Art. # 1431, 10 pages, https://doi.org/10.15700/saje.v38n1a1431

Teacher beliefs and attitudes about inquiry-based learning in a rural school district in South Africa

Umesh Ramnarain and Manzini Hlatswayo
Department of Science and Technology Education, Faculty of Education, University of Johannesburg, Johannesburg, South Africa
uramnarain@uj.ac.za

Despite growing consensus regarding the value of inquiry-based teaching and learning, the implementation of such a pedagogical practice continues to be a challenge for many South African teachers, especially at rural schools. The research reported in this article concerns the interaction between Grade 10 Physical Sciences teachers' beliefs about inquiry-based learning, and their practice of inquiry in their classrooms. This research adopted a mixed methods design. In the first phase of the research, quantitative data were collected by distributing a validated questionnaire to Physical Sciences teachers in an education circuit in rural Mpumalanga, South Africa. The next phase of the research involving teacher interviews, provided a more in-depth explanation of some of the findings, which emerged from the questionnaire survey. It was found that sampled teachers from the rural district have a positive attitude towards inquiry in the teaching and learning of Physical Sciences, and recognise the benefits of inquiry, such as addressing learner motivation and supporting learners in the understanding of abstract science concepts. However, despite this positive belief towards inquiry-based learning, teachers are less inclined to enact inquiry-based learning in their lessons. Teachers claim that the implementation of inquiry-based learning is fraught with difficulty, such as availability of laboratory facilities, teaching materials, time to complete the curriculum, and large classes, which creates tension in their willingness to implement it.

Keywords: inquiry-based learning; pedagogical practice; rural schools

Introduction

Inquiry-based learning (IBL) is a key thrust in school science education, and has for decades been the prominent and central theme of science curriculum improvement (Aldahmash, Mansour, Alshamrani & Almohi, 2016; Dunne, Mahdi & O'Reilly 2013; Wang, Zhang, Clarke & Wang, 2014). In fact, according to Crawford (2014) most conversations about reform-based science teaching include the word 'inquiry.' Inquiry has also been used to characterise good science teaching and learning (Anderson, 2007).

However, despite the strong advocacy for IBL, multiple meanings and interpretations have been put forward. Nevertheless, there is consensus that IBL is based on the epistemology of scientific research, and this suggests that learners should acquire theoretical content, thinking skills (Haug, 2014) and process skills (Breslyn & McGinnis, 2012; Rocard, Csermely, Jorde, Lenzen, Walwerg-Heriksson & Hemmo, 2007; Wang et al., 2014). This holistic approach to science has led to it being termed 'authentic' science, because learners may make their own decisions in terms of the content with which they engage, the manner of presenting the acquired knowledge, their own topic of research, and the methodology used (Hubber, Darby & Tytler, 2010). The essence of inquiry is thus the active involvement of learners, focusing on the 'why' and 'how' and less on the 'what' and it is suggested this helps learners to gain a better perception of what science is and how it is practiced (Rooney, 2012; Zion, 2007).

Inquiry-based learning is also key in preparing a workforce that is adaptable in its thinking and able to operate with greater autonomy. Whereas skills in set routines were desired attributes in the past, today each worker is expected to think critically, solve abstract problems and generate new ideas for improvement (Castells, 2005). Economic growth and competitiveness is dependent on continuous technological improvement and innovation. We live in a knowledge-based economy where knowledge is a driver of productivity and economic growth (Organisation for Economic Co-operation and Development, 1996), and this leads to a new focus on education. In the knowledge-based economy, "learning-by-doing" is paramount, and inquiry-based learning activities could encapsulate experiences that develop thinking skills demanded by the workplace in this economy. These new demands from the workplace and the technological advancements of the world in which we live have served to stimulate much change in national curricula throughout the world.

In "A Framework for K-12 Science Education" for the United States, it is emphasised that students should experience inquiry-based practices and not merely learning about them (National Research Council of the National Academies, 2012). Instead of 'inquiry skills,' the term 'inquiry practices' is used to highlight that the process of inquiry requires the coordination of both knowledge and skills simultaneously. The following 'practices' are identified: asking questions (for science); defining problems (for engineering); developing and using models; planning and carrying out investigations; analysing and interpreting data; using mathematics and computational thinking; constructing explanations (for science); designing solutions (for engineering); engaging in argument from evidence; and obtaining, evaluating and communicating information (National Research Council of the National Academies, 2012:42). This concept of inquiry is now reaffirmed in the Next Generation Science Standards (NGSS Lead States, 2013), where scientific inquiry is now synonymous with a vision of scientific literacy that encompasses skills and knowledge related to Scientific and Engineering Practices (Lederman, JS, Lederman, Bartos, Bartels, Meyer & Schwartz, 2014). In South Africa, IBL is prescribed in the latest national curriculum document called the Curriculum and Assessment Policy Statement (CAPS). This focus on IBL in CAPS is reflected in Specific Aim 2 where the intent is to develop in learners “scientific skills and ways of thinking scientifically at level of academic and scientific literacy that enables them to read, talk about, write and think about biological processes, concepts and investigations” (Department of Basic Education, Republic of South Africa, 2011:16–17).

The benefits of IBL are well-established from empirical research studies. Affectively, doing inquiry is motivational, and stimulates interest in science learning (Osborne, 2010; Piburn & Baker, 1993). IBL has also been shown to contribute to the development of conceptual understanding in science (Leonor, 2015). Scientific inquiry may lead to the development of higher-order thinking skills such as analysis, synthesis, critical thinking and evaluation (Conklin, 2012). Inquiry is also an important means to understanding the nature of science (Abd-El-Khalick, BouJaoude, Duschl, Lederman, Mamlok-Naaman, Hofstein, Niaz, Treagust & Tuan, 2004; Gaigher, Lederman & Lederman, 2014; Lederman, NG & Lederman, 2012) and provides an insight into the world of the scientist (Breslyn & McGinnis, 2012).

Despite growing consensus regarding the value of inquiry-based teaching and learning, research has found that the implementation of such a pedagogical practice continues to be a challenge for many teachers (Dillon, 2008; Smolleck & Mongan, 2011; Trautmann, MaKinster & Avery, 2004). IBL signals a paradigm shift from the traditional teacher-dominated to a learner-centred approach. Here, the role of the teacher as one who acts as a ‘sage-on-the-stage’ in a traditional passive learning environment, is redefined into multiple roles that include those of “motivator, diagnostician, guide, innovator, experimenter, researcher, modeller, mentor, collaborator, and learner” (Crawford, 2014:526). In South Africa, the advent of IBL as a curriculum imperative has been a recent development, and hence only limited research has been done in this regard (Dudu & Vhurumuku, 2012; Ramnarain, Nampota & Schuster, 2016). The research reported in this article is on the interaction between Grade 10 Physical Sciences teachers’ beliefs about IBL, and their practice of IBL in their classrooms.

In particular, the study centres on the beliefs of Physical Sciences teachers in a rural district in the province of Mpumalanga. Mpumalanga is a province that lies in eastern South Africa, bordering Swaziland and Mozambique. It is predominantly rural. In South Africa, the advent of the new democratic political order since 1994, has resulted in a major overhaul of the apartheid education system. One national and nine provincial departments have been created out of 18 fragmented departments that were based on race and ethnicity. This restructuring of the education system has resulted in major gains in post-apartheid South Africa. These include improved access to education, as reflected in school enrolment figures, accelerated provisioning of school infrastructure, more equitable distribution of resources, improved learner-educator ratios, and the introduction of school nutrition programmes (Statistics South Africa, 2010). However, rural education is out of step with educational development in other parts of the country. This is despite the fact that the vast majority of school-going children in South Africa live in rural areas. Correspondingly, factors that mitigate against curriculum reform such as the introduction of IBL appear to be more pronounced in rural districts. A particular focus of this research was therefore on the teachers who were teaching at rural schools.

Accordingly, the following research questions guided this research:

1. What beliefs do Physical Sciences teachers at rural schools hold about IBL?
2. What are the difficulties these Physical Sciences teachers encounter in the enactment of an inquiry-based practice?
3. What is the relationship between these teachers’ beliefs about inquiry and their classroom practice?

Teacher Beliefs

Teachers faced with new pedagogical approaches to education face a number of dilemmas, many of which are rooted in their beliefs and values (Anderson, 2007). Philipp refers to beliefs as “psychologically held understandings, premises or propositions about the world that are thought to be true” (2007:259). Within the context of education, Kagan (1992) refers to teacher beliefs as “implicit assumptions about students, learning, classroom, and the subject matter to be taught” (p. 66). Binns and Popp (2013) underline the significance of teacher beliefs by arguing that it is not educational background alone that determines whether a teacher will use an inquiry-based pedagogy, but also teachers’ beliefs, values and views regarding knowledge and how it is acquired that are significant. Teachers’ beliefs about science, beliefs about the nature of science, beliefs about teaching and learning, and beliefs about inquiry-based approaches influence science teachers’ decisions and choices of pedagogical strategies (Sikko, Lyngved & Pepin, 2012). If teachers’ core beliefs are in conflict with inquiry practices, they act as a hindrance to teachers in choosing inquiry as a pedagogical strategy (Binns & Popp, 2013).

Beliefs held by teachers influence their perceptions and judgement, which in turn affects their choices of teaching strategies and their behaviour in the classroom (Pajares, 1992). Harwood, Hansen and Lotter (2006) argue that while the factors that influence teachers' practices are complex and numerous, teachers' beliefs have been found to influence teachers' teaching practices, how they believe content should be taught, and how they think learners learn. Beliefs are therefore likely to play an important role in whether teachers intend to and/or actually carry out the practice of teaching science as inquiry (Crawford, 2014). Saad and BouJaoude (2012) also assert strongly that one of the major barriers to implementing inquiry practices in science classrooms is teachers' beliefs about teaching, learning and classroom management.

Research that has been conducted outside South Africa has investigated the interconnection between teacher beliefs on IBL and their teaching practice. Studies have reported on how teachers' practice of inquiry has been related to their beliefs about inquiry. In a quantitative study, Haney, Czerniak and Lumpe (1996) reported that teacher beliefs were a strong predictor of their intentions to implement a reform-based pedagogy such as IBL. In a case study of six experienced high school teachers, Wallace and Kang (2004) found that teachers having a belief in inquiry to lead to successful science learning, especially in conceptual understanding, were willing to integrate IBL activities into their teaching. However, research has also reported on an apparent disconnect between teacher belief in IBL and its enactment. It has been found that when a teacher holds an inquiry-driven belief, those beliefs do not necessarily translate into correlated practice. In a study of primary school teachers in Hong Kong conducted by Chan (2010), it was found that while teachers have positive beliefs about inquiry-based teaching and learning, such beliefs have not developed into influencing their choice of pedagogical strategies, and the teachers were seldom found to use inquiry-based teaching and learning approaches in their classrooms. In a study conducted across European countries, it was found that while there is a positive orientation towards inquiry-based teaching and learning, there are significant differences in the actual use of inquiry-based teaching and learning approaches in classrooms (PRIMAS, 2011). Saad and BouJaoude (2012) state that in a study conducted in Lebanon, teachers found that while 85% of the teachers had positive attitudes and favourable beliefs towards scientific inquiry, classroom practices of the teachers indicated that there is no consistent relationship between attitudes and beliefs, and knowledge about inquiry and practices. The research reported in this article sought to establish whether the developments worldwide were similarly exhibited in South Africa.

Research Design and Methodology

This research adopted a "sequential explanatory mixed methods" design (Creswell, 2014:224). This design involves a "two-phase project in which the researcher collects quantitative data in the first phase, analyses the results, and then uses the results to plan (or build on to) the second, qualitative phase" (Creswell, 2014:224). It is regarded as explanatory because the initial quantitative data results are explained with the qualitative data. It is considered sequential because a quantitative phase follows the qualitative phase.

In the first phase of the research, quantitative data was collected by distributing a questionnaire to Physical Sciences teachers in an education circuit in rural Mpumalanga, South Africa. The next phase of the research was explanatory and provided a more in-depth explanation of some of the findings that emerged from the questionnaire survey. Here teachers who participated in the survey were interviewed.

Sampling

A questionnaire was delivered to all 18 schools in a rural district in the province of Mpumalanga. In South Africa, schools are classified according to quintiles for purposes of education funding. Quintile 1, 2 and 3 schools are schools situated in socio-economically deprived areas and are, therefore, known as 'no-fee schools.' Quintile 4 and 5 schools are located in more affluent communities, and are fee-paying schools. In these upper quintile schools, parent bodies also supplement the fees when a need arises to purchase additional resources such as learner-support materials and equipment. All the schools that formed the focus of this research are classified as Quintile 1 (no-fee schools), where the parents do not pay any school fees for their children to attend the schools. An analysis of the poverty rate by the Mpumalanga Department of Finance shows that the district where these schools are situated has a rate of 40.1% of people living in poverty (Department of Finance, Mpumalanga Provincial Government, 2013). The national poverty rate is 35.9%.

Eleven teachers responded to the questionnaire. The average age of the teachers who completed the questionnaire was 39 years, with the youngest being 25 and the oldest being forty-nine. Ten were males and one was female. The experience of the teachers in the profession ranged from a few months to more than 20 years. The sampled schools are poorly resourced and do not have laboratories. Class sizes range between 40 and 50 learners. All teachers had undergone professional development on the interpretation, management and implementation of a new inquiry-based Physical Sciences curriculum.

Data Collection and Analysis

The questionnaire adopted for this study was the PRIMAS (Promoting Inquiry-based learning in Mathematics and Science Education) survey instrument that was developed for a large survey on inquiry-based learning and teaching (IBL) across 12 European partner countries (PRIMAS, 2011). The instrument was firstly piloted with a group of five sciences teachers, who did not form a part of the sample selected. The teachers in the pilot study were asked to identify and comment on items that they regarded as being unclear. No readability issues were raised and the questionnaire was adopted in its original form. The questionnaire comprises items in the form of statements, to which teachers respond on a four-point Likert scale that ranges from 1 (strongly disagree) to 4 (strongly agree). The items are clustered according to constructs on inquiry-based learning. For the purpose of this research, the following three constructs are of interest: teachers' beliefs and attitudes about IBL; teachers' difficulty in the enactment of IBL; and teachers' current practices regarding IBL. In the introduction to the instrument, there is a brief description of inquiry-based learning. This is to ensure that respondents have a common understanding of the terminology used. Here, IBL is described as "a student-centred way of learning content, strategies and self-directed learning skills. Students develop their questions to examine; engage in self-directed inquiry (diagnosing problems – formulating hypothesis – identifying variables – collecting data – documenting their work – interpreting and communicating results) – collaborate" (PRIMAS, 2011:38). The PRIMAS item statements for the constructs, teachers' beliefs and attitudes about IBL, teachers' difficulty in the enactment of IBL, and teachers' current beliefs appear in Appendix A.

In large part, the item statements were positively worded. This meant that a higher score for an item (towards strongly agree) suggested the strength of that construct. A few items were negatively formulated, for example "I see no need to use IBL approaches." In such a case, the items were reverse-scored, where the numerical scoring scale runs in the opposite direction. So, in the above example, strongly disagree would attract a score of 4, and strongly agree a score of 1. Therefore, from a mean score close to 4 for the construct "teacher beliefs and attitudes," it can be inferred that teachers have a positive belief in and attitude towards inquiry-based learning. Similarly, a high score for the construct "teacher difficulty with inquiry-based learning" highlighted the difficulty teachers encountered with inquiry-based learning. Table 1 provides a brief description of the constructs, the number of items per construct and example items.

Table 1 Scales and sample items from PRIMAS questionnaire

Scale	Number of items per scale	Example item
Teacher beliefs	11	IBL is important for my current teaching practice.
Teacher difficulty	15	I worry about students' discipline being more difficult in IBL lessons.
Teacher practice	11	My students are asked to do an investigation to test out their own ideas.

Mean (average) calculations were performed to identify general trends in responses for each of the scales and items. Standard deviations were calculated to determine the degree of consistency among respondents for each scale. Correlation analysis was used to describe the strength and direction of the relation between the constructs and items.

This was followed by the collection of qualitative data through teacher interviews. Through these interviews, the researcher solicited in-depth explanations of some of the findings emerging from the quantitative survey. The interviews were unstructured and comprised open-ended questions "so that the participant can best voice their experiences unconstrained by any perspective of the researcher" (Creswell, 2005: 214). The interviews were initiated through questions such as "what is your view of inquiry learning?" and "are you using an inquiry-based approach in your teaching?" Based on the manner in which the teacher responded to this question, the researcher posed follow-up questions to seek elaboration when necessary, and also to probe teachers on the views they were expressing. All interviews were recorded and later transcribed. Open and closed coding was applied to the data. Saldaña (2009) describes a code as "a word or short phrase that symbolically assigns a summative, salient, essence-capturing name for a portion of language-based or visual data" (Saldaña, 2009:3). Open coding is inductive, requiring that the data be thoroughly read, identifying any similarities, while closed coding is deductive and assigns data to a readily established theoretical framework, where sub-themes are then identified based on this theoretical lens. The second author did an open coding of the data. Thereafter, he looked for connections between the codes. He was guided in this process by the three constructs on inquiry-based teaching and learning that form the focus of this investigation. He was able to group the codes into sub-themes, and later themes, which to a large extent corresponded with the three constructs. The first author then coded the interview data according to codes established by the first author. There was an 86% agreement between the authors in this coding, and consensus was reached through discussion.

Findings

The findings from the analysis of the questionnaire survey were integrated with the findings from the teacher interviews into a coherent whole. The statistical results from the PRIMAS questionnaire are presented in Table 2. The means for each item appears in Appendix A.

The Cronbach's alpha for each construct (scale) was over 0.70, suggesting strong internal reliability within each scale (Pallant, 2007). The low standard deviation for each construct suggests there was consistency in the responses of the teachers.

Table 2 Scale statistics for PRIMAS

Scale name	Cronbach Alpha	Scale mean	*SD*
Attitudes and beliefs	0.72	3.05	0.54
Difficulties	0.81	2.89	0.61
Practice	0.74	2.23	0.52

The interview data explained some of the findings that emerged from the questionnaire analysis. This integration of quantitative and qualitative data generated assertions (Gallagher & Tobin, 1991) on the teacher attitudes and beliefs, difficulties, and practice of inquiry-based teaching and learning. These assertions are presented next.

Assertion 1: Teachers Have a Favourable Belief Towards Inquiry-based Learning

All teachers displayed a positive belief towards inquiry-based learning, with the overall mean for this construct being 3.05 out of 4. From an affective perspective, teachers believe that inquiry-based learning can help motivate learners (M = 2.96, Item 6, "IBL is well suited to overcome problems with students' motivation"). Teachers also spoke on the value for IBL in the interviews, and this is revealed in the following interview excerpts, where they refer to learners' experiences of IBL.

> *Inquiry makes learning fun-filled, so they enjoy it. They* [learners] *can work together on they show interest.*
>
> *It* [IBL] *makes science come alive and they like some action to see what is happening.*

Further to this, the survey results show teachers had a strongly positive response to the statement "IBL is well-suited to approach students' learning problems" (Item 10, M = 3.45). In the interviews, further elaboration was sought on this. Teachers maintained that IBL can make some abstract science concepts more understandable to learners when they are given the opportunity to investigate them practically. This was expressed quite aptly by a teacher during the interview:

> *For me I can see how it* [IBL] *can have strong benefit. There are many sections where they [learners] struggle to get it. I mean they just do not follow the science. But when you can give them a practical on the topic it makes it alive, and then they can see the meaning. They will understand.*

The favourable belief towards inquiry is also underlined by teacher responses to Item 1, "I would like to implement more IBL practices in my lessons," where a mean of 3.64 was achieved. This demonstrates that teachers would want to create more opportunities for learners to participate in IBL activities. This was also revealed in the interviews, where all teachers expressed this desire. The following excerpts reflect this.

> *Due to factors such as resources I can say I am limited in how much inquiry is being done. They [learners] can learn a lot if I am able to bring in more inquiry into the lessons.*
>
> *Overall I can say this* [IBL] *is good for my learners. I wish we could do more of it for all the topics I am teaching. I would be doing more inquiry if there was more time for it. I hope the textbook could suggest more activities for us to do in class.*

Assertion 2: Despite the Positive Belief Towards IBL, Teachers are Less Inclined to Enact IBL in Their Lessons

On the construct 'Practice,' teachers were asked to respond to item statements on learner activities. Their responses to the items were indicative of a teacher-oriented approach. For the item 20, "learners are allowed to design their own experiments," a mean of 2.00 was attained, and this suggests that learners have limited autonomy in the planning of scientific inquiries. This is also underlined in responses to Item 21, "learners are asked to do an investigation to test out their own ideas," where a mean of 2.36 is indicative of teachers having control over learning. A correlation analysis between data for Item 20, "learners are allowed to design their own experiments," and Item 6, "IBL is well suited to overcome problems with students' motivation" on the construct teacher beliefs, shows a strong negative correlation (r = -.84, $p < 0.05$). This reflects that despite teacher belief in the motivational value of IBL, in their practice, they give learners limited opportunity in designing inquiries. A similar negative correlation was shown for the item "learners do practical activity" and the item from teacher beliefs, "IBL is well suited to approach students' learning problems" (r = -.78, $p < 0.05$), with teachers strongly believing that IBL can address learning problems in science, giving low priority in class to learners doing inquiry.

Reasons for the discrepancy (negative correlation) between teacher beliefs and attitudes towards IBL and their enactment of IBL were revealed in the interviews with teachers. This is addressed in the following assertion.

Assertion 3: Teachers Claim that the Implementation of IBL is Fraught with Difficulty and this Creates a Tension in their Willingness to Implement it

The main factors that make the teaching of IBL difficult are availability of laboratory facilities, teaching materials, time to complete the curriculum, and large classes. Responses to item 35, "I don't have sufficient resources such as computer and laboratory apparatus," yielded a mean of 2.84, suggesting that teachers consider the lack of proper facilities to be a consequential factor in enacting inquiry. This concern was also evident in the interviews:

> *I think the people who drafted this policy do not understand what is happening on the ground. We have no laboratories, no equipment and the classes are overcrowded. How can we conduct experiments all the time?*
>
> *There is no sufficient resources, apparatus and chemicals are not available for practical work. The school is poorly resourced and we are struggling.*

A mean of 2.91 for Item 25, "I don't have adequate teaching materials," underlines a need for material that can facilitate IBL. In the interviews, the teachers felt that the materials provided by the education ministry were in line with a traditional teacher-centred approach, and did not accommodate IBL. They also indicated that they did not have the time to develop their own resource material.

> *These learners do not have textbooks or any other source of information for inquiry. I just give them everything and they write notes so that they will have something to study.*
>
> *Our textbooks are mainly content and exercises. The practical activities are demonstrations for teachers, and there is not too much where the learners must do on their own.*

A further concern revealed through the survey was that teachers tended to perceive that "there is not enough time in the curriculum" (Item 24, M = 2.55). This issue was also highlighted during the interviews. Teachers raised the concern that the South African curriculum was heavily content-laden, with a multitude of topics that are required to be covered in a limited period of time. They felt that due to the learner-centeredness of IBL, learners would need much time in working through the stages of IBL such as formulating investigative questions, designing a plan, conducting the experiment, collecting data, analysing the data and communicating findings. This is underlined below in the interview excerpt.

> *Inquiry needs time, and on the other hand, one has to complete the schedule and be at par with the pace setter. It is difficult to find time to conduct investigations.*

Teachers also feel that they are accountable for the performance of learners and fear that they maybe be held responsible if learners perform poorly due to the curriculum not being covered. This is evidenced in the following interview extract.

> *The need to cover certain amount of work within a particular time and the performance of learners in tests. That is important because if learners do not perform because you did not finish the work then you are in trouble.*

A mean score of 2.55 for the item "the number of students in my classes is too big for IBL to be effective" suggests that teachers tend to perceive difficulty in enacting IBL with large classes. This is shown in the following interview excerpts:

> *The number of students in class is too big, and this does not allow effective learning to take place.*
>
> *Due to the large number of learners in classes, it makes IBL difficult. The problem is controlling some learners who just do not care about the work.*

It would thus appear from the preceding findings that although teachers have a favourable view of inquiry-based learning, constraining factors limit its implementation.

Discussion and Conclusion

It was found that the sampled teachers from the rural district have a positive attitude towards inquiry in the teaching and learning of Physical Science; and that they recognise the benefits of inquiry, such as addressing learner motivation, and supporting learners in the understanding of abstract science concepts. This is a significant finding if an inquiry-based pedagogy is to gain traction within the South African education landscape, especially for schools such as those located in rural districts that have been historically sidelined. This is also critical in preparing learners who will eventually operate with greater autonomy that is now needed in the workplace, and thereby contribute to a knowledge-based economy, where such a quality is valued.

Literature already cited (Anderson, 2007; Binns & Popp, 2013; Crawford, 2014; Harwood et al., 2006) attests to the fact that one of the major barriers to implementing classroom inquiry practices is teachers' beliefs about teaching, learning and classroom management. Hence, it would appear that critical to the implementation of IBL is teachers' holding a fundamental belief in the value of this approach. For example, Wallace and Kang (2004) found that teachers who believed that science learning was associated with inquiry-based scientific practices, infused their teaching with inquiry activities. However, this favourable belief does not necessarily translate into teacher practice. Other studies on inquiry-based learning reveal an apparent disconnect between belief and practice (Chan, 2010; PRIMAS, 2011; Saad & BouJaoude, 2012). The findings of research on the relationship between rural South African teachers' beliefs about inquiry-based learning and their teaching practice coincide with this later trend.

In comparing the implementation of inquiry across different teaching and learning contexts, it would appear that a strong mediating influence on the enactment of inquiry is the presence of extrinsic contextual factors, such as the prescriptiveness of the curriculum, content-based examinations, flexibility of the timetable, availability of resources, and class size. In South Africa, these factors are pronounced, and so although teachers respond favourably towards inquiry, they subvert an inquiry-based curriculum. The finding on this interaction between teacher belief about the value of inquiry, and their belief about what is achievable within the reality of the teaching and learning situation, is in agreement with research undertaken by Wallace and Kang (2004), with six experienced science teachers in the United States. Here it was found that teachers hold competing belief systems on inquiry-based teaching. They remark that the first belief strand appears to stem from school culture and centres on constraining factors that limit inquiry. These factors are similar to the extrinsic contextual factors identified for the South African teachers. The second belief set commented upon by Wallace and Kang was more private and "based on the individual teacher's notion of successful science learning" (2004:958). This belief is in line with South African teachers' perceptions on the benefits of learners doing inquiry. The disparity between the two belief sets has resulted in a tension between their perceived value of an inquiry approach and their willingness to reflect this approach in their teaching.

Case study research undertaken by the first author at suburban schools where resources are adequate and class sizes reasonable, and at schools in disadvantaged communities where classes are overly crowded and equipment inadequate for practical work, further highlight how school factors experienced by teachers exert an unwieldy influence on implementation of curriculum reform (Ramnarain et al., 2016).

It is suggested that teachers not be dismissive of IBL, but instead consider inquiry-based approaches that are workable for their teaching contexts. A compromise position on the disconnect between teacher personal beliefs on inquiry and the identified constraining factors on implementation may be to adopt a pedagogical orientation to inquiry that will allow for its enactment. Various frameworks have been used to describe the degree of openness or closure of a scientific investigation based on the degree of teacher control and the extent of learner autonomy. For example, Bell, Smetana and Binns (2005) present a four-level model to illustrate how inquiry-based activities can range from "highly teacher directed" to "highly student-centred." One such teacher-directed approach that has been investigated is predict-observe-explain (POE). The POE strategy was developed by White and Gunstone (1992) and elicits individual students' predictions, and their reasons for making them about a specific phenomenon. Research done on the POE approach has shown it to be a useful way to juxtapose demonstrations that require a low investment on resources and time, with explanations (Coştu, Ayas & Niaz, 2010; Herrington & Scott, 2011; Kearney, Treagust, Yeo & Zadnik, 2001). Based on the identified difficulty teachers at the rural district schools experience in inquiry teaching, it is recommended that future research be pursued in investigating the efficacy of the POE approach to inquiry at such schools.

Note

References

Abd-El-Khalick F, BouJaoude S, Duschl R, Lederman NG, Mamlok-Naaman R, Hofstein A, Niaz M, Treagust D & Tuan HL 2004. Inquiry in science education: International perspectives. *Science Education*, 88(3):397–419. https://doi.org/10.1002/sce.10118

Aldahmash AH, Mansour NS, Alshamrani SM & Almohi S 2016. An analysis of activities in Saudi Arabian middle school science textbooks and workbooks for the inclusion of essential features of inquiry. *Research in Science Education*, 46(6):879–900. https://doi.org/10.1007/s11165-015-9485-7

Anderson RD 2007. Inquiry as an organizing theme for science curricula. In SK Abell & NG Lederman (eds). *Handbook of research on science education*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bell R, Smetana L & Binns L 2005. Simplifying inquiry instruction. *The Science Teacher*, 72(7):30–33.

Binns IC & Popp S 2013. Learning to teach science through inquiry: Experiences of preservice teachers. *Electronic Journal of Science Education*, 17(1):1–24. Available at http://ejse.southwestern.edu/article/view/11346/8116. Accessed 24 November 2017.

Breslyn W & McGinnis JR 2012. A comparison of exemplary biology, chemistry, earth science, and physics teachers' conceptions and enactment of inquiry. *Science Education*, 96(1):48–77. https://doi.org/10.1002/sce.20469

Castells M 2005. The network society: from knowledge to policy. In M Castells & G Cardosa (eds). *The network society: From knowledge to policy*. Washington, DC: Johns Hopkins Center for Transatlantic Relations. Available at https://www.umass.edu/digitalcenter/research/pdfs/JF_NetworkSociety.pdf. Accessed 6 December 2017.

Chan HO 2010. How do teachers' beliefs affect the implementation of inquiry-based learning in the PGS Curriculum? A case study of two primary schools in Hong Kong. PhD thesis. Durham, England: Durham University. Available at http://etheses.dur.ac.uk/320/1/The_thesis_of_Angus_FINAL.pdf?DDD29+. Accessed 24 November 2017.

Conklin W 2012. *Higher order thinking skills to develop 21st century learners*. Huntington Beach, CA: Shell Education.

Coştu B, Ayas A & Niaz M 2010. Promoting conceptual change in first year students' understanding of evaporation. *Chemistry Education Research and Practice*, 11(1):5–16. https://doi.org/10.1039/C001041N

Crawford BA 2014. From inquiry to scientific practices in the science classroom. In NG Lederman & SK Abell (eds). *Handbook of research on science education* (Vol. 2). London, England: Routledge.

Creswell JW 2005. *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson Education.

Creswell JW 2014. *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed). Thousand Oaks, CA: Sage.

Department of Basic Education, Republic of South Africa 2011. *Curriculum and Assessment Policy Statement (CAPS): Physical Sciences*. Final draft. Pretoria: Government Printer. Available at http://schools.pearson.co.za/media/73588/physical-sciences-caps-fet-jan-2011.pdf. Accessed 6 December 2017.

Department of Finance, Mpumalanga Provincial Government 2013. *An analysis of poverty in Mpumalanga, 1996-2012*. Nelspruit, South Africa: Author. Available at http://finance.mpu.gov.za/documents/ea_Economic_research_report_on_%20poverty_in_MP_Nov_2013.pdf. Accessed 11 December 2017.

Dillon J 2008. *A review of the research on practical work in school science*. London, England: King's College London. Available at http://score-education.org/media/3671/review_of_research.pdf. Accessed 8 December 2017.

Dudu WT & Vhurumuku E 2012. Teachers' practices of inquiry when teaching investigations: A case study. *Journal of Science Teacher Education*, 23(6):579–600. https://doi.org/10.1007/s10972-012-9287-y

Dunne J, Mahdi AE & O'Reilly J 2013. Investigating the potential of Irish primary school textbooks in supporting inquiry-based science education (IBSE). *International Journal of Science Education*, 35(9):1513–1532. https://doi.org/10.1080/09500693.2013.779047

Gaigher E, Lederman N & Lederman J 2014. Knowledge about inquiry: A study in South African high schools. *International Journal of Science Education*, 36(18):3125–3147. https://doi.org/10.1080/09500693.2014.954156

Gallagher JJ & Tobin KG 1991. Reporting interpretive research. In JJ Gallagher (ed). *Interpretive research in science education* (NARST Monograph No. 4). Manhattan, KS: Kansas State University.

Haney JJ, Czerniak CM & Lumpe AT 1996. Teacher beliefs and intentions regarding the implementation of science education reform strands. *Journal of Research in Science Teaching*, 33(9):971–993. https://doi.org/10.1002/(SICI)1098-2736(199611)33:9<971::AID-TEA2>3.0.CO;2-S

Haug BS 2014. Inquiry-based science: Turning teachable moments into learnable moments. *Journal of Science Teacher Education*, 25(1):79–96.

Harwood WS, Hansen J & Lotter C 2006. Measuring teacher beliefs about inquiry: The development of a blended qualitative/quantitative instrument. *Journal of Science Education and Technolog*y, 15(1):69–79. https://doi.org/10.1007/s10956-006-0357-4

Herrington D & Scott P 2011. Get in the game with team density. *The Science Teacher*, 78(4):58–61.

Hubber P, Darby L & Tytler R 2010. Student outcomes from engaging in open science investigations. *Teaching Science*, 56(4):8–12.

Kagan DM 1992. Implications of research on teacher belief. *Educational Psychologist*, 27(1):65–90. https://doi.org/10.1207/s15326985ep2701_6

Kearney M, Treagust DF, Yeo S & Zadnik MG 2001. Student and teacher perceptions of the use of multimedia supported predict–observe–explain tasks to probe understanding. *Research in Science Education*, 31(4):589–615. https://doi.org/10.1023/A:1013106209449

Lederman JS, Lederman NG, Bartos SA, Bartels SL, Meyer AA & Schwartz RS 2014. Meaningful assessment of learners' understandings about scientific inquiry—The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching*, 51(1):65–83. https://doi.org/10.1002/tea.21125

Lederman NG & Lederman JS 2012. Nature of scientific knowledge and scientific inquiry: Building instructional capacity through professional development. In BJ Fraser, KG Tobin & CJ McRobbie (eds). *Second international handbook of science education* (Vol. 1). Dordrecht, The Netherlands: Springer.

Leonor JP 2015. Exploration of conceptual understanding and science process skills: A basis for differentiated science inquiry curriculum model. *International Journal of Information and Education Technology*, 5(4):255–259. https://doi.org/10.7763/IJIET.2015.V5.512

National Research Council of the National Academies 2012. *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

NGSS Lead States 2013. *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18290

Organisation for Economic Co-operation and Development 1996. *The knowledge-based economy*. Paris, France: Author.

Osborne J 2010. Arguing to learn in science: The role of collaborative, critical discourse. *Science*, 328(5977):463–466. https://doi.org/10.1126/science.1183944

Pajares MF 1992. Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3):307–332. https://doi.org/10.3102%2F00346543062003307

Pallant J 2007. *SPSS survival manual* (3rd ed). Crows West, NSW: Allen & Unwin.
Philipp RA 2007. Mathematics teachers' beliefs and affect. In FK Lester Jr. (ed). *Second handbook of research on Mathematics teaching and learning*. Charlotte, NC: Information Age.
Piburn MD & Baker DR 1993. If I were the teacher … qualitative study of attitude toward science. *Science Education*, 77(4):393–406. https://doi.org/10.1002/sce.3730770404
PRIMAS 2011. *The PRIMAS project: Promoting inquiry-based learning (IBL) in mathematics and science education across Europe*. Available at https://www.nottingham.ac.uk/research/groups/crme/documents/primas/primas-international-policy-report.pdf. Accessed 20 February 2013.
Ramnarain U, Nampota D & Schuster D 2016. The spectrum of pedagogical orientations of Malawian and South African physical science teachers towards inquiry. *African Journal of Research in Mathematics, Science and Technology Education*, 20(2):119–130. https://doi.org/10.1080/10288457.2016.1162467
Rocard M, Csermely P, Jorde D, Lenzen D, Walberg-Henriksson H & Hemmo V 2007. *Science education now: A renewed pedagogy for the future of Europe*. Luxembourg: Office for Official Publications of the European Communities. Available at https://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf. Accessed 17 December 2017.
Rooney C 2012. How am I using inquiry-based learning to improve my practice and to encourage higher order thinking among my students of mathematics. *Educational Journal of Living Theories*, 5(2):99–127.
Saad R & BouJaoude S 2012. The relationship between teachers' knowledge and beliefs about Science and inquiry and their classroom practices. *Eurasia Journal of Mathematics, Science and Technology Education*, 8(2):113–128. https://doi.org/10.12973/eurasia.2012.825a
Saldaña J 2009. *The coding manual for qualitative researchers*. Los Angeles, CA: Sage.
Sikko SA, Lyngved R & Pepin B 2012. Working with Mathematics and Science teachers on inquiry-based learning (IBL) approaches: Teacher beliefs. *Acta Didactica Norge*, 6(1): Art. 17. Available at https://pure.tue.nl/ws/files/3761879/37603312500790.pdf. Accessed 14 November 2017.
Smolleck LA & Mongan AM 2011. Changes in preservice teachers' self-efficacy: From Science methods to student teaching. *Journal of Educational and Developmental Psychology*, 1(1):133–145. https://dx.doi.org/10.5539/jedp.v1n1p133
Statistics South Africa 2010. *Millenium development goals. Goal 2: Achieving universal primary education*. Pretoria: Author. Available at http://www.statssa.gov.za/MDG/2010_MDG_GOAL_2_ACHIEVE_UNIVERSAL_PRIMARY_EDUCATION.pdf. Accessed 31 December 2017.
Trautmann N, MaKinster J & Avery L 2004. What makes inquiry so hard? (and why is it worth it?). In D Zandvliet (ed). *Proceedings of the NARST 2004 Annual Meeting*. Vancouver, Canada: NARST. Available at http://www.ei.cornell.edu/pubs/NARST_04_CSIP.pdf. Accessed 31 December 2017.
Wallace CS & Kang NH 2004. An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching*, 41(9):936–960. https://doi.org/10.1002/tea.20032
Wang L, Zhang R, Clarke D & Wang W 2014. Enactment of scientific inquiry: Observation of two cases at different grade levels in China mainland. *Journal of Science Education and Technology*, 23(2):280–297. https://doi.org/10.1007/s10956-013-9486-0
White R & Gunstone R 1992. *Probing understanding*. London, England: Palmer Press.
Zion M 2007. Implementing model of an open inquiry curriculum. *Science Education International*, 18(2):93–112. Available at http://files.eric.ed.gov/fulltext/EJ1065885.pdf. Accessed 13 November 2017.

Appendix A: PRIMAS Item Statements

Teacher beliefs		*M*
1)	I would like to implement more IBL practices in my lessons.	3.64
2)	IBL is important for my current teaching practice.	3.55
3)	Successful IBL requires students to have extensive content knowledge.	2.70
4)	IBL is not effective with lower-achieving students.	2.18
5)	I see no need to use IBL approaches.	1.36
6)	IBL is well suited to overcome problems with students' motivation.	3.09
7)	IBL provides material for fun activities.	2.90
8)	I already use IBL a great deal.	2.64
9)	I would like to have more support to integrate IBL in my lessons.	3.55
10)	IBL is well suited to approach students' learning problems.	3.45
11)	I regularly do projects with my students using IBL.	2.64
Teacher practice		
12)	Learners learn through doing exercises.	3.09
13)	Learners start with easy questions and work up to harder questions.	3.18
14)	Learners work collaboratively in pairs or small groups.	2.64
15)	Learners are given opportunities to explain their own ideas.	2.91
16)	Learners have discussions about the topics.	2.82
17)	Learners do practical activities.	2.36
18)	Learners draw conclusions from an experiment they have conducted.	2.64
19)	Learners do experiments by following my instructions.	2.73
20)	Learners are allowed to design their own experiments.	2.00
21)	Learners are asked to do an investigation to test out their own ideas.	2.36
22)	Learners have opportunities to work with little or no guidance.	2.09
Teacher difficulty		
23)	The curriculum does not encourage IBL.	2.00
24)	I don't have enough time to prepare IBL lessons.	2.45
25)	I don't have adequate teaching materials.	2.91
26)	IBL is not included in textbooks I use.	2.09
27)	I don't know how to assess IBL.	2.18
28)	I don't have access to professional development programs involving IBL.	2.45
29)	I worry about students' discipline being more difficult in IBL lessons.	2.27
30)	I don't feel confident with IBL.	2.18
31)	I worry about my students getting lost and frustrated in their learning.	2.73
32)	My colleagues do not support IBL.	2.45
33)	I think that group work is difficult to manage.	2.00
34)	There is not enough time in the curriculum.	2.55
35)	I don't have sufficient resources such as computers and laboratory apparatus.	2.64
36)	My students have to take assessments that don't reward IBL.	2.22
37)	The number of students in my classes is too big for IBL to be effective.	2.55