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Direct or Inquiry? Science Teaching Orientations of Prospective Secondary Science Teachers

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Abstract

Inquiry teaching is advocated in many science curriculum frameworks throughout the world, as it is believed to promote scientific literacy, the main goal of science education. This paper determined the science teaching orientations (STOs) of prospective secondary science teachers (PSSTs) at a Philippine State University, distinguished these STOs by science fields and lesson stages, and compared the STOs by specialization, sex, year level, scholarship, and academic standing. Data were gathered from 63 PSSTs using descriptive and causal-comparative procedures, and their STOs were gauged by their Pedagogy of Science Teaching Test (POSTT) scores. Results revealed that across all lesson stages, and in the two science fields, the PSSTs were significantly more oriented toward inquiry teaching than direct approach. This trend of results is consistent in all sub-groups. Guided inquiry emerged as their most dominant teaching orientation and the didactic direct orientation as the least. Only scholarship and academic standing influenced the PSSTs' STOs. The scholars, and those with high academic standings, were significantly more oriented toward inquiry teaching than their respective counterparts. Such results indicate a bright future for science education as the PSST respondents have manifested stronger inclinations toward the reform-based pedagogical approaches in science.

Introduction

Three kinds of knowledge – content knowledge (CK), pedagogical content knowledge (PCK), and curricular knowledge are crucial for the professional development of prospective teachers (Rozenszajn & Yarden, 2014). Content knowledge includes knowledge of the subject and its organizing structures (Ball et al., 2008). Curricular knowledge is "represented by the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances" (Shulman, 1986).

Pedagogical content knowledge (PCK), arguably the most influential of the three types of knowledge (Ball et al., 2008), has since become a foundation for teaching standards (Hayden & Eades-Baird, 2016). The purpose of PCK is to enhance the understanding of how particular topics, problems, or issues are organized,

represented, and adapted to the diverse interests and abilities of learners (Shulman, 1986). PCK is the amalgamation of knowledge of content and pedagogy that is central to the knowledge needed for teaching. In the words of Shulman (1987), "Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from the pedagogue."

Research has identified some constructs associated with PCK conceptualizations (Güven et al., 2019) – including curriculum, context, purposes, orientations, and instructional designs and profiles of learners. One construct, science orientations, is an important component of PCK. While science orientations were ill-defined in literature, this study adopts the definition of Magnusson et al. (1999). Magnusson and colleagues define science teaching orientation (STO) as teachers' knowledge and beliefs of the goals and purposes of science teaching.

There is a vast repertoire of STOs that a science teacher can choose from. However, most of these methods are simply variants of two fundamental epistemic modes of (or approaches to) instruction: either some form of direct teaching or some form of inquiry instruction (Cobern et al., 2014). Students either develop science content knowledge in an inquiry-based fashion, using guided explorations, or the science content is presented and explained directly to them. In this study, STOs were described in terms of fundamental epistemic modes (FEM) and specific epistemic modes (SEM).

The choice of fundamental epistemic modes is dependent in part on the goals of education in a particular discipline. Therefore, foremost among the goals of science teacher education is to train teachers on how to teach science for conceptual understanding (Cobern et al., 2014). Moreover, the ability to understand scientific explanations is one of the four major interconnected goals identified by major science teaching reform documents advocated in many countries (National Research Council [NRC], 2011).

Inquiry instruction is defined in the literature in a myriad of ways. However, this paper has adopted Binns and Popp's (2013) definition of inquiry instruction as "a student-centered teaching strategy that focuses on questioning, observations, and data analysis." As a heuristic construct, "inquiry" tends to be used as a generic term rather than referring to any single specific methodology (Chichekian & Shore, 2016).

Inquiry instruction is typically advocated in the national science education standards for an increasing number of countries (National Research Council, 2012; Binns & Popp, 2013; Zulfiani & Herlanti, 2018). This teaching approach has been reported to promote scientific literacy and conceptual understanding among learners (Gormally et al., 2009; Knight & Wood, 2005; Romero-Ariza et al., 2020). Inquiry-based teaching approaches, which are advocated in most state and national science education frameworks, are intended to help students master the principles of science, learn how to do science, and understand the nature of science (Sadeh & Zion, 2009).

In stark contrast with inquiry-based instruction is direct instruction in its various forms. Direct instruction is typically portrayed as teaching-by-telling with passive reception (Thomson & Gregory, 2013; Cavanagh, 2004). However, direct instruction can be structured in such a way that it does not necessarily make the learners passive. Hence, direct instruction comes in two variants – didactic direct and active direct.

Inquiry instruction, on the other hand, may either be guided inquiry or open inquiry. The variation of the two fundamental epistemic modes, their respective variations, and the operationalized description per variant is shown in Table 1.

In the Philippine science education framework, inquiry-based instruction, along with other learner-centered and hands-on-minds-on approaches, are advocated for K-12 Science teaching (Department of Education [DepEd], 2012). Such is the case because the main goal of science education in the country is scientific literacy.

Such a mandate bears important implications for science teacher preparation. It is imperative then that pre-service science teachers must be educated and trained on how to implement inquiry-based instruction in their future classes. While the responsibility could easily be placed on the shoulders of science education professors, science professors should share the burden by modeling, or employing inquiry learning strategies in their science lessons (Buck et al., 2008)

Table 1

Structure of the Elements that Define Science Teaching Orientations

Fundamental epistemic mode	Variant for each mode	Operationalized description
Science presented as factual knowledge... "Ready-Made Science"	1 Didactic Direct	The teacher presents and explains science content directly...illustrates with an example or a demonstration. No student activities.
	2 Active Direct	The teacher presents and explains science content directly...students are actively engaged in verification/confirmation.
Science as developed by the process of scientific inquiry... "Science-in-the-making"	3 Guided Inquiry	Students actively explore phenomena or ideas with teacher guidance toward desired science content.
	4 Open Inquiry	Students actively explore a phenomenon or idea as they choose...teacher facilitates the process but does not prescribe.

One way of preparing pre-service science teachers towards reform and standards-based teaching is to determine their science teaching orientations. It is important to assess the science teaching tendencies of pre-service teachers to have a glimpse of how they will implement inquiry teaching. From these assessments, intervention procedures may be introduced to correct and improve practices that are deemed inappropriate for the goals of reform.

Friedrichsen et al.'s (2011) elaborate framework of beliefs about science teaching and learning has led to the exploration of science teachers' STO as a separate element of PCK. At present, two approaches are commonly used to determine science teachers' STOs. The first approach uses content representations (CoRes), which are interpreted based on Magnusson et al. 's (1999) nine PCK components. The second framework uses the Pedagogy of Science Teaching Test (POSTT) developed by Cobern and his colleagues (2014).

Several studies used the POSTT approach to describe the STOs of pre-service and in-service science teachers. In these studies, STOs tend to vary across type of school (Ramnarain & Schuster, 2014) country (Ramnarain et al., 2016), and level taught (Ladachart, 2019b). However, STOs were independent of subject matter taught (Ladachart, 2019a; 2019b). Also, pre-service (Ladachart, 2019a, 2019b; Güven et al. 2019) and in-service science teachers (Sahingoz, 2017) tend to hold a more eclectic orientation, i.e., they can shift from one orientation to another. Moreover, STOs have negatively correlated with the nature of science conceptualization (Ladachart, 2019a, 2019b).

From the above reviews, one can conclude that research in the STOs of pre-service orientation and in-service science teachers is still wanting in the published literature. Even scarcer are studies of this theme among Filipino science teachers, both pre-service and in-service. This author has yet to see published studies on this topic in the Philippine context. The closest so far to the theme of this present research is the study of David et al. (2015) on Filipino education students' conception of teaching and learning. However, these authors used a self-assessment instrument that allowed the respondents to indicate their agreement with either traditional or constructivist teaching principles. Moreover, the study population did not concentrate on PSST. Hence, this study was conceptualized to contribute to the scarce literature on prospective science teachers' science teaching orientations.

It is important to profile the PSSTs in terms of their science teaching orientations (STO) to provide feedback information on how these PSSTs will soon contribute to the science education reform effort advocated by the nation's science education standards. Also, it might be worthwhile to determine the influence of the PSSTs' specialization, sex, year level, scholarship, and academic standing on these STOs. According to Wigfall and Hall (2010) and Solomon (2012), a

teacher's pedagogical choice can be influenced by sex. The choice of teaching approaches may also depend on the subject matter and the context of teaching (Bates, 2019, Ladachart, 2019b). Hence, the PSSTs' specialization was considered a variable. The three other variables were included for policy recommendations. Specifically, the year level was included as an independent variable to provide insights as to whether or not exposure to more pedagogical courses could influence a prospective teachers' pedagogical choice. Finally, science teaching scholarships and academic standing were also included as independent variables to inform scholarship-awarding bodies and teacher recruitment personnel on the recipients' and teacher applicants' tendencies to implement the science teaching reforms advocated in the Philippines. This study then was undertaken to determine the science teaching orientations (STOs) of prospective secondary science teachers (PSSTs) and to ascertain whether or not these STOs differ according to science fields and lesson stages. It also aims to compare the PSSTs' STOs along specialization, sex, year level, science scholarship, and academic standing.

Methodology

Research Design

This study employed the descriptive and causal-comparative methods of research. The descriptive procedure was specifically used in gauging the PSSTs' science teaching orientation. The causal comparative procedure, on the other hand, was used to compare their teaching orientations by specialization, sex, year level, science scholarship, and academic standing.

Population

Sixty-three PSSTs in a teacher-training college in a state-run higher education institution in Benguet, Philippines, during the academic year 2018-2019 constituted the population of this study. This cohort was chosen as respondents because as future science teachers, they are expected to employ inquiry teaching in their future classes. The case institution was likewise chosen because it offers both physical and biological science specializations, and the number of students specializing in the sciences is relatively larger.

The participants' involvement in the study was strictly voluntary, and their confidentiality and anonymity were ensured using a unique code known only to the researcher. The data were then destroyed at the termination of the study. Table 2 shows the distribution of the research population according to the variables.

According to profiles, more respondents came from the Biological Sciences group (58.73%). It must be clear that this study was conducted before the latest national teacher education curriculum, where science education majors were divided into Biological Sciences and Physical Sciences. Moreover, more females (79.37%) than males responded in the study, echoing the observation that teaching is a female-dominated occupation in the Philippines. According to year levels, Level 3 respondents dominated, while the Level 2 cohorts were the fewest. The level 1 science majors were not included in the study as they are

Table 2

Respondents' Profile (n=63)

Variables	Frequency	%
Specialization		
Biological Sciences	37	58.73
Physical Sciences	26	41.27
Sex		
Males	13	20.63
Females	50	79.37
Year Level		
Year 2	8	12.70
Year 3	32	50.79
Year 4	23	36.51
Science Teaching Scholarship		
Science Teaching Scholars	12	19.05
Non-Science Teaching Scholar	51	80.95
Academic Standing		
Low GPA (above 2.00)	16	25.40
Average GPA (1.86 to 2.00)	26	41.27
High GPA (1.00 to 1.86)	21	33.33

yet to take courses in science teaching methods. Besides, they are part of the new teacher education curriculum where biological and physical sciences are now merged into one specialization.

Of the 63 respondents, 12 (19.05%) availed of science teaching scholarship from the science education institute of the nation's science and technology department. Most of these science teaching scholars are assured of a teaching job after graduation from college. Thus, they are generally the first to employ their held beliefs about teaching and learning. Finally, the respondents were grouped in terms of academic standing based on their present grade-point average (GPA) as low, average, and high GPAs.

Research Instrument

The pre-service teachers' science teaching orientations were gauged based on their responses to the pedagogy of science teaching test (POSTT) developed by Cobern et al., 2014). It took the participant 15 minutes to complete the task. The POSTT is composed of a teaching vignette and a question, followed by a set of four options. Figure 1 illustrates the structure of the POSTT.

A sample of the POSTT involving a lesson on force and motion is shown in the section that follows.

Lesson on Force and Motion

Ms. Brandt is preparing a lesson to introduce her 5th-grade students to the relationship between force and motion, namely that a net force will cause an object to speed up or slow down (Newton's 2nd Law). The classroom has available a loaded wagon to which a pulling force can be applied. Ms. Brandt is considering four different approaches to the lesson.

Thinking about how you would want to teach this lesson, of the following, which one is most similar to what you would do?

A. Write a clear statement of Newton's 2nd Law on the board and explain it carefully to my students. Then I would demonstrate the law by pulling on a loaded wagon with a constant force in front of the class as they observe the motion.

B. Raise the question of what kind of motion results from a constant force. I would then guide my students to explore the question themselves by pulling on a loaded wagon and observing what happens. From the evidence, they would then propose a possible law.

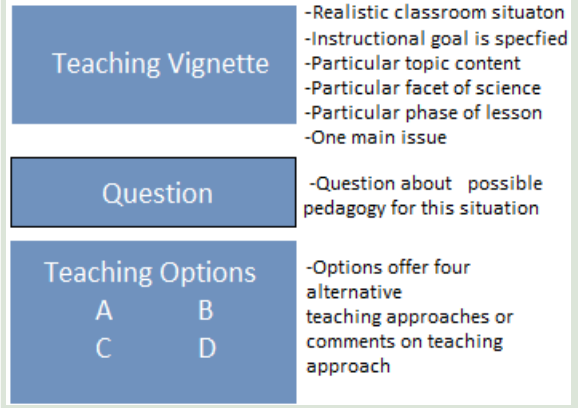
C. Write a clear statement of Newton's 2nd Law on the board and explain it carefully to my students. I would then have the students verify the law by pulling on a loaded wagon themselves and confirming what type of motion results.

D. Raise the question of whether there is any relationship between force and motion. My students would then be free to explore this safely in the lab. Afterward, we would have a class discussion of their findings.

There were 16 items in the POSTT. Each of the three science fields – biological, earth and space, and physical were represented in the construction of the items. The vignettes were also structured so that they represent each of the lesson stages. Table 3 describes the composition of the items in the POSTT.

Figure 1

Structure of the POSTT



Data-Gathering Procedures

The purpose of the study and some ethical procedures were clarified before the POSTT was administered to the 63 PSST respondents. It took them 20 to 30 minutes to accomplish the said instrument. Afterwards, ten respondents were randomly chosen to provide insights into the reasons why they chose a certain teaching orientation. These selected respondents were

Table 3

Structure of POSTT Instruments

Item No.	Science Fields			Science Lesson Stages		
	Earth and Space Science	Life Science	Physical Science	Lesson Beginning	Lesson Proper	Lesson Wrap-up
1		√			√	
2		√				√
3	√			√		
4			√	√		
5			√	√		
6	√					√
7		√		√		
8		√			√	
9		√		√		
10	√				√	
11	√			√		
12			√		√	
13			√	√		
14			√		√	
15			√		√	
16	√					√
Total Number of Items	5	5	6	7	6	3

invited for a 10-minute follow-up interview. Their responses were transcribed and analyzed, and were used to support the quantitative results of this study.

Treatment of Data

Data on STOs were reported in terms of percent (%) instances instead of mean since there are 16 items in the POSTT, and each item was scored as frequencies. Chi-square goodness of fit test was used to determine significant differences between the PSSTs' fundamental epistemic modes (inquiry teaching or direct instruction) within a variable. Meanwhile, the Chi-square test for independence was used to determine significant differences within the respondent variables.

Results and Discussion

Science Teaching Orientations of Prospective Secondary Science Teachers

Looking at the individual STOs of the 63 respondents, 35 (55.56%) hold a strong inquiry orientation, 10 (11.11%) are inclined toward direct teaching, while the remaining 18 (33.33%) tend to have both direct and inquiry teaching orientations (Table 4). One lady respondent chose all inquiry options in the instrument, indicating her avid preference for this pedagogical approach.

In terms of group results, the PSSTs have selected more of the choices that reflected inquiry teaching than those that manifested direct teaching. Overall, the PSSTs chose the inquiry options in 61.91% of the instances, as contrasted

to only 38.09% of instances in the didactic approaches. The goodness of fit test showed that these values are significantly different ($X^2 = 57.143$, $p<.0001$). This result implies that the prospective science teachers participating in this study are conscious of the role of inquiry teaching in promoting active learning and in building scientific literacy. More respondents adhere to the "science-in-the-making" epistemology than to the "ready-made science" view. Further, the result shows that the dominant STOs of future science teachers match the epistemic beliefs advocated in the nation's science education standard, i.e., inquiry teaching, among others. Such a result is reassuring to the nation that at least, the future science educators who responded to this study are naturally predisposed to contribute to the science education reform that its education department is advocating.

PSSTs Reasons for Choosing the Inquiry Mode

When some respondents were probed on their reasons for choosing the inquiry mode over the direct mode, various reasons were provided. One of these reasons pertains to the approach's ability to involve the learners in the learning process. The following are remarks from some of the respondents:

"*I would advocate inquiry approaches because, (in these approaches), (the) students are involved on (sic) the learning process rather than (them being) passive listeners to the teacher,*" PSST 38, Female.

"*Inquiry approaches are better and more suitable methods in teaching because students are more engaged, and their interests are emphasized,*" PSST 3, Female.

"*I believe students learn best when they are actively engaged in testing certain claims once they are hands on (sic) and hearts on (sic) in what they are doing,*" PSSST 15, Male.

Other respondents claim that inquiry teaching tends to appeal to the new generation of learners. A female and male respondents have these words to say:

"*Students nowadays (sic) tend to learn more when there are hands-on activities for them where they can actively take part in the learning process,*" PSST 52, Female.

"*Nowadays, learners become more excited in learning if their interests and methods are considered. Also, learning by themselves become easier because learning resources and equipment are more accessible these days,*" PSST 26, Male.

Finally, some respondents claim that inquiry approaches promote student motivation to learn. Some of the responses are consolidated, viz.:

"*With inquiry teaching, (the) students tend to appreciate themselves and (they) get more motivated if they know that the product they accomplished is through (sic) their efforts to explore and to confirm a certain science content*," PSST 61, Female.

"*They (The students) could further appreciate the essence of what were (sic) taught to them by trying to explore things with the aid of the teacher,*" PSST 43, Male.

The prospective science teachers' predisposition to select inquiry teaching over direct instruction has been reported in a recent article by Sahingoz and Cobern (2020). Using the same instrument to gauge science teaching orientations (POSTT), the author found out that American prospective science teacher respondents tended to prefer inquiry approaches (69.38%) than direct teaching (30.62%).

Inquiry teaching also emerged as the preferred epistemic mode by South African physical science in-service teachers in the work of Ramnarain

Table 4

Science Teaching Orientations (STO) of the Prospective Secondary Science Teachers (PSSTs)

Fundamental Mode epistemic mode	Instances	%
Direct Mode	393 of 1024	38.38
Inquiry Mode	631 of 1024	61.62

and Schuster (2014). Using the POSTT to gauge epistemic modes, the authors found their in-service teacher participants choosing inquiry options (56.71%) more than didactic teaching (43.29%). However, in a duplicate study among Malawian physical science in-service teachers, Ramnarain et al. (2016) noted that the proportion of respondents opting for the inquiry choices did not deviate much from those choosing the didactic modes. In these cohorts of respondents, inquiry teaching was chosen 51.80% of instances, as compared to 48.20% of instances of didactic instruction. Such a result is quite similar to that of Kind (2015) on the dominance (about 50% of the responses) of direct approaches as a pedagogical orientation of pre-service teachers in a UK-based teacher education program. The responses of the participants reflect their "instinct to explain, tell, or show confirmed knowledge", instead of allowing the students to discover and construct knowledge for themselves. Direct teaching is also the pedagogical choice of Tanzanian pre-service teachers in Tarmo (2016). The respondents were observed to adopt transmissive teaching strategies to propagate textbook-based science knowledge, which is not compatible with what is advocated in science reform efforts.

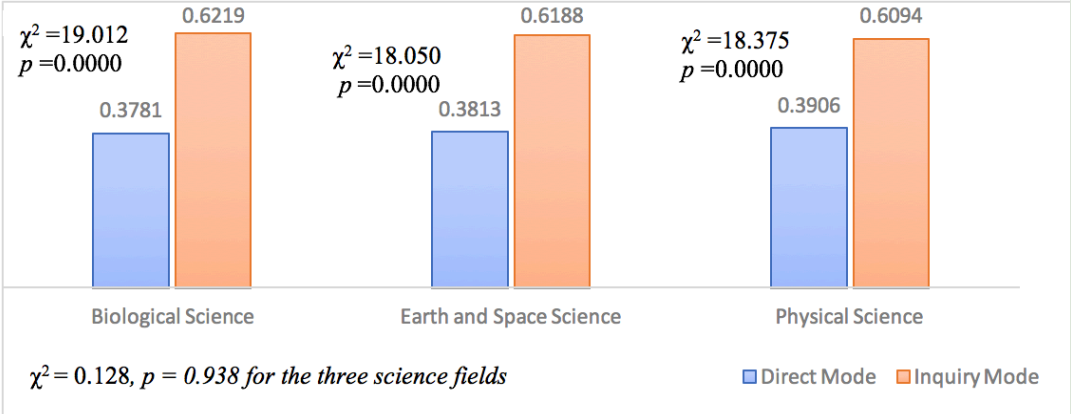
Prospective Secondary Science Teachers' Orientations Along the Three Science Fields

The trends in the PSSTs' FEMs along Biological, Earth and Space, and Physical Sciences were consistent with their overall FEM (Figure 2). In all three science fields, more of the PSSTs chose the inquiry approaches than those depicting direct instructional models. The differences were noted to be significant, with p values all equal to p=.0000. When the PSSTs' FEMs were compared according to science fields, the chi-square test indicated no significant differences (p=.938). Their FEMs are the same, regardless of whether the content to be taught is a biological, earth and space, or physical science concept. This result seems to indicate that the choice of a teaching approach is a character deeply embedded in a teacher's personal teaching philosophy. He or she is firmly resolved to employ either learner-centered or teacher-centered philosophy at all costs, in whatever circumstance he or she is in. Such a result of FEMs' independence with the science field to be taught conforms with the findings of Ladachart (2019) on the science teaching orientations of pre-service science teachers in Thailand.

Further analysis of the results revealed that the PSST respondents tend to favor the inquiry choices in 12 of the 16 items in the POSTT. More respondents opted for the direct teaching choices in two of the POSTT items. These two items were obtained from the Biological Sciences and Physical Sciences fields. The items involve a lesson on how a teacher should teach a lesson on structure and function in animals (Biological Sciences) and the properties of magnets (Physical Sciences). In these items, more respondents chose the options where the teacher carefully explains the concept, then asks the students to apply what they learned. Such teacher procedures depict the direct approach, which is in contrast with the procedures in inquiry

Figure 2

Fundamental Epistemic Modes of the Prospective Secondary Science Teachers Along the Three Science Fields



teaching. Typically, in an inquiry lesson, the students are given time to explore and discover the concept, before the teacher makes clarifications or further explanations.

Moreover, in two Physical Sciences items, the proportion of respondents choosing either inquiry or direct teaching options is more or less balanced. These items are situations in force and motion and light reflection lessons. Finally, the greatest difference in the proportions of respondents choosing either direct or inquiry teaching was in two items in physical science. The two items involve the teaching procedures in the lessons on the behavior of light and shadows and the concept of volume.

Prospective Secondary Science Teachers' Orientations Along the Three Lesson Stages

The trend on the PSSTs' FEM along the three lesson stages is similar to that along the three science fields (Figure 3). In all three lesson stages, more respondents chose the inquiry options than the direct teaching scenarios. Chi-square test showed that observed differences in the proportions of those who chose inquiry and direct approaches are significant.

Comparing the proportion of the respondents choosing either the direct or the inquiry options, relatively more of the PSSTs selected the direct approaches in the scenarios depicting science lesson beginning. In contrast, the greatest proportion of the respondents chose the inquiry options along the lesson wrap-up stages of the science lesson. Finally, the chi-square test revealed that the difference in the proportion of respondents selecting either direct or inquiry approaches along the lesson stages are significant (p=.0480). This result implies that the PSSTs' predispositions for inquiry teaching are strongest along lesson wrap-up and weakest along lesson beginning. The PSST respondents can better enact inquiry practices during lesson wrap-up than during lesson beginnings.

This result could be explained by the fact that in most science classrooms, inquiry practices, especially under guided inquiry, are more commonly done after the lesson. In contrast, inquiry activities at lesson beginnings are quite rare or are difficult to implement in a non-open inquiry condition.

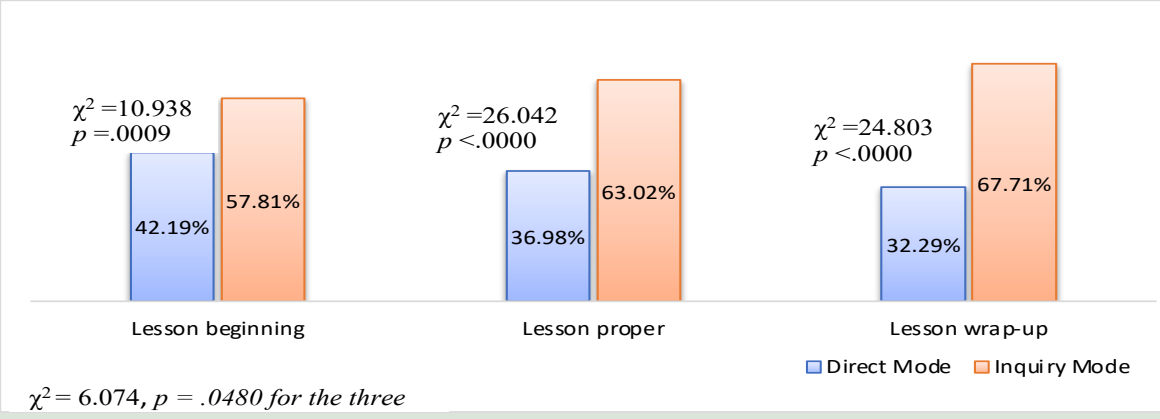
Some specific results have surfaced in the analysis. The PSSTs' FEMs were balanced in scenarios during lesson beginning and lesson proper. Also, in the two situations involving the lesson proper, the respondents tend to favor direct instruction over inquiry teaching. However, the items that attracted the greatest number of inquiry responses were those under lesson proper.

Orientations of the Prospective Science Teachers According to Science Fields and Lesson Stages

Of the 63 respondents, 51 or 80.95% chose all four specific epistemic modes (SEM) at least

Figure 3

Fundamental Epistemic Modes of the Prospective Secondary Science Teachers Along the Three Lesson Stages



once, suggesting that these PSST respondents are quite flexible as they can vary their pedagogical practices. Eleven (17.46%) respondents selected three of the four SEM at least once. Of the eleven, ten did not select the option that depicted didactic direct teaching mode. Finally, respondents selected only either of the two inquiry teaching variants.

The overall result revealed that the SEM representing the largest proportion of the respondents are guided inquiry, followed by active direct (Figure 4). The didactic direct methods were the PSST respondents' least advocated SEM. These findings imply that the respondents hold strong preferences for the epistemic modes that allow for teacher-guided learner exploration toward the desired outcome. In contrast, the instructional modes where a teacher presents and explains science content directly with no student activities do not appeal to the respondents. Further, the goodness of fit test indicates that the proportions of respondents choosing each of the four SEMs are significant ($X^2 = 116.305$, $p < .00001$).

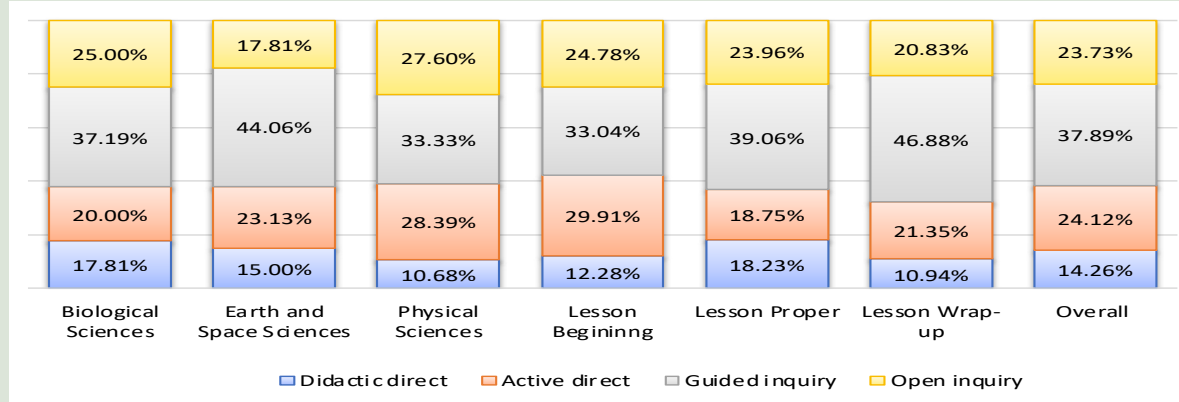
Of the two inquiry variants, more respondents selected the guided inquiry options over the more authentic open inquiry. As for the direct teaching modes, the active direct options (24.12%) were chosen more frequently than the didactic direct modes (14.26%). Chi-square test showed that the difference in each set was significant as the obtained *p*-values were less than .00001.

The findings on guided inquiry and didactic direct teaching being the most frequently and less frequently chosen pedagogical approaches, respectively, find support in the work of Güven et al. (2019). These researchers used the Pedagogy of Science Teaching Test (POSTT) to gauge the teaching orientations of freshman pre-service science teachers, and they came up with trends similar to the result of the study. Moreover, the findings complement the work of Ladachart (2019b) on Thai pre-service science teachers, where most pre-service teachers' science teaching orientations are between the "active direct" and the "guided inquiry." Finally, in his investigation of Turkish pre-service teachers using a different instrument, Feyzioglu (2015) noted that his study respondents were oriented toward structured inquiry. Structured inquiry, according to the model of Banchi and Bell (2008), is one-step higher than confirmation activities. Confirmation activities are technically non-inquiry (Bansiong, 2018; Buck et al., 2008) activities as they simply verify a well-known scientific idea. In contrast, the result of this present study contradicts that of Bansal et al. (2019) on Indian pre-service science teachers being more oriented toward didactic approach over the reform-based inquiry pedagogy. This result in the orientations of Indian pre-service teachers does not conform with the advocacy of the Indian Ministry of Education.

The strong tendency to select guided inquiry over other specific teaching approaches is also reflected among in-service teachers. In a study on Turkish middle school in-service science teachers, Sahingoz (2017) noted the respondents' high orientation toward guided inquiry (38.88%) and low orientation toward didactic direct modes (13.66%). Interestingly, these values are very close

Figure 4

Specific Epistemic Modes of the PSSTs Compared According to Science Fields and Lesson Stages



to the data collected in this present study.

According to research on the impact of instructional guidance during teaching, the use of guided inquiry appears to be more superior than the minimally-guided open inquiry (Kirschner et al., 2006). These researchers explained the superiority of guided instruction in the context of human cognitive architecture, expert-novice differences, and cognitive load. In comparison with guided instruction, the authors contend that,

> unguided or minimally guided instructional approaches ignore both the structures that constitute human cognitive structures, and are less effective and less efficient than the instructional approaches that place a strong emphasis on guidance of the student learning process. The advantage of guidance begins to recede only when learners have sufficiently high prior knowledge to provide "internal" guidance (Kirschner et al., 2006).

Some advocates of guided inquiry claim that guided inquiry-based teaching help students learn science content, master scientific skills, and understand the nature of scientific knowledge (Blanchard et al., 2010; Quintana et al., 2005; Zion & Mendelovici, 2012). Also, with structured and guided inquiry, advocates believe that instructional time is used wisely. The students are less likely to get frustrated by achieving undesirable results or experiencing failure in a guided inquiry lesson. Finally, guided inquiry lessons raise the learners' confidence and reduce their fear of the unknown (Trautmann et al., 2004).

The trend on the most preferred and least preferred SEM is consistent across the science fields and the three lesson stages. Also, the proportions of respondents choosing any of the four SEM is significantly different in all science fields and all lesson stages, with *p* values less than .00001. Along lesson stages, the trend in the overall SEM is consistent along the lesson beginning and lesson wrap-up. At lesson proper, the most dominant SEMs were the two inquiry variants, and the proportions of those choosing the direct modes are essentially the same.

Science Teaching Orientations of PSSTs Compared According to Variables

Across all variables, the inquiry instruction is the more dominant fundamental epistemic mode, echoing the overall trend of results (Table 5). This result means that regardless of specialization, sex, year level, and whether or not respondents are science teaching scholars, the PSSTs' orientations of teaching are geared more toward inquiry instruction. In principle, given the resources, all cohorts of respondents are ready to embrace the mandate of the country's framework of science education standard.

When the PSSTs' FEMs were compared according to the variables, significant differences existed between scholars and non-scholars, and among those with low, moderate, and high GPAs. The science teaching scholars hold significantly lower tendencies to select direct approaches, and consequently, higher orientation toward inquiry instruction than their non-scholar counterparts. Also, compared to the PSSTs with low GPAs, those with high and moderate GPAs are significantly more oriented toward inquiry instruction. Conversely, those with low GPAs showed higher inclinations toward didactic teaching. The science teaching scholars and those with relatively higher GPAs want their learners to explore and discover their science lessons, instead of them providing the information.

The science teaching scholars' higher predisposition toward inquiry teaching has some important implications. Most of these scholars are assured of a teaching job after they have obtained their licenses from the nation's professional regulation commission (PRC). Their inclinations toward inquiry then is a welcome and positive development to the science and technology and education departments as inquiry-based teaching is the sine qua non in science education in the Philippines.

Also, the findings reveal that inquiry orientation is directly related to academic standing. Such a finding is likewise a positive result since academic standing is one of the criteria in the selection of teacher positions in the Philippines (Department of Education, 2015). The PSSTs with higher GPAs have better chances to be hired, and therefore can better contribute to the nation's science education reform efforts.

Specialization, sex, and year level seem not to influence the PSSTs' fundamental epistemic modes. Although those who specialized in the physical sciences, the males, and the Level 4 respondents hold slightly higher inquiry orientations than

Table 5

PSSTs Fundamental Epistemic Modes Compared According to Specialization, Sex, Year Level, Science Teaching Scholarship, and Academic Standing

Variables	Direct Epistemic Mode	Inquiry Epistemic Mode	X^2 and *p*-value
Specialization			
Biological Sciences	38.65	61.35	X^2=0.47
Physical Sciences	37.98	62.02	*p=0.*828
Sex			
Males	35.71	64.21	X^2=0.861
Females	39.13	60.87	*p*=0.353
Year Level			
Level 2	38.89	61.11	X^2=4.404
Level 3	41.10	58.90	*p*=0.111
Level 4	34.09	65.91	
Science Teaching Scholarship			
Scholars	29.69	70.31	X^2=7.434
Non-scholars	40.32	59.68	*p*=0.006
Academic Standing			
Low GPA	46.09	53.91	X^2=9.007
Moderate GPA	36.30	63.70	*p*=0.001
High GPA	34.82	65.18	

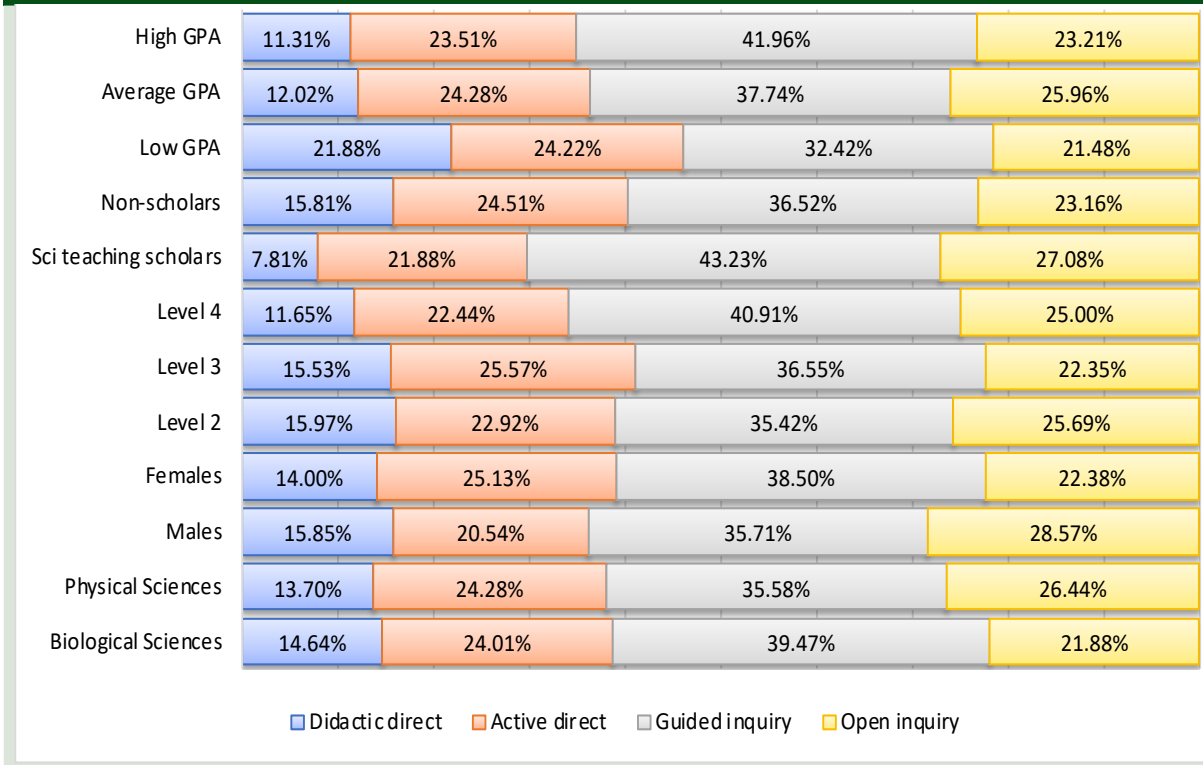
their respective counterparts, the differences are insignificant.

That sex does not influence the PSSTs' FEM seems to contradict what is reported in the research literature (Solomon, 2012; Wigfall & Hall, 2010) on the actual teaching practices of both sexes. Both studies separately reveal that male teachers tend to use lectures more than females, indicating male teachers' inclination towards teacher-centered pedagogical approaches. Furthermore, the year level's non-influence on the PSSTs' FEM suggests that the choice of pedagogical approach does not depend on the number of pedagogy courses one has taken. Rather, such pedagogical choice might be something that is deeply rooted in the PSSTs' views about teaching and learning. Finally, epistemic modes appear to be something solid and permanent, unaffected by the field of study one teaches or plans to teach. Such a result confirms that of Ladachart (2019b), who reported the non-significant relationship between STOs and subject matter among Thai pre-service teachers.

Figure 5 below depicts the specific epistemic modes of the PSST respondents according to variables. Across all variables, the guided inquiry approach was the dominant teaching orientation, with proportions ranging from 32.42% (low GPA respondents) to 43.23% (Science teaching scholars). Conversely, didactic inquiry is the least preferred teaching orientation, with proportions ranging from 7.81% (science teaching scholars) to 21.88% (low GPA respondents). The active direct and open inquiry variants shared the second and third most preferred epistemic modes. Specifically, open inquiry was the second most dominant SEM among the male, science teaching scholars, level 4, level 2, and physical sciences cohorts. Notably, the open inquiry orientations of the male and the physical sciences cohorts are significantly higher than their respective counterparts.

Figure 5

Specific Epistemic Modes of PSSTs Compared According to Variables



When the SEM distributions were compared according to variables, significant differences were detected along science teaching scholarship (X^2 = 10.257), p = .016) and academic standing (X^2 =18.884, p= .003). Such results echo the earlier result on these two variables influencing the respondents' fundamental epistemic modes. The science teaching scholars scored significantly higher than the non-scholars in the two inquiry variants, while the non-scholars scored higher in the two direct teaching variants. Meanwhile, the respondents with average to high GPAs registered higher proportions along the two inquiry variants. The PSSTs with low GPAs, meanwhile, scored higher in didactic direct teaching mode.

The significance of having a balanced science teaching orientation is that it allows the PSSTs to shift from one modality to another, whichever is appropriate to a given lesson or set of students. Thus, those who can easily swing back and forth between didactic and inquiry teaching can better adjust to changing classroom conditions.

Conclusions

This study established that the prospective science teachers involved in the study are strongly oriented to teach following the science teaching reforms advocated worldwide. This strong orientation toward reform-based science teaching is consistent along science fields, lesson stages, specialization, sex, year level, scholarship, and academic standing. The results are essential as the present science education in the Philippines shifted to the integrated science approach from the discipline-based scheme. Specifically, prospective science teachers are more inclined to select strategies that allow teacher-guided student exploration of scientific phenomena or ideas. They are least inclined to select teaching strategies where the learners passively listen to the teacher presenting or demonstrating the lessons. Finally, both fundamental and specific epistemic modes seem to be influenced by science teaching scholarship and academic standing. The results are both positive and reassuring to the

future of science education in the Philippines, as the prospective science teachers are more oriented towards inquiry teaching, a teaching orientation that is consistent with the country's science education reform.

Recommendations

In light of the findings, prospective science teachers may be encouraged to actualize their strong inquiry orientations in their future science classrooms. Moreover, with the concerted efforts of all education stakeholders, science classrooms may be properly equipped to allow for more inquiry-based lessons. Prospective science teachers who are more teacher-centered in teaching orientations may be encouraged to consider more reform-based teaching approaches with the examples and modeling by both science professors and science education professors. While the findings revealed that the respondents are strongly predisposed toward inquiry teaching, specifically guided inquiry instruction, its significance is limited by the fact that this predisposition may not be translated into actual teaching. A follow-up study to track the actual teaching practices of these prospective teachers is therefore recommended.

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