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The Physics teachers' views of inquiry and classroom practices

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Abstract

Inquiry-based instruction has been suggested and practiced in national and international reports on science education. Scientific inquiry aims to enhance learners' engagement in doing science through asking questions, data collection and analysis, and constructing explanations in an iterative process. One of the crucial problems in science education is whether science teachers integrate their views about inquiry into teaching practices. This study examines 30 experienced high school physics teachers' views about inquiry and their classroom practices. The mixed methods design explored physics teachers' views through semi-structured interviews and classroom practices through classroom observations and observation protocols. The results showed less agreement between teachers' views and practices. Teachers tended to teach in traditional ways through lecturing, but they possessed transitional or constructivist views of inquiry. The results offer science educators further insight into the relationship between opinions and practices in designing and conducting professional development programs.

Keywords: classroom observation; inquiry; interview; physics teachers; practices

1. Introduction

Reports published on science education suggest that applying scientific practices should be at the forefront of learning science (NGSS Lead States, 2014). Science teachers should also develop knowledge about scientific practices and have the opportunity to apply scientific practices. This process plays a role in improving the scientific literacy of both students and teachers. Reform-based standards in most countries (USA, UK, Japan, Turkey) aim to address learners' need to construct explanations and engage in argumentation from evidence and justification through science and engineering practices. The 21st-century skills address scientific practices and promote students' engagement in collaboration, higher-order thinking, and problem-solving to develop knowledge of the subject matter. Teachers should enhance views of how students learn and construct knowledge through scientific practices such as asking questions, developing models, constructing explanations, and communicating results. While science teachers believe science is absolute and learned through rote memorization, formula-driven problem-solving, and lecturing, teachers prefer implementing teachercentered instruction (Banilower et al., 2018). Schwartz et al. (2023) support the development of scientific literacy through inquiry practices, social interaction, and scaffolding to develop meaningful science experiences.

Since the beginning of the 21st century, science education in Turkey has emphasized the development of scientific literacy in teaching, learning, curriculum, and assessment to address individual and cultural differences (Ministry of Education in Turkey (MEB), 2005). The recent curriculum design aims to emphasize the integration of scientific inquiry practices, student-centered instruction, and aspects of the nature of science. However, according to PISA (2018) results, Turkey, a developing country, scored lower than the OECD average in science; only 7% of students were top performers in science who could make decisions to apply scientific knowledge in different situations. These results raise concerns about what is happening in science classrooms. The literature showed that science teachers were required to use only the textbook selected by the Ministry of Education, and they preferred lecturing to address the suggestions of textbook developers and conducted experiments with only available equipment in middle schools (Turkmen & Pedersen, 2005). Previous research reports science teaching and learning experiences in middle school, and little was reported on physics teachers' classroom practices in high school classrooms.

The focus of this study is to examine the high school physics teachers' classroom practices and their views of inquiry. The following questions guide the study: What views do physics teachers hold on inquiry? What are physics teachers' instructional practices in their classrooms? How do physics teachers' classroom practices relate to their beliefs of inquiry?

2. Methods

The study has a mixed-method design with quantitative and qualitative strands to answer the research questions (Creswell & Clark, 2011). The quantitative and qualitative strands occur sequentially or independently to address distinct research questions. As to the relative importance of the two strands within the design, this study uses quantitative data primarily, including classroom observations and quantitative coding of participants' views of inquiry. Qualitative data are utilized in the secondary role to support and triangulate the findings.

The participants were 30 high school physics teachers, ten women and 20 men. The participants' ages ranged from the early 30's to 60's, and they had over ten years of teaching experience. These teachers were selected conveniently and purposefully from a metropolitan city in Turkey, where the researchers' university was located. The instructional context was public high schools with a science focus, Anatolian High Schools. The researchers eliminated the vocational schools.

The researcher conducted one semi-structured interview with each physics teacher at their school. Participants were asked open-ended questions focusing on their views of inquiry-based instruction. For example, sample questions were, "What are your views about student-centered instruction? How do you define inquiry teaching?" The interviews were transcribed to conduct open coding and selective coding to determine teachers' views of inquiry at different complexities. After teachers' views were assigned as a code during the first phase of analysis; in the second phase, codes were categorized into three distinct levels based on the complexity: traditional, transitional, and constructivist. These levels were modified from Tsai (2002) where traditional beliefs focused on teaching science as certain facts, transitional beliefs emphasized alternative ways or methods, and constructivist beliefs defined science as tentative, evolving, and based on evidence-based explanations through exploration. In the third phase of the analysis, the levels of teachers' views of inquiry were quantified as traditional (1), transitional (2), and constructivist (3) for quantitative analysis. Moderate interrater reliability for quantitative coding was established by two raters for teachers' views of inquiry; disagreements were discussed for the final analysis.

Additionally, the researcher conducted classroom observations via two teaching observation protocols: Teaching Dimensions Observation Protocol (TDOP) (Hora et al., 2013) and Reformed Teaching Observation Protocol (RTOP) (Sawada et al., 2000). Researchers selected these two proposals purposefully since the instruments have the reliability and validity to assess the quality and dimensions of inquiry-based instruction (Hora & Ferrare, 2014; Marshall et al., 2011). TDOP addresses five dimensions of teaching practice: teaching methods, pedagogical strategies, student-teacher relationships, cognitive engagement, and use of instructional technology. Lesson design and implementation, propositional content knowledge, procedural content knowledge, the use of discourse, and student-teacher relationships are teaching dimensions of RTOP. The researcher used observation protocols during 50-minute classroom observations. The researcher observed 33% of participating teachers (10 teachers) twice (in separate lesson hours) to check the consistency in coding and teaching practices. Intra-rater reliability was 75% across teachers' implementations. Descriptive statistics was used to analyze observation scores. The levels for teachers' teaching were traditional (1), transitional (2), and constructivist (3) for quantitative analysis. The relationship between teachers' views of inquiry and classroom practice was in an inquiry continuum for comparison.

3. Results

3.1. Most physics teachers' inquiry views were at constructivist or transitional level.

Seven teachers defined teaching physics with traditional views as a top-down processing mechanism. For instance, Participant 1 (P1) stated, "Teaching science involves lecturing, transferring accepted knowledge. Teachers need to have subject competency." Eleven physics teachers focused on teaching physics as a process of connecting to real life in solving problems from a transitional perspective. Participant-2 stated:

> "Physics can be taught at different places based on the topic such as a garden, seaside to outdoor pressure to make measurement. Teaching physics involves developing problem-solving strategies through thought experiments and communication."

Teachers' constructivist beliefs about teaching science referred to student-centered instruction through exploration (14 teachers). Participant-3 stated:

> "Teaching science involves experiments to help students actively learn by doing and observing tangible experiences. We need to show applications through using the laboratory to develop students' analytical and critical thinking skills, to make students active and responsible to learn on their own with responsibility."

3.2. Most physics teachers' practices were traditional or transitional-oriented.

The TDOP observations (Table 1) showed that most physics teachers lectured with visuals (LVIS: 52%) or while writing (LW: 60%) on the blackboard or smartboard (CB: 85%) to solve work-out problems (WP: 36%) while students were doing deskwork (DW: 92%) with less amount of student presentation (SP: 6%) or group work (SGW: 0.5%). Teachers asked mostly display questions (IDQ: 64%) with short student responses (SR: 64%). Student engagement level was at the medium level (MED: 67%); teachers aimed to enhance cognitive engagement by making connections to real-life events (CNL: 14%) and asking students to solve a problem

(PS: 38%). Teachers usually emphasized the content (EMP: 91%); some teachers talked about illustrative stories or movies (ANEX: 13%) during the lesson. Teachers also used 15% of classroom time to talk about administrative tasks (AT) and organization (ORG) through transitioning from one topic to another, outlining, or discussing the exams or homework (AT: 16%, ORG: 16%).

Table 1: TDOP* results from the observations (%)

Teacher-Focused	L	LW	LVIS	LDEM	SOC-L	WP	IND	MM	A	AT
	19.33	60.17	52.17	2.17	0	35.67	0	1	0	15.5
Student-Focused	SGW	DW	SP							
	0.5	92.17	6.33							
Teacher-led dialogue	IRQ	IDQ	ICQ							
	18.67	63.5	40.83							
Student-led dialogue	SQ	SR	PI							
	5.67	63.67	0							
Instructional Technology	CB	OP	PP	CL	D	DT	M	SI	WEB	
	85.17	0	0.17	0	1.5	0	0.17	0.67	3.5	
Cognitive Engagement	CNL	PS	CR							
	14.33	38.17	0							
Pedagogical Strategies	HUM	ANEX	ORG	EMP						
	0.67	12.67	15.5	90.67						
Student Engagement	VHI	HI	MED	LO						
	0	16.83	66.67	16.33						

* Detailed code definitions can be found at Hara et al. (2013)

RTOP results (Table 2) also showed that most teachers focused on fundamental concepts of physics to promote learning across physics topics (Propositional knowledge: 90%). These teachers valued students' active participation through mind-on activities, and they acted as a resource to initiate student participation (Classroom culture: 59%). Students could communicate their ideas through multiple representations, but teachers rarely fostered divergent modes of thinking to promote student questioning and comprehensive explanation (Discourse practices: 50%). The teachers were encouraged to utilize representations through thought-provoking problems and other assessments, but the lessons included less intellectual dialogue and challenges to solve complex problems or conduct experiments through prediction, hypotheses, and testing (Procedural knowledge: 37%). Lastly, physics teachers' lesson planning addressed students' preconceptions to include student ideas in classroom direction (Lesson Design and Implementation: 36%). These results showed that physics teachers' classroom practices focused on content representation in multiple ways (diagrams, visuals, or graphs) to solve problems for minds-on activities; teachers rarely emphasized enhancing student voice through comprehension questions. The lessons lack exploration and support of a learning community to help students seek and recognize alternative methods of doing science.

Table 2: RTOP results from observations

Observation Category	%
Lesson Design and Implementation (LDI)	36.00
Content (Propositional Knowledge) (C-PK1)	90.25
Content (Procedural Knowledge) (C-PK2)	37.00
Discourse Practices (DP)	49.75
Classroom Culture (CC)	58.50

3.3. There was a weak correlation between inquiry views and classroom practices.

Table 3 shows how the levels of teachers' views of inquiry and classroom practices relate to each other. The results showed 23% agreement in their views and practices; six teachers indicated traditional views, and one teacher provided transitional views, and they integrated their views into practices. Most teachers' teaching aligned with direct instruction, while their views of inquiry were mostly transitional (eight teachers) or constructivist (six teachers). Nine physics teachers who held constructivist views taught in transitional ways through small demonstrations or simulations to enhance students' engagement. The correlation between teachers' views of inquiry and classroom practices was weakly positively correlated, r (28) = 0.49, $p < 0.01$.

Table 3. The relationship between views and practices

Inquiry views	3	6	9	0
	2	8	1	0
	1	6	1	0
		1	2	3
		Practice		

4. Conclusions

The education community recognizes the significance of classroom-based research for the professional development of science teachers. The Next *Generation Science Standards* suggests three-dimensional learning to integrate disciplinary core ideas with scientific practices and crosscutting concepts through alternative ways of instruction to promote divergent ways of thinking. This study reveals what is happening in physics classrooms and examines physics teachers' approaches to teaching through inquiry. The study showed that physics teachers possessed transitional or constructivist views to teach physics through real-life examples or experimentation. A few teachers held traditional views and focused on the role of lecturing in physics classrooms. This study aligned with Sengul (2024) that teachers' beliefs and views could reflect their tendency to teach in specific ways. Teachers might have limitations such as the role of administrators, curriculum, and students that did not support them in developing an inquiry-oriented teacher identity. Teachers should participate in professional development programs to enhance their knowledge of constructivist pedagogy, which might change their naive conceptions.

Moreover, the results also indicated how the classroom practices of physics teachers aligned or did not align with their views of inquiry. Most teachers emphasized lecturing on the board with limited student engagement while students were doing desk work. Teachers with transitional practices highlighted the role of multiple views and gave real-life examples; there were teacher questions to enhance student voice. There were no constructivist practices, although some teachers held constructivist views. The results showed a weak correlation between teachers' views and practices. The results showed that other factors might facilitate the inconsistency between teachers' views and practices. The study further reports teachers' tendency to teach with a traditional approach without exploration activities. The study suggests support for professional development of beginning and experienced physics teachers to integrate constructivist pedagogies into practice. Further research should explore the factors influencing the consistency and inconsistency between teachers' beliefs and practices.

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