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Factors Influencing Chemistry Teachers' Understanding And Practice Of Inquiry-Based Instruction In Kampala, Uganda

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ABSTRACT
High school students in Uganda perform poorly in science subjects despite the Ugandan government's efforts to train science teachers and build modern science laboratories in many public high schools. This has been blamed on teachers' inability to teach science through Inquiry-Based Instruction (IBI) to motivate students to learn. However, there have been no empirical studies to establish the factors that influence science teachers' understanding and practice of IBI in the country. Therefore, taking the case of Chemistry teachers in public schools in Kampala City, we undertook this study to explore the factors that teachers perceive to influence their understanding and practice of IBI. We collected qualitative data using semi-structured interviews, observation and document analysis. We analysed these data using an interactive open coding approach. We established that the main factors influencing teachers' understanding and practice of IBI were their attitudes; their teaching experience; their motivation; availability of instructional materials; mode of assessment; class size; their pre-service and in-service training; peer support; and time constraints. We conclude that most of these factors are beyond the teachers' control because they are systemic challenges that lie beyond the schools where the teachers were teaching. It is recommended that teacher educators and policymakers address the factors.
Keywords: IBI, STEM, Chemistry education, Teacher training.

1. INTRODUCTION

Inquiry in the science classroom is advocated and expected by science educators. However, it is rare and enigmatic [1, 2]. Many researchers note that even in developed and emerging countries like the US and Singapore respectively, inquiry is not the central organizing theme in most science classrooms [3, 4]. Teachers are primarily using the lecture method through which they give knowledge to students who take it up without actively engaging with it and the processes of its creation and acquisition. Even in laboratory experience, students merely run through step-by-step procedures to verify a known results. There is a great deal of confusion about how to characterize inquiry and what it means to teach science as inquiry [5, 6]. Indeed, many science teachers hold inaccurate conceptions of the concept [3, 7, 8]. This distorted view of inquiry has created formidable barriers to the enactment of IBI in K-12 classrooms.

Many teachers believe that hands-on activities implemented to break the monotony of lectures reflect IBI [9]). However, research on IBI mainly reports the experiences of developed countries albeit science teachers in developing countries like Uganda may be facing different conceptual, pedagogical, cultural and political dilemmas when attempting to implement constructivist reform pedagogies. Also, few studies have investigated how explicit reflective professional development workshops on inquiry affect Chemistry teachers' understanding and practice of IBI. Moreover, even where studies have been conducted on science teachers' understanding and practice of inquiry, they are not discipline specific. This study attempted to close these gaps by investigating the factors influencing Chemistry teachers' understanding and practice of IBI in Uganda.

2. RELATED LITERATURE AND KNOWLEDGE GAP

Research has shown that class size, classroom management, pre-service preparation and state assessments serve to reduce the amount of time spent on science in elementary grades [see e.g. 10, 11, 12, 13) while professional development and strong pre-service programs can promote IBI [see e.g. 14]. In secondary schools in Uganda, however, research on the correlates of IBI is generally nonexistent yet inherent contextual differences exist between these schools and the settings where the aforementioned research on IBI has been conducted in Europe and North America.

The classroom itself may be a barrier to implementing IBI [15]. Accordingly, for teachers to adequately engage in IBI, they may need to engage in *new* roles that require mentoring, guiding, or collaborating [15]. Roehrig and Luft (2004) found that five factors constrained secondary school teachers' implementation of IBI: understanding of inquiry and nature of science, strength of content knowledge, pedagogical content knowledge, beliefs about teaching in general, and management and students' concerns. This study delved into whether such factors are applicable to teachers of Chemistry in secondary schools in Uganda.

Other challenges and constraints to implementing IBI were discussed by [16]. These are categorized into four domains of "dilemmas": conceptual, pedagogical, cultural and political. The *conceptual dilemma* is related to the teachers' understanding of constructivism while the *pedagogical domain* is associated with approaches taken toward curriculum design and learning experiences that accommodate the demand of constructivism. The *cultural domain* includes new classroom roles and expectations during classroom interactions while the *political domain* describes relationship regarding the norms and routines of the school and larger educational community. [16] Argued that acknowledging these challenges and constraints and addressing them in the design of professional development programs may allow for more successful implementation of IBI. Hence, our study investigated the dilemmas in the Ugandan context with the view to contribute to efforts to improve the quality of in-service professional development programs in the country.

Other problems prospective science teachers face when teaching science through inquiry were reported by [17] from three points of view that point to a question: what problems regarding IBI do prospective science teachers have from an objective, a subjective, and a self-reflective perspective? They used video analysis and observation tools as well as qualitative content analysis and open questionnaires to identify problems from each perspective. They found out that the objectively stated problems were comprised of the lack of essential features of IBI, especially concerning supporting learners' investigations and guiding analysis and conclusion. The subjectivity perceived problems were comprised of concerns about teachers' ability and learners' abilities, differentiated instruction and institutional frame conditions, while the self-reflectively noticed problems were mainly comprised of concerns about allowing inquiry, instructional aspects and learners' behavior. They concluded that each of the three perspectives provide plenty of problems, partially overlapping, partially complementing one another, and partially revealing completely new problems. [17] Recommended that science teacher educators consider these three perspectives in the training of prospective science teachers.

Another concern is science teachers' perceptions of intrinsic factors and extrinsic factors. For example, [18] conducted a mixed methods study in South Africa to investigate science teachers' perceptions of intrinsic factors and extrinsic factors influencing implementation of inquiry-based science learning in township (underdeveloped urban area) high schools in South Africa. Quantitative data were collected using an adapted version of the Science Curriculum Implementation Questionnaire (SCIQ). [18] Found a lack of professional science knowledge as contributing towards teachers' uncertainty in IBI. Furthermore, extrinsic factors such as school ethos, professional support, resource adequacy, and time served as significant constraints in the application of IBI at the school. However, [18]'s study was limited in a sense in that he did not carry out classroom observation and it was not discipline specific. Classroom observation would have provided a clearer perspective on the teachers' experiences of implementing inquiry, casting more light on the factors influencing the way this implementation is done. Also, the data collection instrument adapted is somewhat outdated. This study attempted to close these among other gaps.

3. METHODOLOGY

We employed a qualitative research approach based on exploratory case study. Kampala has a total of 21 public secondary schools. Data was collected from a purposive sample of two of these schools. We collected the data using semi-structured in-depth interviews, classroom observation and analysis of schemes of work and lesson plans from eight Chemistry teachers (four teachers from each of the schools). The responses elicited were transcribed. Subsequently, they were coded using NVivo™. Thereafter, we coded the factors influencing the teachers' understanding and practice of IBI arising out of the dataset. Our analysis yielded nine factors. These were divided into internal (two) and external (seven).

4. FINDINGS

4.1 Internal Factors Influencing Science Teachers' Understanding and Practice of IBI

4.1.1 Teachers' attitudes

Some teachers think that IBI is only applicable to learners who are knowledgeable and intelligent. One teacher explained this thus;

What I have seen is that inquiry is more applicable for learners with some knowledge about something. When you find that there is a topic where learners really don't know anything about what you are talking about, and it is something very new, you find that instead of a two-way kind of interaction because I was saying that inquiry is a two-way kind of interaction, it becomes a one way, whereby you have to give each and everything.

This teacher noted that IBI is not suitable to average learners because they do not have the capacity to participate in, and benefit from, inquiry. Another teacher corroborated this view thus:

It also depends on the ability of the learners. At times when you use inquiry methods, there are some learners who are not curious to learn; you may ask your questions and not receive any response. That leaves you to mention what you wanted them to know directly without your first getting what they know before you can tell them. (Interview with Chemistry teacher).

This teacher noted that when he uses IBI to teach "slow learners," he is likely to use a lot of time and hence cover less content. This attitude is likely to influence science teachers' practice of IBI because they think that they will not be able to finish the syllabus since most of the learners are perceived to be average learners by science teachers. Hence, most teachers decide to avoid IBI to make sure that they expeditiously cover content in their lessons.

Some teachers also have an authoritarian, teacher-centered, attitude. This culture is counter to an IBI where the learner is not given freedom to ask questions. In many African cultures, the student who asks questions is viewed as disrespectful to adults and a wiseacre. Hence, the centralized authority in the classroom negatively affects the ability of the teacher to teach using IBI. For example, one of the respondents explained that, "Teachers think that they are superior…in all situations and that they are final." The authoritarian culture among science teachers is a unique concern that has not been articulated in the literature by science education scholars in developed countries like US, UK, and Canada.

4.1.2 Teaching experience.

Another internal factor the teachers perceived to be influencing their understanding and practice of IBI is teaching experience. Some teachers argued that their teaching experience has helped them to improve on their ability to teach using IBI. For instance, a teacher argued that:

Every time you are handling a given concept or a given topic for the second time, you handle it better than you did previously. This is because you know the challenges and you redefine your approach. This helps you to improve your teaching skills with time.

This explanation, which was corroborated by the other teachers interviewed, suggests that teachers with more years of teaching experience are more likely to use IBI. However, one of the teachers interviewed argued that teaching experience may negatively affect many teachers' ability to use IBI mainly because most experienced teachers do not want to plan for their lessons. This teacher explicated this point thus;

…when I had just come from college I was asking more questions than I am doing now. After I had just finished the university, I was following the methodology until when I came and they told me there was no need for a lesson plan, so I don't make one. They demand for schemes only. It is us who trained in under the Secondary Science and Mathematics Teachers' Project (SESEMAT) who are saying that any lesson which is not planned, should not be taught because if you have not planned a lesson, then you have planned to fail teaching.

This implies that besides teachers' years of teaching experience, the quality of in-service training the teacher receives influences his/her ability to understand and practice IBI.

4.2 External Factors Influencing Science Teachers' Understanding and Practice of IBI

4.2.1 Lack of motivation.

Most of the teachers interviewed argued that they cannot teach using IBI because they are not motivated by the meager pay/salary given to them by the government of Uganda. For example, one of the teachers said that;

The barriers [to IBI] could be the limited knowledge of the teachers, and there should be some in-service training [but] another barrier is little payment and motivation.

This teacher argued that the government should pay them per lesson taught because currently there is limited time allocated to teach chemistry content. He noted that when the government pays them per lesson then teachers will be motivated to teach more topics in one school and this may prevent them moving from teaching in many private schools to supplement their income. In concurrence, another teacher explained that;

IBI has a major problem of resources, and the resources we are looking at are in the form of teachers. By the way, people normally forget that the major thing that matters is teachers; do we have time? That is the major problem. Does the teacher have time and that comes into resources? How much is the teacher paid? Because that means that like now I am about to run away, therefore, I may not sit and think how to sit and organize an inquiry-based teaching instructional material. So, that is the major barrier that we have. By the way, the other resources may be there because there is even improvisation, but do we do the preparation? The preparation is not done and why is it not done? Because we are running here and there to make money easily. So, that is the major barrier otherwise, there is nothing else. (Interview with teacher).

This teacher noted that lack of appropriate pay is the main factor that affects him and other teachers to plan an inquiry-based lesson. I also personally experienced this especially when I discovered that all the eight chemistry teachers had at least two extra private schools where they were teaching, even on Saturday. This implied that these teachers are very busy moving from one school to another, including marking exams since most schools do three sets of exams per term (beginning of term, mid-term and end-of-term exams). In such a situation, the teacher will never get time to sit down and plan an IBI lesson.

4.2.2 Lack of instruction materials

The second external factor influencing science teachers understanding and practice of IBI is lack of necessary instructional materials. Some teachers argued that they do not have adequate instruction materials. One of the teachers explained this thus;

Another challenge comes from instruction materials. We don't have things like teaching aids and don't know how to use them alongside the method. At times in some topics, it becomes hard. You will discover that learners don't know anything about what you are teaching and that means that to bring a teaching aid and use an inquiry method also becomes a bit abstract.

Likewise, I asked a teacher to demonstrate real natural phenomena like mixing oils and water to help learners observe and try to explain what happens, instead of just telling students that oil cannot mix with water theoretically. The teacher explained that;

Things have changed. You go to a school, and they can't afford to give you materials. They are making you not to be a science teacher, and yet you are a science teacher. Like for us here, we just don't have big labs. This one, for example, you can see is a lab, but there is nothing. If a lab can be repaired, renovated and equipped, then that would be very good. Then we could also have mobile projectors, white boards, etc.

Another teacher, in agreement with his colleagues, explained that;

Here we request for several things [to use in teaching Chemistry] but they do not provide them. The lab is there but those taps, for example, are not working. And that is just an example all those taps you see do not work. That electricity there you see, I had first to shout then they provided it so that you can see.

4.2.3 Mode of assessment

Some teachers argued that the nature of examinations does not emphasize inquiry-based questions. This has made teachers to continue teaching only about basic facts that help learners to perform well in examinations. One of the teachers explained that;

[the] examining bodies set exams that require recall, and not understanding, of concepts. People will find more relevance in using IBI when the way examinations are set changes.

Under normal conditions, the curriculum should guide instruction. However, in this case, the teacher argued that the mode of assessment guides the instruction because teachers try to teach the basic facts which enable learners pass the national exams. This examination oriented type of education discourages innovation of teaching.

4.2.4 Class size

Some teachers argued that they need moderate class sizes to enable them to teach using IBI. One of the teachers expounded this point thus;

I think to use inquiry we need a moderate classroom whereby the numbers of learners are not very big, and you can reach out to at least each and everybody and understand what each learner needs…where you can easily reach out to everyone and take each learner's idea.

On the contrary, we observed these teachers struggling with large class size in small labs. Hence, most teachers are likely to be discouraged to teach using IBI if the number of students are more than 40 in labs that were planned for 25 students.

4.2.5 Nature of pre-service and in-service teacher training

Most teachers argued that there should be adequate pre-service training in IBI to enable teachers to use inquiry when teaching. One of the teachers suggested that pre-service teacher training should include some research projects that help pre-service teachers to appreciate inquiry. He noted that this would help teacher trainees to come out with reasonable experience to teach using IBI. Yet some of the teachers claimed that their pre-service training did not prepare them to teach using IBI. One of the teachers interviewed noted that the current pre-service and in-service training needs improvement by adding some course units addressing IBI and peer teaching. This was corroborated by another teacher thus;

Now it also goes to the colleges, you will find that these people are also moving up and down. By the way, in the college, it is a bit better, but in the university, there is very little teaching of inquiry-based skills. In college, the people there are more practical. At the University, it is where teaching of inquiry-based skills is dying from, because of the way teaching is done. Perhaps you have been in the Universities, what have you found there? The practical approach is not there. So, if someone was not taught in the practical approach, unless he is creative he cannot use it.

This teacher suggested that teacher training colleges (colleges train diploma teachers to teach lower secondary - form one to form four) are better than universities that train graduate teachers. He was speaking from his experience, because he started as a diploma (grade five) teacher and now he has upgraded to a Master of Science degree (chemistry), and he is also a part-time lecturer in one of the public universities where he teaches chemistry content and methods. He also thinks that government policy on science has a lot to blame about the failure by many science teachers to teach science through IBI. In addition, he recommended that the professors in universities involved in teaching science content courses should be trained in teaching methods so that they can train competent teachers who can use IBI. In concurrence, another teacher explained that:

College didn't help a lot. The issues being addressed in the college are not at all the issues on the ground. The college would not help but when you come to the ground you get challenged, it is only that college prepares you to handle any challenge that will come, but they are not specific.

Unlike the other teachers, one teacher argued that the micro-teaching she did at the University helped her learn to teach science using IBI. Ms. When asked to specify the extent to which she thought her training helped her to teach inquiry, she explained that;

[the training] is helping me because in our university before you come to your school practice you are supposed to teach your peers and department members before you come here. And they assess you before you leave. Even when we are doing our experiments it is individual not in groups, so you write your observations and conclusions individually.

This teacher differed from her colleagues because she argued that her pre-service training helped her to improve her understanding and practice of IBI because she was involved in micro-teaching and conducted experiments individually.

4.2.6 Peer support

Some teachers acknowledged that support from their peers has helped them to improve their ability to teach using IBI. For instance, when we asked one of the teachers as to whether he has been helped by other teachers to improve his knowledge and skill to teach using IBI, he stated that;

I can say yes because during departmental meetings we can exchange ideas on how we can handle different topics using different methods."

Likewise, another teacher noted similar practices thus;

Senior teachers and heads of department have taught us how to use suitable questions that will help you to achieve the objective that you want. He can help you to frame them, that if you are teaching this, you can guide the learners like this with this question and that question.

However, one of the teachers noted that sometimes his peers negatively affect his ability to teach science using IBI. He explained that;

The moment you are lucky, and you are with someone [a fellow teacher] who is creative then you go that inquiry way, but if you are unlucky and you meet someone in the early stages who is not, then you go the other way.

This teacher was of the view that peer teachers' effect depends on the type of peer teachers you interact with. She noted that;

If you interact with those who are creative, your understanding and practice of IBI improve, but if you interact with those who are not, then you will not improve.

4.2.7 Time Constraints

Some teachers argued that they cannot teach using IBI because the chemistry syllabus has too much content to cover in a limited amount of time. Regarding this, one of the teachers explained that;

There are several times when IBI can't be applicable. In private schools, you might find that you are given a certain load that you are supposed to cover within a certain period. So, what you will be mostly interested in is to cover the load instead of seeing whether you have given it in a proper way and the learners have got it.

Most teachers argued that they have limited time to teach through IBI. This may be because all the teachers we interviewed were teaching in more than two private schools and enrolled in postgraduate study programs, in addition to teaching in the public schools were the study was done. Some teachers argued that they have too many lessons to teach. Hence they cannot plan effectively, which makes their use of IBI unlikely.

Most teachers do not have enough time to plan their lessons because they teach in more than one school to improve their income. This is also due to the scarcity of science teachers in Uganda. There are many private schools which cannot afford to employ a full-time science teacher. Hence, these private schools depend on part-time science teachers to minimize their operating costs. This results in science teachers having too many lessons to teach, hence affecting their effectiveness and efficiency in teaching science using IBI.

5. DISCUSSION

We established that the main internal factors that my participants perceived to influence their understanding and practice of IBI in Kampala City high schools were teacher attitudes (myth about inquiry) and teaching experience. Whereas the external factors were lack of motivation, lack of necessary instructional materials, mode of assessment, class size, the nature of pre-service and in-service training, support from peer teachers and limited time in relation to many lessons and much content to cover.

There are two internal factors and seven external factors, which implies that most of the factors participating teachers perceive to influence their understanding and practice of IBI in Kampala city schools are beyond their control. This finding agrees with [26] who established that apart from science teachers' understanding of inquiry, there are other contextual factors that affect science teachers' practice of IBI. Other science education researchers established that class size [19, 20], classroom management [13, 21, 22], pre-service preparation [23], and state assessment [11, 24, 25] have a negative effect on elementary science teachers' ability to practice IBI. Much as their studies focused on elementary science teachers in the US, there are similarities with the high school science teachers in Uganda, especially with the effect of the mode of assessment on science teachers' practice of IBI. However, factors like class size and classroom management may have a different magnitude in Kampala City public high schools. Hence, we need different strategies to address such factors in developing countries like Uganda. I realized during classroom observations that teachers struggled to deal with very large classes (more than 50 students per class) in a small laboratory that had been constructed to accommodate an average of 25 students. Additionally, [15] established that the classroom itself may be a barrier to the implementation of IBI. This agrees with my finding that classroom environment influences science teachers' ability to use IBI. However, one participant argued that she had a good classroom environment that helped her to implement IBI in her classroom.

[16] classified the challenges teachers face into four domains of dilemma: conceptual, pedagogical, cultural and political. Hence, the nine factors that I established from my study may also be classified using [16]'s classification as follows: *conceptual dilemma*, which includes lack of knowledge about IBI (myth about IBI); *pedagogical dilemma*, which includes teaching experience; *cultural dilemma*, which includes an authoritarian culture by many teachers; and *political dilemma*, which includes lack of motivation, lack of necessary instruction materials, mode of assessment, class size, support from peer teachers, the nature of pre-service and in-service training, limited time in relation to many lessons and much content to cover. It is evident that about 77 % of the factors are political in nature. This implies that the contextual factors may have a large influence on science teachers' practice of IBI. Therefore, if science teachers are to practice IBI, there is a need to improve their working conditions in addition to equipping them with knowledge about IBI. This finding is aligned with [26] research that asserted that teachers' understanding of IBI is not the only factor affecting the practice of IBI. There are many contextual factors that influence science teachers' implementation of IBI. [26] Asserted that IBI can only be successfully implemented when confounding variables, like instructional and curricular concerns, personal teaching philosophy, and concern about students, are satisfactorily addressed by key stakeholders in education.

However, these factors are context specific, and hence each country must conduct qualitative studies to establish these factors so that they can be practically addressed. Some of the above factors affect science teachers' understanding and practice of inquiry positively, whereas other factors affect them negatively. For instance, teaching experience and support from peer teachers may have either a positive or negative influence depending on the school context and nature of peers the teacher gains his/her experience. If a teacher associates with teachers with a teacher-centered philosophy, then the teacher is most likely to gain bad peer influence and hence will have insufficient understanding and practice of IBI. Also, some concerns such as poor pay, teachers teaching in many school (limited time in relation to many lessons), authoritarian culture among science teachers and ability to use learners' indigenous knowledge to explain the science content are not articulated by science education scholars in developed countries like the US, UK, and Canada. Hence, these factors may be unique in developing countries like Uganda. Therefore, it is better for policy makers and science teachers' trainers to address internal and external factors that affect science teachers' understanding and practice of IBI to improve the teaching and learning of science subjects in each country.

Factors such as lack of necessary instructional recourses, mode of assessment and too much content to cover in limited time have been evident in other African countries, such as South Africa [18]. In the US, [27] established that time constraint was a dilemma to most teachers who attempted to implement IBI in their classrooms. Hence, addressing these factors by examining the contexts the science teachers are facing with these challenges will help improve the teaching and learning of science subjects in developing countries like Uganda.

6. CONCLUSION

The conclusion based on the findings of this research are that: First, the current pre-service and in-service teacher training in Uganda may not be improving science teachers' understanding and practice of IBI. Secondly, most of the factors affecting science teachers understanding and practice of IBI as perceived by participating teachers in Kampala City public high schools are beyond their control (external/political dilemmas). Therefore, science educators and policymakers have a greater role to play in improving science teachers' understanding and practice of IBI in Uganda.

Recommendations

The findings of this research are important because they show the need to pay attention to both the internal and external factors affecting science teachers' understanding and practice of IBI in developing countries like Uganda. There has been consistent blame by the Ugandan government on science teachers' inability to teach science using the IBI approach. However, our study shows that external factors, such as pre-service training, in-service training, and mode of assessment, need to be addressed by key stakeholders like teacher educators and policy makers (government). Hence, there is an urgent need for the key stakeholders, like teacher training colleges, to revise their content and method courses to integrate an IBI approach. Also, it appears that the current SESEMAT in-service training needs to address context-specific problems/challenges teachers face in Uganda, instead of just adopting the Japanese model they are currently using. Secondly, the Ugandan government needs to address issues like large classes by recruiting more science teachers and constructing adequate laboratories for all public schools.

Although the curriculum development center has tried to review the lower secondary curriculum, there is need to sensitize teachers very soon about the changes of the curriculum that will be launched in 2018. This curriculum was adopted based on the US and UK curricula that require teachers to be able to teach using IBI. However, to date, the teachers are not yet prepared to do so.

Lastly, there is need for further research involving teachers of other science disciplines, like physics and biology, in Uganda since this is the first qualitative study to investigate science teachers' understanding and practice of IBI. Future studies may use both qualitative and quantitative approaches, based on the factors outlined above, to come up with path analysis models explaining how different factors influence science teachers' understanding and practice of IBI in developing countries like Uganda. This may lead to improvement of teaching and learning of science subjects in developing countries.

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