Opinions of Preservice Mathematics Teachers Regarding Conceptual Change Texts Prepared on Limit and Continuity

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Hasan Güveli
Recep Tayyip Erdoğan University, Turkey
https://orcid.org/0000-0001-5432-9045

Ebru Güveli
Recep Tayyip Erdoğan University, Turkey
https://orcid.org/0000-0003-3738-5496

Abstract
Some students have misconceptions. Students' misconceptions make difficult to learn the new subject. Teachers need to know students' misconceptions and take precautions. One of the misconceptions in mathematics is about limits and continuity. In order for teachers to take precautions in this regard, they must have this experience during their education. For this, we have developed explanatory concept exchange texts on limit and continuity for preservice mathematics teachers. What is the views of preservice mathematics teachers the against the concept change texts prepared about limit and continuity is the research question. The 46 preservice mathematics teachers were informed about the subject in "misconceptions in mathematics" lesson and the concept change texts were presented. An open-ended questionnaire was prepared to determine the opinions of preservice mathematics teachers. In this questionnaire, questions whose validity and reliability were checked together with experts were used. The answers were analyzed by thematic analysis and some of the opinions were direct quoted. Some preservice mathematics teachers said that the concept change texts were "awareness" raising and "informative". Some preservice mathematics teachers said it was "difficult". Some of the positive comments that have emerged; they find the concept change texts interesting and enjoy reading, they are surprised and noticed the errors that exist in them.
Keywords: Concept Change Texts, Misconception, Limits and Continuity, Preservice Mathematics Teachers

INTRODUCTION

The majority of students struggle to comprehend fundamental science concepts in their scientific meaning, often perceive these concepts differently than their scientific meaning, and create numerous alternate concepts for each concept that vary from their scientific meaning (Dilber, 2006). Due to the challenges, misperceptions, and alternative concepts inherent in fundamental concepts of mathematics, students grow negative attitudes and opinions about mathematics subjects such as weariness and indifference (Yıldırım, 1993). Students carry and spread their misconceptions for a long time. They adopt and defend alternative concepts they have. To realize effective learning, it is necessary to eliminate misconceptions first (Özkan & Topsakal, 2020:5). In addition, if teachers know the misconceptions in students, it will be easier to take precautions.

Studies show that limit and continuity are subjects that students have difficulty in understanding and have misconceptions about (Monaghan et al., 1994; Hofe, 1998; Szydlik, 2000; Todorov, 2001; Przenioslo, 2004; Barbé et al., 2005; Jordaan, 2005; Quesada et al., 2008; Özmantar et al., 2008; Dönmez, 2009; Aydın & Kutluca, 2010; Biber, 2010; Baştürk & Dönmez, 2011; Baki

& Çekmez, 2013; Özmantar & Yeşildere, 2015; Winarso & Toheri, 2017; Oktaviyanthi & Dahlan, 2018; Akbaş & Baki, 2020; Anwar et al., 2020; Kula et al., 2020). These researches reveal that students have various conceptual misconceptions about the limit and continuity. The most obvious misconceptions in the literature regarding the limit concept are summarized below:

1. A formal definition of the term "limit," which includes the accumulation point.
2. In abstract concepts such as infinity, infinitesimal, and infinitely large: limit and infinity turned out to be concepts that students have trouble comprehending.
3. The most striking situation among students is to examine the continuity of a point that is not in the situation domain and to decide whether the function is continuous or not according to this point.

Reason for these misconceptions is that the students do not understand or have a limited understanding of the definition of limit, including accumulation point, limit definition at infinity, and definition of continuity. Not learning the concept well can also make it difficult to learn the concept of derivative and integral. Since concepts are the building blocks of knowledge, students must first healthily acquire them during the knowledge construction. If the student has not been able to structure the knowledge well, it will be difficult to learn the new knowledge. The student can make mistakes. The student may have alternative concepts. Changing alternative concepts is a difficult task. One way of eliminating misconceptions, changing alternative concepts and structuring a new concept is the concept change approach. In students' conceptual change, Posner et al. (1982) described the following four conditions that facilitate conceptual change: "making a student aware of deficiencies in an existing concept (dissatisfaction)", "helping a student find a way around how a new concept works (intelligible)", "convince the student that the new concept is explainable (plausibility)", and "allowing the student to apply the new concept to other areas (fruitfulness)" (Nadelson et al., 2018:156). Numerous methods based on the theory of conceptual change have been developed to facilitate effective learning. One of them is conceptual change texts (Chambers & Andre, 1997). Conceptual Change Texts (CCT), which raise students' awareness about the alternative definitions they possess, are written texts that serve as explanations of why these concepts are incorrect, in which the scientifically accepted correct concept is explained convincingly, leaving students with the impression (Demircioğlu et al., 2016). In the first stage of CCT, a challenging question, which is prepared to activate the students' prior knowledge and provoke dissatisfaction with their ideas, is posed to students. Then, the identified student alternative concepts are directly presented. It is tried to be refuted by showing the evidence why these alternative concepts are wrong. Finally, scientifically correct explanations are given with examples (Sevim, 2007; Konur, 2010). CCTs can be easily used in crowded classrooms. They are suitable for self-study. Application time is short. It can also be used outside of school. The cost is cheap (Çakmak, 2016). It can also be used as electronic texts on computers (Güveli et al., 2021). CCT is an effective method for conceptual change theory. Because this method focuses on both teacher-student and student-student interaction in the teaching process (Guzzetti et al., 1997).

In a study conducted by Wang & Andre (1991), the effects of conceptual change texts on understanding electrical circuits were examined. According to the researchers, the use of conceptual change text promotes substantive learning of subject-related concepts. There are also many studies that show that students perform better in concept learning with CCTs than in traditional learning (Bayır, 2000; Diakidoy et al., 2003; Balcı et al., 2006; Beerenwinkel et al., 2011; Salem, 2013; Suma et al., 2018; Sel & Sözer, 2019; Banawi et al., 2021)

Güveli et al. (2018) stated that they would prefer "cognitive conflict, "concrete materials", "concept cartoons" and "conceptual change texts" most to eliminate misconceptions in a study they conducted with preservice mathematics teachers on ways to eliminate misconceptions.

Although many studies have been carried out to identify the misconceptions about limit, no study has yet been found to eliminate them with CCT. The objective of this study is to ascertain the

opinions of preservice teachers on CCT, which was established to address misconceptions about limit and continuity. Limit and continuity are complicated concepts for some students. Understanding these concepts is fundamental to understanding integral and derivative subjects. It is important for these concepts, which are often encountered in other disciplines and mathematics, to be learned and taught. The conceptual change texts, which is an alternative approach to these concepts that have misconceptions, have been considered worthy of recognition and reflection on both students and students who will become teachers in the future.

METHODS AND MATERIALS

SCOPE OF RESEARCH

This study is a descriptive study with a qualitative pattern. According to Sandelowski (2010) the main purpose of qualitative descriptive research is to present a direct and simple description of any situation. It was conducted with 46 students studying in the third year (2018/2019) at the Faculty of Education, Department of Mathematics Teaching of a university in Rize/Turkey.

RESEARCH DESIGN

The study began by identifying common misconceptions regarding limit and continuity. Common misconceptions about limit and continuity in the literature were selected (a formal definition of the term limit; limit in abstract concept such as infinite, infinitely small, infinitely large; the issue of continuity). Following that, two math faculty members who are recognized experts in their fields were interviewed to determine the causes and types of these misconceptions. The prominent studies on different types of misconceptions are over generalization, over specialization, mistranslation, and limited conception (Zembat, 2008; Aydın & Kutluca, 2010). Misconceptions on these types were examined, and a consensus was reached with the two experts. During the preparation stage of CCT, the questions that the students were mistaken for were prepared. In the first stage of CCT, a challenging question was given to stimulate students' prior knowledge and create dissatisfaction with their own ideas. The causes and types of these misconceptions were dwelled on. It was attempted to be refuted by demonstrating why these alternative concepts are incorrect. Finally, accurate scientific explanations were given, backed up with examples. The question, misconception, cause of misconception, solutions, and examples were distributed to students of CCT third grade preservice teachers during the lesson "misconceptions in mathematics". Preservice teachers who read the CCT were were asked to answer the questionnaire.

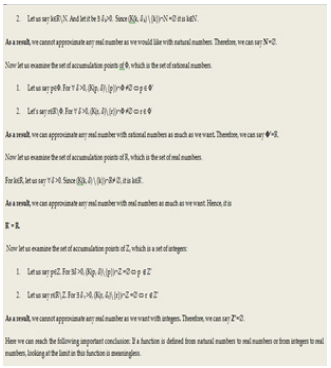

Figure 1 Descriptive Part of the CCT

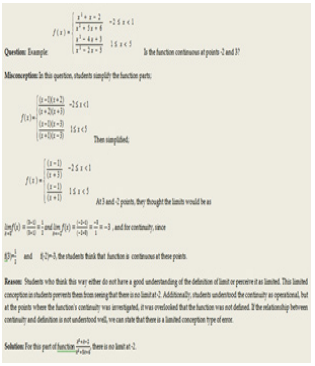

Figure 2 The Part of CCTs Misconception

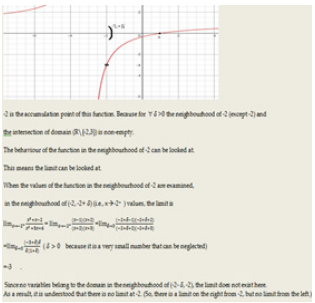

Figure 3 The Part of CCTs Solution

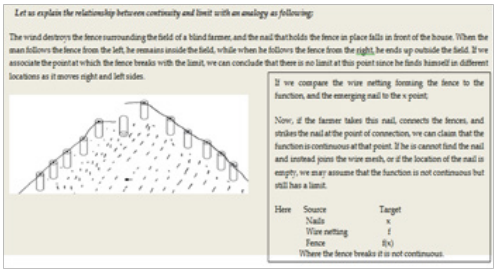

Figure 4 The Part of CCTs Analogy

Data Collection and Data Analysis

The open-ended questionnaire was used as a data collection tool in this study. The open-ended questionnaire consists of 5 questions in total. Two expert opinions has been used on the validity and reliability of the questions. In addition, pilot study has been made with 2 lecturers on the intelligibility the readability of the survey questions. The final version of the opinion questionnaire was administered to 46 third-grade mathematics students.

Questions

- Question 1. "What do you think about the effect of CCT on learning the subject of limit and continuity?"
- Question 2. "What do you think about the effect of CCT on eliminating misconceptions in the subject of limit and continuity?"
- Question 3. "What did you feel while reading the CCT, which was prepared about limit and continuity?"
- Question 4. "What would you do to improve the CCT, which was prepared about limit and continuity?"
- Question 5. "When you become an instructor, will you use CCT in your classroom?"

Thematic analysis method was used in the analysis of the dataset. Thematic analysis is a qualitative analysis method used to analyze, organize, define and report the themes in the data set (Braun & Clarke, 2006). First of all, the main themes were created from the questions, and sub-themes were created from the codes that emerged.

The answers of the preservice teachers were also coded by another researcher. The opinions of 2 experts were taken for the codes and a consensus was reached as a result of the joint work. Therefore, the obtained the data were considered to be reliable for research. The thematic map, which consists of codes, sub-themes and main themes, was drawn in agreement with the opinions of 2 experts. In addition, the views of the preservice teachers were included with the direct quotation in order to support the data. Preservice teachers were coded as S1, S2,...

RESULT AND DISCUSSION

RESULTS

The codes that emerged from the opinions of the preservice teachers were presented as a table together with the themes and sub-themes. Sample opinions are given with direct quotations.

Table 1 Effect of CCT on Learning the Subject of Limit and Continuity

MAIN THEME	SUB THEME	CODES	FREQUENCY (%)
EFFECT ON LEARNING	POSITIVE EFFECTS	*REAL-WORLD EXAMPLES *MEMORABILITY *INSTRUCTIVE *AWARENESS *INFORMATIVE *ELABORATION *SUPPORTIVE	41 (89,1%)
	NEGATIVE EFFECTS	*NOT INSTRUCTIVE	4 (8,6%)

One preservice teacher did not answer this question.

Examples of preservice teachers' opinions;

"CCT makes it easy to learn with real-world examples."(s3)

"..by in corporating errors, the causes, accurate facts, and analogies into the CCT, errors are avoided, and memorability is increased."(s4)

"The CCT is instructive with examples on limit and continuity." (s5)

"While CCT provides warning information about misconceptions and errors, it supports correct information."(s8)

"The student realizes the mistake. Increases awareness." (s10)

"Students may have difficulty reading and comprehending these texts. It does not contribute to students who do not like reading." (s17)

"Before the issue of continuity, the issue of accumulation point and limit should be understood well. I do not think that symbols such as N'=, Q'= and R'=R in the accumulation point can be understood by reading. If I hadn't taken an analysis class, I wouldn't have understood anything. The student cannot learn the subject by reading the CCT alone."(s32)

Table 2 Effect of CCT on Eliminating Misconceptions in the Subject of Limit and Continuity

MAIN THEME	SUB-THEME	CODES	FREQUENCY (%)
EFFECT ON MISCONCEPTIONS	POSITIVE EFFECTS ON MISCONCEPTIONS	*IDENTIFY *ELIMINATE *CONVINCING *AWARENESS *INFORMATIVE	37 (80.4%)
	NEGATIVE EFFECTS ON MISCONCEPTIONS	*NOTELIMINATED *NOT ENOUGH *DIFFICULT	6 (13%)

Three preservice teachers did not answer this question.

Examples of preservice teachers' opinions;

"It is effective because the mistakes are well identified and well explained. In addition, the daily life situations included in the analogy are quite good and catchy examples." (S9)

"Thanks to CCT, errors are presented, along with their causes and suggested solutions. The student is made aware of his or her own misconceptions. That is why I am considering using it as well." (S12)

"I read the CCT on this subject and discovered that I wasn't mistaken in this regard. However, this isn't always the case. Therefore, students who have misconceptions about these texts will overcome them with clear and exemplified texts." (S24)

"I think it would be difficult." (S21)

"Student misconceptions are different. So it can't clear every error..." (S6)

Table 3 Felt While Reading the CCT

MAIN THEME	SUB-THEME	CODES	FREQUENCY (%)
FEEL	POSITIVE FEEL	*ENJOY *INTEREST *LIKE *HAPPY *LUCKY *AMAZE *TITTER *IMPRESSIVE	33 (71.7%)
	NEGATIVE FEEL	*UNAPPEALING *BORING *DIFFICULT *CONFUSED	12 (26 %)
	FEEL NOTHING	*NOTHING	1 (2,17%)

Examples of preservice teachers' opinions;

"I enjoyed reading it. I liked reading what kind of misconceptions the students had. It piqued my interest. If it was in the form of a book, I would enjoy reading it." (S1)

"I was happy once I realized that it is a good

technique that can overcome misconceptions." (S4)

"I saw the mistakes and errors I had made myself before. It was interesting." (S5)

"I felt lucky to anticipate any misconceptions that students might have." (S15)

"I had never thought that such misconceptions could exist. I was amazed!" (S24)

"Seeing the error that I had made myself before, I realized that I was not alone. I like CCT. (S33)

"I tittered once I see the errors which I also had made before. (S36)

"It was impressive in parts because it was like a lecture and in parts because it was connected to real-life". (S37)

"It was unappealing to me because it was excessively verbal." (S39)

Table 4 What Needs to be Done for the Development of CCT

MAIN THEME	SUB-THEME	CODES	FREQUENCY (%)
DEVELOPABILITY	VISUALITY	*SHORT VERBAL EXPRESSIONS *COLORED HIGHLIGHTERS	30 (65.2%)
	CONTENT	*MORE EXAMPLES *MORE ANALOGIES *MORE GRAPHICS *TABLES *EVERYDAY LIFE SAMPLES *CONCEPT CARTOONS *MODELLING	13 (28.2%)
	TECHNOLOGICAL	*SIMULATIONS *ANIMATIONS *GRAPHICAL CALCULATOR	1 (2,17%)

Two preservice teachers didn't answer this question.

Examples of preservice teachers' opinions;

"It should be supported by analogy, graphics, tables, and technology (Simulations, animations, graphical calculator e.g.) (S16)

"There should be more examples." (S17)

"Must learn by doing and living, not by reading." (S32)

"It should be more simples." (S34)

"I prefer to use concept cartoons." (S41)

Table 5 Willingness to use CCT as a Teacher

MAIN THEME	SUB-THEME	CODES	FREQUENCY (%)
USEABILITY	YES- AVAILABLE	*EFFECTIVENESS *BENEFICIAL *USEFUL	30 (65.2%)
	NO-UNAVAILABILITY	*DIFFICULT	13 (28.2%)

Three preservice teachers didn't answer this question.

Examples of preservice teachers' opinions;

"Yes, I think it's effective in eliminating the errors." (S5)

"Yes, I think iCCT is useful for the student to learn the subject and misconceptions" (S7)

"Yes, CCT are beneficial texts for misconceptions." (S26)

"I can not prepare it myself, but I will use it if ready-made texts are given." (S9)

"I wouldn't use them. Because they are very difficult." (S21)

You can see the thematic map summarizing the views of preservice teachers about CCTs in Figure 5.

Figure 5 Thematic Map of Pre-Service Teachers' Views on CCT

Discussion and Conclusions

The vast majority of preservice teachers stated that CCT was effective in learning the subject of limit and continuity. According to Wang and Andre (1991), using conceptual change text facilitates meaningful learning of subject-related concepts.

Our research the common code in both main themes was "awareness". This statement shows that CCT has an awareness-raising feature both in learning the subject and in removing the misconceptions. If the student has a misconception, the student does not know it. Unless the student confronts mistake, the student does not realize that is mistaken. The student knows the concept of alternative correctly and believes in it. According to Sel & Sözer (2019), CCTs are effective in raising awareness such as seeing the causes of conceptual errors, feeling the current concept deficiencies, understanding and accepting scientific facts.

Preservice teachers stated that thanks to CCT, students will realize their misconceptions and knowledge. Güveli et al (2018) in their study, stated that preservice teachers preferred concept change texts in concept teaching and removing misconceptions. This finding is in parallel with the finding in our study.

Some preservice teachers stated that CCTs were "not enought". Manimozhi & Srinivasan (2021) suggested in their study that there should be more and easier problems in CBSE Textbooks (in Mathematics of VI Standard). The views of pre-service mathematics teachers in our study were in this direction. Easier and more exercises can be added to CCTs. Visuals can be increased in CCTs and supported with concept cartoons.

Some preservice teachers stated that CCTs were "not eliminate" students'misconceptions. For this, we recommend researchers to conduct an experimental study for CCTs on limit and continuity.

Many students said the CCTs were "informative". The reason why they think so; CCTs were showing misconceptions and the reasons for these misconceptions. The only way to prevent a permanent misconception is to discuss the misconception and to make mutual communication. Although the issue of addressing misconceptions in the classroom is a matter of debate, this problem should be discussed in the classroom and resolved without exposing or offending students (Bingölbali & Özmantar, 2010, p.23). Discussing and eliminating misconceptions in the classroom will allow the existing misconceptions to be corrected, as well as preventing possible misconceptions and necessary precautions will be taken. If the teacher starts a new theme before revealing and resolving the misconceptions, the student will not be aware of the error, maybe he will transfer his error to the new theme and even make new mistakes. Therefore, the errors seen in students during the education process should be intervened immediately and these errors should be eliminated as soon as they are seen.

One of the common codes revealed in our study was the "difficulty" code. Some of the preservice teachers stated that they had difficulty reading the CCTs. Some found it difficult for CCTs to clear their misconceptions. Others, as teachers, found it difficult to use CCTs in the classroom. Perhaps what was meant as difficult was the issues of limit and continuity. CCTs were also difficult for preservice teachers who found these subjects difficult. As a matter of fact, there are many studies in the literature about students who find the subject of limit and continuity difficult and make mistakes in these subjects (Monaghan et al., 1994; Hofe, 1998; Szydlik, 2000; Todorov, 2001; Przenioslo, 2004; Barbé et al, 2005; Jordaan, 2005; Quesada et al, 2008; Dönmez, 2009; Biber, 2010; Baki & Çekmez, 2013; Winarso & Toheri, 2017; Oktaviyanthi & Dahlan, 2018; Akbaş & Baki, 2020; Anwar et. all, 2020). A preservice mathematics teacher stated that students' misconceptions are different, so CCTs cannot clear every mistake. As learning is different, so are mistakes. However, presenting the mistakes made will prevent possible mistakes. Indeed, the preservice mathematics teacher, who felt "lucky" to have read the CCTs, felt that way because the preservice teacher saw what mistakes were made.

One preservice mathematics teacher expressed that CCTs will not contribute students who do not like to read. We believe that; It is very difficult for students who do not like to read to be successful in mathematics. Students should be guided to read and understand what they read. Mathematics is closely related to reading and reading comprehension. It is recommended that students who struggle to comprehend what they read more books. "Reading slows the rate of memory corruption. Reading helps improve a person's memory by exercising the brain muscles. After all, reading strengthens the brain and enhances memory."(Alex-Nmecha & Horsfall, 2019, p:7). Hasani et al., (2021) recommended the strategy of learning by reading for children's (primary school) concept learning. Moreover, reading is an activity that develops imagination. The relationship between mathematics and imagination can be examined in other studies. For preservice teachers who are bored with reading, CCT can be made more interesting. The preservice teachers who expressed negative opinions stated that they would not use the CCT in their own classes, preferring instead to use concept cartoons. According to preservice mathematics teacher, CCT would be more successful if it is accompanied by additional practical activities, examples, and analogies, or technology. Here we can say that CCT has both positive and negative aspects. These negativities can be eliminated by supporting CCT with different techniques such as technology, concept cartoons, and modelling. CCTs enriched in this way could lead to future studies.

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Author Details

Hasan Güveli, *Recep Tayyip Erdoğan University, Turkey,* ***Email ID****: hasanguveli@erdogan.edu.tr*

Ebru Güveli, *Recep Tayyip Erdoğan University, Turkey,* ***Email ID****: ebru.guveli@erdogan.edu.tr*