Science teachers understanding of inquiry-based science teaching (IBST): Case of Rwandan lower secondary school science teachers

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Abstract
This paper aims at finding out Rwandan lower secondary school science teachers' understanding of inquiry-based science teaching (IBST). A two phases' sequential explanatory mixed methods was adopted. Data were collected by means of a survey questionnaire administered to a purposeful sample of 200 science teachers followed by illuminating semi-structured interviews with a sub-sample of 10 purposefully selected teachers. Both descriptive statistical and content analyses were used. It was found that participants do not have a common understanding of inquiry. Most teachers associate inquiry teaching with a few of its specific characteristics while others had a very different understanding. The study suggests that a working definition be provided in the curriculum. Since IBST is mainly associated with practical activities in nature, and given many types of practical work, the curriculum should be clear about what practical to be treated in an inquiry approach to avoid a potential confusion among teachers.

Key words: *Inquiry, Inquiry-based science teaching (IBST), Science teacher.*

Introduction

Background and purpose of the study

Following the 1994 genocide in Rwanda, with its side effects on all sectors of the country's life including education, a range of school reforms have been implemented. In science education, the most recent reform was the revision of the lower secondary school science curriculum which introduced among other aspects an inquiry- based teaching approach. The implementation of the recently revised curriculum started in 2007 but not much was done in terms of teachers' preparedness to embrace this change. Just some sporadic workshops and few in-service training activities about the use of the new curriculum were organised. A question that rose was that if teachers are to teach science through inquiry, what is their understanding of what inquiry is? In fact, various scientific bodies such as the National Research Council (NRC) and the American Association for the Advancement of Science (AAAS) Project 2061 provide different definitions of scientific inquiry but teachers who are looking for a detailed operational definition that can serve as a guide for inquiry-oriented instruction are still struggling. The given broad characteristics and associated examples remain of little help (Wenning, 2011). Therefore, as a science teacher educator, the researcher felt that it was important to investigate the teachers' understanding of Inquiry-based science teaching (IBST) as a new component brought into the curriculum.

The purpose of this paper is to investigate and analyse the Rwandan lower secondary school science teachers' understanding of IBST. In fact, the understanding of scientific inquiry is a prerequisite for implementing inquiry based instruction in the classroom (Wenning, 2005). However despite the frequency of occurrence of the concept "inquiry", in almost every talk about reform in science education, it is still seen as an elastic word stretched and twisted to fit people's differing worldviews (Wheeler, 2000) and thus painted with different understandings. Whether inquiry is seen as a characteristic of a desired form of teaching or a certain type of learning activity, there is a great agreement that for students to understand inquiry and use it to learn science, their teachers need to be wellversed in inquiry and inquiry-based methods (NRC, 2000). Therefore the need of investigating the teachers understanding of an inquiry-oriented science teaching seems to be justified especially in a context where it is newly introduced in the curriculum. This study would to some extent serve as a platform to refer to by both science teacher educators and professional development providers when envisaging the most relevant strategies to enhance teachers' understanding of IBST and thus to implement it.

Theoretical and conceptual framework

The principal theory underpinning this study is the constructivism. It is seen as a driving theory of learning in modern education and more particularly in science education, where it is used to guide the development of new teaching methods (Baviskar, Todd, Hartle & Whitney, 2009).The most shared interpretation of what constructivism means is the change in the focus of teaching, putting the learners' own efforts to understand at the centre of the educational enterprise, which in the context of the present study has a focus on inquiry. In this paper the author posits that "there is not one true definition of inquiry waiting to be discovered, but an understanding of inquiry is constructed by individual participant" (Keys & Bryan, 2001, p. 633). This is in line with the four postulates associated with the knowledge construction and acquisition or any attempt to construct meaning of the world around us (Fritcher, 2008) enabling one, and in this case the teacher, to adopt and adapt required change.

In the editorial of the 'Constructivist Foundations, 1(1)', Reigler (2005) highlighted two major aspects of constructivism that he named its plurality and its common denominator. On one hand he indicated that there is no simple answer to the question "What is constructivism?" arguing that there are many constructivist schools as constructivist concepts have been developed in various scientific disciplines" (p.2). On another hand, he acknowledged not only the difficulty but also the impossibility of lumping together the many independent disciplinary roots and proponents of constructivism (Reigler, 2005). The two aspects constitute the constructivist challenges but at the same time may constitute a platform towards teachers' understanding of what IBST is.

Modern science reflects the ideas of constructivism. Therefore, the best way of teaching science is to use these constructivist ideas. The use of inquiry, especially in teaching science, seems the most prominent considering that one of the advantages of IBST is that it enables students to learn in an active way. Although there are specific teaching methodologies that are strongly constructivist, such as inquiry-based teaching methods, it is not necessary to use one of these methods to be constructivist.

From an instructional point of view, constructivist learning environments are more open in the sense that they allow the learner freedom to engage with a variety of resources and to build on prior knowledge and experience to solve a problem or do a project referring to the degree of learners' autonomy when involved in inquiry-related activities. In this regard one can assume that learners do this intuitively where they improvise in any given learning situation, by involving mental schemata, experience, intuition, other people as well as a variety of resources to solve problems (Lederman, 2003). This does not apply to memorizing information or solving textbook problems, where the answer can often be constructed from a textbook. It rather refers to solving unstructured problems (Karen, 2002).

This understanding of learning from the constructivist perspective enables making the distinction between meaningful and rote learning, as follows:

> *To learn meaningfully, individuals must choose to relate new knowledge to relevant concept and proposition they already know. In rote learning … new knowledge may be acquired simply by verbatim memorization and arbitrarily incorporated into a person's knowledge structure without interacting with what is already there* (Bodner, 1986, p. 877).

When applied to science, learning from the constructivist perspective may be viewed in terms of students' pathways from certain pieces of their already existing conceptual structure (prior knowledge and experience) towards science conception. In fact, constructivism suggests that as we experience something new, we internalize it through our past experience or knowledge construct we have previously established, as advocated by Penner (2001), arguing that "learning activities begin by considering the role of students' current knowledge, how knowledge is constructed, and the role of the activity in building knowledge" (3).

Inquiry-based science teaching

A number of dictionaries, such as the *American Heritage Dictionary of English Language* or the *Collin English Dictionary*, define the term "inquiry" as posing of questions, finding out something, and the search for information or the carrying out of an investigation. The *Webster's Third International Dictionary* (1996) goes far to define it as "an act or an instance of seeking for truth, information or knowledge, investigation, research, or a question or query", and indicates that the roots of the word 'inquire' mean "to ask for information or questioning" (p.1167). However, the NRC (1996) associates the concept 'inquiry' to that of 'science', and provides a more detailed definition that constitutes the foundation of its application in science learning, posing that:

> *Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in the light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations; and communicating the results* (p. 23).

As inquiry comes to be associated with science teaching, the literature uses interchangeably the terms inquiry-based science teaching and inquiry-based science instruction. IBST emerged from science education reforms but with the publication of the National Science Education Standards (NSES). Despite its importance in the science community, many authors report that the current definitions of inquiry-based instruction provide a vague description of the terms and its classroom applications (Anderson, 2002; Colburn, 2000; Cuevas, Lee, Hart and Deaktor, 2005; Haefner and Zembal-Saul, 2004; Keys and Bryan, 2001; Wee, Shepardson, Fast and Harbor, 2007 & Windschitl, 2000). The NSES addressed inquiry in two ways. On one hand, they see inquiry as content in which learners should understand scientific inquiry and the abilities they should develop from their experience with scientific inquiry. On another hand, they associate inquiry with teaching techniques and the process of learning with inquiry-oriented activities.

The literature attempted to further describe the IBST. For example, Flick (2003) highlighted the three aspects that include the process of how modern science is conducted, an approach of teaching science, and knowledge about the nature of science (NOS). As for Lederman (2003), inquiry-based instruction encompasses processes such as using investigative skills; actively seeking answers to questions about specific concepts; and developing students' ability to engage, explore, consolidate, and assess information. Leonard and Penick (2009) went far as to offer suggestions for determining whether one's classroom activities engage all students in true inquiry. They contend that in the most ideal classroom, students learn through inquiry rather than learning about inquiry. This implies that "they apply the process of inquiry to problem, devise ways to obtain and analyse data, discuss the meaning of their data and experiences and finally communicate their findings and ideas with others" (p. 25).

When students are involved in inquiry they go through the five steps that constitute the essential features of inquiry (NRC, 2000) described as follows. Firstly, learners are engaged by scientifically oriented questions. In the best of cases these questions should come from the students, even though often they are provided by the teacher. Secondly, learners give priority to evidence, allowing them to develop and evaluate explanations that address these scientifically oriented questions. Here the teacher does not simply provide recipe-like instructions for each experiment; rather learners plan and decide how experiments are to be conducted. Thirdly, learners formulate an explanation from evidence to address scientifically oriented questions. This explanation should refer to the initial question they were trying to answer. Fourthly, once students have made the explanation based on the data they collected, they evaluate it and consider whether it fits into the evidence they already have. Lastly, learners communicate and justify their proposed explanation. Each of these features of inquiry, when applied in a classroom, varies both in terms of the amount of learner self-direction on the one hand and the amount of the teacher's or material direction on the other hand. Through this process, science teachers create a most enabling learning environment.

In the Rwandan O-level science curriculum inquiry is envisaged as an investigative aspect and is described in terms of the general objectives of teaching each of the three science subjects, namely biology, chemistry and physics. In each of these three subjects students are expected to be able to observe phenomena, perform research, experiment, analyse results and draw accurate conclusions from experiments, and therefore must move from knowledge of direct experience to a level of scientific ideas (MINEDUC, 2007). The curriculum suggests teaching and learning activities that include experiments and practical demonstrations carried out by learners under the teacher's guidance in order to reinforce learning. However more recent studies, like those of Anderson (2002, 2007) and Windschitl (2004) who acknowledge that most teachers have very little experience with inquiry in a formal scientific sense, and as a consequence they display a very naïve and informal conception of inquiry in the classroom. They contend that inquiry teaching is defined differently by different researchers and has many meanings and that even when used in a particular field of science education it has multiple manifestations, making it difficult to clearly define. Furthermore, Wee, Shepardson, Fast & Harbor (2007) highlights that teachers are unclear about the meaning of inquiry (while they are the key agents of its implementation. This applies too for Rwandan teachers. For them, to facilitate the learning process, it is as important as it is for teachers to understand inquiry, develop their skills of inquiry, and learn science concept through inquiry.

To sum up, this study is framed in the constructivist theory of teaching and learning that implies an inquiry-based approach in the science classroom. Within the context of this proposed study, data related to teachers' understanding of inquiry-based science teaching will be interpreted on the light of the NRC's (2000) variations of the essential features of an inquiry classroom. Indicative actions of both teachers and learners are best detailed in Inter Academic Panel (2010), describing their interaction during an inquiry-based science lesson. Through the Rwandan curriculum lens, these actions include a minimum of observing phenomena, performing research, carrying out experiments, collecting and recording data, analysing results, drawing accurate conclusions from experiments and communicating, which are expected to be performed by learners (MINEDUC, 2007) under the close guidance and unrestricted facilitation of the teacher, who creates and monitors the whole learning environment.

Methodology

The present paper investigates the lower secondary school science teachers' understanding of inquiry-based science teaching. In the attempt to answer the research question, a pragmatic research approach which led to using mixed methods was adopted and both quantitative and qualitative data collected. The researcher was persuaded that using solely quantitative or qualitative methods would be insufficient to provide complete answers that met the purpose of the present study. In a first instance, the general views of a large group of teachers were explored but with the need of a deep understanding of the phenomenon under investigation making a mixed methods approach more appropriate. With this regard, a survey of a big number of teachers was used followed by in depth interviews with few selected individual from the surveyed group. The first set of data was interpreted from a post positivist perspective while interviews' data were analysed from an interpretive perspective allowing the use of multiple epistemological perspectives in mixed methods.

The population from which the sample of teachers who participated in the study was drawn was made up of all science teachers at lower secondary school in Rwanda in place in the 2010 academic year. The selection of participants included non-probability quantitative approaches to sampling and purposive qualitative approaches. For the first phase of this study, it was thought at first glance that the sampling method would be stratified, with proportional allocation of sample size considering five strata made up of the four provinces of Rwanda and Kigali (the capital city). However, it was found more appropriate to adopt the purposive sampling method. With this regard, the researcher used his own judgement to consider a number of other characteristics of the population (Mertler & Charles, 2008), that may better draw a more representative sample beyond the mere matter of numbers. Thus, apart from being science teachers at lower secondary level regardless of their major science specialization, the participants were selected from all types of schools countrywide on the basis of a range of criteria, including whether the school was public, private or government subsidized and single-sex or co-educational, whether it was located in a rural, urban area, resourced or under-resourced, to list but a few. This was done with the aim of getting countrywide representativeness. Based on the above consideration the survey was conducted on a sample of 200 science teachers purposively selected from 100 schools countrywide. Of the 200 questionnaires administered, only 150 were fully completed and returned, say a return rate of 75%. In the second phase sequence, a purposeful sample of 10 teachers was considered for interviews. The selection was based on similar criteria used in selecting teachers surveyed during the first phase. This second phase aimed at seeking more in-depth explanation of findings from the survey, and therefore the interview schedule was developed in the light of the data and findings from the first phase in respect to the design of the study.

The data analysis was done guided with the design of the study. The first step consisted of data reduction that included coding and editing data from the survey. Once the codebook produced, this first set of data was captured into SPSS spreadsheet and then cleaned before analysis. Descriptive statistics was the mostly used at this stage generating tables of frequencies and percentages. As for interviews, after transcription, data were also coded generating major themes and categories before interpretation. The two set of data were then combined for discussion and interpretation. It is at this stage that the methodological triangulation was used to enable the researcher to search for convergence among multiple and different sources of information to form themes or categories (Golafshani, 2003) in preparation to presenting findings.

This use of multiple methods and then methodological triangulation were considered for reliability purpose. As for the validity concern, data collection instruments were piloted and translated both in French and English allowing participants to use the language they felt they were more fluent. Furthermore, the study involved a 'cross-over tracks' approach, consisting of an iterative mixed-method process such that emerging findings from one method helped to shape subsequent analyses (McMillan & Schumacher, 2010).

Regarding the ethical consideration, the informed consent, central canon of research policy, was sought and obtained prior to any attempt to fieldwork and confidentiality was respected throughout the study. In addition, anonymity was enhanced by using specific codes as identifiers of participants every effort was made to guarantee confidentiality.

Results

Findings of the present study were organised and presented in a way suggested by Gallagher and Tobin (1991) consisting of stating an assertion and support it with data from all sources used in the study. In this study findings were expressed as one main assertion and three associated sub-assertions each supported by evidences from both the survey and interviews.

Main assertion
There is not a common understanding of inquiry. Most teachers associate inquiry teaching with a few of specific characteristics such as learner-centred teaching and practical work. However, some teachers displayed an understanding of inquiry-based science teaching which does match that of the curriculum or the general community of educators.

This assertion was formulated as a result of analysis of responses to the open-ended question from the questionnaire where teachers were asked to describe their understanding of what IBST was and further details from a similar probing question from interview. Data analysis revealed that respondents have varying understandings of the concept of IBST mainly made up by short descriptions. Due to the openness-end nature of the question asked and for the purpose of coding, these responses were sorted into the following seven categories:

1. Practical work of some nature: Responses grouped under this code refer to learners doing practical work, carrying out experiments or some kind of hands-on activities;
2. Learner-centred activity: Refers to learners doing more work than the teacher and being actively involved in the learning process, or emphasis put on learners' active participation;
3. Learning by discovery: Learners working on their own and discovering new information based on their prior knowledge, but with some guidance;
4. The teacher as facilitator and guide: Where the teacher's role is reduced to providing guidance to learners rather than giving them all the information;
5. Doing research and self-study: Learners' participation by searching for information from various sources such as the library, Internet, school surroundings, etc.
6. Learners questioning: Learners' involvement by formulating questions to be answered through a number of specific steps, mostly associated with practical work in the form of investigation; and
7. Learning that is relevant to daily life and learners' interests: Learning for application in learners' daily experiences.

The following table (Table 1.1) summarizes the frequencies of appearance of these categories.

Table 1.1 Distribution of teachers' understandings of IBST

Teachers' characteristics of inquiry	Frequency	%
Practical work of some nature/ investigation	62	47
Learner-centred teaching	59	42
Learning by discovery	22	17
Teacher as facilitator and guide	19	14
Doing research	11	7
Questioning is central	5	5
Relevant to daily life and learners' interests	4	3
Don't know or not informed	13	9
Unrelated to teaching method	12	8
Total	**207**	**152**

As it can be seen from this table, the total number of responses is higher than the total number of respondents, because most of them associated it with more than one aspect used for describing inquiry. Therefore if, for example, "learning by discovery" was associated with "research" like in this response from a teacher: "Inquiry based science teaching means teaching science by doing research and lead the learners to discovering the reality" (Teacher 23), then it was reported both under the category "Doing research" and "Learning by discovery".

Responses from interviews corroborated those from the survey. What emerge from the data is that the most common characteristic associated with inquiry-based science teaching was some form of activities involving either the teacher or learners. These responses were coded and are reported in Table 1.2.

Table 1.2. Distribution of teachers' interview responses

Teachers' understandings of IBST	Teachers responding	Frequency
Learner-centred teaching/ involve learners in their learning process	5; 6; 8; 10; 11; 12; 14; 15	**8**
Teaching where learners work in a group under teacher's facilitation/ guidance/supervision.	5; 9; 11; 13; 14; 15	**6**
Teaching where learners carry out investigation and practical work of some nature	3; 6; 7; 12; 13	**5**
Teaching that involves learners in research following the scientific process	3; 6; 12; 14	**4**
Teaching that brings learners to discovery	1; 4; 10	**3**
Teaching for solving everyday problems and long life	1; 2	**2**
Not sure / confused	2; 7	**2**

Like in the survey, respondents suggested more than one characteristic to display their understandings, and as a result the total frequency of occurrence of each category appears higher than the number of respondents. To provide more details about the teachers' understandings, three sub-assertions were generated. They were also discussed and supported on the light of data from the two sources.

Sub-assertion 1: The most common characteristic of IBST is some form of activity involving practical work

Practical work of some nature was referred to as a main description of IBST. This was reported by nearly half (47%) of the teachers who answered the questionnaire. For analysis purpose any form of demonstration, practical work, experiment, investigation, or hands-on activities was coded as involving practical work. For example, one teacher reported that "I understand it as a teaching by investigation, to teach by using the teaching materials i.e. by all means ensuring that the lesson is more practical than theoretical" (Teacher 45). Data from the survey indicated that teachers understand inquiry-based science teaching in terms of a combination of several constructs such as discovery and research with the facilitation of the teacher like in the following response where a teacher reported that IBST is a teaching by which "the learner manipulates, discovers and summarizes easily new notions which reinforces the understanding because the learner him/herself conducts the experiment while the teacher is there as facilitator, talking less" (Teacher 48).

Data from interviews also revealed an understanding of IBST as a teaching which is more practical oriented. The practical aspect was depicted in many responses, where it was referred to as experiments or a scientific investigation with other related activities. For example, this teacher said:

> *According to my understanding, inquiry-based science teaching is a teaching approach based on learners' activities, that involves learners in their learning process through a number of activities such as asking questions, designing and carrying out an investigation, conducting experiment, collecting data, and presenting results based on evidence. Actually it is an approach that brings learners to work following the scientific process* (Interview NT).

When inquiry teaching was associated with scientific investigation, details were provided as activities that learners get involved in, including attempts to answer specific question like scientists through a number of activities such as observing, asking questions, trying to find answers and explanations. As this teacher explained:

> *Ah! Inquiry-based science teaching is a method of teaching where the learners carry out investigations and then after carrying out those investigations they come up with the results and the teacher can help them to improve what they come up with. By using this approach learners are involved in a number of activities including posing questions on a particular phenomenon, attempting to answer those questions by providing evidences, trying to come up with explanations and then presenting these explanations to others* […]. (Interview NP)

Similarly, the following example also shows an understanding of inquiry in terms of learners' activities, all highlighting the practical aspect of inquiry:

> *Well, actually I understand inquiry-based teaching as that teaching approach which emphasizes learners' hands-on activities. Among activities learners go through when learning science through inquiry are observation, posing questions and probing explanation based on scientific evidence, carrying out investigation, collecting information, measuring, interpreting results and communicating results* (Interview MD).

It can be noticed that from both the survey and interviews IBST was understood as learner centered teaching approach which is more practical oriented. However, when probed for more details during interviews they moved around a more formal definition, associating INBST with practical work including a range of other aspects such as discovery, learners doing scientific investigation, learners' active participation and learner doing research. It can be seen that interviews provided more detailed answers than the questionnaire, and it was therefore worthwhile combining the two methods of data collection. This description shows that practical work in its variety of forms is the characteristic most commonly associated with inquiry. No single common definition of what inquiry based science teaching was provided.

Sub-assertion 2: Teachers associated learner-centred teaching and teachers acting as facilitators with inquiry-based science teaching.

In this study IBST was also referred to as learner-centred teaching, and in many cases associated with other aspects but in particular with the teacher's facilitation and guidance. Data from both the survey and interviews provides sound examples. For example, one teacher indicated that IBST is teaching centred on the learner and which resorts to the practical, while the teacher is just a facilitator (Teacher 4). With an almost similar description, another teacher commented saying that IBST is a teaching more centred on the learner, who becomes more responsible in the teaching and learning process while the teacher is the facilitator (Teacher 149). In another instances three aspects were brought together to describe IBST. In this example a teacher associates the teacher's facilitation with discovery and learner-centred teaching and contends that "Inquiry-based science teaching takes into account all activities which help learners to discover and strengthen new concepts and ideas. It is a teaching and learning process centred on the learner. The teacher is a facilitator" (Teacher 145). Sometimes the description included a number of activities showing the learner centrality of the process and the facilitation role of the teacher. For example, another teacher reported so saying that "the learner manipulates, discovers and summarizes easily new notions which reinforces the understanding because the learner conducts the experiment him/herself while the teacher is there as facilitator" (Teacher 48).

Responses from interviews corroborated data from the survey. For example the following two quotes illustrate such convergence:

> *It is a learner-centred teaching approach where learners take active role in their learning process under the guidance of the teacher. The teacher is actually a facilitator or a guide* (Interview MD).

> *The way I understand the inquiry-based science teaching, eeh, it is a teaching approach that emphasizes on learners' active participation, where learners are fully involved in hands-on activities by being engaged into activities that bring them to acquire knowledge by their own but with the close guidance of the teacher* (Interview HJD).

In some cases, a more detailed description was provided as far as to indicate the role played by both the teacher and learners in an inquiry-based science lesson like in the following example.

> *I see it as a teaching approach based on learners' activities rather than centred on the teacher, known as the traditional 'chalk and talk' teaching approach or direct instruction. In the inquiry-based science teaching approach, learners take more responsibility of their learning process for being involved in well-designed activities while the teacher becomes their facilitator or their guide*.

This quote illustrates the learners' involvement under the teacher's facilitation.

Sub-assertion 3: Some teachers do not have an understanding of inquiry-based science teaching that matches that of the curriculum or general community of educators.

The analysis of teachers' responses about their understanding of IBST revealed that although the majority displayed different levels of understanding, this was not the case for all. Some gave answers unrelated to the question, as they may have misinterpreted the question, and others obviously had different ideas as to what inquiry was. From the survey, a total of 25 responses were either off topic or not associated with any characteristics of inquiry as referred to in this study.

This lack of understanding was also noticed in interviews, even though further probing questions revealed that some characteristics could be depicted. That was the case for teachers 2 and 7, who were reported to be not sure or confused, but when probed provided some meaningful descriptions. This teacher displayed difficulty in expressing herself and gave an unrelated response: "this approach, if for example I try to follow this curriculum that we were given, for me this curriculum is well organized" (Interview KE).

However, when probed to provide more details, she reported the following supporting the assertion that practical work of some nature was associated with inquiry-based teaching:

> For me I see that this approach of teaching will encourage learners to do experiments, if I can say, not to simply concentrate on reading theories, rather doing practicals and experiments. So what I can say is that this curriculum or the teaching approach is well organized. (Interview KE)

As for teacher 2, although the learners' independent work under a teacher's facilitation was mentioned, the response is a bit confusing and does not indicate an understanding of inquiry:

> *The inquiry-based science teaching, I suppose that it is a method that we use to help students to understand science, to work themselves helped by their teachers and at the end they will be able to solve or to increase the quality or the production and they can be able to find their job* (Interview NN).

The two last quotes show either a lack of understanding as to what IBST is or simply a misunderstanding of the related question, showing that some respondents do not hold views that correspond with any of the commonly accepted characteristics of inquiry.

Discussion and conclusion

Discussion

The purpose of this paper was to find out the understanding that teachers hold about what IBST is as an approach newly introduce in the Rwandan lower secondary school science curriculum. Their understanding was interpreted with reference to the five essential features of classroom inquiry and their variations (NRC, 2000) in many instances, and the activities of both teachers and learners that take place in every inquiry-based science lesson (IAP, 2010) as well as the Rwandan revised O-level science curriculum as part of the framework of this study. Although they did not all provide similar understanding, many responses included a number of characteristics found within the descriptions provided in the abovementioned references. Except the few who showed a complete lack of understanding, all others have understandings that have a place in the broad description of IBST and learning as framed in this study.

It was found that teachers associate inquiry teaching with a number of characteristics, such as a learner-centred teaching approach with much focus on practical work. However, not all participants displayed the same understanding, and the understandings of some were far from an acceptable description as provided in the literature or as framed in this study. This was expected as the literature itself supports that there is a lack of a concrete set of examples of inquiry indicating the lack of a common understanding of the science inquiry teaching method among teachers. Furthermore, it would be expected teachers to have different views for they come from different background, qualifications and contexts. From, the researcher's ontological perspective, it is even impossible to ever have everyone thinking and understanding inquiry the same way. Both pre-service and in-service science teacher training should try to bring them closer as possible to similar understanding.

Even the NSES do not set clear definitions of what constitutes inquiry in various contexts and see it as a teaching approach, as process skills and as content (Anderson, 2007). This variety of understanding associated with the difficulty to give a concise description of inquiry-based science teaching has shaped this study, as teachers also displayed the same lack of a single definition of inquiry teaching and rather associated it with a number of characteristics related to teachers' and learners' actions in a classroom. All elements of the definition of inquiry, such as making observations, posing questions, planning and carrying out an investigation, searching information, gathering, analysing and interpreting data and communicating results were highlighted in the majority of teachers' responses about their understanding of IBST. It was also found that information about understanding from the questionnaire was slightly different to that from the interviews. While the first focused on what IBST is, the second was that teachers reported on their understanding of inquiry in terms of what takes place in an inquiry-oriented classroom. These findings are not surprising since the literature acknowledges that inquiry teaching is defined differently not only among different researchers but also among educators. Anderson (2002) highlighted this point, arguing that the literature on inquiry tends to lack precise definition and rather rely on examples. The same reality would be expected with teachers in this study, considering the fact that inquiry is a very new concept in Rwandan educational science and is still at an earlier stage of its implementation.

Conclusion

This study revealed that teachers who participated in the study had varying understanding of what IBST as indicated through the main assertion. Specific claims aimed at answering the question were made through the associated sub-assertions: (a) the most common characteristic of IBST is some form of activity involving practical work; (b) teachers associated learner-centred teaching and teachers acting as facilitators with inquiry-based science teaching; and (c) some teachers do not have an understanding of inquiry-based science teaching that matches that of the curriculum or general community of educators.

It was felt that these findings were not surprising, given the variety of meanings found in the literature, which acknowledged the variety of interpretations of the concept of inquiry given people's differing worldviews (e.g. Wheeler, 2000). For example, it was reported in some science education literature that there seems to be a common, ill-informed understanding among science teachers that inquiry learning is all about hands-on science activities (Atar, 2007). In the context of the present study this was even more understandable. A possible explanation for this finding was associated with the fact that science education is a young discipline in the history of education in Rwanda, and inquiry was introduced only very recently in the discourse of science education. From this study, teachers' understandings may be an indication of the way IBST was implemented. This suggests that there is a need for teachers to be more familiar with the role and function of inquiry, since it is well evidenced that among other factors, understanding of scientific inquiry is seen as a prerequisite for implementing inquiry-based instruction in the classroom. From an interpretive perspective used to analyse teachers' views, it was not expected to find all participants to hold the same understanding as the intended curriculum does. With this regard, a working definition with supporting examples should clearly appear in the curriculum documents. Since inquiry-based science teaching is mainly associated with practical activities in nature, and given many types of practical work, the curriculum documents should be clear about what practical to be treated in an inquiry approach to avoid a potential confusion for teachers.

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