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PRESERVICE SCIENCE TEACHERS' ORIENTATIONS TOWARDS TEACHING SCIENCE TO MIDDLE SCHOOLERS

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ABSTRACT

The purpose of this study was to explore the orientations preservice science teachers (PST) hold in preparing to teach science to middle schoolers and how their beliefs were reflected in their CoRes. As the framework to evaluate PSTs' orientations, Magnusson, Krajcik, and Borko's (1999) nine orientations were utilized. Eleven senior preservice science teachers (PST) were selected to participate in the study using a convenience sampling method. Each preservice science teachers prepared six CoRes on different science topics. The result indicated that most of the CoRes were designed around didactic-based orientation and any of PSTs prepared the CoRes based on conceptual change and activity-driven instructional approaches. Moreover, the study provide evidence that PSTs hold multiple orientations. Results from this study suggest that, among other factors presented in the literature such as early experience, PSTs orientation may be affected by the objectives in the curriculum as well.

Keywords: Science teaching orientation, pedagogical content knowledge, content representations, instructional approaches.

INTRODUCTION AND REVIEW OF RELATED LITERATURE

One of the earliest study about science teaching methods was written exactly one century ago by John Dewey. In 1916, Dewey published a paper in which he described the methods in science teaching. He pointed out that method means a way to a result, a means to an end, a path to a goal. Method, therefore, varies with the end to be reached (Dewey, 1916). In Turkey, there have been three major curriculum reforms in science education since last two decades (in 2000, 2004, and 2013). The perspective of *teaching* science based on behaviorist approach turned into *learning* science based on constructivist approaches starting from 2000 curriculum reform. Although, there are some similarities between these two philosophies, they differ in important aspects such as methods they propose to teach students in classroom settings. The proponents of behaviorist learning theory advocates that students are passive learners while the opponents, mainly constructivist, claim the opposite. In other words, the supporters of constructivist learning theory view students as active learners who build their learning based on their past experience in which they construct meaning. It is apparent that behaviorism and constructivism's path to teach students in classroom settings differ from each other apparently as supported by Dewey.

Shifting educational philosophy from behaviorist to constructivist approaches is relatively easy when compared to practice of that specific approach. In fact, teachers' orientations toward teaching science play a key role in implementations. It is apparent that the classroom practice based on constructivist approach is virtually impossible without teachers' orientations toward teaching science shift from behaviorist to constructivist. Borko and Putnam (1996) defended that knowledge and beliefs [orientation] lead teachers' instructional practices from beginning to the end in diverse ways such as, decision of learning objectives, the use of textbooks and other resources, assessment of learning, and the content of assignments. Orientations toward teaching science refer to "teachers' knowledge and beliefs about the purposes and goals for teaching science at a particular grade level" (Magnusson, Krajcik, & Borko, 1999, p. 97). Orientations toward teaching science is an important component of pedagogical content knowledge [PCK] (Magnusson et al., 1999) and plays a key role in reforms to be successful. As a result, science education literature seeks for research to explore teachers' orientations toward teaching science and change or combine their orientations in coherence with the goals of curriculum reforms (Abell, 2007; Nargund-Joshi, Rogers, & Akerson, 2011).

Magnusson et al. (1999) critically analyzed the science education literature and identified nine different orientations to science teaching: process, academic rigor (Lantz & Kass, 1987), didactic, conceptual change (Roth, Anderson, & Smith, 1987), activity-driven (Anderson, & Smith, 1987), discovery (Karplus & Thier, 1967), project-based science (Ruopp, Gal, Drayton, & Pfister, 1993; Marx et al., 1994), inquiry (Tamir, 1983), and guided inquiry (Magnusson & Palinesar, 1995). Table 1 indicates nine orientations with the goal of teaching science and the characteristics of instruction for each orientation. Magnusson and colleagues alerted that some teaching strategies, such as the use of investigations, may be the specific to more than one science teaching orientation. They clarified that in such moments what distinguishes a teacher's orientation to teaching science is the *purpose* of employing it not the *use* of it. Magnusson et al. (1999) provided the following example for such situations teachers with a discovery, conceptual change, or guided inquiry orientation night [*sic*] each choose to have students investigate series and parallel circuits, but their planning and enactment of teaching relative to that goal would differ. The teacher with a "discovery" orientation … would expect his students to discover that there are different types of circuits and he would supply the appropriate name for the different types as students discovered them. The purpose of the instructional activity would be for students to discover what they can about electrical phenomena through pursuing their own questions. In contrast, the teacher with a "conceptual change" orientation might begin by having her students talk about their ideas about electricity to have them become aware of their own ideas and differences between their ideas and others, and to give her some sense of some of the misconceptions they have about electricity. … She would expect the students to compare the explanations of one another to identify differences among them, and she might provide the view of scientists for them compare as well with their own explanations. The hope is that students would be persuaded by the greater explanatory power of the scientific view to adopt that view following opportunities to test out and apply their understanding of it (pp. 97-102).

Some researchers preferred other term referring to orientation. For example, Trigwell, Prosser, and Taylor (1994) selected the term *approaches to teaching science*. They identified five different orientations in teaching science: information transmission (a teacher-focused strategy with the intention of transmitting information to students), conceptual acquisition (a teacher-focused strategy with the intention that students acquire the concepts of the discipline), conceptual acquisition (a teacher-student interaction strategy with the intention that students acquire the concepts of the discipline), conceptual development (a student-focused strategy aimed at students developing their conception), and conceptual change (a student-focused strategy aimed at students changing their conceptions). In her PhD studies, Friedrichsen (2002) studied different science teaching orientations and suggested that orientation could be classified under two main categories namely teacher-centered orientations, and orientations based on reform efforts and associated curriculum projects. Considering, possibly comparing, traditional and current reform efforts, Friedrichsen subdivided orientations based on reform efforts and associated curriculum projects into two. She situated process, activity-driven, and discovery orientation as based on the reform efforts of the 1960s; and conceptual change, project based science, inquiry, and guided inquiry orientation as based on contemporary reform efforts and curriculum projects. Some other researchers preferred to simplify these classification. For example, Käpylä, Heikkinen, and Asunta (2009) assigned science teaching orientations into two as constructivist teaching orientation (student-centered teaching methods) and conceptual teaching orientation (teacher-centered methods).

METHOD

The purpose of this study was to explore the orientations preservice science teachers hold in teaching science to middle schoolers and how their beliefs were reflected in their CoRes. Through critically analyzing PSTs' content of CoRes, this study gave the researchers an opportunity to uncover their orientations.

To date various methods have been introduced to measure individuals' science teaching orientations. We preferred to use Magnusson et al.'s (1999) nine orientations to explore participants' orientations. Friedrichsen, Driel, and Abell (2011) identified several critiques of using nine orientations described by Magnusson et al. in different studies. They criticized that although having a week empirical basis, some researchers assigned individuals to one of these nine orientations. They further mentioned that any individual may have more than one orientation depending on the topic or the grade level. During the study, we have taken those critiques into consideration. Besides, as a researchers we further suggest that if previous research has described the context and individuals' orientations in that context, then we believe that it is worth reporting. Having multiple orientation depending on the topic or the grade level does not mean that a teacher could not perform teaching practice based on one of these nine orientations in particular setting. In fact, human behavior is influenced by the setting and activities can best be understood in the setting in which they occur (Fraenkel & Wallen, 1993). Therefore, our aim was twofold: exploring participants' orientation in particular setting, and exploring participants' pool of orientations in multiple context. There are other studies which reported the prevailing orientation of individuals although some features of other orientations was occasionally observed (e.g. Friedrichsen et al., 2008; Schwarz and Gwekwerere, 2007). The evidence presented thus far supports the idea that orientations are not mutually exclusive.

Eleven students studying in teacher education program in elementary science were recruited for this study using a convenience sampling method. All of the participants were senior preservice science teachers (PST). Just over half the sample (58%) was female. For the purpose of exploring participants' orientations, subjects were asked to prepare content representations (CoRe). CoRe originally developed by Loughran, Mulhall, and Berry (2008) to represent conceptualizations of teachers' collective PCK around a specific science topic including "the key content ideas, known alternative conceptions, insightful ways of testing for understanding, known areas of confusion, and ways of framing ideas to support student learning" (p. 1305). CoRe was introduced to the participants at the beginning of the study. Each preservice science teachers prepared six CoRes on a specific science topic. Data analysis were based on how preservice science teachers plan their teaching on specific topics. The way they plan teaching science was used as an indicator for their orientation in that topic.

More specifically, this study seeks to address the following research questions:

- What are the preservice science teachers' orientations around specific science topics?
- Do preservice science teachers' orientations differ depending on the topic?

Table 1: The Goals and the Nature of Instruction Associated with Different Orientations to Teaching Science

ORIENTATION	GOAL OF TEACHING SCIENCE	CHARACTERISTICS OF INSTRUCTION
Process	Help students develop the "science process skills." (e.g., SAPA [Science: A Process Approach]).	Teacher introduces students to the thinking processes employed by scientists to acquire new knowledge. Students engage in activities to develop thinking process and integrated thinking skills.
Academic Rigor	Represent a particular body of knowledge (e.g., chemistry).	Students are challenged with difficult problems and activities. Laboratory work and demonstrations are used to verify science concepts by demonstrating the relationship between particular concepts and phenomena.
Didactic	Transmit the facts of science.	The teacher presents information, generally through lecture or discussion, and questions directed to students are to hold them accountable for knowing the facts produced by science.

Conceptual Change	Facilitate the development of scientific knowledge by confronting students with contexts to explain that challenge their naive conceptions.	Students are pressed for their views about the world and consider the adequacy of alternative explanations. The teacher facilitates discussion and debate necessary to establish valid knowledge claims.
Activity-driven	Have students be active with materials; "hands-on" experiences	Students participate in "hands-on" activities used for verification or discovery. The chosen activities may not be conceptually coherent if teachers do not understand the purpose of particular activities and as a consequence omit or inappropriately modify critical aspects of them.
Discovery	Provide opportunities for students on their own to discover targeted science concepts	Student-centered. Students explore the natural world following their own interests and discover patterns of how the world works during their explorations.
Project-based science	Involve students in investigating solutions to authentic problems.	Project-centered. Teacher and student activity centers around a "driving" question that organizes concepts and principles and drives activities within a topic of study. Through investigation, students develop a series of artifacts (products) that reflect their emerging understandings.
Inquiry	Represent science as inquiry.	Investigation-centered. The teacher supports students in defining and investigating problems, drawing conclusions, and assessing the validity of knowledge from their conclusions.
Guided Inquiry	Constitute a community of learners whose members share responsibility for understanding the physical world, particularly with respect to using the tools of science.	Learning community-centered. The teacher and students participate in defining and investigating problems, determining patterns, inventing and testing explanations, and evaluating the utility and validity of their data and the adequacy of their conclusions. The teacher scaffolds students' efforts to use the material arid intellectual tools of science, toward their independent use of them.

Note: Adapted from Magnusson, S., Krajcik, J., and Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching.

FINDINGS

During the analysis of CoRe, two authors studied independently to evaluate participants' orientations toward science teaching. Then, they come together and discussed the dominant orientation of teacher candidates in each particular CoRe. The analysis indicated that there were only small discrepancies in interpretations and they were resolved by negotiation and researchers reached an agreement.

Table 2 presents the results obtained from the analysis of PSTs' CoRe. This table is quite revealing in several ways. First, from the table, it can be seen that by far the greatest percent of total classifiable CoRe (37%) were designed around didactic-based orientation (23 out of 63). Moreover, what is interesting in this table is that nobody could prepare the CoRes based on conceptual change and activity-driven instructional approaches. Similarly, only three CoRes were organized based on process approach. Another interesting finding was that the researcher neither individually nor as a group could decide three CoRes to be compatible with any of these nine orientations.

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In Table 3 we have tabulated each PSTs' CoRes based on topics. It is apparent from this table that all PSTs hold multiple orientation. In fact, some preservice teacher designed lesson in the same topic based on different orientations. For example, PST 1 prepared three lesson plan about the different objective of the topic *absorption of light*. In the first CoRe, his dominant orientation was guided inquiry while the leading orientation in the second CoRe was academic rigor. The third CoRe of PST 1, however, was based on Project-based science. Alike, PST 2 prepared 6 CoRes during the course of the study. Her fourth and fifth CoRes were about density. Her science teaching orientations in fourth and fifth CoRes were academic rigor and didactic respectively.

Another interesting finding was that all PSTs prepared her/his CoRes based on didactic science teaching at least one time. Indeed, 5 of 11 PSTs' (PST2, PST3, PST6, PST7 and PST8) orientations in their 3 CoRes (out of 6) were represented the characteristics of didactic teaching in which they focused on transmitting the facts of science through lecture or discussion.

DISCUSSION AND CONCLUSION

This study aimed to investigate preservice science teachers' orientations through CoRes prepared on different science topics. For in-depth exploration, each preservice science teachers were asked to prepare six CoRes. A thorough analysis of CoRes yielded important results for the research on science teaching orientation. First, it was found that a variety of orientations were identified from PSTs' CoRes. They were didactic, academic rigor, inquiry, guided inquiry, discovery, process, project-based. Two orientations, activity-driven and conceptual change, were not identified during data analysis. Among them didactic approach to science teaching was the one most preferred by PSTs. Actually each PST preferred didactic orientation at least one of their six CoRes. The second result found to be important was that each PST was inclined to show a mix of orientations on either same or different topics. This means that PSTs can have multiple orientations as research showed (Nielsen, 2011). This result may be related to the fact that participants of this study prepared CoRes based on objectives in the national science curriculum. Objectives in the curriculum are quite different in terms of cognitive domain. On the one hand, some objectives were related to define science concepts; on the other hand some of them refer to the discovery of science concepts. That is based on the objectives, PSTs shape their orientation. To exemplify, one of the objective was "students can define the sound". For this objective, didactic orientation was used. However, when another objective "students can test the brightness of the lamp in parallel and series circuits" was investigated, it was noticed that academic rigor orientation was dominant. That is we believe that objectives that students should gain at the end of the lessons may serve as an indicator of PSTs' orientation toward science teaching. Therefore it is not unusual to come up with multiple orientations for each PSTs. For a more valid interpretation of this; future studies in which participants were interviewed around this result, should be conducted.

Table 2: Number of CoRe Prepared Based on Specific Science Topic

Instructional Approach	Number of CoRe	Specific Science Topic
Process	1	Weather events
	1	Electrical circuits
	1	Chemical and physical change
Academic Rigor	1	Resistivity
	2	Parallel and series circuits
	1	Sound propagation
	1	Refraction of light
	1	Thermal conductivity
	1	Changes of phase
	1	Homogeneous and heterogeneous mixture
	1	Velocity
	1	Density

	1	Absorption of light
Didactic	1	Conductors and insulators
	1	Resistivity
	1	Rocks and minerals
	1	Fossils
	1	Power plants
	4	Sound
	1	Thermal insulation
	2	The resultant force
	1	Models of the atom
	1	Excretory system
	1	Weather events
	2	Electrical circuits
	1	The reflection of light
	1	Skeletal System
	1	Density
	1	Cell
	1	Circulatory system
	1	Types of teeth
Conceptual Change	0	
Activity-driven	0	
Discovery	1	Simple Machines
	1	Properties of matter
	1	Five senses
	1	Nutrition
Project-based science	1	Erosion and landslides
	1	Simple Machines
	1	Expansion and contraction
	1	Models of the atom
	1	Absorption of light
Inquiry	1	Energy transformation
	1	Shadow formation
	2	The reflection of light
	1	Force and motion
	1	Blood Function and Composition
	1	Respiratory system
	1	The effects of smoking and alcohol on the body
	1	Digestive System
Guided Inquiry	1	Electrical Conductivity
	1	Lenses
	1	Organ transplant
	1	Earthquake
	1	Seasons
	2	Sound Propagation
	1	Absorption of light
Unclear	3	

Note: The data on Table 2 belong to 11 PSTs and each prepared 6 CoRes.

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Table 3: Each Preservice Science Teachers' Orientation on Different Science Topic

Participants	Science Teaching Orientation	Specific Science Topic
PST 1	Guided Inquiry	Absorption of light
	Academic rigor	Absorption of light
	Project-based science	Absorption of light
	Discovery	Nutrition
	Didactic	Types of teeth
	Inquiry	The effects of smoking and alcohol on the body
PST 2	Didactic	Skeletal System
	Process	Chemical and physical change
	Inquiry	Respiratory system
	Academic Rigor	Density
	Didactic	Density
	Didactic	Cell
PST 3	Academic Rigor	Parallel and series circuits
	Didactic	Electrical circuits
	Didactic	The reflection of light
	Didactic	Sound
	Inquiry	The reflection of light
	Guided Inquiry	Sound Propagation
PST 4	Inquiry	Force and motion
	Didactic	The resultant force
	Project-based science	Models of the atom
	Academic rigor	Velocity
	Didactic	Models of the atom
	Process	Weather events
PST 5	Discovery	Properties of matter
	Project-based science	Expansion and contraction
	Academic Rigor	Changes of phase
	Didactic	Sound
	Inquiry	Shadow formation
	Inquiry	The reflection of light
PST 6	Didactic	Thermal insulation
	Project-based science	Simple Machines
	Discovery	Simple Machines
	Inquiry	Energy transformation
	Didactic	Electrical circuits
	Didactic	Power plants
PST 7	Didactic	Conductors and insulators
	Didactic	Resistivity
	Project-based science	Erosion and landslides
	Didactic	Fossils
	Process	Electrical circuits
	Academic Rigor	Resistivity
PST 8	Academic Rigor	Thermal conductivity
	Academic Rigor	Parallel and series circuits
	Didactic	Circulatory system
	Guided Inquiry	Electrical Conductivity
	Didactic	Sound
	Didactic	Excretory system
PST 9	Academic rigor	Homogeneous and heterogeneous mixture
	Academic rigor	Refraction of light
	Didactic	Sound

	Discovery	Five senses
	Guided Inquiry	Earthquake
	Unclear	
PST 10	Guided Inquiry	Lenses
	Guided Inquiry	Sound Propagation
	Didactic	The resultant force
	Guided Inquiry	Seasons
	Inquiry	Blood Function and Composition
	Unclear	
PST 11	Didactic	Weather events
	Didactic	Rocks and minerals
	Inquiry	Digestive System
	Guided Inquiry	Organ transplant
	Academic rigor	Sound propagation
	Unclear	

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