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LIFE SCIENCES TEACHERS' UNDERSTANDING, PERCEPTIONS AND ADOPTION OF INQUIRY-BASED SCIENCE EDUCATION IN SELECTED SOUTH AFRICAN HIGH SCHOOLS

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Abstract

In recent years, Inquiry-Based Science Education (IBSE) has emerged as one of the most effective and beneficial science teaching practices for developing science concepts in learners and for motivating them in the study of science subjects. IBSE is a pedagogical practice that allows learners to develop key scientific ideas and to understand the natural world, using skills employed by scientists. Like most science school curricula around the world, the South African life sciences national curriculum (referred to as Curriculum and Assessment Policy Statement - CAPS), advocates for the adoption of IBSE. Despite the growing consensus about the cognitive and motivational benefits of IBSE, this pedagogical approach is seldom implemented by life science teachers, due to various factors. This qualitative research, involving a case study, explored the knowledge, perceptions, and adoption of IBSE by four life sciences high school teachers, conveniently selected from public schools around Johannesburg, in South Africa. Data were collected using semi-structured interviews, and the findings show that participating teachers have substantial knowledge and positive perceptions of IBSE. However, they are less inclined to adopting IBSE in their life science classrooms due to inhibiting factors. We recommend the training of life sciences teachers in effective way of abating the constraints of implementing IBSE effectively.

Keywords: *Inquiry-based, science education, perceptions, knowledge.*

1. Introduction

Recently, there has been increasing consensus among science education scholars, regarding the importance of Inquiry Based Science Education (IBSE) in enhancing the learning of science subjects (Ramnarain & Hlatswayo, 2018). IBSE was defined by Ramnarain (2014, p.66) as "...a teaching approach that allows learners to develop key scientific ideas, through learning how to investigate, and building their knowledge and understanding of the world, using skills employed by scientists', such as, asking questions, collecting data, reasoning, reviewing evidence and drawing conclusions". Researchers (Hodgetts, et al, 2015; Ramnarain & Hlatswayo, 2018; Ramnarain & Schuster, 2014) have identified several benefits of IBSE, which include: Understanding of scientific concepts and phenomena; development of critical thinking skills, rational decision-making, problem-solving skills; enhancement of learners' acquisition of scientific practices; and motivation of learners to study science, and to pursue science related careers. In acknowledgment of the importance of IBSE, many countries have established educational projects and programs (Scientix in Belgium, Fibonacci in France, SiS Catalyst in the United Kingdom, and Primas in Germany, as listed by Rundgren [2018]) that promote the IBSE pedagogy.

In South Africa, the national curriculum (Curriculum and Assessment Policy Statement - CAPS) advocates for the adoption of IBSE in science classrooms (Department of Basic Education - DBE, 2011). In the life sciences CAPS document, advocacy for the adoption of IBSE is reflected in specific aim number 2 of the curriculum, which relates to; "Investigating Phenomena in Life Sciences (DBE, 2011, p.15)". This aim requires learners to "...be able to plan and carry out investigations, as well as to solve problems that require some practical ability. p. 15). According to the life sciences CAPS, "…this ability is underpinned by an attitude of curiosity and interest in wanting to find out how the natural world and the living things in it, work. p.15". The need to investigate natural phenomena and to arouse learners' curiosity and interest in the study of science is characteristic of the IBSE pedagogy. Adoption of IBSE in life science classrooms could enhance learners' understanding of life sciences concepts and processes, as well as develop pertinent cognitive and practical skills in learners.

Despite growing consensus among researchers about the learning benefits of IBSE and the advocacy to adopt the learning approach in science classrooms, this teaching approach is rarely adopted in South African science classrooms (Ramnarain & Hlatshwayo, 2018). Studies on the adoption of IBSE elsewhere have also identified a similar trend. For example, a study conducted by Kang and Keinonen (2016), involving 184 Finland and 143 Korean teachers, showed limited adoption of IBSE in science classrooms. In cases where IBSE is adopted, one sees a diversity of inquiry-based learning methods, which impacts on its comprehension by teachers (Kang & Keinonen, 2016; Ramnarain & Schuster, 2014). The adoption of IBSE is especially scarce in life sciences education, where learners often learn facts, terminologies, theories and process, which they often just memorize, without the need for investigations (Wilson, 2017), making IBSE seem unnecessary in this subject.

Teachers' reluctance to adopt IBSE could also be partly explained by their lack of knowledge and negative attitudes towards the teaching approach, as well as contextual teaching constraints (Wilkins, 2008). In this respect, Wilkins (2008) suggested a theoretical model, which relates teachers' knowledge, attitudes, and beliefs to their choices of instructional practices. Similarly, Sikko, Lyngved and Pepin (2012) stated that teachers' beliefs about science, the nature of science, teaching and learning, and beliefs about inquiry-based approaches, could influence their decisions and choices of pedagogical strategies. Furthermore, Hutchins and Friedrichsen (2012) found out that teachers with positive attitude towards inquiry instruction could use inquiry practice better. If teachers' core beliefs conflict with inquiry practices, they could act as a hindrance to their choice of inquiry, as a pedagogical strategy (Binns & Popp, 2013).

Literature also presents counter-arguments about assertions that beliefs influence practice. For instance, a study conducted by Saad and Boujaoude (2012) in Lebanon, involving 34 teachers showed that holding positive beliefs about IBSE does not necessarily translate into implementation in the classroom. Considering the varied views about the relationship between knowledge, attitudes and practice, an exploration of life science teacher's knowledge, perceptions and practices of IBSE became necessary to understand life science teachers' reluctance to implement IBSE in their classrooms. This information could be useful in the revision of life sciences teacher training curricula and educational policy to emphasize training of teachers in the implementation of this germane pedagogy.

2. Objectives

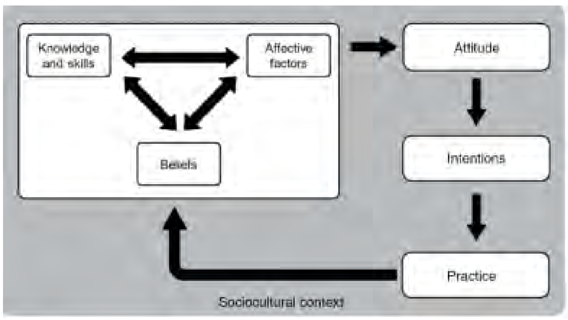
The objectives of the study were to:

1. Determine life science in-service teachers' knowledge of IBSE.
2. Establish life science in-service teachers' perceptions about IBSE.
3. Investigate the adoption of IBSE by life science in-service teachers.

3. Conceptual framework

The study was guided by the "strongly simplified model of the relationship between attitude, intentions and practice", proposed by Hofer and Lembens (2019). According to the proponents of the model, knowledge and skills, affective factors, and beliefs interact in complex ways to influence teachers' attitudes, which determine their intentions (plans, resolutions, prospects) and may consequently influence their practice (Hofer & Lembens, 2019). Figure 1. illustrates these interactions and their outcomes.

Figure 1. A strongly simplified model of the relationship between attitude, intentions and practice: Adopted from Hofer and Lembens (2019).



In the study reported here, attributes related to the three dimensions of Hofer and Lembens (2019)’s the model; knowledge and skills, affective factors and beliefs, in relation to attitudes, intentions and practice, were explored. The assumption in this study was that the three dimensions of Hofer and Lembens (2019)’s model mutually interact with each other to influence teachers’ attitudes and consequently their decision (intention) to either adopt IBSE in their classrooms or not (Hofer & Lembens, 2019). In this study, the dimension of knowledge and skills involved the determination of participating teachers’ understanding of the concept of IBSE. The affective factors and beliefs dimensions were established by exploring teachers’ perceptions of the pedagogical approach. Teachers’ attitudes, intentions and practices were explored by obtaining their views about the adoption of IBSE.

4. Methodology

A qualitative research approach, involving a case study design, was used to collect data from four life sciences teachers, with the aim of gaining insights into their knowledge and perceptions about IBSE, and the adoption of IBSE in their classrooms.

4.1. Population and sample

The population of the study comprised of secondary school life sciences teachers in Johannesburg, South Africa. A convenient purposive sampling method was used to select the four teachers who participated in the study. Table 1 shows the demographics of the study participants.

Table 1. Demographic information of participants.

Teacher	Gender		Age (in years)			Qualification (Degree)		Teaching experience (in years)		
	Female	Male	25-30	30-35	35+	Bachelor of Education	Honours	0-2	2-4	4+
1	√	-	-	-	√	-	√	-	-	√
2	√	-	-	√	-	√	-	-	√	-
3	√	-	√	-	-	√	-	√	-	-
4	√	-	√	-	-	√	-	√	-	-

4.2. Data collection and analysis

Qualitative data were collected using 30-minute semi-structured interviews, after obtaining ethics clearance and relevant permissions from stakeholders. The interview schedule was piloted using two life sciences teachers who did not participate in the main study. Data collected from interviews were analysed using a thematic data analysis method, where video recorded interviews were transcribed and coded. The following codes were used: A ‘T’, followed by a number represented a participant (for example, T2 represented teacher two), lower case roman numerals represented themes (i, ii, iii), and lower-case letters (a, b, c, d…) represented interview items. For example, ‘T1ai’ represents a response provided by teacher ‘1’, for interview item ‘a’, under theme ‘i’. Coded statements were categorized into the pre-determined themes: Teachers’ knowledge of IBSE, their perceptions about IBSE, and their adoption IBSE. Emerging patterns were used to make inferences and conclusions about the study findings.

5. Discussion of findings

Participants’ knowledge of IBSE was determined by establishing their; definition of IBSE, understanding of the features of IBSE, and the difference between IBSE and practical work. The findings from the study indicated that teachers have adequate knowledge of IBSE, in the sense that they were all able to provide satisfactory definitions of IBSE, and that they were able to cite some of the characteristics of IBSE, such as; questioning, investigating, collecting data, formulating hypothesis, and making inference based on evidence from collected data. These features have been identified in literature (Mashita, Ramli & Karyanto, 2017; Ramnarain, 2014; Suduc, Bizoi & Gorghiu, 2015) as characteristic of the IBSE pedagogy. Regarding the difference between IBSE and practical work, the participating teachers were conversant of the difference between the two instructional approaches. They associated IBSE with discovery, research, problem-solving, collection of evidence, and reasoning, and they related practical work to following instructions, a set of rules, or a prescribed method(s) for conducting experiments. The finding that teachers are knowledgeable about IBSE seems to conflict with some perception in literature (Binns & Popp, 2013; Yoon et al., cited in Kang & Keinonen, 2016) that most science teachers are not knowledgeable about IBSE. Large scale studies that investigate teacher knowledge of IBSE may be necessary to confirm or invalidate the findings from this study.

Participating teachers' perceptions about IBSE were determined by obtaining their views regarding the; necessity of adopting IBSE in their life sciences classrooms, the feasibility of teaching IBSE explicitly, and their opinions regarding the ability of IBSE to enhance learners' understanding of life science concepts. From the interview responses, it became clear that participants have positive attitudes towards IBSE. All participants affirmed the need to implement IBSE in life science classrooms, citing the benefits of IBSE, such as: Learner engagement in the learning process; opportunity to apply learnt content; motivation to learn life sciences; enhancement of learners' knowledge and understanding of abstract life science concepts; and the enhancement of creativity, as reasons for the need to implement IBSE. Researchers (Mashita, Ramli & Karyanto, 2017; Ramnarain, 2014; Ramnarain & Hlatshwayo, 2018; Suduc, Bizoi & Gorghiu, 2015) have also highlighted similar benefits of IBSE. For instance, Ramnarain and Hlatshwayo (2018) pointed out that IBSE develops learners' experimental skills, it makes science more enjoyable, and it leads to increased scientific knowledge and understanding. When teachers were asked whether inquiry skills can be explicitly taught to learners or they automatically acquire them through participation in inquiry activities, three of the four participating teachers said they can be acquired through both direct teaching and participation in inquiry activities, while one teacher only agreed with the latter. Regarding the role of IBSE in enhancing learners' understanding of life sciences concepts. All teachers responded in the affirmative, which is a stance held by many scholars (Hodgetts, et al., 2015; Ramnarain & Hlatshwayo, 2018). These findings offer a beacon of hope for the adoption of IBSE in South African life sciences classrooms, if contextual constraints are abated.

Finally, the adoption of IBSE in life sciences classrooms was explored by determining; the frequency with which participants implemented IBSE activities in their classrooms, participants' opinions regarding the adoption of IBSE by other life sciences teachers, effective ways of implementing IBSE in life sciences classrooms, and the challenges of implementing IBSE. Three of the four teachers were less inclined to implementing IBSE in their classrooms, citing constraining factors as reasons for their reluctance. One teacher indicated that she uses IBSE to teach certain topics, as the approach is not applicable to all topics. The teacher cited genetics, excretion, the endocrine system and the History of life on Earth, as examples of life sciences topics that cannot be easily taught through IBSE, while evolution and environmental studies were mentioned as examples of topics that could be taught through IBSE. Binns and Popp (2013) also attested to fact that some teachers seem to believe that not all topics are suited for inquiry-based learning, especially in biology. Furthermore, all teachers felt that other life sciences teachers are not likely to implement IBSE in their classrooms adequately, because of the same challenges experienced by participating teachers. This finding resonates with findings from similar studies, which found that science teachers seldom implement IBSE in their classrooms, due to contextual factors (Kang & Keinonen, 2016; Ramnarain & Schuster, 2014).

As alluded to earlier, some scholars (Hofer & Lembens, 2019; Sikko, Lyngved & Pepin, 2012) found a link between knowledge, affective factors, beliefs and practice. Contraly, the finding from this study seems to suggest a lack of correlation between teachers' understanding and perceptions about IBSE, and their classroom practice. This phenomenon was also observed by other researchers (Ramnarain & Hlatshwayo, 2018; Saad & BouJaoude, 2012) who found a negative correlation between teachers' beliefs and the implementation of IBSE. It appears that although the participants support the implementation of IBSE, pedagogical challenges prevent them from adopting the teaching approach in their classrooms.

Regarding the challenges of implementing IBSE, participating teachers highlighted: Limited time to implement IBSE, due to curriculum overload; lack of teaching resources; large class sizes, prescription of teaching and learning materials by the curriculum; and learners' lack of capacity to engage in IBSE activities. Ramnarain and Schuster (2014) identified similar constraints in their study titled "The pedagogical orientations of South African Physical Sciences teachers toward inquiry or direct instructional approaches". If the implementation of IBSE is an objective in science education programs in South Africa, the challenges experienced by teachers need to be mitigated.

6. Limitations of the study

The limited number and the homogeneity of participants in study reported here dictates that the findings cannot be generalized to the population of life sciences teachers in Johannesburg and in South Africa, as a country. In addition, since only female life science teachers participated in the study, the findings do not reflect the IBSE knowledge and perspectives of male life science teachers.

7. Conclusions and recommendations

The results from this study show that participating teachers have adequate knowledge and positive perceptions of IBSE. However, they are less inclined to adopting or implementing IBSE in their classrooms because of constraining contextual factors. Based on these findings, I recommend the explicit training of pre-service and in-service teachers in effective ways of abating constraints to the adoption and implementation of IBSE in life science classrooms.

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