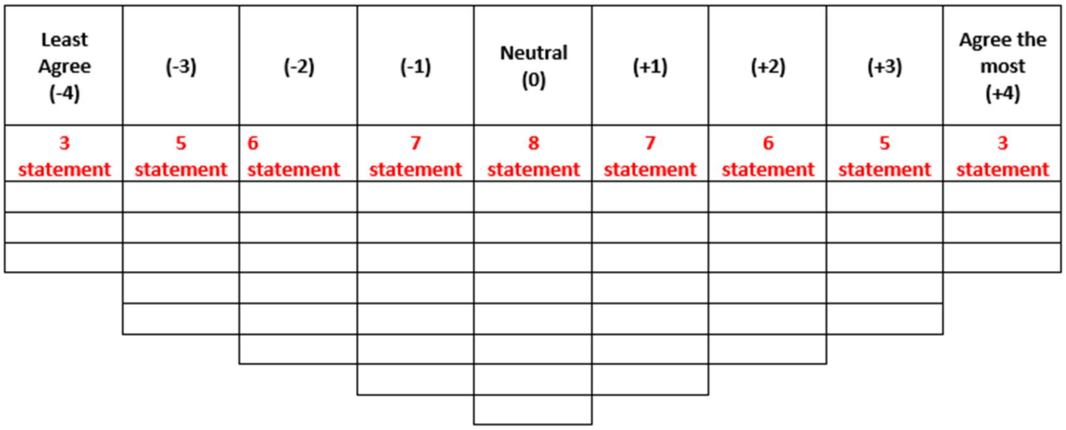

Figure 1. The Q string.

In the data analysis process, participant responses were uploaded into PQMethod (Schmolck and Atkinson, 2012), a software program commonly used to analyze data in Q methodology studies. Factor analysis was performed using principal component analysis (PCA). Factor loadings were generated with Varimax rotation. Factor rotation is a process used to explore clusters of similar Q-sets in order to identify perspectives that are more frequently supported by participants. Although there are multiple methods of factor rotation, the general goal is to capture the maximum variance explained in Q analysis. Therefore, varimax rotation was preferred in this study because this method "maximizes the variance of each factor loading by making high loadings higher and low loadings lower to simplify factor interpretation" (Akhtar-Danesh, 2016, p. 34). As a result, statistically and theoretically, it was decided that a three-factor solution best explained the data. In this study, it was determined that the 50 Q rankings loaded on three factors.

In presenting the findings as a factor pattern, this study followed the steps suggested by Stenner and Watts (2012) to provide a more comprehensive interpretation of each factor and its interconnections. First, for each factor, the discriminative statements provided by the PQMethod were extracted. Second, qualitative data from semi-structured interviews with two participants who expressed this process more strongly than the three identified factors were also used. This stage was requested to ensure that we captured a detailed interpretation of each perspective. Finally, the findings are presented, bringing all the elements together.

FINDINGS

While analyzing the opinions of mathematics education faculty members regarding the obstacles in the distance education process, the existence of a common denominator among the participants was first examined. For this, principal component analysis and rotations were performed in "PQMethod 2.35" program and the distribution in Table 1 was obtained.

Table 1. Factor loadings table.

Participant	Q sort	Factor 1	Factor 2	Factor 4
1	MCG	0.3497	**0.4242**	0.0089
2	TG	**0.5133**	0.084	0.0886
3	DO	**0.7781**	0.1531	0.0163
4	SY	**0.5782**	0.3127	0.3886
5	TO	0.0445	0.1636	**0.7424**
6	MAB	0.3932	**0.507**	0.0287
7	MST	**0.6107**	-0.2996	-0.2375
8	HKG	**0.5017**	0.2889	-0.13
9	MC	0.0895	**0.6687**	-0.0307
10	DSM	0.2068	**0.5265**	0.2281
11	TKU	**0.4322**	0.2225	0.2737
12	MEK	0.0715	**0.623**	0.0999
13	NS	0.0127	0.2709	**0.306**

Table 1 shows the distribution results of the 13 participants according to the factors. The values in the factors are shown in bold. The formula "Standard error = (1/√ number of statements) × 2.58" developed by McKeown and Thomas (2013) was used to determine the significance value of the factors. In line with the given formula, "0.36" was determined as the significance value in this study. As a result of the principal component analysis and rotation, it was determined that 13 participants could be explained under 3 factors. To clearly understand which factor the participants were closer to, the factor loadings are shown in bold. It was determined that there were 6 participants in the first factor (column), 5 participants in the second factor, 2 participants in the fourth factor, and no one in the third factor. The fact that 6 of the 13 faculty members (approximately 46% of the group) gathered in one dimension can be interpreted as a general characteristic of the group. Based on this statement, it can be said that the opinions of the faculty members teaching in the field of mathematics education regarding the obstacles they face in the distance education process are similar.

To determine in which common denominator this similarity converges and which sentences are more important, Table 2 presents the items, Z values for the items, and the Z score ranking of the items in each group (factor). The items are ranked according to the degree of approach to the items of the 6 participants gathered under factor 1.

Table 2. Z Values and the order of importance of the items.

Factor / Item	Factor 1		Factor 2		Factor 4	
	Z	Rank*	*Z*	Rank*	*Z*	Rank*
I have experience in using distance education	2.09	1	1.77	1	-0.17	29
My students are not as engaged in distance education as they are in face-to-face classes	1.89	2	1.47	4	0.33	20
Students are reluctant to take responsibility for their own distance education.	1.87	3	1.46	5	0.09	26
Students take refuge in ethical barriers to class participation (such as not being available for the camera).	1.48	4	1.49	3	1	10
During the distance education process, students often get distracted from the course by engaging with different web tools (social media, internet blogs, news, etc)	1.19	5	0.63	13	0.33	21
Students are reluctant to respond to the teacher and participate in class	1.15	6	1.11	6	0.59	16
Faculty members make little effort to give feedback	1.14	7	-0.9	42	-0.83	39
My students come to class unprepared in terms of prior knowledge	0.93	8	-0.76	40	-0.75	37
The online assessment process is not reliable.	0.9	9	0.93	9	1.83	1
Lack of face-to-face/social interaction between the individual student and the teacher fosters a sense of isolation.	0.83	10	0.32	23	1.25	7
Students show less effort due to the relative absence of learner-student interaction	0.78	11	0.03	27	1.5	4
My students do not have sufficient devices (i.e. laptops and tablets) for distance education use	0.69	12	-1.03	44	-0.92	41
Faculty members do not have enough time to give feedback	0.64	13	0.21	26	0.83	13
The time allocated to distance education with a-synchronous follow-up of courses causes a conflict of priorities	0.57	14	-0.54	37	0.16	24
Students lack confidence in using distance education technologies	0.51	15	-0.73	39	1	11
Textbooks are not suitable for distance education use	0.49	16	-0.29	32	-0.76	38
Faculty members do not show sufficient effort in the use of distance education	0.43	17	0.38	21	1.25	6
My students' internet connection is not sufficient	0.37	18	-1.43	46	0	27
Students do not help in the successful implementation of the distance education system	0.36	19	-0.27	31	0.42	17
A favorable environment for distance education (no distractions, quiet, no hesitation to talk,...etc.) cannot be created.	0.35	20	-0.39	34	-1.08	42
Insufficient support from the family in the distance education process	0.34	21	-0.37	33	-0.33	31
There are difficulties in representing mathematical concepts and generalizations in distance education	0.28	22	0.72	12	1.32	5

Table 2. Continues

The use of multiple representations in solving math problems in distance education is more limited than in face-to-face courses.	0.25	23	0.9	10	0.66	15
My students have anxiety that they cannot learn in distance education courses	0.09	24	0.43	19	0.09	25
I do not have enough time to prepare distance education materials due to workload.	-0.02	25	0.94	8	-0.67	36
Students are not computer literate	-0.11	26	-0.63	38	-0.25	30
My students cannot access the distance learning system	-0.13	27	-0.94	43	-0.09	28
Students lack experience with technology in problem solving and performing basic tasks.	-0.14	28	-0.42	36	1.75	2
Distance learning is not suitable for the use of tangible materials	-0.15	29	0.41	20	0.92	12
The school does not have sufficient equipment (computer, camera, graphic tablet, etc.) for distance education	-0.18	30	-1.3	45	-2	50
My students do not have sufficient knowledge and skills in the use of distance education	-0.22	31	0.31	24	0.26	22
Web-based applications (virtual manipulatives) are seen as the only alternative material in distance education	-0.24	32	-0.04	28	-0.92	40
Students have technical problems in responding to the teacher and participating in the lesson	-0.29	33	-0.4	35	0.67	14
Schools mandate assessment tools that are not suitable for students' use of distance education.	-0.32	34	0.83	11	-1.83	49
The arrangements made by the school do not support the use of distance education	-0.52	35	-1.72	47	-1.42	46
Hardware such as graphics tablets are not as useful as chalkboards	-0.53	36	0.23	25	1.5	3
My school's internet connection is not sufficient	-0.57	37	-2.08	48	-1.09	43
In distance education, more homework can be assigned than usual because the subjects are not completed.	-0.6	38	-0.16	29	1.16	8
My school's distance education system is not sufficient	-0.6	39	-0.81	41	-0.49	32
The content of the teaching subject is difficult to be understood by students through distance education	-0.7	40	1.05	7	-0.59	34
The faculty's teaching methodology is not suitable for distance learning	-0.72	41	-0.19	30	-1.66	48
The school does not provide sufficient training for faculty members to improve their courses.	-0.86	42	0.55	15	-1.25	45
My school does not provide professional development opportunities for the qualified use of distance education.	-0.88	43	0.52	17	-1.16	44
The school does not have sufficient access to digital libraries.	-0.94	44	1.53	2	-1.5	47
The content of the teaching subject is not suitable for teaching using distance education.	-1.25	45	0.33	22	1.09	9
I believe that using distance education is not useful.	-1.73	46	0.44	18	-0.5	33
The use of distance education is not suitable for me	-1.79	47	0.54	16	-0.67	35
A student-centered pedagogical practice is not possible in the distance education process	-1.81	48	0.59	14	0.25	23
I do not have sufficient knowledge and skills to use distance education	-2.03	49	-2.4	50	0.34	18
I am not confident in using distance education	-2.29	50	-2.32	49	0.34	19

* Indicates the order of individuals' paying attention to the item in the relevant factor.

The most positive item approached by the group of 6 participants in Factor 1 was "I have experience in using distance education", while the most negative item was "I am not confident in using distance education". The consensus of the participants that they have experience in distance education is that they gained this experience with COVID-19 before the earthquake. When the items listed under Factor 1 are analyzed, it is seen that the obstacles in front of distance education originating from the student are expressed. In other words, the participants' general attitudes were similar in terms of the positive Z values of these items regarding the obstacles to distance education caused by the student. In addition, Factor 1 alone explained 25% of the total variance.

The respondents in Factor 1 are those who have superior experiences of using distance education, and they also argue that the barriers to distance education are student-oriented. As a strong explanatory factor for those in Factor 1, T stated that students are not as engaged in distance education as they are in face-to-face education, and support of this view

> TG: "...I think that face-to-face interaction is important in mathematics education in order to intervene in the learning process that takes place in the student's mind...".

Other participants also gave explanations supporting these views. Another point is that the answers given by the participants in this factor on why they least preferred the statement "I do not have enough knowledge and skills to use distance education" indicate that they have gained sufficient experience in distance education during the COVID-19 process. To support this view, DO is a strong explanatory factor for those in Factor 1,

> DO: "...I think that I have sufficient knowledge and skills with my experiences in the pandemic process and the experiences I gained from the technology-supported mathematics teaching courses I have given and the applications and course contents I developed online quizzes."

However, it was also found that the participants in Factor 1 emphasized that the continuous development of technology-supported teaching tools in distance education and the addition of new applications is not an easy task to follow.

While the first item in Factor 2 was the same as the first item in Factor 1 (i.e. they stated that they were experienced in distance education), in the following items, they stated that the obstacles in front of distance education stemmed from the lack of facilities. If we categorize the inadequacies of facilities selected here, it is seen that rather than tools such as the internet and computers, there are subscriptions to electronic libraries, and ethical barriers that prevent participation in the course (not being available to turn on the camera). In this factor, the items "My school's internet connection is not sufficient" and "I do not have sufficient knowledge and skills to use distance education" were the items with the least participation of the participants.

The participants in Factor 4 evaluated the obstacles they encountered in distance education specifically in mathematics and stated that distance education is not compatible with the teaching nature of mathematics. The most preferred items under this factor are "Online assessment and evaluation process is not reliable" and "Equipment such as graphic tablets are not as useful as blackboards". The participants classified under this factor think that distance education is more disadvantageous than mathematics education. The ideas of the group that believes that the pedagogical continuation of mathematics teaching with distance education is not fully efficient due to its nature are seen here. As a strong representative of this group, TO,

> TO: "I observed that in distance education courses, especially in math problems, they do not engage in deep thinking to reach a solution." He tried to clarify this situation with his statement.

Another participant in this factor is NS

> NS: "Especially the fact that students do not share their solutions with the teacher or their classmates even if they make a solution is an indication that the value of the solution is not very valuable for them. I think this solution that is not seen as valuable is a proof of their interest."

When the opinions expressed here and the items emerging from Factor 4 are taken together, it is stated that distance education is not fully compatible with the nature of mathematics teaching.

Factor 1 can be called "student-related barriers", i.e. individual, similar to the TIPEC definition put forward by Ali, Uppal and Gulliver (2017) in their study; factor 2 can be called "technology-related barriers", i.e. technology-related barriers according to TIPEC's definition; and factor 4 can be called "pedagogical barriers", i.e. pedagogy-related barriers according to TIPEC's definition.

A Z-score analysis covering all 13 faculty members participating in the study would reveal the overall picture more clearly. In this respect, a Z-mean (Z-mean) score was calculated for each term in each factor in Table 3. When calculating the Z-mean score:

$$Z_{\bar{x}} = \frac{Z\ value\ of\ the\ positive\ sentence\ related\ to\ the\ term - Z\ value\ of\ the\ negative\ sentence\ related\ to\ the\ term}{\text{Number of items}}$$

The formula was used. In addition, a general average score was obtained for the emerging factors.

Table 3. The average Z values concerning the barriers to distance education.

	Factor 1 (6 person) $Z_{\bar{x}}$	Factor 2 (5 person) $Z_{\bar{x}}$	Factor 4 (4 person) $Z_{\bar{x}}$	$\bar{X}$
Student	0.73	0.83	0.58	0.71
Teacher	1.44	1.03	0.68	1.05
Curriculum-Pedagogy	1.53	1.52	1.87	1.64
Technology	0.47	1.06	1.19	0.90

When the overall average Z score of all participants is taken into account, it is seen that the barriers caused by curriculum and content have the most positive effect (Xz = 1.64), followed by barriers caused by teachers (Xz = 1.05), barriers caused by school and technology deficiencies (Xz = 0.90) and finally barriers caused by students (Xz = 0.71).

The most significant (i.e. discriminative) items of the factors were "Faculty members spend little effort to give feedback" for Factor 1, "The school's access to digital libraries is not sufficient" for Factor 2, and "The online assessment and evaluation process is not reliable" for Factor 4, respectively. In addition, the item on which the participants agreed without discriminating between any pair of factors was "Students are reluctant to respond to the teacher and participate in the lesson".

The other two questions asked to the participants were aimed at determining whether they found distance education useful and how they defined the place of distance education in the future. About distance education, all participants argued that it would not be useful on its own, at least for mathematics education. They argued that distance education alone is not suitable for the nature of mathematics and that courses that use both distance and face-to-face models together are more suitable for mathematics education. They stated that there were difficulties in the process of teaching the phenomenon concept in mathematics lessons organized only with distance education.

> MCG: "There is no possibility of more than one demonstration of the concept in distance education. For this reason, when students do not understand or need an additional example or a different demonstration during the teaching of the lesson, solutions are not developed instantly."

It is seen that the issues expressed here are supportive of the expansion of Factor 4. Another question we asked was how the participants positioned distance education in the future. The participants reported that they do not think that distance education in mathematics education will be only online or only face-to-face in the future. The general opinion of the participants is that distance education and mathematics education will be more systematic in the future. The most frequently stated view was that they emphasized a blended education model. In this regard, a participant in the factor of technology-based barriers to distance education (factor 4) stated that they did not think that distance education and mathematics education would be more systematic in the future:

> MCG: "...I think a HyFlex or hybrid model where students are more active and have a responsibility would be more effective for online courses..."It can be said that organizing online courses with such a mixed method is seen as an alternative to remove the obstacles to distance education due to the nature of mathematics education mentioned in the previous sections.

DISCUSSION AND CONCLUSION

This study, whose findings are shaped by Q methodology, is based on the determination of the obstacles encountered in the continuation of mathematics education in universities with distance education after the earthquake disaster through the opinions of faculty members. This process aims to determine how distance education and mathematics education are perceived by faculty members, whether faculty members are united around a common view on the obstacles to distance education, and the prominent obstacles. The participants of the study consisted of 13 faculty members who teach mathematics education courses at universities. The data were collected in two phases; in the first phase, the perceptions of the faculty members about the obstacles in front of distance education with 50 Q sentences, and the second data collection process was completed with 4 open-ended questions to reveal these extreme values in more depth as a result of determining common and different opinions. The results of the study are limited to the data collected with the Q method and 13 people were randomly selected among the faculty members teaching mathematics education courses in the Marmara region. In addition, it was assumed that the participants answered the data collection tools honestly and expressed their views on the barriers to distance education.

When the findings obtained from the opinions expressed by the faculty members teaching mathematics education courses about the barriers to distance education are evaluated in general, it can be said that the participants have a common attitude towards the barriers to distance education and this common attitude is student-related barriers. While 4 factors were expected in determining the barriers to distance education in parallel with the literature before the research (Ali et al., 2017; Mailizar et al., 2020; Yeh and Tsai, 2022), 3 factors emerged in this study regarding the barriers of faculty members to distance education in mathematics. Unlike the literature, the obstacle that did not emerge here was the obstacles arising from the teacher. According to the answers of the participants, whether consciously or not, a factor of teacher-related barriers did not emerge among the barriers to distance education. The situations represented by the other factor loadings were similar to the literature. As stated in the findings, these factors were student-based barriers in Factor 1, technology-based barriers in Factor 2 and pedagogical barriers in Factor 4, respectively, according to the highest explanatory power. In summary, while explaining the barriers to distance education, the participants attributed the highest value to student-related barriers. This result is similar to the studies in the literature, which suggest that the biggest part of the e-learning implementation barrier is at the student level (Almantar et al., 2020). As in the literature (Sherman and Howard, 2012), the fact that the participants in this study generally agree that students do not have sufficient knowledge proves this. Students' technological skills are important in obtaining learning resources in distance education (Rasheed et al., 2020), and this inadequacy of students triggers distance education barriers arising from them. Danchikov et al. (2021) determine the effectiveness of students' technological skills in online learning. According to the findings, factor 2, i.e. technology-related barriers, was found to be explanatory at the second level. Technology-related barriers include factors such as teachers' personal beliefs about technology integration, willingness to change, and teachers' pedagogical beliefs, which are defined as second-order barriers, and are endogenous (Ertmer, 1999; Tsai and Chai, 2012).

It is known that educators are not sufficiently prepared for the transition to an online teaching environment (Rahiem, 2020), so technology integration teaching is designed as a part of face-to-face teaching (Gürbüz et al., 2022). Teachers with experience in teaching in online environments do not face as many barriers as teachers with little or no online teaching experience. It can be said that the fact that the participants declared that they were quite experienced in this subject, together with the distance education fever experienced all over the world with COVID-19, was effective in their putting technology-related barriers in second place. Extensive research has also been conducted to address teachers' beliefs and understandings about the technology-enriched learning environment (Ellis et al., 2006; González, 2010; Sherman and Howard, 2012; Schweighofer and Ebner, 2015; Svihla et al., 2015; Saxena, 2017; Durff and Carter, 2019). Existing studies have mainly focused on e-learning integration barriers during the regular academic semester when schools are open and students are prepared. In this respect, in terms of barriers to distance education in emergencies (such as COVID-19 or Earthquake disasters), it was determined that technological barriers came after student-related barriers in emergencies. The last determining factor was the barriers defined as Factor 4, which describes the pedagogical and curricular barriers. Although pedagogical barriers are associated with the mismatch between students' assessments and e-learning or the curriculum's lack of support for technology-based applications (Hew and Brush, 2007), in this study, pedagogical barriers were generally seen to be due to the difficulty of mathematics teaching pedagogy and students' mathematics learning habits. Similar to the views in the literature (Yeh and Tsai, 2020) regarding the pedagogical barriers to distance education, the participants in the specific case of mathematics teaching see that once the pedagogical barriers are overcome, the quality of mass online education can be improved to a satisfactory level. In other words, the participants in factor 4 represent the beliefs that once pedagogical barriers are overcome, other barriers will disappear.

In general, it was seen that the 4 factors put forward with the methodology in the study yielded results compatible with the literature. However, it was determined that the barriers arising from the teacher did not carry a factor load in the study. Another unique result was the identification of barriers arising from the nature of mathematics. It was understood that there are unique obstacles specific to the field of mathematics due to pedagogy and curriculum. In this respect, investigating the barriers to field-specific extended education will provide more accurate findings. In this study, which was conducted with Q methodology and supported by qualitative data, the identified barriers to distance education were consistent with the general literature. Q methodology reveals that it is a compatible tool for various studies in similar situations.

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