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The Impact of Professional Development on Dialogic Teaching for Science Teachers in Saudi Arabia

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Abstract: This study investigates the impact of a professional development that embed interactive/dialogic strategies on the enactment of these strategies to teach science-based inquiry in Saudi Arabia. Seventeen science teachers attended the professional development that embed dialogic conversation into teaching science-based inquiry. The instrument developed by previous researachers was adapted to explore the science teachers' use of the dialogic inquiry strategies prior and after their participations. This instrument consisted of 18 items with a Likert scale (alpha Cronbach = 0.79) and observe the strategies used in the stages of receiving information, and how teachers recognize and use the information collected about students' thinking to develop dialogic inquiry. The overall results indicated that science teachers became more capable to develop dialogic inquiry strategies to interact with their students. Some strategies were highly developed at the receiving phase such as, writes down observations (M= 3.67), and interprets data (M=3.52), at the recognising phase (provide neutral responses M=3.41). However, strategies that indicate the use of students' ideas to develop further inquiry did not exceed the moderate level (asking how/why questions (M=2.90). Science teachers also met with some difficulties to develop some strategies such as help the learners to come to an agreement upon an explanation (M=2.52). The study underlines the significance of incorporating dialogic conversation strategies into the professional development programs to help science teachers to enact scientific inquiry.

Keywords: Dialogic Taching, Scientific Inquiry, Professional Development

1. Introduction

Previous research has highlighted that science teachers lack adequate dialogic skills that allow them to interact with their students in science-based inquiry settings [1-4]. With minimal opportunities for dialogic discourse within science classrooms' students, the development of scientific explanations can be influenced [5]. Teachers often face difficulties while trying to enact the type of classroom discourse required by inquiry instruction [6-8]. Classroom talk is dominated by teachers, and little discourse is designated for students' reasoning [3].

Teachers need to develop skills that encourage learners to explain what they think while giving appropriate examples, listen and respond to others' ideas, and use appropriate language for explaining scientific phenomena [9]. The learners need more opportunities to reason, to modify their ideas in light of the evidence, and to develop "bigger" ideas from "smaller" ones. Teachers require strategies that not only concern the questions that are posed to elicit initial responses from the students, but that should also promote students' reflections and participations in the enviorenment where knowledge is shared between the teacher and students; these should be gradually integrated to produce a dialogic outcome [10].

The teacher's role is the key to scaffolding students' explanations when an inquiry approach to teaching is carefully implemented. Teachers' professional programs are considered as effective tools for enhancing the quality of students' explanations of science [11]. Teachers are better able to develop a higher quality of discourse when they are trained to use specific strategies to challenge and scaffold students' thinking. Thus, science teachers need a professional development program that integrates features of dialogic teaching into scientific inquiry with sustained follow-up and continuous support.

2. Literature Review

2.1. The Meaning of Inquiry

Science-based inquiry has been a more central part of the framework for K–12 as established by the National Research Council (NRC) and carried forward in the Next Generation Science Standards (NGSS) [12]. The word inquiry refers to various teaching methods that can all be used by scientists to study the natural world and propose explanations that are based on evidence from their work [13]. Inquiry can be understood "as a knowledge-building process in which explanations are developed to make sense of the data and then are presented to a community of peers so they can be critiqued, debated and revised" [14, p. 43]. Inquiry in science is defined by the NGSS as a process that requires a broad spectrum of cognitive, social, and physical activities [12]. Some authors such as [15] described inquiry at its most basic level as supporting learners to answer questions by giving priority to logic and evidence and by going beyond the simple asking of questions, and so guiding them to make sense of their data before giving an explanation in a social environment. Inquiry is not only asking questions; it includes utilizing process skills to find answers for the question defined, as "human systems grow toward what they persistently ask questions about" [16, p. 7].

2.2. Dialogic Inquiry

Dialogic models of language were considered some of the most important frameworks for conducting research on the practice of scientific inquiry [17]. It is significant to encourage interactive discourse in science classrooms in order to develop the dialogic inquiry that allows the construction of scientific explanations [5]. Refrence [18] argued that "exploratory talk provides an important means of working on understanding, but learners are unlikely to embark on it unless they feel relatively at ease, free from the danger of being aggressively contradicted or made fun of" (p. 5). Therefore, the nature of classroom discourse in science-based inquiry requires a learning environment that promotes the sharing of knowledge between the instructor and learners to build upon each other's contributions at accepted standards of reasoning with extended student contributions and uncertainties [19, 20].

Refrence [21] also proposed a particular tool—a reflective toss—as a means of supporting teachers who are moving toward a more reflective discourse; this clarifies the students' thinking to consider different points of view and helps them monitor their own thinking. This approach was based on the practice of throwing the responsibility of thinking back to the students by posing a new question in response to a prior discussion. By using this reflective toss, the teachers can extend a series of discourse exchanges in which they elicit further responses from the students and can further guide their thinking by posing questions that encourage them to articulate their own thoughts and ideas.

Studies such as [22] discussed the "assessment conversation" that stresses the dialogic strategies teachers may use during interactions in science classes. These strategies are designed to be interactive and dialogic in nature. They are consistent with the socio-cultural perspective, which conceives learning as a social and collaborative activity in which teachers and students develop their thinking together [23]. These strategies at the heart of inquiry-based learning practice help teachers make their students' thinking explicit and scaffold their learning [22, 24].

The first step in the assessment conversation is to receive students' ideas. In this step, teachers seek to make their students' thinking explicit by requesting them to share their prior knowledge and understandings in relation to a new learned concept. The goal of the pattern of talk is to collect information about the students' thinking. Refernce [25] discussed the importance of non-evaluative strategies to begin the conversation cycle, such as requesting students to predict and/or provide the observations and data science teachers need to comprehend higher levels of "pragmatic awareness" of language-mediated processes to appropriately enact dialogic skills. This can change the manner in which science teachers talk to their students and how they support them to meet the demands of inquiry-based learning.

Teachers may also use different strategies to clarify the learners' ideas and support them in explaining what they know [22]. However, a teacher-centered approach encourages the transmission of content or the direction of classroom conversations to what the teacher expects to hear [10].

The second step of dialogic interaction requires teachers to value their students' ideas and encourage their contributions to classroom discussion. In this step, teachers use different strategies: for instance, confirming previous responses; clarifying, repeating, and encouraging diverse responses; or providing neutral feedback. These strategies support teachers in encouraging further inquiry by allowing their students to interact with scientific meaning via the re-checking of their data, discussing their ideas with other group members, and comparing the different explanations of the different groups. However, science education researchers found that many teachers mostly move through conversations to convey the content without investigating the students' ideas and conceptions [26, 27].

In the third stage, the teachers try to look for the most important information about the students' thinking to determine their required actions and encourage further investigations. Strategies such as "connecting to previous learning" and "comparing and contrasting alternative explanations" were found to be effective in helping students carry out the investigations and find answers for themselves [24].

2.3. Statement of the Problem

Reforming science curriculum to shift its focus to the way how and why people learn has been widely reported [28, 29]. In Saudi Arabia, for example, reforming science education has become a central issue [30]. In 2007, the government assigned top priority to the improvement of its scientific and educational infrastructure in response to the requirement for improved scientific methods to match global standards [31].

In 2008, the Saudi Ministry of Education, in collaboration with the Obeikan Research Development Company, introduced a new science curriculum. This curriculum was partly based on a translation of science textbooks produced by Macmillan and McGraw-Hill [30].

The new science curriculum places heavy emphasis on the learners' construction of knowledge instead of telling or installing, which refers to the constructivist theory of teaching and learning [30]. In the constructivist theory, the teachers' roles are changed from knowledge providers to learning facilitators [32]. Students are considered active agents in the learning process and should be engaged in meaningful learning to construct their own explanations from their experiences [33]. In practice, inquiry-based instructional approaches have been suggested in the latest curriculum reform in Saudi Arabia [34].

The enactment of scientific inquiry demands teachers to engage learners in dialogic argumentation to construct, justify, and evaluate scientific explanations is thus a fundamental aspect of scientific inquiry [35, 36]. This requires science teachers to utilize the type of talk that promotes reasoning and scientific arguments [37].

The inquiry-based approach to teaching science provides opportunities for students to discuss and debate ideas and can thus be an effective method for achieving a higher level of scientific literacy [38]. Students actively engage in understanding new information through discussion and argumentation. In inquiry-based practices, students' ideas are acknowledged and valued in the development of the classroom discussion rather than being discounted and redirected to what teachers expect to hear [10].

Observing Saudi science teachers, however, indicated a lack of dialogic inquiry strategies and the need to shift their practice from authority-based classroom relations to talking as the inquiry-based learning context demands [27]. Teachers thus need to allow opportunities for students to explain and argue different viewpoints by shifting from the traditional pattern of discourse to more dialogic interactions [5].

To that end, the research question of this study is: How does professional development that embeds dialogic strategies impact Saudi science teachers' implementation of dialogic inquiry?

2.4. The Aim of the Study

This study is intended to enhance science teachers' practices of dialogic inquiry through a professional development program that embeds dialogic strategies to engage students in scientific-extended dialogic discussion that allows opportunities for inquiry-based learning practices. To achieve this goal, the study adapted the dialogic conversation cycles initially discussed by [22, 35] and further elaborated by previous reserachers [39]. These strategies refer to the instructional dialogues between teachers and students that "collect information about student learning, comparing it to the teacher's expectations, and taking action to move students toward learning goals" [39, p. 208).

3. Method

3.1. Participants

Seventeen science teachers participated in this study. They were all in-service science teachers from Albaha, Saudi Arabia who had a range of experience of 7–20 years. They voluntarily participated in the professional development program after arranging it with the supervision team at the Albaha directorate of Education. They taught general science to students who are 12–14 years old at the secondary school level. Before their participation, the aim and procedures of this study were explained to them.

3.2. The Instrument

This study adopted a classroom observation form to capture the science teachers' use of dialogic strategies when teaching science-based inquiry. The coding system of these strategies was adapted from Ruiz-Primo and Furtak [39].

This coding system identified each strategy in the phases of classroom discussion when initiating inquiry dialogue, the teachers' reaction to the students' contributions after receiving their ideas, and the strategies used to encourage the learners' explanations to develop further inquiry.

The science teachers' practices were determined using a five-point scale (Very High, High, Moderate, Low, Very Low). This scale ranged from a lower level, which was numerically represented by the number 1, and a higher level, which was numerically represented by the number 5. The categories were thus divided to

(1) very low (1–1.80)
(2) low (1.80–2.60)
(3) moderate (2.60–3.40)
(4) high (3.40–4.20)
(5) very High (4.20–5).

4. Results

4.1. Science Teachers' Use of Dialogic Strategies to Initiate Inquiry Dialogue

The results show that the participating teachers improved their use of strategies that encourage inquiry teaching from pre- to post-participation in the professional development. Table 1 shows that despite the variations in the development of the teachers' use of strategies to initiate classroom conversations, the mean scores improved for all these strategies. The pre- to post-results indicated that requesting students to write down their observations and clarifying and interpreting their ideas were frequently used by science teachers with mean scores of 3.67 and 3.52, respectively. Moderate mean scores were observed for strategies that engaged students to compare and contrast ideas (M = 3.04) and those asking for the construction of scientific explanations (M = 2.62). The lowest observed strategies used by science teachers in the elicitation phase were those asking learners to provide evidence to support their answers (M = 2.48), predict what would happen (M = 2.43), and lower the evaluation of the quality of evidence (M = 2.19).

Table 1. *Science teachers' strategies to initiate inquiry dialogue.*

Request students to:	Pre-intervention		Level of practice	Post-intervention		Level of practice
	Mean	Std. Deviation		Mean	St. Deviation	
Make predictions/seek learners' prior knowledge	1.76	.624	Very low	2.43	.68	Low
Formulate scientific explanations	1.809	.601	Low	2.62	.58	Moderate
Interpret and clarify ideas	3.00	.447	Moderate	3.52	.62	High
Compare or contrast ideas	1.95	.497	Low	3.04	.59	Moderate
Write down observations	2.19	.679	Low	3.67	.57	High
Provide evidence	2.0476	.49	Low	2.48	.51	Low
Evaluate the quality of evidence	1.14	.358	Very Low	2.19	.60	Low

The above findings suggest the need for professional development that supports science teachers to initiate dialogic inquiry approaches. The participating teachers developed more dialogic conversations that support better learner engagement. The science teachers frequently clarified and interpreted the learners' ideas, but only reached a moderate level by asking learners to provide evidence and formulate scientific explanations. The science teachers also accepted the learners' ideas with rare investigations of the evidence they provided to support their claims. This can be associated with the teachers' knowledge of how to appropriately explore the learners' prior knowledge. This is in line with previous studies such as [40] who noted that unexpected student responses after the teacher's "opening move" could force the teacher to decide on "whether to follow the new thread" or "bring the conversation back to where the teacher intended" (p. 21). Some inquiry questions that were asked to engage the students were above their current experiences, and thus the teachers may have changed these questions to retain emphasis on the learning goals. This is consistent with the findings of [41], who found that opening a conversation without considering the students' level of understanding could cause confusion rather than the development of higher-order thinking in the students.

4.2. Science Teachers' Strategies to Support the Learners' Participation

Table 2 presents the strategies used by science teachers to consider and value the learners' ideas and participation. The data demonstrates that the science teachers strongly developed strategies such as confirming the correctness of the learners' ideas (M = 3.61) and providing a neutral response (M = 3.40). Confirming the correctness of the learners' ideas may value their contributions, but does not challenge them, as it quickly constrains the dialogue through an appeal to find the "best answer" (Duschl & Gitomer, 1997). However, providing neutral responses without indicating if the learners are right or wrong helps postpone judgment, and so encourages more student-centered practices and displays different ways of thinking to the whole class.

At the Moderate level, the science teachers utilized strategies such as elaborating on the students' ideas (M = 2.90) and encouraging peer assessment (M = 2.81). The science teachers' encouragement of diverse ideas was still at the Low level, but slightly improved from 1.43 to 2.23 after taking part in the professional development. This shows that despite improvement in some dialogic strategies, science teachers still face difficulties with involving students in extended discussions that further challenge them to collect evidence about the students' reasoning. Previous studies showed that elaborating students' ideas creates a conversation that facilitates the teacher-student interaction, but this was through praising, asking easy questions, as well as adding more information [10, 21]. This is an international challenge, for there are science teachers in many countries who also have similar difficulties adopting further engagement in a number of "talk moves" [41, 5].

Table 2. *Science teachers' strategies to value learners' talk*

Teacher recognition of students' responses	Pre-intervention		Level of practice	Post-intervention		Level of practice
	Mean	Std. Deviation		Mean	St. Deviation	
Elaborate on students' ideas	2.38	0.50	Low	2.90	0.77	Moderate
Confirm the correctness of the ideas	2.00	.45	Low	3.61	0.59	High
Provide neutral responses	1.90	0.53	Low	3.41	.68	High
Encourage diverse explanations	1.43	0.51	Low	2.231	.44	Low
Encourage peer assessment	1.57	0.60	Low	2.81	0.57	Moderate

4.3. Science Teachers' Use of Learners' Ideas to Develop Dialogic Inquiry

The results in Table 3 indicate that the science teachers slightly improved the use of students' ideas to develop further inquiry. At the Moderate level, the science teachers developed the use of how and why questions to challenge or redirect the students' thinking (M = 2.90). However, supporting students to reach consensus on an explanation or connecting with previous learning was at the Low level, despite a mean improvement from 1.95 to 2.52 and 1.43 to 2.23, respectively. This helped the teachers explore the students' level of understanding in more detail. Nevertheless, the teachers' frequent use of additional information (M = 3.41) and extended examples (M = 3.61) shows that they took responsibility when their learners did not continue the discussion.

Table 3. *Science teachers' strategies of using learners' ideas.*

Develop dialogic inquiry	Pre-intervention		Level of practice	Post-intervention		Level of practice
	Mean	Std. Deviation		Mean	St. Deviation	
Promote further explanations	2.38	0.49761	Low	2.90	.76842	Moderate
Come to an agreement on an explanation	1.95	0.501	Low	2.52	.68	Low
Connect to previous learning	1.43	0.507	Low	2.23	.44	Low
Provide additional information	1.90	0.53	Low	3.41	.68	High
Provide extended examples	2.00	.045	Low	3.61	.59	High

5. Conclusion

This study investigated strategies that support the implementation of dialogic teaching in science-based inquiry classrooms. The science teachers in this study were able to develop better inquiry strategy practices that initiate students' ideas, such as asking students to write down their views on a scientific concept. They also valued the students' contributions by confirming and interpreting their prior ideas. The results further showed the need for professional development that extends scientific talk and helps science teachers enact dialogic inquiry teaching. The science teachers in this study needed to know the different methods that can be used to acknowledge and promote student thinking; these include the capturing of diverse responses from different groups and displaying these responses to the whole class. The teachers also needed to take appropriate actions via strategies that could use the students' ideas as a basis for further inquiry. These actions provide, for instance, appropriate scaffolding for the learners to reach evidence-based explanation and encourage them to connect their reasoning by re-checking their data.

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