Investigation of Preservice Teachers' Theory Use Through Course Video

Seval Deniz KILIÇ [1] Ercan MASAL [2]

[1]denizk12@hotmail.com, Muğla Sıtkı Koçman University,Muğla

[2] emasal@sakarya.edu.tr, Sakarya University, Sakarya

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ABSTRACT

The use of theory which has been described as an efficient tool to build a bridge between theory and practice has recently become one of the subject matters which the mathematics educators pay attention. The main purpose of this study which examines the preservice mathematics teachers' levels and nature of use of theory is to enable preservice teachers to enrich their practical knowledge with theory. As a result of this case study which consisted of 20 preservice mathematics teachers and adopted qualitative research methods, it was found that the preservice teachers' habits of use of theory accumulated to the level of description and in addition to this, theory use mostly accumulated to the third level. That is, the preservice teachers have a great tendency to explain the current situation. At the end of the study, it was suggested that the preservice teachers should be provided rich learning environments which promote the use of theory and are enriched with technology and they should be guided appropriately to increase the candidates' quality and level of theory use.

Keywords: nature and level of theory use; theory-enriched practical knowledge

INTRODUCTION

One of the most important factors that determine the success of mathematics teachers is undoubtedly their ability to build a bridge between theory and practice. Thus, an ability to develop and use a theory has become one of the subjects which mathematics educators give importance and study (Da Ponte 2013; Lerman 2013). In fact, at the root of these studies lies the effort to integrate theory and practice together as stated by Freudenthal (1991). Many researchers have been working on to "fill the gap between theory and practice" for more than hundred years (Cochran-Smith and Lytle, 1999; Dewey, 1904; Leikin and Levav-Waynberg, 2007; Korthagen, 2010). The reason for the use of theories which are based on theories used in applications and emerged under different names such as ''grand theories,'' ''middle range theories,'' and ''local theories,'' (Silver and Herbst, 2007) in mathematics education is to enable preservice teachers to judge their or the others experiences more deeply (Oonk, Verloop&Gravemeijer, 2019). The preservice teachers' selection and use of knowledge when required will help them to develop theory-enriched practical knowledge and to internalize the potential knowledge they have (Oonk, Goffree&Verloop, 2004). In case of such needs, teachers (or candidates) will have used theory and acquired "theory-enriched practical knowledge". In fact, the reason why the preservice teachers are expected to use theory is to enable them to go beyond interpreting traditional assignments, solutions or situations as true or false and reveal their opinions about their tasks (*National Council of Teachers of Mathematics, 2000). There are studies in literature emphasising that there must not be a gap between theory and practice (*Freudenthal 1991; Oonk, et al., 2019). According to Freudenthal(1991), theory is not something to be applied but a dynamic process which constantly nourishes practice. An individual observes others' actions and nourishes his practical knowledge which is acquired via either written or oral reflections with theoretical knowledge because it is considered that theoretical knowledge has a narrative character (Clandinin &Connelly 1996; Lin 2002; Pendlebury, 1995). In this case, it is useful to discuss what the theory use is, its nature, and the levels of theory use.

Conceptualizing the Nature of Theory Use and Levels of Theory Use

Benefiting from the framework suggested by Sparks-Langer, Simmons, Pasch, Colton, and Starko (1990) for reflective thinking, for theory use Oonk, and his colleagues (2015) developed a new framework on the nature of theory use. The relationship between these two frameworks was presented in Table 1:

Table1. A transition from reflective thinking to the nature of theory use

Framework forReflectiveThinking	Nature of TheoryUse
(2) layperson description; (3) events described with appropriate terms	A. Factual description
(4) explanation using personal preference as the rationale	B.Interpretation
(5) explanations via principle or theory as the rationale;	C. Explanation
(6) explanation via principle or theory and considering context factors; and (7) explanation considering ethical, moral, or political issues	D. Responding to situations

The explanations of the components of theory use in Table 1 are given below:

Factual description: The preservice teacher explains actual events only; no opinion or view is given.

Interpretation: The preservice teacher expresses an opinion but does not offer evidence (using phrases such as I think or in my opinion).

Explanation: The preservice teacher explains why the students or teacher act or think in a certain way. These explanations are neutral and certain based on either facts or observations (Thus, indicator words or phrases such as for this reason, probably, it could be possible that).

Responding to situations: The student describes what could be done or thought differently in a class or learning environment as a teacher (using phrases such as I expect, I predict, I would do, I make, - I intend to, with the intention of).

Considering these four items, its relation with professional noticing as stated by Jacobs and her colleagues (2010) could be viewed. In this sense, reflection can be considered as a catalyst of "professional noticing", a concept which is used to express the ability to recognize and act on key indicators important for one's profession(Oonk, et al., 2019). Preservice teachers' capacity to attend, interpret, and decide—three interrelated skills of professional noticing—could naturally enable them to develop a network of concepts for considering practice expertly. In order to develop this network of concepts, it is important to introduce the concepts used by the preservice teachers. Thus, inspired from the studies of Oonk, et al., (2015), different concept codes were introduced for this study.

In fact, Freudenthal (1991) was influenced by three levels suggested by Van Hiele (1973) for mathematical thinking and described the relation between theory and practice and the levels of theory. Van Hiele (1973) emphasized that there would be transitions between these levels described for mathematical thinking (geometry and arithmetic) (Korthagen, 2010). It is possible to concretize the levels described by Van Hiele (1973):

Level 0: Shapes are only evaluated with their images (a student can distinguish a square and a circle).

Level 1: shapes are discussed with their properties; thus, an association is in question (this shape has three angles, one of which is right-angled and the other two are acute angles, thus, this is a right-angled triangle).

Level 2: The relation between the shapes' properties is important (eg, if the triangle is isosceles, the median line is also the height).

All these levels were associated to the use of theory by Oonk, et al. (2015). This relation was explained in Table 2:

Tablo2. The relation between Van Hiele's levels and levels of theory use

Van HieleLevels	Oonk, et al.Levels of TheoryUse
(*) No recognition of an object [fictitious level, invented by the authors (Oonk, et al., 2015)]	(1) Does not recognize and use a theoretical concept
(0) Recognizes an object only by its appearance (names the form of objects correctly)	(2) Recognizes theoretical concept(s) (correct description within a context; no network)
(1) Junctions (meaningful relations) in a network of relations between properties of objects	(3) Junctions (meaningful relations) in a network of relations between concepts
(2) Logical thinking within the structure of a network of relations between properties	(4) Logical thinking within the structure of a network of relations between concepts, develops a relation between relations

The first item (*) *was added from necessity in order not to have a technical problem in the table* (Oonk, et al., 2015).

Technology Based Learning Environment Promoting Theory

There are many studies in literature which mention the advantages of including technology within the experiences of preservice technology teacher (Borko, 2016; Brophy, 2004; Gaudin and Chaliès, 2015; Goldman, Barron,&Derry, 2007; Herbst, Chazan, Chen, Chieu &Weiss, 2011; Lampert &Ball, 1998; Masingila & Doerr, 2002; Sherin & Dyer, 2017; Stockero, 2008). Preservice teachers' observation of the others' experiences and reflecting their observations either verbally or in writing will enable them to enrich theoretical knowledge they have. The studies which state that professional noticing could be developed in this way support this finding (Schack, Fisher, Thomas, Eisenhardt, Tassell, & Yoder, 2013; Van Es & Sherin, 2010). With the intention of determining theory use and its level, a section from a video based lesson recorded in a real classroom setting was used in this study.

Only a section of the video was examined closer in the study, not the whole video-recorded lesson. The reason for this is to identify preservice teachers' status and level of theory use about a section from a sample lesson. The study which was designed as a case study aims at finding a clue about a big picture based on the findings specific to sub problems. Hence, the sub problems of the research were determined in that way:

1- In what ways do the preservice teachers use knowledge they have when they are asked to analyse a lesson experience they were presented by using their theoretical knowledge?

2- What is theoretical quality of the explanations made by the preservice teachers while analysing a sample lesson experience?

METHODOLOGY

Context and Participants

According to the curriculum description of the Council of Higher Education in Turkey, subjects and concepts for algebraic learning field included in secondary school mathematics curriculum are involved in algebraic concepts and teaching approaches course content. Before the implementation, individual and group tasks were assigned to the preservice teachers to do some research on algebraic concepts and misconceptions, and then the assignments and presentations were watched in the classroom and discussed. Moreover, considering these subjects, the lecturer (or faculty member) who is also the researcher prepared different activities and presentations and discussed the contents with the students.

The study and discussion of theoretical knowledge lasted nearly four weeks and then the preservice teachers watched a section from a video-recorded lesson in a real classroom setting by using a projector. This section includes nearly 15 minutes of a sixth grade course. It was thought that this duration was enough for an introductory study. The teacher of this course is a mathematics teacher with 16 years' work experience working in a state school located in a big city. The preservice teachers were asked to watch the lesson video and describe the case in this study. They were informed to list what they observed in the lesson, what situations drew their attention, and their suggestions if there were any. The research was carried out with 23 pre-service teachers studying algebraic concepts and teaching methods course in a state university in 2015-2016 academic year spring term. The students continue their third year of studies in mathematics teaching. All students volunteered to participate in the study. However, students coded as PT6, PT7 and PT10 were excluded from the research due to some weaknesses such as deficiencies in reflective observation form and illegible handwriting. Thus, the study consisted of 20 students.

Instruments, Procedure, and Data Collection

As the preservice teachers are expected to use theory, it is important to identify what these theories are. With this purpose, similar to the studies of Oonk, et al., (2015), the sample video recording was watched and analyzed by two mathematics educators individually in order to determine these theories and the concepts included in the lesson video were revealed. The concepts revealed were examined together and the concepts about which were run into contradiction were discussed again and finally a mutual agreement was reached. Considering this, the concepts obtained from the lesson video were expressed in figure 1:

Figure1: The concepts obtained from the sample video

Concept, misconception, variable, problem, algebraic expression, equation, worksheet, verbal expression, numerical pattern, activity sheet, non-algebraic expression, letter symbol, algebraic thinking

ANALYSIS

Reflection analysis instrument

Nature of theory use and levels of theory use sections explained in Tables 1 and 2 and its occurrence process in the previous section were used together for the analysis procedure. While grading and categorizing, the students' reflective opinions were analyzed by two field educators individually and put in suitable columns in Table 3. While analyzing the reflective opinion forms, the video recording was watched when required and they had chance to observe the data in –depth.

Tablo. 3 The relation between the nature of theory use and levels of theory use

Nature of theory use	Level of theory use
PT only writes the case s/he observes (description).	Does not use concept or uses very few (Level 1).
PT interprets about the situation (interpretation).	Uses very few concepts and does not build meaningful relations between the concepts (Level 2).
PT explains the current situation by using indicator words or phrases such as because or thus (Explanation).	Uses most of the concepts and can build meaningful relation between the concepts (Level 3).
PT predicts possible alternatives to the teacher's approach (Responding)	While suggesting different approaches for different student levels, develops meaningful relational networks between the concepts (Level 4).

Results

Results Related The First Research Question

The preservice teachers were asked to analyze a lesson experience presented to them by using their theoretical knowledge in order to answer the first research question. As a result of the analysis carried out according to the first column in Table 3, the candidates' frequency of theory use is given in Table 4:

Table. 4 Distribution of preservice teachers' (PT) frequency of theory use according to the categories of theory use

Description	Interpretation	Explanation	Response to situations
PT1	-	-	-
PT 2	PT 2	PT 2	**PT 2**
PT3	PT3	PT3	**PT3**
PT 4	PT 4	**PT 4**	-
PT 5	-	**PT 5**	-
PT8	**PT8**	-	-
PT 9	PT 9	**PT 9**	-
PT11	PT11	-	**PT11**
PT12	**PT12**	-	-
PT13	**PT13**	-	-
PT14	-	-	-
PT 15	**PT 15**	-	-
PT16	PT16	-	**PT16**
PT17	PT17	PT17	**PT17**
PT18	**PT18**	-	-
PT19	PT19	**PT19**	-
PT20	**PT20**	-	-
-	PT21	PT21	**PT21**
PT22	**PT22**	-	-
-	**PT23**	-	-

When Table 4 is examined, it is viewed that the preservice teachers' opinions have a decreasing tendency from description to responding. 18 candidates (90%) expressed their opinions in description section, 17 of them (85%,) in interpretation, 8 of the (40%,) candidates shared their opinions in explanation section, and finally 6 (30%) of them in responding section. These findings were found in the study of Oonk, et al., (2019) as 25%, 12%, 42%, 21%, respectively. It is found in this study that the students used more theories in each category. Different from the mentioned study, the students were accumulated at explanation section in the study by Oonk, et al., (2019). This situation may have resulted from the training given to the preservice teachers by the abovementioned researchers before the research.

On the other hand, some students expressed their opinions in such a way that these could be put in more than one category. In order to make evaluation on the basis of the last category the students could reach, the codes in Table 4 must be considered in bold. According to this, 2 students (10%) could reach description level, 8 of them (40%) to interpretation level, 4 students (20%) could reach explanation level, and 6 (30%) of them could reach responding level. These findings are supported with direct quotations given below:

Description(PT14):"*The students constantly answered the concept of variable as changeable. With the guidance of the teacher, they said that any number can go into the place of variable. They did not have any difficulty in expressing x-3 verbally but they thought that 3a could be a two digit number. Then, they saw that the expression 3a was 3 times a*".
When the opinion of PT14 was examined, the preservice teacher could not go beyond explaining the current situation.

Interpretation (PT8):"*The students have some ideas about a variable. Some could explain what it meant. When the teacher wrote some algebraic and non-algebraic expression on the board, s/he asked them whether or not they were algebraic expressions. One of the students said that the expressions with a letter were algebraic expressions. One student said that 3a could be a two-digit* *number. This shows that this student could not take the step from arithmetic to algebra. In fact, the students who stated that the ones that have letters could be an algebraic expression are expected to say that the letters express the variables".*

While PT18 describes the in-class situation, he also interprets the events. Although his interpretation is not exactly correct, the expression *"one student said that 3a could be a two digit number. This reveals that this student could not take the step from arithmetic to algebra"* verifies that the candidate makes an interpretation.

Explanation (PT19):*"The students have opinions about the concept of variable and they can express their opinions with simple sentences. But the teacher wrote "I have got x lira" on the board and asked the variable in the sentence. After getting the answer from the students that "x is a variable", she did not ask the question "why". I think that students answered uncomprehendingly. The teacher should have made them explain why they said that x was a variable. I did not find the comments about the concept of variable satisfying at the beginning of the lesson. That's why it should not have been told briefly and it should have been emphasized because it is quite important to understand algebra and it is a complicated subject for students. The teacher used the "x" symbol for the non-algebraic expressions that were written on the board. To me, using x is a wrong action which can cause misconception within the students because the students who could not adapt to the lesson can perceive the multiplication sign as "x". One of the students gave the answer "3a" could be a two digit number. Here the student could not distinguish arithmetic and algebra and could not take the step from arithmetic to algebra. The student accepted "a" as a variable and could not realize that the operation in between was a multiplication".*

The preservice teacher coded as PT19 could explain the students' approaches with data based on his observations. For example, the statement "*The teacher used "x" symbol for the non-algebraic expressions with the examples on the board. To me, using x is an action that will lead to misconception with the students because the students who could not adapt to the lesson can also perceive cross sign as unknown "x""* exhibits that the candidate could explain his observations with evidence.

Response to situations (PT21):*"The students are not unfamiliar with variable because they studied it in numerical pattern subject. But, the teacher said that 3a was an algebraic expression but 7/2 was not an algebraic expression and thus this pushed students to memorization. Here, the teacher should have asked the answer from the students. He should have explained why we called X an algebraic expression. The student really explained the expression " I have got x lira in my pocket. If I spent 5 liras, then I will have x-5" very well. By saying that 3a is a two digit number, one student showed that he could not take the step from arithmetic to algebra".*

Considering the explanations by PT21, it is viewed that the candidate offered alternatives to the teacher's practices and made suggestions. The statement "*the teacher said that 3a was an algebraic expression but 7/2 was not an algebraic expression and thus this pushed students to memorization"* can be accepted as a suggestion.

Results Related to the Second Research Question

The second research problem was to determine the quality of the explanations the preservice teachers made while analyzing an experience of a sample lesson. With this purpose, the criteria presented in Table 5 and whose theoretical structure was determined by Oonk, et al., 2015 was used. The findings obtained according to the theory levels presented in Table 2 reveal the preservice teachers' quality of theory use.

Tablo. 5 Distribution of preservice teachers' levels of theory use

Level 1	Level 2	Level 3	Level 4
PT1	PT2	PT3	-
	PT4	PT8	
	PT5	PT9	
	PT12	PT11	
	PT13	PT15	
	PT14	PT16	
	PT23	PT17	
		PT18	
		PT19	
		PT20	
		PT21	
		PT22	

When Table 5 is examined, it is seen that there are no preservice teachers at the last level. There is 1(5%) student in level 1, 7 students (35%) in level 2, and 12 students (60%) in level 3. However, the number of students in level 3 is higher than all other levels. These findings shows parallelism to the study findings of Oonk, et al. (2015). These views with direct quotations from each level were presented below:

Level 1 (PT1):*"The student related it to the previous lesson. He concluded that when there was a letter, it was algebraic and when there wasn't a letter, it was not algebraic. I did not approve his explanations in that way. I don't think that students gained deep learning. Because the lesson is based on memorization, it looks as if they do not have a meaningful and permanent learning. "*
When the opinion of the preservice teacher in the first category was examined, it drew attention that he used a single (algebraic) concept. The candidate could not establish a meaningful relation.

Level 2 (PT 4):*"He said that 3a could be a two digit number. The student here may have not considered "a" as a variable but a constant. A few answers were given by the students about what a variable was such as a variable is changing, inconstant. According to this response, the concept of variable has not been learnt properly yet. The students said that x was a variable with X-5, but they told this because they saw x but without knowing its meaning. They said this without knowing what the variable refers to because when the teacher wrote x-5, they did not tell what it meant".*
When the preservice teacher's views in level 2 were examined, it drew attention that the candidate used more than one concept but she could not establish reasonable relations between these concepts. She connected the perception of 3a as a two digit number to the fact that the concept of variable was not learned properly but this explanation conflicts with the previous explanation that a variable is a changing number.

Level 3 (PT 9):*"There was a mistake that 3a could be a two digit number. I think that most students did not understand that it was a multiplication. It was not emphasized a lot. Moreover, whether or not it was an algebraic expression was not discussed a lot. The concept of variable was mentioned but it may not have been interpreted. It could lead to the mistake that an unknown is a letter because every letter is not unknown such as e, c. They can say each expression with a letter an algebraic expression. In my opinion, explaining a subject with one example is not enough".*

What draws attention with the preservice teacher's views in level 3 is that the candidate used many concepts and she associated these concepts meaningfully to each other. Particularly, the statement "*Because every letter is not unknown such as e, c*" reveals that the candidate can establish meaningful relations between the concepts.

DISCUSSION AND CONCLUSION

This study examined preservice teachers' nature and levels of theory use. Based on the different studies stating that learning environments designed by using video recordings of a lesson developed student noticing (Schack, et al. 2013; Van Es & Sherin, 2010), this study is considered to be a introductory study which will shed light on preservice teachers' nature and levels of theory use. In this study, the preservice teachers had an opportunity to integrate theory and practice.

Nearly all student teachers could use at least one of the theoretical concepts presented in Table 1. This means that most student teachers could associate theory and practice within the context of presented learning environment. Primarily, the findings related to the nature of theory use reveal that preservice teachers were mostly in the description stage. Considering that the order was description, interpretation, explanation, and response to situations, it is an expected result to have the most accumulation in the last stage. Considering the research findings, it draws attention that the candidates were inclined to interpretation and explanation but they did not support their observations with concrete evidence and sometimes their evidence was improper and inconsistent.

Considering the findings about level of theory use, it draws attention that there are very few students in level 1. Level 4 which means to develop new relations is a level in which it is expected to have the smallest number of preservice teachers. Considering the previous studies, there were not any students in this level (Oonk, et al., 2015; Oonk, et al., 2019). In this study, similar to previous studies, no prospective teachers were involved at this level. It was found in the previous studies that preservice teachers' verbal reflective skills included more theories and evidence than written ones (Jaworski, 2006). Thus, it could be useful to include verbal reflections beside the written reflections in the future studies.

This study did not focus on the relation between the preservice teachers' prior knowledge and the nature and levels of theory use. However, the accumulation especially in the section of explanation (Level 3) exhibits that the preservice teachers could develop meaningful relations between the concepts. It is known from literature that teachers having less content knowledge focus on realities and procedures more and teachers having extensive content knowledge are more inclined to search conceptual relations (Putnam & Borko, 1997) and this means that the candidates' prior knowledge in this level at least would be adequate.

This study was designed as a case study. The effect of systematically watching lesson videos on preservice teachers' use of theory could be discussed in long term studies because the research studies carried out about the use of theory to build a bridge between theory and practice are studies whose effectiveness are approved in teacher education (Oonk, et al., 2015; Oonk, et al., 2019). Therefore, the use of theory in the teaching of prospective teachers should be encouraged.

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