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Teaching Orientations of Freshman Pre-Service Science Teachers

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ABSTRACT

The aim of this exploratory research is to understand teaching orientations of freshman pre-service science teachers and their rationales for those orientations. Through a mixed method, the current study collected quantitative (Pedagogy of Science Teaching Test) and qualitative (semi-structured interviews) data to deepen and analyze the research. The sample of the quantitative part in the study consisted of 143 freshman pre-service science teachers (122 females and 21 males) purposefully drawn from a state university in Turkey. To understand their rationales of their teaching orientation preferences, semi-structured interviews were conducted with fourteen interviewees, who held varying science teaching orientations. The findings of this research showed that the freshman pre-service science teachers had a variety of orientations that were not influenced by their earlier science learning experiences. Also, the results indicated that the orientations were largely related to the freshman pre-service science teachers' conceptions of 'roles of teachers and students, students' grades and nature of subject matter' rather than their immediate experiences as learners. The current study recommends that these conceptions should be adressed in the teacher education programs with appropriate experiences that engage pre-service teachers to critical reflection throughout the teacher education program.

Keywords: PCK, preservice science teachers, teaching orientations.

INTRODUCTION

The goal of science teacher education programs is to develop pre-service teachers' knowledge, skills and values of teaching. The factors affecting teachers' practices in a class are numerous and complex (Harwood, 2006). However, it is well recognized that teachers' science content knowledge and pedagogical knowledge are important for an effective science teaching (Hashweh, 1987; Tobin & Garnett, 1988; Ball & McDiarmid, 1990; Cohran, 1997). Shulman (1986, 1987) accepts pedagogical content knowledge (PCK) as an important teacher knowledge for effective science teaching. Different from teachers' general pedagogical

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knowledge, PCK is conceptualized as a type of unique teacher professional knowledge that lies at the intersection of pedagogical knowledge and subject matter knowledge (Cochran, 1997). It involves "…the ways of representing and formulating the subject that makes it comprehensible to others" (Shulman, 1986, p.9). This formulation of PCK includes three key elements: subject matter knowledge, students' learning difficulties, and conceptions of a specific disciplinary area. Since its original formulation, numerous science education studies have focused on PCK conceptualizations, development of teachers' PCK, and the effect(s) of the PCK on science teaching (Cochran et al., 1993; De Jong, Van Driel, & Verloop, 2005; Fernandez, et al., 1995; Friedrichsen et al., 2011Gess-Newsome & Lederman, 1999; Grossman, 1990; Kaya, 2009; Loughran et al., 2004; Magnusson et al. 1999; Marks, 1990 Shulman, 1987). These studies have suggested that strong disciplinary knowledge or subject matter knowledge does not itself turn into an effective science teaching since teachers need to consider students' learning difficulties and pre-existing conceptions of the content developed through a variety of experiences, including formal instruction. Hence, a variety of instructional strategies, activities and representations specific to the content should be used in an orchestrated manner to develop student understanding.

PCK conceptualizations have evolved over time without any complete agreement on components of PCK and its measurement (Loughran, Muhall & Perry, 2008). Further, PCK conceptualizations include such constructs as curriculum, context, purposes, orientations, and instructional designs and profiles of learners. One critical construct related to PCK is "teaching orientations," which is argued in different contexts with different definitions. For example, Anderson and Smith (1987) firstly define it as "general patterns of thought and behaviour related to science teaching and learning" (p. 99). Magnusson et al.'s (1999) PCK model of 'orientations toward science teaching" component refers to teachers' knowledge and beliefs of goals and purposes of science teaching. In view of Magnusson et al. (1999), the teaching orientation acts as a conceptual tool that guides teachers' decisions of curriculum, instruction and assessment. After an extensive literature review, Friedrichsen, van Driel and Abell (2011) contends that science teaching orientation is a complex set of beliefs comprising of views of science, goals and purposes of science teaching, and beliefs of science teaching and learning (see Figure 1). Furthermore, Friedrichsen, van Driel and Abell (2011), who aligned Magnusson et al.'s (1999) hierarchical PCK model with other PCK components, concur that science teaching orientations go beyond a conceptual tool that filters or shapes the content and development of the other PCK components. This conceptualization puts a substantial emphasis on "orientation toward science teaching" as a critical component of the PCK.

Research suggests that teaching experience is a major source for the development of PCK, which is complex and nonlinear process (van Driel & Berry, 2010). Earlier studies have often investigated experienced teachers' PCK (e.g., Loughran, Mulhall, and Berry 2004) or preservice teachers' development of the PCK (e.g., Nilsson 2008; Nilsson and Loughran 2012). Science teaching orientations, however, have not been widely studied due to the messiness of this construct (Fredrichsen & Dana, 2005). Given Friedrichsen et al.'s (2011) framework of beliefs about science teaching and learning, science orientations can be studied as one element of the PCK.

In a recent study, Boesdorfer and Lorsbach (2014) investigated how an experienced, respected high school teacher's orientation toward science teaching was reflected in her teaching practice in an introductory chemistry course. In this qualitative case study, authors concluded that orientation toward science teaching was an effective tool for understanding experienced teacher's beliefs and practices. They also emphasized that it could be used to improve their teaching practices.

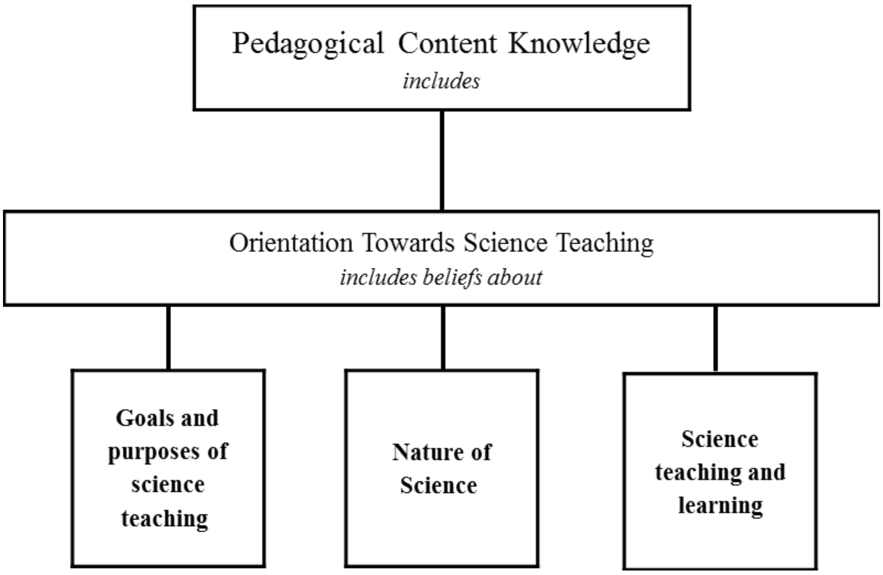


Figure 1. Orientations towards science teaching proposed by Friedrichsen et al (2011)

Friedrichsen (2002) classified the science teaching orientations as teacher-centered (referring to didactic teaching learning activities) and student-centered orientations (referring to discovery based teaching learning activities). Based on the reform movements in science teaching, open and guided inquiries have become a significant part of the latter orientation. Inquiry orientation represents science as inquiry and science teaching as an investigation activity (Magnusson et al. 1999).

Zulfiani and Herlanti (2018) assessed inquiry perceptions and abilities of senior pre-service biology teachers from two different universities in Indonesia. The results of the study indicated that their inquiry perceptions and abilities fell into a high category. Although they had a better understanding of inquiry, all pre-service teachers implemented structured inquiry rather than guided and open inquiries in their plans. Zulfiani and Herlanti (2018) suggest that guided and open inquiry should be integrated into science teacher preparation programs. Similarly, Nasution (2018), who investigated the effect of the inquiry-based teaching on learners' science achievement, found out that the students, who attended the inquiry science lessons, had a better achievement than the conventional group.

Understanding the development of teachers' PCK calls for longitudinal studies that take their backgrounds and stages of their careers into account (Abell, 2008; Davis, 2003). The present study, as the first step of a longitudinal study, aimed to reveal any change in pre-service science teachers' orientations and justifications towards science teaching as well as these preferences over time through their teacher education program at the university. By doing so, the present study would shed light on their preferences about science teaching and contribute to discussions on pre-service teachers' beliefs about teaching practices in terms of teacher-centered and student-centered approaches.

The present research considered teaching orientations as pre-service teachers' preferences of inquiry levels. Specifically, the purpose of this research was to investigate the teaching orientations and beliefs about science teaching/learning of freshman pre-service science students enrolled in a four-year undergraduate program. Therefore, the present study aimed to answer the following research questions:

- What are the freshman pre-service science teachers' orientations towards science teaching?
- How do the freshman pre-service science teachers justify their science teaching orientations?

METHODS

The present study employed the mixed method sequential explanatory design (Creswell et al., 2003). This design gives priority to quantitative data, which is a major component of the design to answer research questions. Later, qualitative data is gathered and analyzed to extend and explain the results obtained from the quantitative data. Since this study focuses on beliefs of freshman pre-service teachers (who have no formal teaching experiences) on one aspect of science teaching orientations, it is important thatthey see themselves making instructional decisions in as many diverse situations as possible. The POSTT instrument, specifically designed to assess science teaching orientations, was used as an appropriate tool to gather quantitative data from a relatively large group participants' beliefs to answer the first research question. Qualitative data were collected through semi-structured interviews that probed purposefully selected participants' answers, and provided data to answer the second research question). These multiple data collection methods were properly aligned with the purpose and process of the research.

a) Sample

The sample of the study included the freshman pre-service science teachers in a state university located in Istanbul. This university accepts students from all over Turkey based on the results of the National University Entrance Examination, which is regularly conducted every year. All high school graduates, who want to study at a university, must sit in the exam. Upon graduation, pre-service science teachers are qualified to teach science in primary schools at grades 5–8.

The Pedagogy of Science Teaching Test (POSTT) was given to 143 freshman pre-service science teachers (122 females and 21 males) at a research oriented university. Of these pre-service science teachers, 14 interviewees (2 males and 12 females), who had various teaching orientations(5 interviewees with teacher-centered orientation; 6 interviewees with student-centered orientation; and 3 interviewees with balanced orientation--no apparent tendencies with approximately equal range of choices), were selected for the individual interview.

b) Data Collection Tools

In order to measure science teachers' preferences about science teaching and related justifications, two data collection tools were used: Pedagogy of Science Teaching Test (Cobern et.al, 2014) and an in-depth interview.

Pedagogy of Science Teaching Test (POSTT) was used to measure pre-service science teachers' beliefs about science teaching and learning (see Cobern et al., 2014 for details). The instrument provides a set of items on science pedagogy for specific teaching scenarios with four possible responses in instructional spectrum labeled as direct didactic, active didactic, guided inquiry, and open inquiry. Spectrum of responses is based on two different epistemological approaches for science teaching: Ausubel's meaningful learning and discovery learning (see Table 1).

Cobern et al. (2014) stress that,

> *These are not to be seen as rigid compartments, but as a useful way of broadly characterizing instructional approaches found in practice. It is likely that a variation exists in exactly how people feel each instructional type should be defined, but the brief descriptions give the basic nature of each and make the distinctions between them clear.*

Beyond this, instructional method details will depend on the particular aspect of instruction involved in each case, and hence on the item at hand. Using items based on this set of basic approaches, science teaching orientations could be identified, responses could potentially be quantified, and teaching orientation profiles obtained (Cobern et. al, 2014, p.6).

Table 1. *Pedagogical foci for item responses and the epistemological spectrum* (Adapted from Cobern et al 2014, p.6)

Fundamental Epistemic Mode	Variant for each mode	Operationalized Description (abbreviated)	
Science presented as factual knowledge…	1 Direct Didactic	Teacher presents and explains science content directly and illustrates with an example or demo without any student activities.	Reception Learning
“Ready-Made-Science”	2 Active Didactic	Teacher presents and explains science content directly. Students engage in verification/confirmation of the science content knowledge presented by teacher.	↓
Science as developed by process of scientific inquiry…	3 Guided Inquiry	Students actively explore phenomenon or idea with teacher guidance toward desired science content.	
“Science-in-the-Making”	4 Open Inquiry	Students actively explore a phenomenon or an idea as they choose…teacher facilitates process but does not prescribe.	Discovery Learning

POSTT instrument include 100 assessment items, which are set in a context of specific science topics and teaching situations. All items were cast in a standard multiple-choice question format. Among the items developed for the POSTT, 16 items were selected to test the participants. Each POSTT version contained a range of science (biology, chemistry, earth science and physics) teaching scenarios in several different grades (from 1 to 8).

The purpose of the interviews was twofold. The first was to investigate prior and present science learning experiences of pre-service science teachers and if those experiences are related to their POSTT responses. Second was to understand their rationalizations of their POSTT responses. To do this, two items from the filled instrument for each individual were specifically selected to probe the rationale behind their decisions during the interviews. Item selection was done in a way that each interviewee explained a choice aligning with their orientation tendency and one that did not align. Additional items were discussed to clarify their perspectives if necessary. During the interview sessions, they were allowed to look at questions that they answered in the POSTT. Then, the questions “Why did you choose the option you selected? Why did you not choose the others?” were asked. Follow-up questions were asked based on their responses. The interviews, which were conducted individually, lasted about 20-40 minutes.

c) Data Analysis

The POSST’s choices are indicative of a specific instructional variant; didactic direct, active direct, guided inquiry and open inquiry. Individual responses to each question and their profile distributions for each preferred pedagogical orientation were identified. For the purpose of organizing the data, the participants, who had 10 or more choices of direct didactic and active didactic, were classified as holding a teacher-centered orientation. Those, who had

10 or more choices of guided inquiry and open inquiry, were classified as a holding student-centered orientation. Choices between 7 and 9 for both didactic and inquiry were classified as holding a balanced orientation. Later, frequencies and percentages of their instructional choices and average tendencies were individually determined. All data were visualized to allow a comparative interpretation.

For qualitative analysis of interview data, all audio-recordings were firstly transcribed in verbatim, and then, exposed to inductively open coding without a priori codes using a constant comparison as an analytic tool (Strauss & Corbin, 1990). Then, frequent open codes were axially coded under general categories. Finally, selective coding was done to reduce the data to core categories that cut across all cases. As a result, 4 major themes representing all participants' responses were developed. Two authors independently coded the qualitative data. All three stages of coding were refined through discussions until the authors agreed upon the analysis. The third researcher checked the overall consistency of analysis after each stage had been completed. Inter-rater consistency and detailed audit trail were utilized to address the validity and reliability of the research.

FINDINGS

a) Nature of Science Learning Experiences

Most of the interviewees (n=12) had quite structured and teacher-directed science learning experiences. They generally described that their learning experiences usually focused on content learning for standardized exams. Laboratory activities were rare and contained either teacher demonstration or cookbook type laboratory activities in which students followed step by step the structured procedures.

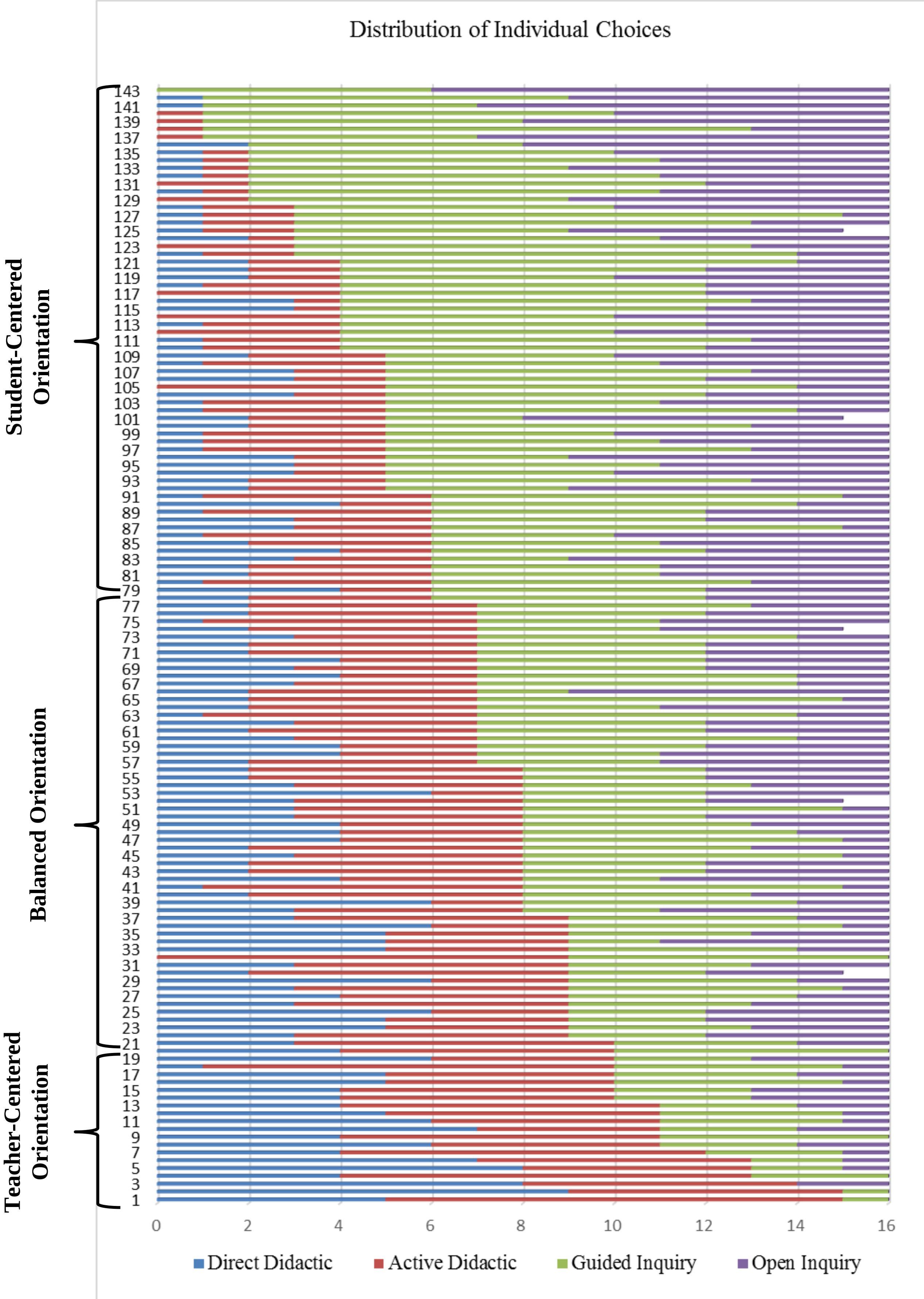
Almost all of the participants stated that they did not attend out of school science experiences (e.g., field trips), or effect of family having a science related profession on their science learning. A few of them depicted that they subscribed to popular science magazines designed for K-12 learners, and were interested in following science-related documentaries. However, they expressed that out of school science experiences had a very little effect on their science learning if not at all.

b) Science Teaching Orientations

The quantitative results showed that all of the participants had multiple teaching orientations ranging from 'no apparent orientation' preference to 'high' preference for the spectrum of orientations (see Table 2). For the purpose of organizing the data, the frequencies of the pre-service science teachers, who had 10 or more choices of direct didactic and active didactic (labeled as holding teacher-centered orientation) were 21 (14,7%). While the frequencies of the pre-service science teachers, who had 10 or more choices of guided inquiry and open inquiry (labeled as having student-centered orientation) were 71 students (49,6%), those, who possessed 7-9 choices for both didactic and inquiry (labeled as holding a balanced orientation) were 51 (35,7%). Overall, their individual results revealed that they tended to have more student-centered teaching orientation even though they had teacher-oriented, content-focused formal science learning experiences.

The cumulative quantitative results analyzed at single POSTT item level (143 participants x 16 Items =2288 - 5 items were coded as missing data) showed that more than half of choices were selected for inquiry orientation (58,5%) as compared to didactic orientations (41,5%) and , least being the direct didactic (Figure 2).

Table 2. *Distribution of the individual choices to the POSST items.*



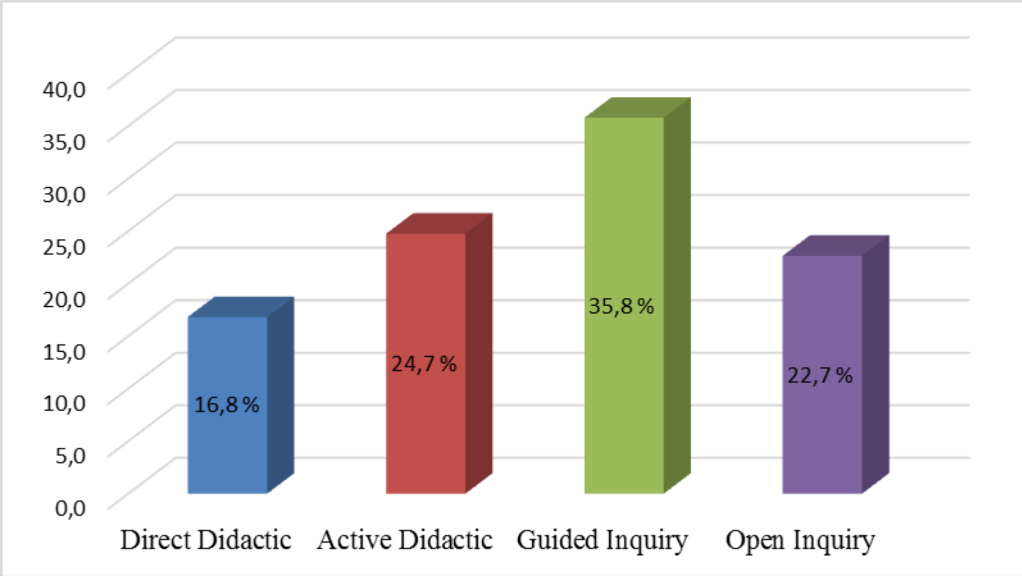


Figure 2. Percentages of the teaching orientations

c) Rationale for Choices

The pre-service science teachers, who were classified 'teacher-centered orientation, student-centered orientation and balanced orientation' based on their responses to the POSTT, were interviewed to provide their reasons for the choices. This procedure purposed to identify the common patterns of their reasons when justifying their responses. That is, this procedure did not intend to match their reasons with science orientations as all participants showed variations considering all items. When participant rationales for their choices were analyzed it was found that participants made their choices largely based on their conceptions of 'roles of teachers, roles of students, student grades levels and nature of subject matter rather than their immediate experiences as learners.

All mentioned that the role of the teacher acted as key element at teaching science. They, who had all three categories of the orientations, stated various degrees of teacher involvement in the teaching and learning processes. These roles were stated on a spectrum from direct knowledge transmission to guided learning process for students.

> If we teach something new to students, we should not let them confuse their minds and show them directly. ... Different ideas might come up and these lead to confusion.(A sample quotation for teacher-centered orientation).

> Teacher should start with an intro by showing the relationship... But, he should not provide knowledge directly. (A sample quotation for balanced orientation).

> Here, direct knowledge is presented. This is not correct for university, high school and even for kindergarten. …There should be assistance with some hints. (A sample quotation for student-centered orientation).

Secondly, most participants viewed the role of the student as an important element for the teaching and learning process. Their explanations for the choices mostly included what the students would be doing under various instructional approaches and how they would feel when engaging in the learning tasks.

> Students should explore... If I explain them directly, they will understand a little. But, if I let them be free, they will explore and I will see what they know and I will interfere when needed (A sample quotation for student-centered orientation).

> I do not think students like writing stories. I imagined myself when I answered this question. I think students want to learn at that moment. They should learn by discussing the issue at that moment. Let's write a story and then discuss... I do not think they will like this method (A sample quotation for balanced orientation).

Thirdly, most participants thought the age of the student as another important factor for the teaching and learning process. They tended to consider that students at earlier grades should have engaged the learning tasks in more teacher-directed activities because of a lack of enough prior knowledge and skills to regulate their own learning.

> Since these are third graders, I wanted teacher to present to the kids first so that they have a sound understanding. (A sample quotation for teacher-centered orientation)

> These kids are first graders. I'd give explanations in general rather than explaining the aim of the experiment. They are not able to understand the goal of the experiment at this age. (A sample quotation for teacher-centered orientation)

> To the third graders, it might be better to explain things on a picture, let them think, and then make them fill out the chart. By this way, I will be able to figure out whether they really understand or just memorize.(A sample quotation for student-centered orientation).

Finally, Participants thought that inherent complexity of the subject matter knowledge also influenced their teaching preferences. In such cases, more teacher-centered approaches or varied methods needed to reach the objectives of the lessons.

> It is not important to make students discuss on the chart (food webs). Teacher should show the relationships on the chart. This subject is too open-ended; students might conclude something wrong.(A sample quotation for balanced orientation)

> I, myself, hardly understand about shadows. It is better to make use of both visualization and experimentation. (A sample quotation for teacher-centered orientation)

DISCUSSION and CONCLUSION

The present study investigated the freshman pre-service science teachers' science teaching orientations before taking any science pedagogy content. This research is the first-step of a longitudinal study monitoring any change and progress of science teaching orientations through a science teacher education program in a research oriented university located in Turkey. Describing their profiles, determining their teaching orientations, and understanding their rationales for the choices among different orientations were the initial aims of this research.

The interviewees stated that almost all of them had structured and teacher-directed science learning experiences. This seems to have highly reflected the features of the science education that they had attended at their primary and secondary school years in Turkey (Kizilaslan, Sozbilir, & Yasar 2012). Hence, based on the experiences that they had as learners of science, it was reasonable to expect that most of them might prefer didactic type because teachers tend to teach as they were taught (Marshall, 1991). However, the present study found that they preferred various teaching orientations. Surprisingly, pre-service teachers had more student-centered orientation than the teacher-centered orientation. This finding is consistent with the earlier studies suggesting that both pre and in-service science teachers hold multiple teaching orientations that can be utilized differentially based on contextual factors that deemed important by the teachers (Friedrichsen et al., 2011). Moreover, some participants of present study explicitly stated that they rarely experienced classroom experiments, field trips, and different types of science learning activities but were eager to utilize such practices in their teaching careers. So, their immediate experiences as learners had much less effect on their teaching orientations than expected. Rather, their orientations are based on broad categories of roles of both teacher and learner in the learning process, their conceptions about students' developmental level both at knowledge and skill level and the nature of the material to be learned.

These categories seem to be early structures of the PCK, but identifies to some extent: a) who should be doing what in learning environment, b) what students can understand and do, and c) inherent complexity of the material to be learned. Each of these elements related to the learning environment are used by participants to justify their preference of either teacher- or student-centered practice during teaching learning process. As expected, they did not refer to the instructional strategies, but made specific comments about appropriateness of the learning activities offered for the choices and related them with inherent difficulty of the subject matter knowledge and students' developmental levels. This again seems to have been an indication of their attempts to coordinate content, activities and learners with each other. These PCK elements need to be further developed and aligned through the research based knowledge and practices in teacher education programs. Such an approach is in a parallel with earlier learning researches underlining the importance of initial conceptions (Posner, Strike, Hewson, & Gertzog, 1982).

One of the major discussions about the teaching orientations is about effectiveness of the teacher-centered (i.e., didactic methods) and student-centered practices (e.g., inquiry-based, problem-based, and collaborative methods). Science education curricula have emphasized the student-centered practices and encourage teachers to use guided or open inquiry in their classrooms (NGSS, 2013, MEB, 2017). Moreover, constructivism, in which the learner constructs his learning based on his experiences, is an ideal approach to teach science (Yeany, 1991). On the other hand, Mugaloglu (2014) discusses the problems of constructivism in a science class referring to potential outcomes of social negotiation in the classroom. In addition, Kirschneret (2006) argues that the student-centered practices may lead to cognitive overload. Briefly, it is not an easy task to reach a definite conclusion for the question; "Which of the teacher-centered or student-centered practices is the best one to teach science?" Since teachers may have different preferences and beliefs, it is important to understand their beliefs of the teacher-centered or student-centered teaching practices/approaches. Indeed, the relevant literature acknowledges the importance of the teachers' beliefs about the teaching practices in that their beliefs are considered as a central component of the PCK (Nielsen, 2011).

Suggestions

Because this research involved in a teacher education institution, generalizability of the results may be somewhat questionable. Further research needs to be conducted within varied contexts of the science teacher education to find out whhether or not similar observations are made.

As this research was an initial exploratory study, future studies should also investigate how the identified elements of the PCK interact with one another and how the pre-service science teachers use them to justify the teaching orientations.

Teacher education programs should seriously consider pre-service teachers’ pre-existing knowledge of the teaching and learning process to challenge them and gradually develop the elements of the PCK. Such attempts call for a longitudinal or a developmental study.

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