Research in Social Sciences and Technology (RESSAT)
E-ISSN: 2468-6891

Unlocking the Power of Inquiry: A Case Study on Elementary Science Professional Development Program

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Abstract

Elementary teachers often struggle with how to design and implement inquiry instruction with their students. This study examines the awareness of inquiry-based teaching amongst elementary science teachers through a workshop intervention, conducted in a private school in Karachi, Pakistan. The case study design deployed, highlighted the learning experiences of 24 participants that took part in the professional development workshop. A qualitative survey was carried before the intervention followed by focus group discussion and participant observations after the intervention. The findings of this study were that before the science training the participants were superficially aware of the fundamentals of inquiry-based methods and techniques and knew its importance. However, in-depth process knowledge and skills/strategies required for an effective inquiry was an identifiable shortcoming. Because of the workshop, the participants demonstrated an improved understanding of what entails an inquiry process and features of scientific inquiry. This research should inspire and inform professional developers about gap in inquiry-based science teachings. Furthermore, the study aims to motivate private schools in Pakistan to invest in inquiry-based science teaching as a tangible long-term benefit which can translate into better teaching practitioner.

Key words: *Inquiry based teaching, scientific inquiry, elementary science*

Introduction

Pakistan Education Statistics 2015-16 shows that 48 % of teachers are employed in private sector education. Private schools have catered to the gap left by the public school (Warsi, 2005) but getting supply of adequately trained teachers is still a challenge. Due to rapid growth in the number of private schools in Pakistan, it is easy to get teaching job without any formal teacher training and/or education. Pakistan Education for All 2015 National Review Report states that very few teachers employed have a teaching degree from a university.

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The role of the teacher is to develop conceptual understanding in an effective manner. The lack of professional development and lack of pedagogical knowledge inhibits teacher to elicit student's conceptual knowledge before or after the lesson. In a research conducted by Plourde (2002) it was noted that less than one third of the teachers in elementary school felt that they were qualified to teach science. Major reason for this was perhaps many elementary teachers were not taught by their teachers the investigative methodology and as such the cycle persists (Nabors, 1999). It's a cycle that continues to perpetuate itself as the teachers emulate the teachers that they have had when they were in school. The teachers in Pakistan are used to teacher centric methodology which is a one-sided imparting of scientific knowledge. This means that the knowledge of students is text book based and in fact they do not learn but memorize concepts to get through standardized tests and core concepts remains naïve in their minds (Christie & Afzaal, 2005; Halai, 2008; Tarman & Kuran, 2015; Yigit & Tarman, 2016).

Because of the acuteness of the problems discussed above, inquiry-based teaching methods have been recommended by professionals (NRC, 2000; Anderson, 2002; Khan, 2012; Erbilgin, 2017) to help teachers to improve their learning in science education as well as to widen their interest in science and develop their personal scientific literacy. For an effective delivery of inquiry-based lesson a science teacher require experience related to inquiry (Akhter, 2013). However, no research has been carried by private sector education either at regional and national level that objectively measure conception of inquiry-based practices of in-service teachers in science classroom.

This research outlines a case study of an elite private school in Karachi, Pakistan that engages elementary science teachers to experience inquiry-based science education through series of professional development workshops.

The salient research questions of the study are addressed below

1. What do teachers know about inquiry-based teaching and learning in science before the professional development workshop?
2. How does teacher's awareness of inquiry-based science concepts improve after the professional development intervention?

Method

Research Design

Based on interpretivist philosophy a case study methodology was used to investigate the research question. The target audience (respondents) of the study were twenty-four elementary science teachers from grade 1 to 5 of an elite private school. The school is of socio-economic class (SEC) A+, educated parents and the school is consciously working on professional development of all teachers. The school follows British curriculum (O-Levels). There has been a lot of emphasis on in-house training and development of teachers in workshops on subjects of Math and English but there have been no such workshops on Science.

Intervention Plan

The science training workshop plan was adopted from online curriculum for professional developer developed by Institute of Inquiry [2](IFI - funded by National Science Foundation). The primary goal of the training and development workshop was to plant a seed in the minds of the teachers so that they can reflect on their current practices and provide strategies to learn science by inquiry based activities. The workshop aimed to bring about small but reflective change in teacher's belief pattern by providing them with the teaching best practices of inquiry based teaching techniques. The overview of the workshop is mentioned in Table 1.

Table 1: *Overview of Workshop Intervention Plans*

Table-1 Overview of Workshop Intervention Plans
Session 1: Introduction to Inquiry Facilitator introduces the aims and objectives of the science professional development workshop. After the brief introduction about the workshop. The researcher conducted survey to elicit in-service teacher's prior knowledge and belief about inquiry based pedagogy from all the teachers attending the workshop
Session 2 : Comparing Approaches This part of the workshop required a lot of planning. Three different workstations of hands on lessons were set up structured, guided and open inquiry. Teachers carried out simple investigation in groups. After carrying out the investigation they were asked to consider how and why each approach may be effectively used in the classroom. Discuss the limitations of each approach.
Session 3: Science Process Skills Activities and plan adapted from the professional development curriculum from the Institute of Inquiry.

[2] https://www.exploratorium.edu/education/ifi/workshops/fundamentals

There are two parts to this workshop.

1. In part one teacher worked in pairs, rotating through five very short hands-on tasks that required the use of different science process skills.
2. After providing the opportunities to experience the process skills the facilitator formally introduces different process skills required for inquiry and discussed the importance of skills at different developmental levels

Session 4: Scientific Method

Teachers underwent two complete guided investigations. Scientific method was formally introduced. They designed their investigation, collected data, organized and interpreted data using graphs and tables and draw conclusion based on evidence.

Session 5& 6: Subtle Shift

This workshop was designed in three parts:

Part 1

Teachers were provided with three different activities of the same topic. Teachers analysed each activity critically among groups to identify the skill based learning through each activity. In addition to this they compared all three activities and identified and analysed the level of learner control given by the teacher.

Part 2

To further solidify and practice shifting of traditional lessons to inquiry based lesson plan. Participants worked in groups to bring subtle shifts in their lessons.

Part 3

Teachers read excerpts of case studies related to effective inquiry based practices. After reading teachers reflected in groups and identified features of inquiry learning.

Population and Sample/ Study Group/Participants

Purposive sampling technique was deployed while selecting the teachers. It was done on purpose based on grade level and number of subjects they taught. Sample included only those teachers who taught multiple subjects along with science subject. The teaching experience ranged 0 - 15 years and demonstrated diverse levels of competence and knowledge base in science.

Data Collection Tools

Data was collected at different times during the span of the study and as such this ensured that progression of the concepts learned were explored and documented accordingly.

Initial conception and understanding of inquiry-based science teaching was collected using pre-workshop survey forms having both open and close ended questions. Keeping in view the

qualitative nature of the research questions data was collected at different stages of the workshop intervention through participant observation and focus group discussions.

Data Collection

The data collection of participant observations was done through pre-designed observation check list along with journal entry of field notes. All the focus group discussions were recorded on audio tape and the contents were transcribed and analyzed.

Data Analysis

Pre Intervention

Survey data showed that most of the participants demonstrated positive perceptions about benefits of inquiry based teaching. Almost all respondents connected inquiry based teaching to generation of curiosity among learners. They knew that inquiry based teaching "*engages students to become inquisitive about learning"*. They believed that this approach provides "*students with a platform to question, explore and investigate the world around them*. *When students inquire they learn the reasons, facts and logic behind a certain matter."* Inquiry through engagement in science questions is as per the NSES which states that such activity refers to the variety of activities involving students and teachers through which they develop the knowledge and understanding of scientific concepts (NRC, 2000).

Teachers believed that "*inquiry leads to better understanding as this mode of teaching generates enthusiasm/motivation amongst students"*.

"When students relate subject learning to their prior knowledge they will eventually take more from the subject matter".

Data shows that although teachers have positive beliefs about inquiry based teaching but they do not have detailed understanding of different levels of inquiry and essential features of classroom inquiry.

Post Intervention

The findings of focus group discussions and field notes after the session are summarized under following themes:

Different approaches towards inquiry

After the intervention participant teachers shared their understanding through focus group discussion about features of three different approaches towards inquiry. There conception on different approaches towards inquiry are compiled in Table-2.

***Table 2**: Comparison of different investigations*

Structured	**Guided**	**Open-Ended**
• Teacher has full control over the problem or questions being addressed and outcome of the problem • Teacher has control over the procedure, materials to use **Advantage**: • Easier to manage • Controlled environment • Clear instructions • Known outcome • Suitable when time and material limitations. • Better for early age groups • Safe and risk free for teachers **Disadvantage**: • Limited skill-based learning. • Low level thinking i.e. completely teacher controlled. • Not much room for exploration • Minimal discussion • Limited freedom of thought	• Teacher has control over the questions being addressed. • Both teacher and learner have shared control over procedure of the investigation. **Advantage**: • Opportunity to think critically and out of box • Promotes competition and collaborative work • Encourages discussion and engagement • Allowing students to apply concepts. • Room for mistakes and trial and error (for student and teacher) **Disadvantage:** • Less curiosity as questions proposed by teacher and not child • Overwhelming for students with little or no background knowledge • Requires higher degree of teacher involvement (scaffolding).	• Learner has full control on all aspects of the approach. • Learner poses the question, designs and plans the investigation and uncovers the outcome. **Advantage**: • Highest level of thought involved • Skill based active engagement • Improves questioning skills • Exposure to various ideas (exploration skills) and variety of tools • Ownership of work in students. • Creates opportunity to pose questions, inquire, reflect, infer and conclude • This stays as a long-term learning and impacts the student. • Problem solving skills **Disadvantage**: • Overwhelming • Chaotic resulting in classroom issues • Safety issues for students • Less directions less focus • Time consuming and stressful • Unpredictable outcome

Scientific Method and Fair Testing

The participants said that guided inquiry facilitated their understanding of scientific method, science process skills and fair testing. They identified the importance of control variable while carrying out the fair test.

"To make data valid I ensured that the mass and size of the marble remain the same."

"I realized that there are so many environmental factors that may affect my readings."

"For e.g. while rolling a marble on different surfaces the direction of wind changed the direction of the marble causing the distance covered by the marble to change."

They also experienced that designing an experiment took the most amount of time and energy.

"It took me a while to design a method by which I can ensure the same force must act on the marble. I discovered after trial and error that if I place a marble on a slope instead of flat surface will cause the marble to roll."

"Our group had to beat our brains how to prevent the marble from rolling too far and measure the distance. Every time we roll the marble moved off the track. I covered the plank with different medium and rolled the marble on it but then I saw another group rolling the marble from an incline first and then testing rolling it on different materials."

Process Skills

Almost all participant realized that their science process skills required for carrying a fair investigation were inadequate. They realized that investigation requires multiple science process skills. Different science process skills includes hypothesizing, predicting, designing an experiment to test the hypothesis, controlling and identifying variables, measuring, data gathering and analysis and communicating conclusion based on evidence. The abundant research material clearly points out that teachers must understand and develop the scientific thinking process to instil the same in students.

Challenges

Participants stated that fear of chaos and time restriction made them more comfortable in structured lab activities. Data from field notes reported participant's level of confidence in generating evidence based conclusion to be very low. They experienced most amount of confusion and chaos during designing and data collection phase.

Research based practices.

Participants reported that analyses of the classroom vignettes from research literature provided deep insights on different strategies about how professionals around the world have incorporated

inquiry in their classrooms. This was a good exposure to the teachers on importance of research literature and how it can benefit them in their professional growth and development.

Subtle Shifts in Inquiry

Participant teacher's also discussed about the need of bringing subtle inquiry based shifts in their lessons. Subtle shift explained by Rankin (2013) are strategic changes in pedagogy or gradual changes to the existing activities/lesson plan to give students more responsibility to use process skills. They reported to have difficulty in giving adequate amount of control to the learner in classroom. The major challenge confronted by them while planning for inquiry lessons was the maintenance of balance between content and process and creating a harmony of the two to the benefit of student growth and development.

Findings

Participants after the intervention reported that researching on inquiry based methods increase their awareness on how to design activities that not only engages them to understand the content but also develop skills required for inquiry. They realized the need to plan investigations, use appropriate tools and techniques to gather data, formulate explanations from appropriate evidence, evaluate their explanations in light of alternatives, and then communicate and justify their proposed explanations (National Research Council, 2000). In doing so, students not only learn content but also develop understanding of how scientists study the natural world and learn the skills needed for inquiry. After the intervention teachers realized the complexity and difficulty in making small shift in the old lesson plans. Table-2 summarizes few ways by which they can rearrange lesson to bring inquiry based subtle shifts in their lesson.

Discussion, Conclusion and Implications

The major outcome of this intervention was progress in participant's understanding of the concept of inquiry-based science teaching. Workshop intervention and exposure to research-based materials created general awareness about different approaches towards inquiry and features of inquiry- based science lessons.

At the start of this study the participants had superficial knowledge and understanding and as a direct consequence of this workshop they deepened their knowledge base and started the process of appreciating the various aspects of inquiry.

The workshop provided opportunity to participants to apply their learning and reflect on their practices. It provided direction for teachers as to what kind of experiences and skills are required for effective delivery of inquiry lessons and how to communicate them effectively.

Nevertheless, this one intervention was merely a stepping stone in the journey of understanding and application of inquiry-based teaching in science teaching as this kind of instruction demands a significant shift from ingrained traditional teaching methodologies

This requires sophisticated pedagogical content knowledge and process skills that are not gained overnight or studied by learning books. It is the process of learning, implementation, customization, feedback, reflection and practice on a day-to-day basis that will improve the learning outcomes in the long run.

Table 3- *Directions to enhance inquiry based teaching by participants*

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Rearranging the order of activities

- Adding open ended reflective questions
- Analyzing relevance of activity with big idea.
- Giving attention to discourse and productive talk
- Inclusion of science process skills
- Inclusion of formative assessments
- Anticipation of students' responses
- More engaging activities
- Construction of knowledge based on prior experiences
- Emphasis to skill based learning

Recommendations

Inquiry is demanding on the teachers and students who need to be better equipped and planned. Teachers need to create systems for organization and management of materials and guide students through the process.

As inquiry-based teaching is a paradigm shift where school administrator are the key facilitators in providing teachers with an enabling environment to foster this change. This implies providing them with a variety of support from opportunities to learn, material and tools including and not limited to equipment (science learning centers, lab facilities etc.) and flexibility in designing of curricula. Additionally, moral support and encouragement to move away from old school learning methodologies are necessary.

This research can be extended over a larger period and a larger sample size to further consolidate findings for any public policy or reform base for teaching. Also, a detailed study can be conducted to explore how teachers prepare and execute their inquiry based lesson plans and find a correlation between inquiries in science and conceptual understanding of content or acquisition of scientific skills.

Limitations

Since the study is based on a four-month period the same stretched over a period of a year or two may result in more concrete findings and researcher would better assess the gap between preaching and practice. As such, the subtle changes need a larger duration research to monitor the impact over time.

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