Educational Policy Analysis and Strategic Research, V 15, N 1, 2020

Science Methods Course Influence on Pedagogical Orientations of Pre-Service Science Teachers

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Abstract

The main purpose of the study is to gain insight on to what extent taking a science methods course correlated with the science teaching pedagogical preferences of pre-service science teachers. The study recruited twenty K-8 teacher education students enrolled in lower division science courses at a large American public university, some of whom had completed a science methods course and some not. A sequential exploratory mixed-methods design involving both quantitative and qualitative parts was used. The quantitative data were collected using the POSTT assessment instrument to identify pedagogical orientations profiles of the participants. A subset of students was subsequently interviewed so that they could explain their responses to the POSTT items. The data points out that many participants whether they had taken a methods course or note tended toward an inquiry science teaching orientation. When participants chose similar instructional preferences, however, their reasons often varied. The data indicated that students having taken a methods course think more broadly about factors that should influence choices of instructional practice (e.g., grade level, prior knowledge, interest areas). The findings suggest that a science methods course can have a positive influence on pre-service teachers with respect to the development of an inquiry science teaching orientation. The POSTT items have potential use within science methods courses for the formative assessment of pre-service teachers' orientations toward science instruction.

Keywords: Pedagogical orientation, preservice science teacher education, science methods course

DOI: 10.29329/epasr.2020.236.7

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Introduction

Implementing successful science instruction to teach science for conceptual understanding is demanding. Pre-service science teachers should learn to combine science content knowledge with science pedagogical knowledge such that they develop an appropriate science teaching orientation. Primary teacher education programs worldwide typically include at least one science methods course that will have many topics with the goal that pre-service teachers learn effective science pedagogy (Abell, Appleton, and Hanuscin, 2010). There are many approaches to the teaching of science and so the science methods course not only helps pre-service science teachers learn about the differences between effective and ineffective science teaching, but also about the many best practices of teaching science. Most methods courses promote student-centered pedagogies, but pre-service teachers may have orientations toward science teaching that range from teacher-centered (traditional) to student-centered (constructivist), from direct instruction to instruction through open discovery (Chan and Elliott, 2004; Hewson, 2007). What the science education community typically expects is that the science methods course leads students to develop more student-centered, inquiry orientations toward science teaching (NRC, 2012; NGSS, 2013).

Theoretical Framework

The theoretical framework for this study was drawn from Shulman's (1986, 1987) work on Pedagogical Content Knowledge (PCK) as extended by Grossman (1990) and Magnusson, Krajcik, and Borko (1999) to include teaching orientations. PCK refers to content specific pedagogical knowledge as opposed to knowledge about general instructional strategies. The modified PCK/teaching orientations model involves nine teaching orientations: didactic, academic rigor, process, activity-driven, discovery, conceptual change, project-based science, inquiry, and guided inquiry (Magnusson et al., 1999). Later, Friedrichsen (2002) classified these orientations under the two main categories: teacher-centered orientations (didactic and academic rigor) and orientations based on reform efforts (process, activity-driven, and discovery) and associated curriculum projects (conceptual change, project-based science, inquiry, and guided inquiry). Cobern, Schuster, Adams, Skjold, Muğaloğlu, Bentz, and Sparks (2014), having a specific interest in the teaching of science content, developed an assessment device that borrowed from the concepts of PCK and Ausubel's theory of meaningful learning (Ausubel et al., 1986) to develop the idea of a Science Teaching Orientation based on a Science Teaching Orientation Spectrum: didactic direct, direct active, guided inquiry, and open discovery. With respect to this spectrum and the concept of a Science Teaching Orientation, Cobern et al. (2014) reported the development and validation of a science teaching assessment instrument called the Pedagogy of Science Teaching Test (POSTT)[1]. The POSTT items are intended to

[1] For more details concerning validity of the instrument see (Schuster et al., 2007).

represent instruction for meaningful learning ranging from direct to inquiry instruction as defined below (Cobern et al., 2014, p.2270):

I. Didactic Direct (DD): The teacher presents the science concept or principle directly and explains it. The teacher illustrates with an example or demonstration. No student activities, but the teacher takes student questions and answers them or clarifies.

II. Direct Active (DA): Same as the direct exposition above initially, but this is followed by a student activity designed to demonstrate the presented science concept.

III. Guided Inquiry (GI): Topics are approached by student exploration of a phenomenon or idea, with the teacher guiding them toward the desired science concept or principle arising from the activity. The teacher may explain further and give examples to consolidate. Questions are dealt with by discussion.

IV. Open Discovery (OD): Instruction is minimally guided by the teacher. Students are free to explore a phenomenon or idea in any way they wish, and to devise ways of doing so.

The first two instructional strategies refer to direct-based learning and second two instructional strategies refer to inquiry-based learning. Each POSTT item presents a classroom vignette describing a specific science topic in a realistic K-8 science teaching context. Each vignette is followed by possible responses ranging from direct instruction through guided inquiry to discovery learning as mentioned above. The items have a multiple-choice format with four responses representing set teaching strategies. An item example from POSTT survey is provided in the Appendix (see Appendix1). The responses from several POSTT items are compiled as a profile, in the form of a histogram, with the Science Teaching Orientation Spectrum forming the x-axis and participant response frequency the y-axis (See Figure 1 in Findings). These profiles are indicative of the person's science teaching orientation. Based on such profiles, the study reported in this paper employed POSTT items to address two research questions:

1. What is the range of pedagogical preferences among pre-service science teachers who have taken a science methods course and who have not?

2. What reasons do pre-service science teachers give for their pedagogical preferences?

2a. What are the between-group similarities?

2b. What are the between-group differences?

Methodology

Research Design

Participants responded to selected eight items from the Pedagogy of Science Teaching Test (POSTT) with each participant's responses summarized as a pedagogical preference profile. These POSTT items were selected from amongst 100 items. These eight items decided to apply in order to involve primary school grade levels and the content of the science curriculum. The qualitative data were subsequently collected through semi-structured interviews with a targeted subset of participants to help interpret their POSTT survey results. Audio recordings of the interviews were transcribed and coded by the authors. Thus, the study used a sequential explanatory mixed-methods design involving both quantitative and qualitative data. The qualitative and quantitative data formed an integrated database (Creswell & Plano Clark, 2007). In our use of this approach, we report quantitative statistics in support of qualitative quotes from the database. We also explain and interpret quantitative results by analyzing follow-up qualitative data (Creswell, 2014, p.211).

Research Participants

Twenty pre-service, K-8 teacher education students enrolled in three lower division science courses at a large American public university participated in the study. Thirteen of these had not yet taken a science methods course and seven had. The participants completed the POSTT survey online using a Qualtrics survey software program. Subsequently, participants were invited by email to attend follow-up interviews. The science methods course taken by students at this university is typical of such courses. A primary course aim is for students to develop science pedagogical content knowledge for student-centered science instruction in elementary and middle school science classrooms.

Data Collection Procedures

To address the first research question, the participants took the POSTT assessment instrument. The participants were instructed to read each POSTT item vignette and evaluate the teaching in the vignette by choosing among the responses listed after each item (see Appendix 1 for the example of POSTT item). In addition, a blank box was placed under each POSTT item so that the participants could share reasons or comments for their instructional choices. A profile was constructed for each participant.

To address the second research question, a subset of four participants were subsequently interviewed. Two had taken a methods course and two had not. The interviewees were purposely selected so that each interviewee who had taken the methods course was matched with one who had not. Two interviewees were matched for having given similar profiles and similar responses to the same POSTT items. Conversely, two interviewees (one who had taken the methods course and one who had not) were matched having different profiles and quite different responses (direct vs inquiry) to the same items.

During the interviews, participants were shown their own POSTT responses and asked questions about their responses. The researcher probed for explanations illuminating why a participant would prefer one teaching strategy instead of another. Referring to the POSTT items, an interview concluded by asking the interviewee for any additional comments on how he or she would teach any of the science lessons (see interview protocol in Appendix 2). The length of the interviews ranged from 20 to 30 minutes. Interviews were audio recorded and the records were transcribed for analysis. The second author conducted an independent validation of the coding. Themes in response to the research question were derived from the codes.

Data Analysis

Figure 1 below shows the profiles for each participant. The audio recorded interviews were transcribed and coded using standard techniques to identify reasons interviewees had for choosing similar or dissimilar instructional preferences in response to different instructional vignettes. The coding of each transcript was reviewed and compared until an agreement was reached with the second investigator (to secure inter-coder reliability). Codes were developed into categories, and finally merged to generate themes addressing the second research question. The first investigator performed all the initial data analyses and interpretation. The second investigator conducted independent analyses. The analyses were discussed until consensus was reached.

Findings

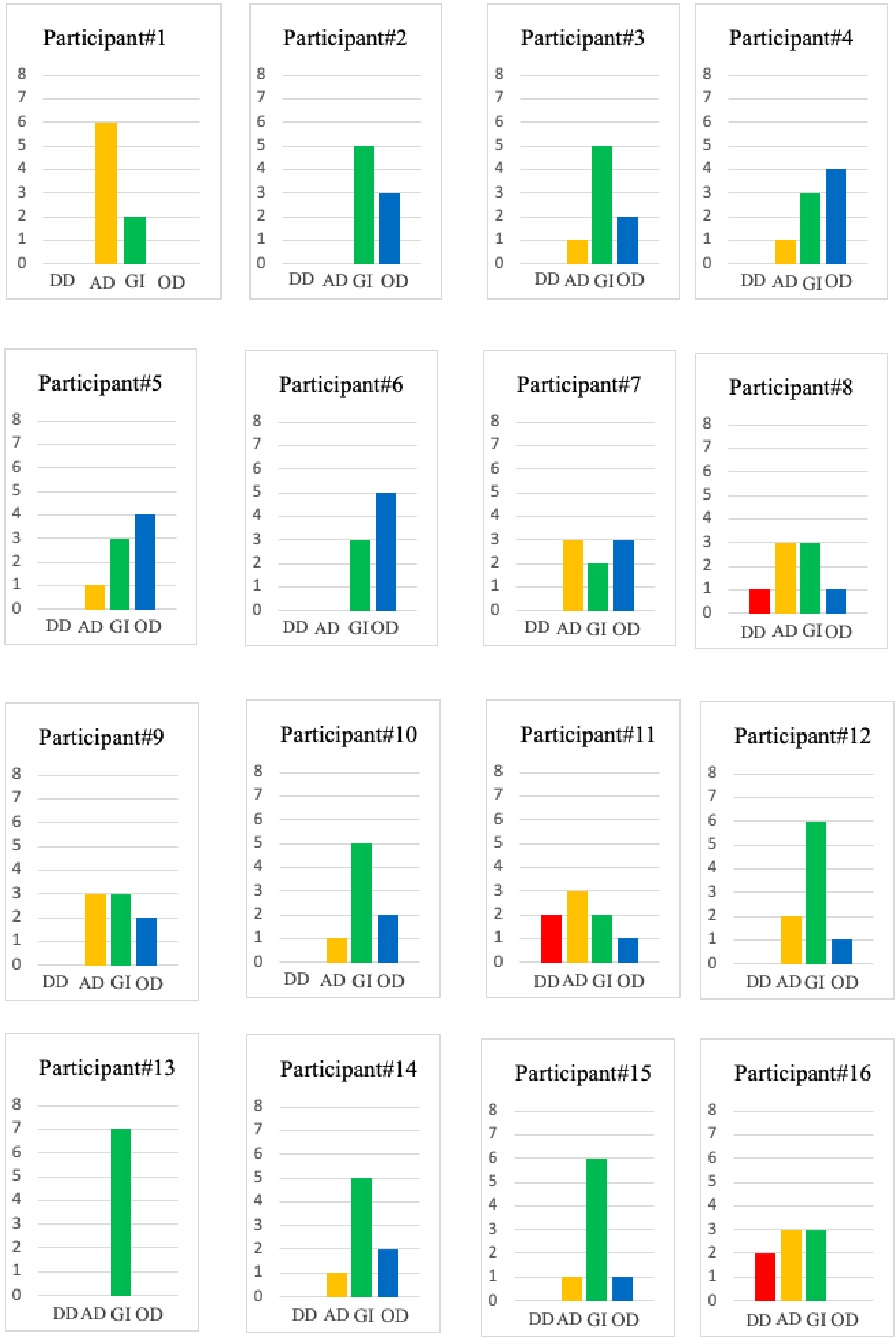
Our research first asked about the range of pedagogical preferences among pre-service science teachers who have taken a science methods course and who have not. The findings in response to this research question are summarized in Tables 1, Table 2 and Figure 1 below. The participants who had not taken a methods course used the full range of the Science Teaching Orientation Spectrum. The participants who had taken a methods course used much of the Spectrum, but not Didactic Direct. Fourteen of 20 participants favored some form of inquiry whether or not they had taken a methods course. The Guided Inquiry and Open Discovery approaches were chosen more frequently than the Didactic Direct and Direct Active approaches. The profiles of the participants indicated that those who had not taken the science methods course were more likely to choose a direct instruction response than were the participants who had. However, the characteristics of the response distribution for all the participants showed a tendency to prefer inquiry-based instructional preferences (111 of 160) rather than direct instructional preferences (49 of 160). Especially guided inquiry was chosen because almost half of the responses were this pedagogical instruction (76 of 160).

Table 1. Instructional Preferences of the Participants

Items								
Participant	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
P1	DA	DA	DA	GI	GI	DA	DA	DA
P2	GI	OD	GI	OD	GI	GI	OD	GI
P3	DA	OD	GI	OD	GI	GI	GI	GI
P4	DA	OD	GI	GI	GI	OD	OD	OD
P5	OD	DA	GI	OD	GI	GI	OD	OD
P6	GI	GI	GI	OD	OD	OD	OD	OD
P7	DA	OD	OD	OD	GI	GI	DA	DA
P8	DA	DA	DA	GI	GI	GI	DD	OD
P9	DA	DA	OD	GI	GI	GI	DA	OD
P10	DA	OD	GI	GI	GI	GI	GI	OD
P11	DA	OD	GI	DA	GI	DD	DD	DA
P12	GI	GI	GI	GI	GI	DA	DA	GI
P13	GI	OD	GI	GI	GI	GI	GI	GI
P14	DA	OD	GI	GI	GI	GI	GI	OD
P15	GI	GI	OD	GI	GI	GI	DA	GI
P16	DD	DA	DD	GI	DA	GI	GI	DA
P17	DA	GI	GI	GI	GI	GI	GI	OD
P18	DD	DA	GI	DA	GI	DD	DA	DA
P19	DA	OD	GI	GI	GI	OD	DA	OD
P20	DD	DD	DD	DD	GI	GI	DD	DD

Table 2. Aggregated item response for each participant

Participant	Direct Didactic	Direct Active	Guided Inquiry	Open Discovery	Science Methods Course
P1	0	6	2	0	No
P2	0	0	5	3	No
P3	0	1	5	2	No
P4	0	1	3	4	Yes
P5	0	1	3	4	No
P6	0	0	3	5	Yes
P7	0	3	2	3	Yes
P8	1	3	3	1	No
P9	0	3	3	2	No
P10	0	1	5	2	No
P11	2	3	2	1	No
P12	0	2	6	0	Yes
P13	0	0	7	1	Yes
P14	0	1	5	2	No
P15	0	1	6	1	Yes
P16	2	3	3	0	No
P17	0	1	6	1	Yes
P18	2	4	2	0	No
P19	0	2	3	3	No
P20	6	0	2	0	No
Total (n=160)	13	36	76	35	---


Participant#1
8
7
6
5
4
3
2
1
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DD AD GI OD
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Participant#4
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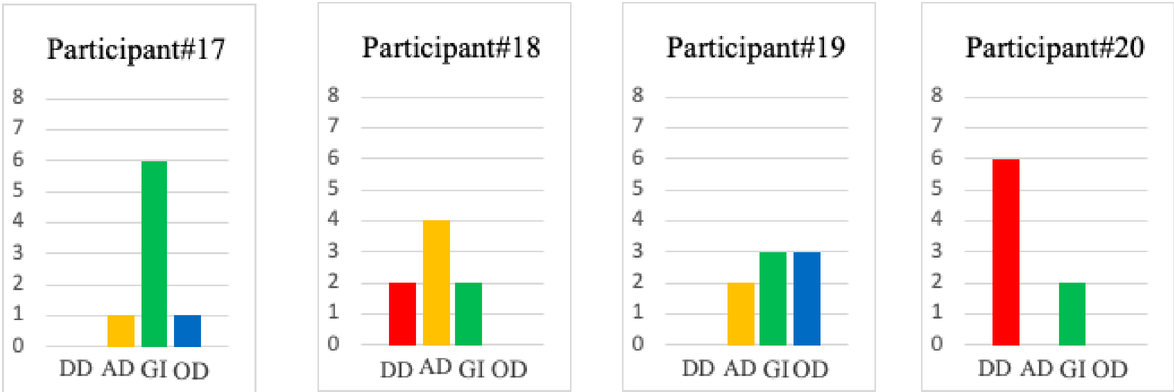

Figure 1. Item response histograms for each participant

The second question we asked was about the reasons participants had for their pedagogical preferences. We addressed this research question by comparing the pedagogical reasoning given by two participants who made the same pedagogical choice on a particular item (between-groups similarities), and the pedagogical reasoning given by two participants who made different choices on a particular item (between-groups differences).

Between-group Similarities

Item 1 is about a 6^{th} grade frog dissection lesson. Participant 1 (who had not taken the methods course) and Participant 7 (who had) both chose the DA response: the dissection should be used as a '*follow-up step-by-step student activity after Mr. Goodchild explains exactly what students will need to notice about the frog anatomy.*' For Participant 1, teacher guidance was clearly important noting that rather than beginning with the activity:

"[the students need] a little bit of guidance. Then, they dissect and just the teacher is kind of there to just help them or explain if they have a confusion about what they saw." (P1$_{\text{Interview, Item1}}$)

Participant 1 also suggested that the teacher:

"…could pass out a diagram worksheet and get student participation with explaining [or] filling in the parts of the frog anatomy. Then they can do the lab by looking at their sheets and comparing [the] diagram info with the real thing…" (P1$_{\text{Interview, Item1}}$)

Participant 1 noted the importance of the teacher's role commenting that,

"…giving them a frog and having them open it. It is kind of leaving them a little bit too blind." (P1$_{\text{Interview, Item1}}$)

Reflecting on her own educational experiences, Participant 1 commented that:

"I have been in multiple classes where they hand me stuff and… OK, what do they even want me to do with this? I think it just leaves you a little bit blind. Yes, it allows you to be creative I guess, but if you really have no idea what is going on it leads to a lot of confusion and I think a lot of waste of time in education, when there could be just a quick 5-minute discussion of the whole class, so everybody is on same page…” ($P1_{Interview}$)

As important as is the teacher, Participant 1 also noted the importance of student activity and limitations on direct instruction.

“I don’t like teacher led discussion… students should kind of figure it out after they have initially seen what the teacher told them in the beginning. The teacher gives them a little bit of guidance.” ($P1_{Interview}$)

“[the teacher] doing all the explaining isn’t too appropriate.” ($P1_{Interview}$)

“[the students] start… like they formulate some questions. I kind of like that and just a little bit… teacher-driven, but kind of letting them, answer their own questions through experiments and stuff…” ($P1_{Interview}$)

As noted, Participant 1 had not taken the science methods course but she had taken several science content courses designed for K-8 pre-service teachers. Her occasional comments about these courses suggest that they may have influenced her ideas about the importance of teacher direct instruction coupled with student activity. Across the eight items, Participant 1 chose the DA response six times and the GI response twice.

Although Participant 7 also chose the DA response for Item 1, her reasons were quite different and indicated the influence of her science methods course. Participant 7 specifically used the word ‘*inquiry’* and commented several times on the importance of student involvement in the lesson. For example:

“I think to me inquiry-based means getting the students involved as much as possible by doing the labs, allowing them to do the labs themselves… hands-on stuff, instead of just writing it down on the board and having them copy it or just lecturing to them. And then, I mean I would like to be able to do it with you know trying to have many activities and labs as possible… try to get them involved, get them out of their seats, get them doing hands-on activities as much possible in the classroom.” ($P7_{Interview}$)

Across the eight items, Participant 7 chose the DA response three times while choosing inquiry-oriented responses five times. The frog dissection item, however, was one of the items where she preferred the DA response over an inquiry-oriented response. She reasoned that the students would not have sufficient prior knowledge for a less direct instruction lesson to be effective.

“… if you are going to have [the students] go through and dissect a frog that is great inquiry with them involved… but I… don’t think you are going in blind, not really knowing what they are dissecting. So, I think after you teach and explain the different parts of the frog or anatomy that the students need to know. Then I think they can go through and dissect the frog with at least some background, of what they are doing." ($P7_{Interview, Item1}$)

"I feel like [the students] wouldn't really know what they were looking at if they haven't really learned about it. If they have had background knowledge… they know [what] they are looking at." ($P7_{Interview, Item1}$)

"Once students have learned about the anatomy of the frog, they can dissect one to get a better understanding of the anatomy. It's a good idea to give them some information before dissecting so they have some idea what they're looking at." ($P7_{Interview, Item1}$)

Participants 1 and 7 appear to agree that the inquiry-oriented responses for Item 1 are too '*blind*.' They both use this word suggesting that they both think that for the lesson to be successful the students need more background knowledge. Unlike Participant 1, however, Participant 7 gives evidence of knowing more about pedagogy in that she specifically speaks of inquiry instruction but never suggests that a 'teacher-driven' lesson might be appropriate.

Item 5 is about an 8th grade light reflection lesson. Participant 1 (who had not taken the methods course) and Participant 7 (who had) both chose the GI response:

"The light reflection should be investigated by students through posing a question about reflection. Then, the students should experiment and discuss about their findings. Last, the lesson should be completed by giving a summary of the law of reflection." (Item5)

For the light reflection lesson, Participant 1 underlined the importance of student exploration instead of memorization. She approved of the fact that:

"…the teacher gave a question about reflection and they were able to explore' and that, …they were given multiple resources to explore…" ($P1_{Interview, Item5}$)

However, Participant 1 also suggested that the teacher should guide students for better understanding. Referring to the scenario, Participant 1 commented approvingly that,

"… [the teacher] gave them little bit of guidance then they explored for a while and then she explained what that their findings meant..." ($P1_{Interview, Item5}$)

Participant 1 reasoned that guidance is important because comprehension is important,

"…for improving state test score of the students…" ($P1_{Interview, Item5}$)

Participant 1 approves of students 'summarizing in their own notes of what they have seen' and the teacher:

"…giving a summary at the end' so that what the students have is 'the teacher's knowledge in combination with they saw." ($P1_{Interview, Item5}$)

Participant 1 seemed to think that the students will not adequately comprehend the lesson without at least some direct instruction. When asked about GI and DA instruction, Participant 1 commented:

> "[GI] seems good! [DA] wouldn't be bad either because I do think the law [of reflection] is important to know. Maybe a combination." ($P1_{\text{Survey Comment}}$)

Participant 1's reasoning about Item 5 is thus similar to her reasoning about Item 1 where her preferred pedagogy was DA.

As with Item 1, Participant 7 also chose the GI response, and again her reasons were different and indicated the influence of her science methods course. For example, Participant 7 reasoned that grade level was an important factor when deciding on an instructional approach. She approved of an inquiry approach:

> "Especially since [the students] are older 8th grade students you can challenge them little bit more with '…' giving them … questions, so they have to do the investigation and they have to come up with reasoning for it. Instead of just giving them, telling them about reflection. First you can allow them to do their own investigations and then you can kind of reflect back on it. Let them tell you what they think and then give them a little summary of reflection." ($P7_{\text{Interview, Item 5}}$)

Whereas with Participant 1 there was some ambiguity as to her preferred pedagogy, Participant 7 clearly prefers inquiry strategies. With respect to teaching science, she commented that:

> "… biggest part is just getting them involved as much as possible and not just giving them worksheets because, I mean that is the way when I was in school that is how and it always was, kind of just do some worksheets and it was more of a special occasion to do a fun lab or do something like that; like that was considered a treat to do something fun like that." ($P7_{\text{Interview}}$)

> "The best way for students to learn is through inquiry." ($P7_{\text{Survey Comment}}$)

Participant 1 made no similar declaration about inquiry instruction.

Item 8 is about a 1st grade magnetism lesson. Participant 1 (who had not taken the methods course) and Participant 7 (who had) both chose the DA response:

> "*The teacher should recall magnets attract materials which contain iron and then small groups of students should use bar magnets to sort the food containers aspect of coining iron or not.*" *(Item8)*

Participant 1 thought that the teacher should remind students of what they had learned about magnetism in a previous lesson. Thus, the students would have 'a reason' for doing the magnetic attraction activity, which she also thought was important. Referring to item 8, she said:

> "I would tell the class to recall the magnet… that magnets attract, so it was something they previously had found. So, even if it something like that, just refresh memories, start them with something not just hand them all the stuff and say find what you find. You know they need a reason why you are doing the experiment… [the students] are really investigating something and he is just giving them the resources to investigate." ($P1_{\text{Interview, Item 8}}$)

The balance between direct instruction and student activity, for Participant 1, appears to be about a perceived need for the students to have a clear goal or rationale for activities:

> "You know the students need a reason why you are doing the experiment." ($P1_{\text{Interview, Item 8}}$)

She thinks that activities need to be goal-driven with teachers giving:

> "A little bit of help… but students are mainly doing [the activity] with the teacher still wrapping stuff up." ($P1_{\text{Interview, Item 8}}$)

> "They have a goal… and they were able to complete that goal with given materials, yet not a direct layout of how to find out." ($P1_{\text{Survey Comments, Item 8}}$)

Like Participant 1, Participant 7 thinks the teacher should give some directions for the activity; but her specific reason is that 'students were 1st graders.' She contrasts 1st and 8th graders:

> "… you just gave them the stuff and said go ahead and with 8th graders you can do that with a little more older students, but for 1st graders you want to let them explore by themselves as much possible but you also don't want to just… you can't expect the 1st graders to be able to do same as 8th grader or 5th grader. …You have to give them a little more structure with the lab or whatever you are doing." ($P7_{\text{Interview, Item 8}}$)

> "With younger students, you need to make sure to let them explore, but you [can't] just give 1st graders a magnet and some materials and expect them to learn much. You have to give them some guidance." ($P7_{\text{Survey Comments Item 8}}$)

Participant 7 drew on her personal experience noting that:

> "I've been in a 1st grade classroom, I mean you wouldn't get a lot done that way because they are not old enough or advanced enough at that point to …" ($P7_{\text{Interview, Item 8}}$)

Summarizing the findings for Research Question 2a, both participant 1 and 7 preferred a more direct instructional approach but one that involved student activities for 1st grade lesson on magnetism. Their preference was for DA instruction. However, they held this preference for different reasons. Although she approved of students having activities to do, Participant 1 preferred DA instruction because it is the teacher's job to provide the students with direction. The activities need to be goal-driven with the goal provided by the teacher. Participant 7, however, who clearly preferred inquiry instruction for Item 5, considered the effect of student age in Item 8. She believed that 1st graders as younger students needed more information before the doing the activity than would 8th graders. As with Item 1, her preference for inquiry instruction is moderated by other factors.

Similar instructional strategy preferences can be held for different reasons. In general, while Participant 1, who had not taken the science methods course, thinks the duty of the teacher is to directly define the knowledge and purpose of the lesson, Participant 7, who had taken the science methods, considered the importance of grade level and science content in choosing same teaching strategy. In addition, even though Participant 1 thinks that student involvement in a lesson is important, she thinks that the teacher needs to lead the activity and finally summarize the lesson. In contrast, Participant 7 maintains the teacher should encourage the students to lead and then summarize their experiment themselves.

Between-group Differences

Item 2 is about a 1st grade Earth rotation lesson. Participant 20 (who had not taken the methods course) chose DD and Participant 17 (who had) chose the GI response. In this item, as Ms. Rice shines a flashlight on a globe, she poses questions to her students to help them understand 'how day and night are related to Earth's rotation.' Participant 20 disagreed with Ms. Rice's indirect teaching approach noting the importance of teacher explanation and demonstration. Drawing on her personal experience she commented that:

> "I like people to explain stuff to me… for instance if you are telling me something I would like you to explain to me what you are trying tell me, so I have a better understanding of what I am doing or make sure I understand exactly what you are saying." (P20$_{\text{Interview}}$)

> "… if you the teacher can show me and explain it and better understanding because I'm more visual I'm a visual learner. So, I have to see everything and then by me seeing it will help me be able to understand and then by someone explaining it to me…" (P20$_{\text{Interview, Item 2}}$)

Reflecting on how she teaches, Participant 20 commented that:

> "…when I teach it is going to be presentation and experience experiments, so they (the students) have that hands-on and visual and be able to understand the concept of what is being taught…" (P20$_{\text{Interview}}$)

> " …how I would teach chemistry is [that] I would start it off with a presentation to explain each one of my topics [then] I would do that experiment… so my students would be able to understand how the topic connects with their experiments." (P20$_{\text{Interview}}$)

Although Participant 20 chose the DD response for Item 2, some of her comments suggest that she values hands-on learning when the hands-on activity follows teacher instruction. For example, she commented that the teacher can catch student interest or curiosity for the experiment by first explaining the experiment:

"So, with an, experiment being able to see how it's done, having hands-on, it will make the experiment more exciting for students… Even though you are going to be explaining you… also will be able to do that experiment and be able to understand how it works… what happens… throughout the experiment you will be see that." ($P20_{Interview}$)

Participant 20 might more accurately be described as a DA teacher.

Unlike Participant 20, Participant 17 approved of Ms. Rice's GI approach though she thought that there could have been more class discussion.

"I think with 1st graders especially like beginning with a lecture saying like trying to explain it before they see it; it really wouldn't grab their attention. But, having, you know a cool activity and like watch this and try to explain how it happens and then saying well this is what was happening. I think is a lot more attention grabbing for 1st graders…" ($P17_{Interview, Item 2}$)

"I wanted to add that (the teacher) should have… a class discussion and then… get their ideas instead of just telling them and then follow that by saying like these are the true things about how day and night happens…" ($P17_{Interview, Item 2}$)

However, because these students were only in 1st grade, Participant 17 thought that some teacher direction was important. She thought that the teacher should guide the students more after the students did the experiment and finally they should summarize their own knowledge. She shared her idea with commented that:

"I think 1st grade students could have fun doing it their own. But, I think they would need a lot of guidance just seeing it, seeing her perform it and then trying to come up with conclusions." ($P17_{Interview, Item 2}$)

From her response to Item 2 and from her comments, Participant 17 appears to favor GI instruction. When asked about her methods course, Participant 17 commented that she had completely changed her ideas about teaching science due to her methods course.

"… [Before taking science methods course] I [would] have been more teacher-based, like worksheets, books and stuff like that. And I didn't enjoy teaching that way. So, it wasn't really my preference, but after having experience with inquiry and using it in like my pre-internship, that is my preference now. I would rather have students explore. And then, kind of harness those ideas than just give them the ideas because it is more fun for them. It is more meaningful. But I can't say that I really had a preference. I just didn't know about inquiry before because as a student I never came across it yet." ($P17_{Interview}$)

Participants 20 and 17 both appear to value hands-on learning. They clearly differ in that Participant 20 values direct instruction leading to hands-on activities, while Participants 17 is much more inquiry-oriented. The difference as reported by Participant 17 is her experience with the science methods course.

Item 7 is about a 7th grade lesson on how a sundial works. Ms. Navetta has a demonstration model with lines marked at various angles and labeled with the hours of the day. As with Item 2, Participant 20 (who had not taken the methods course) chose the Didactic Direct response and Participant 17 (who had) chose the GI response. When asked about how to conduct the sundial lesson, Participant 20 favored direct instruction. She believed that the teacher should explain the sundial to the students before conducting a demonstration. She reasoned that that the students would not be familiar with a sundial.

"I would have to explain to them what a sundial is because most people don't know what sundial is…. For instance, like explaining then showing. And then see how the sundial they can actually see how it actually works." ($\text{P20}_{\text{Interview, Item 7}}$)

As noted under Item 2, Participant 20 refers to herself as a 'visual learner':

"I am a visual learner, so I have to see stuff before actually be able to explain to someone like what it is… you actually have a model, you are showing them a model and then you also explain… so they could see how the sundial indicates the correct time of day coming back." ($\text{P20}_{\text{Interview, Item 7}}$)

Like Participant 20, Participant 17 saw the need for teacher guidance in this lesson; but unlike Participant 20, Participant 17 preferred to use the demonstration in an inquiry fashion.

"… [the teacher] didn't just throw them into a situation that could confuse them, so she explained how to set up the sundial even though she didn't call it that or explain it. And then, she just asked them to come out and observe it every hour. And then, they would find a pattern in that… I would summarize at the end with the whole class have a discussion."($\text{P17}_{\text{Interview, Item 7}}$)

On the other hand, Participant 17 also thought that the OD option was viable commenting that:

"I think [OD] could have been a good option too." ($\text{P17}_{\text{Interview, Item7}}$)

Participant 17 emphasized the importance of making the lesson relevant to the students:

"I would connect it to historical context because they would, that would probably be one of their questions is, 'What is this good for because we all have digital clocks and cell phones now?' But, and then I would talk about I would ask them… when would this not be right. Is the sundial always right or is it, sometimes could it be wrong? Just again, most of my questions I put at the end I would summarize at the end with the whole class have a discussion." ($\text{P17}_{\text{Survey Comment}}$)

As with Item 2, Participants 20 and 17 clearly differ in that Participant 20 places more value on direct instruction, while Participants 17 is much more inquiry-oriented. In Item 7, Participant 17 also demonstrates sensitivity to the importance of helping students see the relevance of a lesson.

Item 8 is about a 1st grade magnetism lesson. The students have already learned that bar magnets attract materials containing iron. For today's lesson Mr. Golden provides a variety of containers made of plastic, aluminum, steel, and glass. In responding as to how they would conduct the lesson, Participant 20 (who had not taken the methods course) chose the DD approach while Participant 17 (who had) chose the OD approach.

Participant 20 chose the response that says: 'I would remind the class that magnets attract materials which contain iron (including most steels), and then show them how the bar magnet attracted the containers made from steel or iron, but not any of the other containers.' For her, it was important that the teacher explain lesson concepts:

> "… [the teacher] is explaining to students what magnets are and what type of iron it contains and then it shows them how magnets contain, attracts the containers and how they are made… [the teacher] gives more general information that they will need to know about magnets." ($\text{P20}_{\text{Interview, Item 8}}$)

When asked about the DA response, she commented that although the DD and DA responses were similar, she preferred the DD response because the DA response:

> "… doesn't give that much information." ($\text{P20}_{\text{Interview, Item 8}}$)

Again, she demonstrates the value she places on direct instruction. When specifically asked about the GI approach, she indicates that with the GI approach the students are not given enough information:

> "And for GI it tells students about the assignment and they have to think about… they don't really get... information about magnets. So, they really basically [are] not told about the assignment. They are not told… what is [a] magnet … [the approach] doesn't give information about that." ($\text{P20}_{\text{Interview, Item 8}}$)

When asked about OD, Participant 20 contrasts DD with OD. For DD, the students were:

> "…basically given… the container so they be able to see and then they will be able to know how the magnet bars contain, attracts to the containers." ($\text{P20}_{\text{Interview, Item 8}}$)

Participant 20 is implying that the teacher is giving information to the students. Whereas for the OD approach:

> "[The students] don't have that. It just like a more hypothesis and no experience like no experience or observation of them being able to see what is going on like visualize." ($P20_{\text{Interview, Item 8}}$)

Apparently Participant 20 views OD as something different from regular science teaching. About the OD approach, she commented that:

> "I thought this was more of like a science hypothesis, more like a science experiment... more like them having hands on and being able to see like which container like they have would be they have the options to see which container holds magnets and which container doesn't." ($P20_{\text{Interview, Item 8}}$)

While Participant 20 values direct instruction, it is not clear what role a science experiment might play in a science lesson.

Participant 17 only had a few comments about Item 8 and they were quite opposite to Participant 20. First, she took note of the grade level:

> "… because they are 1st graders, I don't think that they would know what iron is and, so asking them to find out which ones contain iron or not, you would have to explain that iron is a metal and I just think there is too many… because of their age I think there is too many… too many directions left out. I don't think they would automatically know all, we have to use bar magnets." ($P17_{\text{Interview, Item 8}}$)

At first glance, the above comment might be interpreted to mean that Participant 17 thought the lesson needed more direct instruction. However, she goes on to indicate that she thinks the content is beyond 1st graders but that a lesson allowing students to 'play' with the materials would be appropriate.

> "They would be provided with the bar magnets and the food containers and they would know to play with those two things instead of having to figure out to go get bar magnet on their own." ($P17_{\text{Interview, Item 8}}$)

Participant 17 went on to say that she had:

> "… done a similar lab with 4th graders and they were able to conclude that magnets attract to metals. I had to explain that it is not all metals, just iron." ($P17_{\text{Survey Comment}}$)

For Item 8, it was clear again that Participant 20 values direct instruction while Participant 17 values inquiry instruction. Across eight items, Participant 20 chose the DD response six times and the GI response twice. Across the same eight items, Participant 17 chose the DA response only one time while choosing inquiry-oriented responses seven times. The other difference between the two is the sensitivity that Participant 17 shows toward the importance of grade level when making instructional decisions.

Summarizing the findings for Research Question 2b, Participant 20 and 17 clearly prefer different instructional strategies. Participant 20, who has not taken the science methods course values direct instruction leading to hands-on activities, while Participants 17, who had taken the science methods course, is much more inquiry-oriented. Participant 20 values direct instruction; participant 17 does not. Moreover, Participant 17 thinks that it is important for students to see the relevance of a lesson, and she thinks that grade level must be considered when making instructional decisions. In contrast, Participant 20 did not mention other factors that might be important to consider when making instructional decisions.

In summary Research Question 2, the results suggest that K-8 pre-service teachers who had taken the methods course and who had not taken both similar and dissimilar pedagogical preferences held for different reasons. The participants who had not taken the science methods course often preferred the more teacher-based, direct instruction item responses. These participants appear to think that students obtain knowledge and comprehend the purpose of a lesson better when the teacher provides explanations and explicit instruction. These participants supported the use of hands-on activities but under the control of the teacher. However, some participants who had taken the science methods course also favored more direct instruction in some circumstances. These participants explained that depending on students' prior knowledge, the science content of a lesson, student grade level, and their own teaching experience, a DA instructional approach can be preferable.

Both participant groups preferred the guided-inquiry responses for one or more of eight items. The participants who had taken the methods course used the word 'inquiry' in their explanations for their choices and appeared to understand its meaning. On the other hand, although choosing an inquiry-type response, the participants who had not taken the methods course did not use the word 'inquiry' and they seemed to have difficulties explaining their choice for inquiry-based instructional strategies.

While for some items, the two types of participants responded similarly to the same items, often they did not. The participants who had not taken the methods course were more likely to choose direct instruction responses. In contrast, the participants who had taken the science methods course tended to choose more inquiry-based responses. These participants seemed to focus more on learning processes. They appeared to hold the opinion that inquiry instruction leads to meaningful learning. They also paid more attention to student interest and curiosity, the importance of posing questions, observing, discovery, group discussion, and experiment summary of students.

Discussion

The findings indicate that the participants who had taken a science methods course and those who had not can have both similar and dissimilar instructional preferences. When the preferences are similar, however, the two groups have different reasons for their preferences. Even when both groups prefer the same strategy, the reasoning of the pre-service science teachers who had taken a science methods course involved more factors, such as prior knowledge of the students, science content, and grade level when they decide on a specific instructional strategy. Whether the two groups agree or not on an instructional preference, the reasoning of the pre-service science teachers who had taken the science methods course tended to be more detailed.

Moreover, most of the pre-service science teachers who had taken a science methods course knew the meaning of inquiry instruction. Several pre-service science teachers, when interviewed, said that they had changed their minds about science instruction after taking a science methods course. Their preferences shifted from direct instructional approaches to inquiry instructional approaches. Whereas the interview data indicated that many of the pre-service science teachers who had not taken the science methods course had an inadequate understanding of inquiry-based teaching and tended to choose more direct instructional approaches. Especially, they assume that doing activity refers to inquiry-based teaching and prefer Direct Active instructional approach pretending inquiry instructional approach.

Conclusion

This study was grounded in Shulman's concept of Pedagogical Content Knowledge as augmented by the work of Magnusson et al. (1999) and others. We specifically drew upon the Cobern et al. (2014) theoretical and empirical work that developed the Science Teaching Orientation Spectrum (didactic direct, direct active, guided inquiry, and open discovery) and the POSTT. Our work contributes to previous POSTT research by Asrin, L. (2014), Güven et al. (2015), and Ramnarain and & Schuster (2014). We were able to use the POSTT to address research questions regarding the impact of science methods instruction on preservice K-8 teachers' orientation towards science instruction. Our findings suggest that taking a methods course does make a difference with respect to preservice teachers' orientations toward science teaching approaches aspect of their instructional preferences. However, we also note a significant limitation of our research. Our data is self-report data and it remains to be seen whether what preservice teachers say they will do in the classroom is what they actually do.

On the other hand, Sahingoz (2017) suggests that teacher self-reports can be accurate. We conclude by noting that the POSTT has potential as a formative assessment tool within a science methods course. Using POSTT items could promote classroom discussion about approaches to teaching science and help methods instructors better assess their students' instructional orientation development.

Acknowledgement

The authors would like to thank K-8 pre-service science students who participated in the study for their cooperation.

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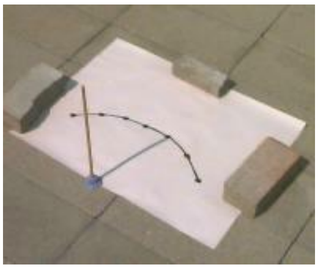
APPENDIX

Appendix 1. An item example from POSTT survey

Sundial

Ms. Navetta is planning a 7th grade lesson on the changing position of the sun in the sky during the day and how this is the basis of a simple 'sundial' to tell time of day. The basic sundial is a simply a vertical stick on a piece of board, and in sunlight the angle of the stick's shadow can be marked on the board. Ms. Navetta also has a larger demonstration model with lines marked at various angles and labeled with hour of day.



Ms. Navetta considers various ways to conduct the lesson. Of those below, which is most similar to how you would teach?

A. Explain how a sundial works related to sun position in the sky. Have each group assemble a basic sundial, using a prepared handout sheet with lines and hour markings. Then take the students outside to try out their sundials and see that they indicate the correct time of day. **(DA)**

B. Do not explain sundials but take the students outside and have each group set up a stick and board. Ask them to brainstorm what this might be useful for, and to expand on their ideas. Have them come back every hour, anticipating that they will mark a series of shadow lines to make a sundial. **(OD)**

C. Explain how a sundial works, in relation to sun position in the sky. Then gather the class outside around the demonstration model, so they can see how the sundial indicates the correct time of day. Come back an hour later to see that the shadow has moved to the next marking.**(DD)**

D. Instead of explaining sundials take the students outside and note the location of the sun in the sky. Have each group set up a stick and board and mark the position of the shadow. Ask them to suggest how this might be used as a 'shadow clock' to tell time of day. Have them come back every hour and mark a new shadow angle, labeling it with the hour, to make a sundial. **(GI)**

Appendix 2. Interview Protocol

1. Could you look at "…" question? Please, explain why did you choose response "…"?
2. Why did you not choose the other responses?
3. How would you teach this science lesson?
4. Do you think taking science methods course affected your teaching strategy preferences? Could you explain it? (for the participants who have taken science methods course)