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IMPLEMENTING DIALOGIC INQUIRY IN QATARI MATHEMATICS AND SCIENCE CLASSROOMS: CHALLENGES AND PROVOCATIONS

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Abstract

In relation to an international concern to encourage inquiry-based pedagogies in Science Technology, Engineering and Mathematics (STEM) subjects and the issues of transfer in teacher professional development (PD), we report on the aspirations and perceived challenges of teachers in Qatar as they embark on PD to introduce inquiry-based learning into their mathematics and science classrooms. Data from initial interviews with eighteen teachers, with Grades 4 to 8 mathematics and science classes, were analysed in relation to challenge factors from inside and beyond their classrooms. The findings are used to provoke our awareness and understanding of the issues of shifting pedagogies that might arise during PD programmes.

Keywords: Inquiry-based learning; professional development; shifting pedagogies; WebQuests

Introduction

A growing body of research suggests that student-centred inquiry-based learning can support student achievement (Bickford, Tharp, McFarling, & Beglau, 2002; Lowther, Ross, & Morrison, 2003). Furthermore, there is an international consensus that an innovative economy in the twenty-first century prospers through Science, Technology, Engineering, and Mathematics (STEM) (Gluckman, 2011; Prinsley & Johnston, 2015). Consequently, many nations are now looking towards an education system that achieves a high level of student achievement, engagement and innovation in STEM subjects.

Contrary to these priorities, education systems often fail to engage students in STEM subjects. These subjects become unpopular to study at secondary and tertiary levels (Gluckman, 2011; Said & Friesen, 2013; White & Harrison, 2012). Hence, there is a potential dilemma. If students are to gain the competencies and dispositions that would prepare them to contribute to twenty-first-century innovative economies, education systems need to adopt new richer pedagogies that will promote inquiry and critical thinking (Fullan & Langworthy, 2014). However, even with professional development, there is often a disconnect between theory and practice that can impede teachers' adoptions of richer pedagogies (Korthagen & Kessels, 1999). Some of this disconnect can be accounted for by the stresses that teachers experience when introducing a new pedagogy into their classrooms (Wiley, 2000). Grant and Hill (2006) outlined challenges for teachers that come from both outside and within their classrooms. More recently, Fullan and Langworthy (2014) referred to the influence of external realities, such as curriculum content and standardised assessments, and how these realities can act as "barriers to the widespread adoption of new pedagogies" (p. 9).

This paper explores how teachers in Qatar might perceive such challenges as they embark on a professional development (PD) programme intended to promote shifts in pedagogy through the use of inquiry-based learning in their mathematics and science classrooms. We report on interview data of eighteen teachers interviewed at the start of a professional development (PD) programme. The teachers' perceptions of inquiry-based learning, as well as their aspirations and concerns in introducing the pedagogy into their classrooms, are analysed in relation to the challenges identified by Grant and Hill (2006). The findings are used to provoke our awareness and understanding of the issues that might arise during PD programmes.

Pedagogies for inquiry-based learning

Inquiry-based learning is a way of working in classrooms to construct and re-construct knowledge between participants in specific contexts (Wells, 2001). Theoretically underpinned by a view of knowledge as a generative process of meaning-making, knowledge is seen as actively constructed by students rather than a stable body of facts. In relation to this theoretical perspective, inquiry-based pedagogy attempts to present authentic learning opportunities and to develop students' critical thinking skills (Artigue, Dillon, Harlen, & Lena, 2012). When working in a systematic inquiry about questions or topics that are of interest, students are encouraged to build on each other's ideas, draw inferences and identify their own assumptions; hence the knowledge learned is held critically.

A definition of inquiry-based learning is not clear-cut (Cuevas, Lee, Hart, & Deaktor, 2005), and it may be more helpful to view inquiry-based learning as a continuum. In this paper, we refer to Tafoya, Sunal, and Knecht's (1980) classification of different types of inquiry that presents as a continuum from teacher-directed to student-centred pedagogy. At one end, there is little or no inquiry. The teacher tells students the outcome of a problem and gives instructions on how to carry out an experiment or investigation in order to confirm the outcome. Further along the continuum, students are given a structured step by step process in how to investigate a given prompt or question. In the middle is guided inquiry, where the teacher gives a prompt or question as a starting point, and students find their own way to answer the question. At the other end is a fully open inquiry where students initiate their own questions and formulate their own processes to answer their questions.

Pedagogy that relates to the student-centred end of the continuum differs from teacher-directed pedagogy. In a teacher-directed classroom, a teacher has a firm grasp on the subject content and leads the students towards solutions. In student-centred pedagogy, the students find the knowledge themselves and, in doing so, the learning may move away from directed objectives and content (Lipman, 2003). This shift of the control of learning from teacher to student may pose a number of challenges for some teachers.

Challenge factors influencing shifts in pedagogies

One way of classifying challenges to the adoption of new pedagogies was described by Grant and Hill (2006), who identified five factors that might affect teachers' decisions to use student-centred inquiry-based pedagogy. One factor is the "integration of student-centred learning within the larger realities beyond the classroom" (p. 23). Guidance and directives in many national curricula often suggest inquiry, creativity, and problem-solving, but standardised assessments primarily measure the reproduction of content knowledge. As such, the time spent on developing student-centred learning may not be reflected in standardised assessments. Teachers are accountable for their students' subject preparation and may feel that the quality of teaching is judged by how well they can deliver content to students in relation to their specialised content knowledge (Fullan & Langworthy, 2014). As a result, teachers may be reluctant to transfer from a teacher-centred pedagogy that they feel will ensure students meet the subject content.

A second factor is the "recognition and acceptance of new roles and responsibilities on the part of teachers and learners" (p. 20). A new pedagogy means a new didactic relationship with students. In moving from direct teaching to a facilitator of inquiry, teachers may feel that their responsibility for learning is reduced. There may be a sense that the teacher "gives away" (p. 20) the responsibility of learning to the students.

A third factor is the "comfort level of teachers and learners" (p. 21). By comfort level, Grant and Hill were referring to the physical layout and dynamics of the learning environment that may change in inquiry-based learning. For example, if there is a shift to small group work and more collaboration, there may be a consequential increase in talk and student movement around the classroom. The classroom environment feels less controlled and may be disquieting and uncomfortable for some teachers.

A fourth factor is "tolerance for ambiguity and flexibility" (p. 22). If the idea of comfort level is concerned with the physical environment of the classroom then tolerance for ambiguity and flexibility is a social and emotional factor. In teacher-directed classrooms, the learners interact with content that is commanded by the teacher. In inquiry-based learning, the range of questions in an investigation can be broad and there is a risk that the students may meet learning objectives other than those intended. Teachers may feel there is a risk in tolerating such ambiguity in their classrooms. Ambiguity might also unsettle students when taking on learning from sources other than the teacher or textbook.

Fullan (2013) promoted the integration of technology as a powerful tool in transforming pedagogy, and the use of the internet can give students access to discover knowledge in a more authentic way. However, a teacher's "confidence in integrating technology" (p. 23) presents a fifth factor. As well as the teacher's own confidence in using and managing technology, integrating technology may mean less time for other curriculum content. The teacher may feel they become an instructor of technology or a trouble-shooter and will need to make decisions about how best to use the technology. The use of technology may also relate to tolerance of ambiguity and flexibility. The teacher may no longer have command of the content or direct the learning. In shifting to a more student-centred pedagogy, teachers need to feel they can take risks related to these challenge factors. The move away from high levels of teacher direction is a risk that some teachers may not be prepared to take. When introducing pedagogies for inquiry-based learning to the mathematics and science classrooms in Qatar, we were interested in whether the teachers perceived any potential challenges. We wanted to explore the teachers' current understanding and practice in inquiry-based pedagogy, and to determine their aspirations and perceptions of potential challenges in implementing more student-centred pedagogy.

The study

The project aimed to evaluate a PD programme intended to support teachers in Qatar develop more student-centred inquiry-based learning in their middle school mathematics and science classrooms. The Qatar National Research Strategy (2012) saw the promotion of STEM subjects as a priority in developing Qatar's position as a diversified knowledge-based economy, and in particular, to "strengthen K-12 and undergraduate programs in the fundamental sciences and mathematics" (p. 2). Furthermore, the Ministry of Education and Higher Education Qatar (2018a) recognised the use of technology and inquiry as a way to promote more exciting and engaging learning environments and to increase students' motivation and encourage creativity.

National curriculum standards, established by the Curriculum Standards Office (CSO) in Qatar, set out the expected curriculum and attainment in key subject areas, including science and mathematics (Ministry of Education and Higher Education Qatar, 2018b). Skills, such as critical thinking, enquiry, and reasoning, are emphasised in the science curriculum, and real-world problem solving is valued in the mathematics curriculum. Curriculum guidance states that reasoning, inquiry, and problem solving should be integrated across the content for both mathematics and science.

In order to encourage the teachers to move to more student-centred inquiry-based learning, workshops were provided by PD Specialists that set out the continuum from Tafoya et al. (1980). A key part of these workshops is the introduction of WebQuests as a specific didactic tool, intended to scaffold moves towards more student-centred pedagogy. A WebQuest is "an inquiry-orientated activity in which some or all of the information that learners interact with come(s) from resources on the internet" (Dodge, 1995, p. 1). The use of WebQuests has been shown to support students in investigating beyond the classroom and to become independent, active learners using higher order thinking (Calder, 2011; Göktepe, 2014; Salsovic, 2007). According to the creators of WebQuests there are six sections: introduction, task, process, resources, evaluation and conclusion (Dodge, 2001), and the teacher's role

is to plan, guide, and facilitate learning as the students work through the six sections. We perceived that this clear structure would scaffold shifts in pedagogy and encourage learning within small group work. Furthermore, the WebQuests have the benefit of being conducted over the period of one lesson, and so would be manageable within the context of the schools.

Results and analysis

In this paper, we present analysis of the first initial interview from the eighteen teachers involved in the PD. There were two teachers, one mathematics and one science, from each of the nine schools. The eighteen teachers had a range of teaching experiences from one year to twenty-two years. Schools are separated by sex in Qatar, and the classes of students involved in the project ranged from Grade 4 to Grade 8. All the teachers have at least a degree-level qualification, either in the subject area they are teaching or in education, with a specialisation in the subject area, they are teaching. As such, all teachers expressed a high level of confidence in the subject they taught. They stated how they were well aware of the content knowledge.

The interview questions analysed in this paper were:

- What do you understand by the term inquiry-based learning?
- What types of inquiry-based learning have you used in mathematics or science?
- How well do you feel students can investigate and test out their own ideas in mathematics /science?
- Do you have any worries or concerns about introducing inquiry-based learning in your classroom and if so what are they?

Teachers' responses to these questions were analysed according to three themes: current understanding and use of inquiry-based pedagogy, aspirations for introducing inquiry-based pedagogy, and concerns for introducing inquiry-based pedagogy. Pseudonyms have been used to identify responses from teachers.

Current practice in relation to inquiry-based learning

Three teachers, all mathematics teachers, stated that they did not use any pedagogies for inquiry-based learning, at least in relation to their current understanding. Other teachers' descriptions of current practice suggested students might be encouraged to search for answers but that the teacher saw their role as the provider of knowledge.

A Grade 7 teacher explained how his students tested their ideas according to his instructions and that they questioned him to verify their ideas. A Grade 5 teacher indicated that her students needed guidance and structure and that she provided steps for them to follow. As she stated:

> *Aliya: Our role here is to guide them [the students] to achieve the objective.*

This perception was echoed by another teacher who felt it was her responsibility to explain the lesson.

Some teachers did not feel their students were capable of investigating and testing out ideas. These perceptions were across all the grades, so were generally not age-specific. However, a Grade 4 teacher referred to the age of her students as a possible concern:

> *Fatima: Because they are still young, and their ideas are too simple that they do not reach the creativity level.*

This teacher also stated that:

> *Fatima: I mainly use it [inquiry-based learning] for the higher achiever students because they have special skills.*

Further teachers commented that there were creative students who could discuss their ideas with each other. A few teachers referred to the students' attitude and motivation to complete an inquiry independently.

Aspirations for inquiry-based pedagogy

Teachers generally felt that inquiry would support students' learning. They referred to relevance, motivation, engagement, and confidence. Some teachers commented that inquiry would enhance learning and deepen understanding and justified this by suggesting students learn from their mistakes in researching knowledge themselves and that relating to reality helps to understand concepts.

Eight teachers stated that they had no concerns in introducing inquiry-based learning in their classrooms. Some of these teachers claimed that their students were motivated. For example, a Grade 4 teacher stated:

> *Achmed: The students that I will be applying this strategy with are motivated and willing to try any new strategy.*

Other teachers recognised that they would need to raise students' awareness and increase motivation or encourage investigation but that these were not concerns. For example, a Grade 7 teacher said:

> *Kaelen: I have no concerns about the application of inquiry-based learning because I will encourage students to work, research and investigate.*

Several science teachers felt that the nature of the subject related well to inquiry-based learning. For example:

> *Nadir: Teaching science depends mainly on inquiry.*

> *Rahel: It depends on scientific experiments. Observation, putting hypothesis, testing it and making a conclusion.*

> *Fabia: I have only a little concern regarding students' reactions toward a new way of learning. Because we already apply inquiry in science lessons.*

Concerns in introducing inquiry-based pedagogy

Where there were concerns, these often related to meeting the needs of individual students with lower academic performance. Some teachers felt that the ability of the students would affect how well they could implement the inquiry. For example, one Grade 5 teacher stated:

> *Dakini: Some students have a weak focus, so they may not follow my instructions. Or if they read the written instructions, they may not understand them well enough to perform the tasks.*

In other cases, teachers commented on the motivation and attitude of students, and whether they would accept a new way of learning. As one teacher said:

> *Hahn: I am afraid that students will not accept this method in education.*

One teacher referred to concerns regarding behaviour management, possibly in relation to use of small group work, and how a few students might restrict the work of other students in the class. Other teachers referred to potential difficulties in managing a large number of students.

Some teachers were concerned that resourcing the online materials and websites needed for developing the WebQuests would take too much time, and that inquiry would limit the time needed to work through the curriculum. Teachers were concerned about the availability of online resources, whether the internet resources would be suitable for the academic level of the students, and whether they would be safe. A few teachers were concerned about the reliability of the internet connection, the need for technical support, and the limited skills of the students in using the technology.

In order to help implement student-centred inquiry the teachers felt that tools and strategies should be "simple, easy, and safe" so that the students could carry out activities themselves. The teachers also felt that being well organised with good planning and classroom management would be important. One teacher stated that she would need to plan the lesson "correctly" and that the PD should provide them with clear strategies and tools to support them.

Discussion

In this discussion, we consider how the themes presented in the results relate to Tafoya et al.'s (1980) continuum and to Grant and Hill's (2006) challenge factors. It seemed that the majority of teachers felt that, at least in some way, they engaged their students in a level of inquiry, investigation, or problem solving in their current practice. When the teachers described their approaches, they often resembled structured pedagogy rather than guided or open inquiry. Science teachers appeared to aspire more to including inquiry due to the nature of the subject but, again, their approach often related to experiments directed by the teacher.

Comments from some teachers indicated they might not tolerate ambiguity and flexibility. These teachers felt they should be in command of the subject content in order to meet the lesson objective. This sentiment was reflected further in relation to roles and responsibilities. They saw their responsibility was to control the learning, and some teachers expressed concerns that they might be derelict in their duties as the teacher in meeting students' learning needs. Furthermore, some teachers asked that the PD would provide tools, strategies and systems that would be easy and simple to use, and that they would be helped to plan to use the WebQuest correctly, suggesting there might even be some lack of tolerance for ambiguity and flexibility in how to interpret the use of a didactic tool.

Furthermore, some teachers felt their students' prior training and expectations might impede their ability to take on responsibility for their learning. There were also concerns that their students would lack tolerance for ambiguity if the teacher were not the main authority of the learning. In both regards, students might experience discomfort and so may not achieve in their learning. Comments in relation to comfort factors and the physical environment of the classroom, were evident when the teachers expressed concern about the number of students and potential behavioural issues. These teachers may have been concerned about a potential loss of control in managing group work within a more dynamic environment, hence challenging their skills of class management and causing discomfort for themselves and their students.

Whilst none of the teachers expressed concern in their own confidence in using technology, a few commented on issues with internet connections and technical support. Several teachers referred to the potential lack of suitable resources that would meet the learning needs of their students. As the medium for learning was Arabic, and the number of appropriate websites in Arabic are more limited than in English, then this would not be an unreasonable concern. A few teachers raised the issue of safe resources. This concern might relate to both confidence in the use of technology and to tolerance for ambiguity and flexibility. The teacher would not be in command of the information, so would not be able to monitor the content.

Many of the concerns raised by the teachers refer back to views of quality teaching. Some teachers felt they were accountable for their students' subject preparation (Fullan & Langworthy, 2014). The teachers in this study did not refer to external realities in an explicit way, so it is not possible to ascertain how much this sense of accountability was influenced externally. An alternative perspective is that the teachers held this view internally. All the teachers were well qualified and confident in their specialised subject knowledge. Their concern to deliver the content to their students well may have related to an internally held conception of their role, and status, as teacher and view of quality teaching. Whether this concern was externally influenced or held internally, the resulting challenge would be for these teachers to transfer from a teacher-directed pedagogy, where they have control of the subject content, to one where they are asked to give the learning away to the students.

Conclusion

In introducing student-centred pedagogy to these teachers, it was becoming clear that some of the teachers could be challenged by a range of factors. They might feel they are taking risks in relation to their repertoire of teaching strategies and their existing didactic relationships with their students. Both teachers and students may need to unlearn established expectations in their classrooms, and this unlearning may involve challenges, risks and discomforts. As stated in the introduction, there is often a disconnect between theory and practice in transforming pedagogies within PD (Korthagen & Kessels, 1999). In this project, the teachers' perceived risks, suggest provocations in shifting to

inquiry-based learning. In particular, teachers perceive risks in meeting the learning needs of students, in managing their role of monitoring and guiding an inquiry, and in their students' acceptance of a new pedagogy. We intended that the use of WebQuests would provide a didactic tool to shift pedagogy towards student-centred inquiry. With the potential lack of tolerance for ambiguity and flexibility of some teachers, the use of WebQuests might become another process to support the continuation of structured approaches to inquiry, rather than helping the teachers to overcome the perceived risks.

The schools and teachers involved in the project were willing participants (a condition of ethical approval for the project) and so were open to developing their pedagogy. The teachers were generally positive about the use of inquiry-based learning and expressed the benefits to students that a more student-centred pedagogy might bring. However, several of the teachers were uncertain of the potential of inquiry-based learning as a means to achieve content learning objectives. In this regard, a case study of professional development in Qatar could provide information that resonates with teachers' professional experiences and curricular demands internationally and could help us understand further the disconnect between theory and practice in shifting pedagogies through PD programmes.

Acknowledgement:

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