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A Look into Turkish Preservice Teachers' Translation Skills: Case for Model Representations

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Multiple representation enables students to connect different ideas and gain a deeper understanding of the mathematical concepts involved. The integration of mathematical model representation in order to model and interpret physical phenomenon and solve real world problems is one of the major objectives of mathematics learning in high school curriculum (NCTM, 2000). In this respect, this study focused on Turkish preservice teachers' process of translation of model representation among four representation types. The result of this study indicate that Turkish preservice teachers lacked knowledge on the competencies of translation to and from model representations. Results also indicate Turkish preservice teachers' tendency to use another representation type as transitional stage to model representations.

Keywords: Multiple Representation, Mathematics Education, Preservice Teachers, Teacher Knowledge.

Literature Review

Employing multiple embodiments of the concept in the learning environment is essential in mathematics education not only its role in exemplifying abstractions but also creating a solid conceptual understanding of a single concept by illustrating interconnectedness between the representations. While the problems are analyzed, using different mathematical demonstrations such as creating table and graph or using algebraic expressions efficiently play a central role in the process of conceptual understanding as well as application of inquiry. In this respect, Friedlander and Tabach (2001) call attention to consider both advantages and disadvantages of each representation since in the case mathematics learning, the use of symbolic, tabular, graphical and modeling representations aids learners to create their mental constructions and lead the way to effective and meaningful learning.

In addition to applying multiple representations, the process of model representation is other fundamental components of mathematical education. Jacobson (2014) described the ability to model as requiring students to "use their understanding of arithmetic operations to make mathematical sense of problem situations and to relate this sense making to functions represented by equations, tables, and graphs" (p. 155). NCTM Standards (2010) for school mathematics emphasized that mathematical model representations encourage students learn how mathematics works in the real world and sense about what they have done during the mathematical process. NCTM Standards (2010) for school mathematics emphasized that mathematical model representations encourage students learn how mathematics works in the real world and sense about what they have done

during the mathematical process. In this sense, investigating Turkish preservice teachers' mathematical models helps researchers to a better understanding of how one simplifies, constructs and works mathematically on a problem, which are key elements of mathematical thinking. In light of this, the purpose of this study is to gain insight into Turkish preservice secondary school mathematics teachers' representational practices of mathematical models in the context of mathematical functions. The data collection process was completed before preservice teachers studied multiple-representation topic in the secondary mathematics teaching methods course. The purpose of this selection of data collection timing was purposeful in order to depict what secondary school teacher candidates would know without addressing multiple representations in methods class.

Methodology

Participants and Settings

This study is a part of a larger study that examined the Turkish preservice teachers' translation process among six representation models. Twenty-four senior-year preservice teachers from a public university in Istanbul voluntarily participated in this study. The students of this department had to take high scores from university entrance exam, in other words, these participants were successful high school graduates who have to score pretty high in mathematics. Furthermore, senior students of the department have to take various advanced level mathematics courses like group theory, analysis, probability and statistics from mathematics department of the university. Thus, the a common assumption for Turkish context is that the senior year preservice teachers from this department are pretty well equipped in terms of content knowledge. So, one purpose of this study was to investigate how mathematically high achieving preservice teachers perform in terms of translation between representations for functions, a central concept that they will teach.

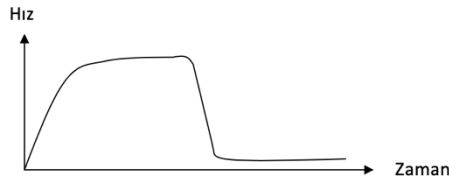
A questionnaire was designed to address participants' way of representing combination of translation pairs among graphical, model, tabular and algebraic. The participants had to translate those modes univocally without the intervention of the researchers. In order to maximize return rates and ensure data trustworthiness and credibility, the researcher was in charge of recruiting and collecting data from questionnaire. In this sense, data collection process took place within one-hour research method course while the preservice teachers were attending the course early in the academic year under researcher's supervision.

Instruments

The questionnaire questions were derived from manuscripts (Carlson et al. 2002; Leinhardt, Zaslavsky and Stein, 1990; Shell Centre for Mathematical Education (University of Nottingham) and adopted in Turkish by the researchers. Since this study was a part of a larger study, six questions particularly related to translation pairs including model representations were used in this research. The figure 1 below illustrates two of the examples in the questionnaire which illustrated translation from graphical representation to model representation and from model representation to graphical representation respectively. The question on the left side required participating preservice teachers to indicate which sport among fishing, pole vaulting, sky diving and javelin throwing would produce a graph like in the given shape below. This question is related to translation from

graphical representation to model representation. The other question on the right side asked preservice teachers sketch a rough graph to demonstrate how the distance from A will vary with the distance from B and this question is related to translation from model representation to graphical representation.

Aşağıda verilen grafik hangi spor dalı ile ilgili olabilir? (Shell Centre for Mathematical Education (University of Nottingham), 1985)



Balık Tutma

Sırkla Atlama

Paraşitle Atlama

Cirit Atma

Ok ile gösterilen araçlar aşağıda gösterilen dairesel yol üzerindeki yörüngeyi takip ederek sabit hızla hareket etmektedir. Verilen modele göre aşağıda verilen grafikleri tamamlayınız. (Leinhardt, Zaslavsky, & Stein, 1990)

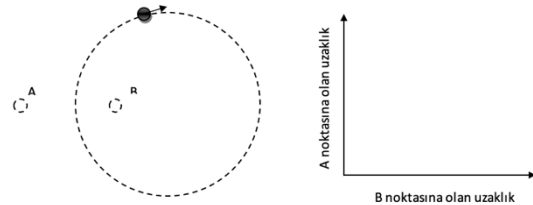
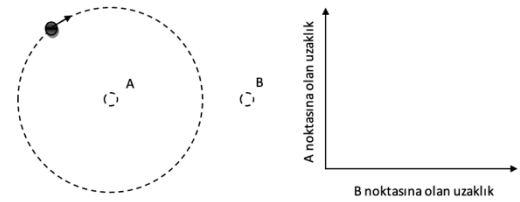


Figure 1. Two tasks in the questionnaire

After collection of 24 preservice teachers' results in the questionnaire, researchers decided to evaluate questionnaire data quantitatively, in which participants were scored by criterion referenced standards according to their translation scores. Total translation score reflects the sum of the translation score of participants and obtained by preservice teachers' score in translating among tabular, graphical, algebraic and model representations between a minimum score of 0 (indicating limited correct translation activity), a score of 1 (indicating a partially correct translation activity) and maximum of 2 (indicating correct translation activity). Limited correct translation activity included participating preservice teachers' mathematically incorrect attempts to translate into specified translation type. Partially correct translation activities comprised preservice teachers partially correct mathematical procedures and calculations in the given translation pairs. Preservice teachers who completed all procedures correctly were given correct translation activity score. The sample preservice teachers answer in the second question in Figure 1 are shown in Figure 2. The following examples in Figure 2 illustrates between limited translation, particular translation and complete translation points for the translation pair of from model representation to graphical representation.

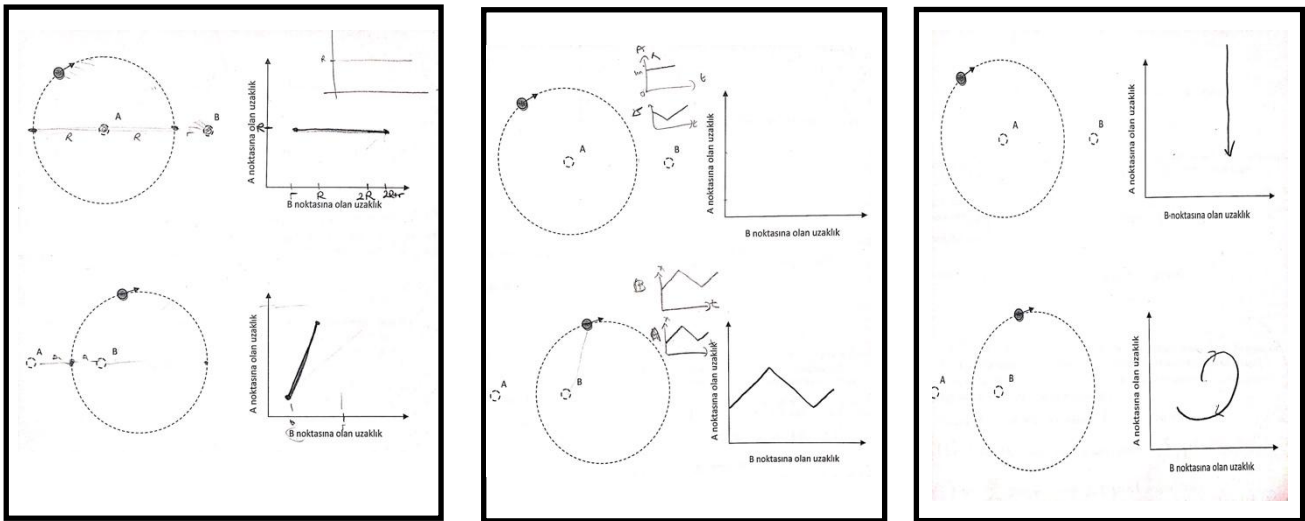


Figure 2. An example of correct translation activity, partial translation activity and limited translation activity respectively

While academic experts examined the items and provided comments and reflections for content appropriateness, a Turkish language teacher reviewed the questionnaire's grammar, punctuation, and word selection, and three experienced mathematics teachers checked the participants' responses to ensure interrater reliability.

Results

As this study aimed to examine the Turkish preservice teachers' ways of translating from and to the model representation of functions, it was expected the Turkish preservice teachers to coordinate the given representations and model representations. The results of Turkish preservice teachers' responses concerning their translation scores in the questionnaire were summarized in Table 1.

Representation types	Limited Translation (0)	Partial Translation (1)	Correct Translation (2)
Model → Graphical	4 (16,66%)	13(54,16%)	7 (29,16%)
Model → Tabular	6 (25%)	15 (62,5%)	3 (12,5%)
Model → Algebraic	16*(66,67%)	8 (33,33%)	0*(0%)
Graphical → Model	9 (37,5%)	11(45,83%)	4 (16,66%)
Tabular → Model	6 (25%)	16 (66,67%)	2 (8,33%)
Algebraic → Model	4 (16,66)	13 (54.16 %)	7(29,16)

Table 1. Number of Turkish preservice teachers in each group

The table showed the number of preservice teachers in three categories that formed according to their scores in each translation types. The translation score reflects how accurate preservice teacher's translation process in which tabular, graphical and algebraic representations are mapped

onto model representations and vice versa. Preservice teachers were given a minimum score of 0 (indicating limited translation activity), a score of 1 (indicating a partial translation activity) and maximum of 2 (indicating ability to translate among multiple representations).

Besides, 24 Turkish preservice teachers' mean score for each translation pairs were presented in Table 2.

	Model → Graphical	Model → Tabular	Model → Algebraic	Graphical → Model	Tabular → Model	Algebraic → Model
Mean Score of Each Group	1,12*	0,87	0,33*	0,79	0,83	1,12*

Table 2. Mean Score of Each Translation Pair

According to Table 1 and Table 2, the translation pair from model representation to algebraic representation has the lowest rate in mean scores. The participating Turkish preservice teachers' ability to establish meaningful links from model representation to algebraic representation was considered weak. In parallel with this, 16 Turkish preservice teachers out of 24 got zero translation points when translating from model representation to algebraic representation whereas no participants could perceive the goal of making conceptual shift between these two kinds of representations.

However, translation pair from algebraic representation to model representation was recorded having the highest mean rate with 1,12. The question relating to translation from model representation to algebraic representation was based on cumulative quadratic functions whereas its reverse pair was written as an example of linear functions. When looking to participants' responses, Turkish preservice teacher was unable to define dependent and independent variables in the context of model representations in this translation pairs. In conclusion, we can easily conclude that the score of participant Turkish preservice teachers were accumulated in partial translation score which points their limited ability to translate among several representation types.

Discussion

An important element of effective mathematics teaching at secondary school is using multiple representations and guiding students to translate between the representations (NCTM, 2000). Demonstrating model representation of functions is not only algorithmic process, it is also related to formulating problem situation, choosing appropriate variables according to given representations, determining the relationships between representations and verifying the model and its implication. Within this context, integration of model representation as mathematical practice in teaching and learning mathematics is targeted an area of interest in revised mathematics curriculum (MoNE, 2018). The department of curriculum studies of the Ministry of Education (Talim ve Terbiye Kurulu Başkanlığı, TTKB, 2017) identified symbolic, model, graphical and tabular representations as a way for developing appropriate solution strategies for real life problems. In this line, effective and fluent usage of model representation is an important practice associated within this goal. In that respect, this study is important since this research evaluated Turkish preservice teachers' translation ability from one type of representation to another.

Yet, as functions are the concept of interest in translation items, the results also shed light on the underlying algebraic ideas such as variable, covariation etc. behind the translation procedure. When examining participating Turkish preservice teachers' responses, they achieved to translate from algebraic representation to model representation, in which they were required to write a real-life example according to a linear equation. On the other hand, participants failed to satisfy necessary requirements to write a reasonable algebraic expression which is suitable for a quadratic growth. This evidence suggested that participating Turkish preservice teachers might have a lack of knowledge on functions since not only did they show difficulties to recognizing expressions in the different types of models, but also complications in explaining the models' specificities of the models in the context of tasks given. It is also important to note that participants had difficulty when stating independent and dependent variables in the graphical and algebraic representation. Thus, the results of this study support notion of addressing content knowledge in methods courses which have main purpose of mathematics teaching methods.

Furthermore, the findings collaborate with other studies reporting Turkish preservice teachers' difficulty with covariational thinking of functions (Carlson, Jacobs, & Larsen, 2001; Zeytun, Çetinkaya & Erbas, 2010). It is pointed in the literature that well developed understanding of function is possible by exploiting relationships between two variables (Carraher & Schliemann, 2002). Participants' limited conceptual understanding on functions cause them to struggle interpreting the given type of representations and finding a model representation.

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