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Elementary Teachers' Educational Beliefs and Their Instructional Approaches: In Search of a Meaningful Relationship

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Authors' contributions

This work was carried out in conjunction between the two authors. Author DFS designed the paper, carried out the review of literature, conceptualized the arguments and wrote out the initial draft of the paper. Author BJO provided the impetus for carrying out the study, took part in designing it, perused the draft, refined the arguments, and produced the final draft. Both authors read and approved the final manuscript.

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ABSTRACT

This paper reviews the literature and raises arguments that elementary school teachers' instructional approaches in science are in part influenced by a variety of their educational beliefs. These instructional approaches are discussed relative to their being either the traditional content-focused approaches or the recommended inquiry-based approaches. It is suggested that since teacher education science curricula has for many years been emphasizing inquiry based approaches to science instruction, there is probably some very compelling reasons why teachers generally fall back to using the traditional approaches. Since the research literature has indicated that individuals' beliefs are strongly influential in their decisions and behaviours, the conclusion is made that this may also apply to teachers with regards to a variety of their educational beliefs influencing their science teaching approaches. Three types of educational beliefs were suggested by the literature as being likely to influence teachers' instructional decisions. These are epistemological, science teaching and learning and science teaching efficacy beliefs. In addition, the situation specific construct applicability beliefs was conceptualized by the authors of this paper to

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explain teachers' beliefs about various social, psychological and environmental factors affecting their attempts at inquiry based science instruction.

Keywords: Inquiry based instruction; traditional instruction; educational beliefs; epistemological; applicability; science teaching efficacy.

1. INTRODUCTION

The general quality of science instruction in schools has suffered almost constant criticism from as far back as the early 20th century. At that time, John Dewey proclaimed his displeasure at the way science as a school subject was being portrayed as simply a body of knowledge rather than a process of inquiry [1]. Dewey's assertion actually highlights the dichotomy which formed the basis of arguments concerning appropriate strategies of science instruction up to the present day. This dichotomy stems from whether science should be regarded as the body of knowledge that has accumulated over the centuries, or as the process of scientific inquiry that resulted in that body of knowledge, or indeed as a combination of both.

Researchers are in general agreement that science has, up to the present day, been taught in schools as predominantly a body of knowledge [2,3,4,5,6]. That this continues in the modern era could be regarded as surprising considering the focus of teacher education science curricula as well as the science curricula of both elementary and secondary schools on the teaching of science as a process of inquiry. This is inquiry-based instruction (IBI) and has been articulated as the recommended approach for science instruction by reputable researchers and organizations for over half a century.

It is important to now consider the possible reasons why teachers, despite receiving training in the use of IBI during their period of teacher education, would generally fall back on the use of the traditional, content focused instructional strategies. One area of research over the last 30 years is in teachers' thought processes and its influence on their day to day instructional decisions.

Since the 1980s, there have been several studies investigating the role of individuals' beliefs in their actions and decision making. Pajares [7] did a synthesis of such studies and indicated that they were generally based on the assumption that beliefs are the best indicators of the decisions individuals make throughout their lives (e.g. Bandura, 1986; Dewey, 1933; Nisbett and Ross, 1980; Rokeach, 1968). Pajares therefore concluded that research into teachers' beliefs is important since it may inform educational practice in ways that had previously not been accomplished by the educational research of the time.

Irez [8] also noted Dewey's interpretation of the crucial importance of beliefs in that it:

> "…covers all matters of which we have no sure knowledge and yet, which we are sufficiently confident of to act upon" (p.17)

Sigel (1985) provided a definition which took into consideration the importance of individual's experiences in the development of beliefs. According to Pajares [7], he defined beliefs as "Mental constructions of experience, often condensed and integrated into schemata or concepts… are held to be true and that guide behavior" (p. 313). This definition also highlights the view that beliefs do not necessarily require a condition of truth. Irez [8] synthesized the definitions of a number of researchers (e.g. Clark and Peterson, 1986; Nespor, 1987; Pajares, 1992; Richardson, 1996) and provided the general definition that:

> "Beliefs are psychological constructs that (a) includes understandings, assumptions, images or propositions considered to be true, (b) drive a person's actions and support decisions and judgments, (c) have highly variable and uncertain linkages to personal, episodic and emotional experiences, (d) although undeniably related to knowledge, differs from knowledge in that beliefs do not require a condition of truth" (p.17)

The assumption can therefore be made that, teachers' instructional decisions in their science lessons may be a function of a number of factors, one of which is the educational beliefs that they hold. The question that now arises is how do teachers' beliefs that affect their instructional practice originate? Even more importantly, what is the nature of the beliefs which would cause trained teachers to move away from the teaching approaches and strategies learnt and practiced at teachers' college and instead use strategies deemed inappropriate by the education literature? To answer these questions one needs to understand the nature of the recommended inquiry-based approaches compared to the traditional content-focused approaches. In addition, what is the possibility that particular educational beliefs may favour one approach or the other?

1.1 Instructional Approaches to Science Instruction

In the context of the classroom, an approach to instruction can be considered to be the way in which a teacher conceptualizes instruction and how it should be conducted to best facilitate student learning. This is related to teachers' pedagogical content knowledge (PCK) which was described by Shulman [9] as teachers' representation of how their content knowledge and general pedagogical knowledge of a subject discipline interact to produce understandings of how particular topics and issues could be organized and represented in instruction to cater for the diverse needs and interests of learners. This combines with teachers' knowledge of context to form what Grossman [10] refers to as the four general areas of teachers' knowledge. However, he also claimed that PCK probably had the greatest impact on teachers' instructional practices.

Magnusson, Kracjik and Borko [11] linked teachers' PCK to their instructional approaches in science when they identified various orientations to science teaching as components of PCK. They, in effect, defined these orientations as the general way in which teachers viewed science teaching within particular grade levels. Nine orientations to science teaching were proposed which were later categorized by Friedrichson [12] into two groups:

a. Teacher centered orientations: Didactic and academic rigor.
b. Orientations based on the reform initiatives and curriculum projects of the 1960s and continuing: Process, activity driven, discovery, conceptual change, project-based science, inquiry and guided inquiry.

The first category is taken to represent the traditional approaches to science instruction, while the second represents IBI approaches.

Anderson and Smith described teachers' orientations as the combination between teachers' thought processes and their actions [13]. These thought processes include the knowledge structures identified by Grossman (1990) and also teachers' educational beliefs related to that knowledge. The actions represent the instructional strategies used by a teacher related to these thought processes. The determination of a teacher's approach to instruction can therefore best be determined by using a 'conceptual yardstick' that would allow some kind of measurement to be made along a continuum of 'teaching practice' identified earlier as ranging from teacher-centered traditional approaches to student-centered inquiry-based approaches, with the latter being identified as the preferred approach for effective science instruction.

1.2 Traditional, Content Focused Instructional Approaches

Chiapetta and Koballa characterized much of the science teaching that presently occurs at all levels of the education system as teaching the 'products of science' [4]. This assertion is targeted at the widely held view that generally the teaching of the science is focused on the content found in textbooks and other curriculum documents with comparatively less attention placed on the methods of scientific inquiry used to generate that knowledge.

The teaching of science as a 'body of knowledge' has arguably remained the primary approach to science instruction at all levels of the education system up to the present day. Hence the references to this approach as 'traditional'. It is a teacher-centered approach where the teacher is, as described by Ibrahim, primarily focused on content coverage and sees the students as knowledge reservoirs [5]. Damnjanovic also described the students as regarding their teachers as expert knowledge sources and responsible for their learning [14]. The OECD [14] goes further and describes this approach as direct transmission, with the teachers' role being to:

> "…communicate knowledge in a clear and structured way, to explain correct solutions, to give students clear resolvable problems, and to ensure calm and concentration in the classroom" (p.92)

Referring to the orientations to science teaching, traditional science instruction is represented by the didactic and academic rigor orientations. Magnusson et al. [11] described the teacher with a didactic orientation as one whose goal is to "transmit the facts of science" (p 100). The goal of one with an academic rigor orientation is to "represent a particular body of knowledge" (p 100). For science instruction this would include rigid verification exercises like laboratory work and demonstrations.

Recent developments in the U.S. give compelling evidence of the resilience of these traditional approaches to science instruction. In 2011, the National Research Council (NRC) published their 'Framework for k-12 Science Education' which gives clear indication of teachers' reluctance to move away from traditional approaches. For example, there is the claim that k-12 science instruction still focuses on breadth rather than depth of content and students generally are not made to experience how science is actually done [16].

That research evidence suggests that this approach is still the most popular one used by teachers is an indication that, for a number of reasons, teachers are making the decision to stick with it despite their assumed knowledge of the preferred inquiry based approaches. The research literature actually provides some of these reasons, a few of which appear quite compelling. For example, there is the argument that teachers 'experiences during their many years as students results in attitudes and beliefs about teaching and learning that far outweigh their teacher education experiences [6,7,15,17,18] With regards to science instruction, these attitudes and beliefs may cause teachers to generally be more comfortable using the instructional strategies they were used to as students.

Another argument is related to the emphasis of many schools on student success at examinations. Duffy and Raymer linked this to a general tendency of teachers to use traditional instructional strategies which are more aligned to content coverage [19]. They also linked this to students' superficial learning of content since they tended to be more focused on identifying what will be on a test than developing a deep understanding of the subject matter.

Jones and Carter also raised the argument that some teachers may actually believe that traditional approaches are most effective for science teaching [6]. Reasons given for this included teachers actually experiencing success as students being taught science by a 'favourite teacher' using traditional approaches, teachers themselves continually being appraised as effective teachers using traditional approaches, and, as expounded by Jones and Carter, teachers who either, lack content knowledge or student-centered pedagogical skills, and are therefore more comfortable using traditional didactic approaches [6].

Despite these possible reasons for the predominance of traditional approaches to science instruction, most modern researchers are of the view that, as indicated by Levitt, passive instruction is an ineffective tool for learning science concepts [11], and, according to Chiappetta and Koballa, encourages poor learning strategies such as memorization of poorly understood facts [4].

1.3 Inquiry Based Instruction

In the early 20th century, Dewey criticized the content-focused science instruction of the time, arguing instead for IBI where the focus was on the development of the thinking and reasoning skills as well as the methodological skills of scientific inquiry [1]. These views actually formed the basis for the curriculum initiatives that started in the U.S. in the 1960s and spread to countries worldwide. This curriculum reform movement focused on primary and secondary school curricula and emphasized student centered instruction, development of scientific attitudes and process skills, the use of practical experience for students, and a focus on breadth rather than depth of content [21]. The process, activity, and discovery orientations to science teaching outlined by Magnusson et al. stemmed from these curriculum initiatives [11]. They described the goal of teachers with a process orientation as helping students develop process skills. Those with an activity orientation have the goal to involve students in hands-on activities, while those with a discovery orientation have the goal of providing opportunities for students to discover science concepts through their own activities.

These curriculum reform initiatives, however, did not have the expected improvement in science instruction in the U.S. This was revealed by a series of publications in the 1980s including Project Synthesis supported by the National Science Foundation, and 'A nation at risk' by the National Council on Excellence in Education. These reports resulted in renewed emphasis on curriculum reform but, according to Bybee, Powell and Trowbridge [1], it was through a series of benchmarks and standards for IBI published by the American Association for the Advancement of Science [22] and the National Research Council [23]. These benchmarks and standards were adopted by curriculum developers internationally, and formed the basis for their curriculum development initiatives.

Although many definitions of IBI were since put forward by researchers and organizations, the one originally put forward by the NRC [23] encompasses most of them:

> "…a multifaceted activity that involves making observations, posing questions, examining books and other sources of information,…planning investigations, reviewing what is already known in light of experimental evidence, using tools to gather, analyze and interpret data, proposing the results, use of critical and logical thinking, and consideration of alternative explanations" (p. 23)

This definition illustrates the project-based science as well as inquiry orientations to science teaching put forward by Magnusson et al [11]. They indicated that the goal of the teacher with a project-based science orientation is to "involve students in the investigation of authentic problems (centered on) driving questions" (p 100). The goal of a teacher with an inquiry orientation is to represent science as inquiry using investigation-centered instruction.

The NRC definition also highlights particular differences between IBI and traditional instruction that may actually influence teachers' decisions as to their day to day instructional strategies. For example, the activity oriented nature of IBI may not appeal to teachers who are primarily focused on content coverage. Teachers may also question whether they can actually access all the required resources for IBI. Also of importance is whether teachers consider that they are confident enough, or possess the necessary science content knowledge to have the level of classroom discourse that would stimulate the critical and logical thinking required by IBI.

Justice, Rice, Roy, Hudspith and Jenkins outlined Dewey's ideas of IBI as a belief that students need to develop critical thinking skills rather than memorization skills [24]. They therefore defined IBI as:

> "…instructional practices designed to promote the development of higher order intellectual and academic skills through student-driven and instructor-guided investigations of student generated questions" (p.843)

This definition focuses attention on inquiry as an intellectual process. It brings out the important point that student experiments and other manipulative activities cannot on their own be considered to be following an inquiry process. There must be some critical examination and production of ideas, problems, experimental results, conclusions etc. Another key element of this definition is the student-driven, instructor-guided investigations of student-generated questions. This illustrates a most basic aspect of inquiry: the curiosity of human beings. Teachers are expected to stimulate student curiosity relevant to the topics being covered, which will lead to student investigations of their own questions. The instructor acting as a guide through this process illustrates the guided inquiry orientation to science teaching, the goal of which is to form a "community of learners whose members share responsibility for understanding the physical world [11].

Also of relevance to IBI is the conceptual change model of learning which stemmed directly from constructivist ideology and is based on the view that by the time learners encounter the formalized science instruction in the classroom, they have already constructed a multitude of pre-conceptions about the natural world. These pre-conceptions have been given names such as misconceptions, alternative conceptions, and naïve theories since they often do not correspond well with the scientific knowledge that is taught [4]. Wandersee, Mintzes and Novak described these conceptions as tenacious and resistant to change by conventional teaching strategies [25]. So in the science classroom, teaching strategies must, in effect, facilitate a process of conceptual change in students.

Magnusson et al [11] described the conceptual change orientation to science instruction where the teachers' goal is to "facilitate the development of scientific knowledge by confronting students with contexts that challenge their naïve conceptions (p.100). Liang and Gabel [26] identified a number of conceptual change teaching approaches that have been developed and have been shown to promote students' conceptual understanding of science as well as improving their attitudes towards science teaching and learning (e.g. Driver, 1988; Gabel, 1998; Hand and Treagust, 1991; Heuson and Heuson, 1983; Stofflette and Stoddert, 1994). Chiappetta and Koballa [4] gave a general description of these approaches indicating that students' prior knowledge is elicited and they are made to reflect on and confront their pre-conceptions of phenomena. Opportunities are also provided for students to find personal meaning with the new concepts from their interactions with objects, events and people.

Elementary teachers have themselves been on the receiving end of these instructional approaches due to their experiences as students. In addition, it is in the years of teacher education that they are formally exposed to the science instructional strategies that fall under the umbrella of either traditional approaches or IBI approaches. These experiences would most likely have resulted in the development of particular educational beliefs which may actually be instrumental in influencing their preferred instructional approaches. It is therefore pertinent to understand the nature of the educational beliefs that may occur in teachers as a result of their experiences with the aim of determining the appropriate interventions needed that would lead to a more effective implementation of IBI.

2. ELEMENTARY TEACHERS' EDUCATIONAL BELIEFS

2.1 Importance of Studying Teachers' Thinking Processes

Clark and Peterson [27] actually classified the process of teaching into two major domains: (1) teachers' thought processes, and (2) teachers' actions and their observable effects. They were clearly alluding to a strong influence of these thinking processes on the actions of teachers. This was further discussed by Fang [28] when he identified two underlying assumptions of research on teachers' thinking as:

1. Teachers are professionals who make reasonable judgments and decisions within a complex and uncertain community.
2. Teachers' thoughts, judgments and decisions guide their classroom behaviours.

2.2 Resiliency of Teachers' Beliefs

An important reason cited in the literature for attention given to teachers' beliefs is the resiliency of beliefs, even in the face of compelling factors contrary to these beliefs. Pajares [7], in his synthesis of belief research, alluded to the difficulty of belief change even under circumstances when it is logical or necessary for them to. This raises an important question. Are all beliefs of the same intensity, and hence equally resistant to change? Rokeach [29] was of the view that beliefs do differ in intensity and power. He posited that beliefs vary along a central-peripheral dimension, and the more central the belief, the more it will resist change.

Rokeach's ideas bear important implications for teachers' beliefs and practices. It can be reasonably concluded that the more central teachers' beliefs are those that have withstood the test of time since, as indicated by Rokeach [29], these beliefs have obviously resisted change. Pajares [7] agreed when he asserted that the earlier beliefs developed by individuals are the ones most difficult it is to alter. Therefore, if teachers developed beliefs about teaching and learning as far back as when they were students in primary and secondary schools, and these beliefs persisted in them as teachers, it can be argued that these are central beliefs that may resist change even in the period of teacher education. Pajares [7] also asserted that beliefs that are newly acquired are the most vulnerable and, hence, subject to change. Therefore, any beliefs that teachers may acquire as a result of teacher education, may be peripheral beliefs, and these may quickly change when teachers enter schools. This will especially be the case if these peripheral beliefs are contrary to the longer established central beliefs.

2.3 Teachers' Personal Experiences and the Development of Beliefs

Rokeach [29] described beliefs as having a cognitive component which is most likely the result of personal experiences of individuals that are associated with the development of particular beliefs. With regards to teachers, various researchers have described beliefs related to the teaching-learning process as evolving over time due to a variety of factors including cultural influences and teachers' experiences of schooling and instruction (e.g. [17], [30]). Researchers, however, have provided different interpretations as to exactly how personal experiences contribute to the development of beliefs. Eraut (1985) for example, postulated that any significant experience of an individual remains in the long term memory as a photographic image that continually contributes to the creation and recreation of knowledge, and hence beliefs (Cited in [7]). Nespor [31] argues instead that these previous episodes or events actually colour the comprehension of subsequent events.

Since teachers' previous experiences influence the development of beliefs about the teaching-learning process, then it should also influence their behaviours as teachers. Meyer, Tabachnik, Hewson, Lamberger and Park [32] expressed the view that these beliefs act as filters for the new ideas learnt during teacher education. Fang [28] argued that these beliefs can be embodied in a teachers' expectation of his or her students' performance, or the teacher's theories about a particular subject area's learning and teaching. This is of particular relevance to science teaching, which has historically been delivered using traditional didactic modes. Strong beliefs about the effectiveness of traditional modes of instruction may have been developed which would influence, not only how a teacher reacts to IBI, but ultimately how he or she interacts with students during science instruction.

2.4 Teachers' Beliefs and Their Classroom Practices

The proposed influence of teachers' beliefs on their classroom practices is based on the assumption that beliefs generally are very effective in predicting behaviours of the individuals possessing them [7,29,33,34]. Every day, teachers are expected to make a variety of classroom decisions. In addition, a number of planning decisions are made by teachers on a daily, weekly, termly and yearly basis. These decisions can be made individually or in conjunction with other teachers, and should be reflected in the classroom practices of individual teachers. The question which arises is: to what extent are the educational beliefs of individual teachers reflected in firstly, the planning decisions made, and secondly, their classroom practices?

Jones and Carter [6], commenting on the complex belief systems held by teachers, indicated that these beliefs influence teachers' instructional discourse, instructional strategies, classroom management, selection of topics, and their assessment practices. It can also be argued that these belief systems also influence how teachers interact with other teachers during the instructional planning process. For example, new teachers may have low teaching efficacy beliefs, and hence, may continually give way to the ideas of more experienced teachers, whose teaching approaches and strategies may be different from that of the new teachers. Hence, the classroom practices of these new teachers may be more in line with the ideas of their more experienced colleagues than a reflection of their own beliefs.

If, however, the assumption is made that teachers' classroom practices are generally the result of their own cognition rather than influenced by other teachers, then educational beliefs developed by teachers during their periods of schooling as well as teacher education, may be an important contributing factor to the nature of these practices. Levitt [20] cited Peterman (1993) who found that the main way in which teachers express their educational beliefs is through their behavior in the classroom. These beliefs were indicated by Nespor [31] as influencing teachers' perceptions and judgments in the classroom, which in turn affect their behavior.

More recent studies on teachers' beliefs and practices have indicated that the relationship may not be as straightforward as beliefs influencing practice. Smagorinsky, Cook, Moore, Jackson, and Fry [35] noted that new experiences may actually lead to changes in and/or additions to beliefs. This was supported by the research of Jones and Carter [6] which suggested that once instructional behaviours are enacted, responses to teachers' actions affect their beliefs just as beliefs affect actions. They, however, pointed out that any alterations to teachers' beliefs based on, say, student responses would depend on the strength of the students' responses, as well as the strength of the teachers' beliefs. If, as earlier discussed, the newly acquired beliefs from teacher education are weaker than the longer established beliefs from teachers' experiences as students; then it is these weaker beliefs that would be the ones which would more likely change as a result of inadequate student responses. Beliefs about IBI may be an aspect of these newly acquired beliefs. It should also be noted that inadequate responses may not only be from students. It could also be from other teachers, the school administration, and even parents.

Jones and Carter [6] pointed to research showing a conflict between teachers' beliefs and their practices (e.g. King, Shumow and Lietz, 2001). Reasons given for this conflict include weak content background, and weak instructional skills of teachers. A contrary argument to these findings is that they may not necessarily be indicating a conflict between teachers' beliefs and practice. It may be that the conflict is between practices and weakly held beliefs originating from teacher education experiences. Despite these experiences, stronger held beliefs from the many years of schooling may be still present, and teachers resort to them in the face of practical constraints to the beliefs originating from teacher education.

What then are the particular educational beliefs that can influence teachers' instructional practices? Pajares [7] indicated that the construct of educational beliefs can be classified into teacher efficacy beliefs and epistemological beliefs. Levitt [20] also identified teachers' beliefs about teaching and learning as important in that they "underlie the processing of a multitude of information a teacher is presented with in the classroom" (p.4). Enochs and Riggs [36] identified science teaching efficacy beliefs which, in effect, combined teacher efficacy, self efficacy and self esteem. In order to improve elementary teachers' science instructional practices, it is important to consider how these beliefs may develop in teachers, how they could be measured in teachers, and also how they may be reflected in teachers' instructional practices.

2.5 Measurement of Beliefs

If educational beliefs are so important in determining teachers' instructional practices, then it is vitally important that researchers are able to, as accurately as possible, measure these beliefs. This is easier said than done since beliefs can be said to be individuals' construction of the reality they have been exposed to and so cannot be directly observed. It must be inferred from what individual's say or do. According to Rokeach [29], any inference drawn from individuals with a view of determining their beliefs, must take into account ways in which individuals give evidence of these beliefs. He added that this could include belief statements, statements about intentions to behave in a pre-disposed manner, or the actual behaviour related to the belief in question.

Many researchers have adopted qualitative methodologies for the determination of individuals' beliefs (e.g. [20,37,38]). Strategies range from structured and semi-structured interviews to lesson observations. The argument is that these methodologies are most appropriate for the study of beliefs since, as expressed by Pajares [7], effective probes and strategies must be used to uncover deeply held beliefs. While this is a fair argument, the debilitating drawback is that qualitative methodologies limit the size of the population that can be investigated.

Despite the appropriateness of qualitative methodologies, a number of researchers (e.g. [5, 36, 39]) adopted quantitative methodologies for the measurement of teachers' beliefs. One argument for this is that although beliefs are constructed realities, and therefore individualized, it is felt that these beliefs can be measured relative to enabling or inhibiting certain behaviours. This is similar to what has repeatedly occurred in research on attitudes over the last few decades. In this regard, the views expressed in Onwuegbuzie [40] that the relationship between quantitative and qualitative paradigms is one of isolated events lying on a continuum of scientific inquiry, are pertinent. Therefore, as asserted by Munby [38], the choice of whether to use quantitative or qualitative methodologies (or both), would depend on the type of data that is to be collected, as well as the use which is to be made of that data.

2.6 Categories of Teachers' Educational Beliefs

2.6.1 Teachers' personal epistemological beliefs

Yilmaz-Tuzan and Topcu [41] cites a definition of epistemology by Hofer (2002) as the "origin, nature, limits, methods and justification of human knowledge" (p.65). So personal epistemological beliefs can simply be defined as an individual's beliefs about the nature of knowledge and how we come to know. Jones and Carter [6] went further and described these beliefs as playing a mediating role in an individual's processing of new information. Yilmaz-Tuzan and Topcu [41] described the possibility of an individual holding several epistemological beliefs at the same time, and that these beliefs shape a person's epistemology.

Personal epistemological beliefs are of particular relevance to science education, particularly the teaching-learning process, since on one hand, individual's personal epistemologies may most likely have been strongly influenced by their experiences as students in schools. On the other hand, teachers' personal epistemologies would most likely influence the way they conceptualize the teaching-learning process and hence, what learning is like for individual students. Jones and Carter [6] also expressed the view that teachers' personal epistemologies may serve as mental exemplars for "constructing and evaluating their own teaching practices" (p.1072). It is therefore also likely that teachers' personal epistemologies may also be reflected in their classroom behavior.

Researchers have provided different interpretations as to what generally constitutes personal epistemologies, and how these epistemologies develop in individuals. According to Yilmaz-Tuzan and Topcu [41], some researchers are of the view that personal epistemologies develop in stages similar to Piagetian cognitive development (e.g. Kegan, 1982; King and Kitchener, 2004; Perry, 1970). Two key stages in that development were identified by Yilmaz-Tuzan and Topcu [6] as:

1. Dualist: Knowledge seen as certain and authoritative.
2. Relativist: Knowledge seen as "cumulative constructions of observations but subject to judgment by different individuals" p.66).

Hofer and Pintrich [42] went further and identified the more advanced stage of evaluativistic epistemologies where knowledge is seen as individuals' construction of observations but with evaluation based on argument and empirical evidence. Yilmaz-Tuzan and Topcu [41] identified other researchers as having described personal epistemologies as a collection of beliefs (e.g. Schommer, 1988; Schommer and Walker, 1997). They adopted a multi-dimensional perspective which was explained by Yilmaz-Tuzan and Sami Topcu [41] as individuals having a multiplicity of beliefs about the certainty of knowledge, source of knowledge, justification of knowledge, acquisition of knowledge and the structure of knowledge. Using this multi-dimensional perspective, Schommer [39] hypothesized five epistemological beliefs:

1. Certain knowledge – beliefs about the stability of knowledge ranging from unchanging to tentative.
2. Simple knowledge – beliefs about the structure of knowledge ranging from isolated bits and pieces to integrated concepts.
3. Omniescent authority – beliefs about the source of knowledge ranging from omniescent authority to reason and empirical evidence.
4. Quick learning – beliefs about the speed of learning ranging from quick or not at all to gradual.
5. Innate ability – beliefs about ability to learn ranging from fixed at birth to improvable.

Both views of the development of epistemological beliefs recognize that there is a gradual continuum of which knowledge could be perceived by individuals. This continuum ranges from a view of knowledge as certain and authoritative to knowledge that is tentative, uncertain, and based on human reasoning and empirical evidence. The relevance to science teaching and learning can be clearly seen. Teachers whose epistemological beliefs are more dualist in nature, and hence, sees knowledge as certain and authoritative, may be more inclined to use the traditional, teacher-centered approaches to instruction than student-centered IBI. On the other hand, teachers with more relativist beliefs, who see knowledge as tentative and based on human reasoning and empirical evidence, may be more inclined to use IBI rather than the traditional approaches.

When the other dimensions of Schommer's hypothesized epistemological beliefs are examined, the same reasoning could be applied to show that the nature of a teacher's epistemological beliefs may be reflected in the teacher's approach to science instruction. For example, for the dimension 'simple knowledge', if a teacher sees knowledge as isolated bits and pieces, then his or her teaching strategies may be inclined towards traditional content-focused, text-book driven strategies. In contrast, a teacher who sees knowledge as integrated may utilize more student-centered strategies aimed at implementing a more cohesive and relevant science curriculum. If the assumption is made that teachers' epistemological beliefs develop as a result of their experiences in formal education, then their 'simple knowledge' beliefs may actually be inclined to a belief of knowledge as discrete isolated concepts. This is because traditional science instruction has focused on breadth of content with students being expected to learn a wide range of disconnected facts. This would partly explain their continued reliance on traditional approaches.

For the dimensions of 'quick learning' and 'innate ability', teachers who believe that students' ability to learn is fixed, may be inclined to use teacher-centered approaches, while those who believe that all students can learn, albeit at different rates, and students ability to learn can be improved, will be more inclined to use student-centered approaches. Again, many teachers' experiences being taught using traditional approaches, involved mixed ability classroom situations where the majority of students experienced much difficulty learning the science content. For elementary teachers, this, in many cases, resulted in them either failing, or dropping the pure science subjects. This may be instrumental in the development of simple 'quick learning' and 'innate ability' beliefs in these teachers.

With regards to teachers' 'omniscient authority' beliefs, experiences from both formal and informal learning experiences may be instrumental in the development of simple beliefs. This include the focus of instruction on notes, textbooks, and the teacher as the source of knowledge, as well as societal influences such as that of religious and other doctrines.

2.6.2 Teachers' beliefs about science teaching and learning

With regard to teaching, Chai, Teo and Lee [43] cited a number of researchers (e.g. Enstwistle et al., 2000; Kane, Sandretti and Heath, 2002; Samuelowicz and Bian, 2001; Teo, Chai, Hung and Lee, 2008) who classified teachers' beliefs about teaching into two broad categories:

a. Teaching as a process of knowledge transmission.
b. Teaching as facilitating students' knowledge construction.

With regards to science teaching, the first is in harmony with the traditional approaches, while the second indicates an important aspect of IBI. Elementary teachers' beliefs about science teaching would most likely have had its strongest influence first from their experiences being taught science in primary and secondary schools, and secondly from their experiences in teacher education classrooms. These two experiences may be quite contradictory for teachers since they were most likely exposed to traditional instruction in primary and secondary schools while their teacher education experiences would have focused on IBI. The actual beliefs developed would most likely depend on which of the experiences had a stronger impact on teachers' cognition. Researchers, such as Nespor [31], claim that the experiences of many years of primary and secondary school should far outweigh the two years of teacher education. Therefore, any beliefs about science teaching developed by teachers during primary and secondary school experiences may actually persist beyond teacher education. These beliefs may actually favour traditional approaches to science instruction. It can therefore be concluded that elementary teacher education should not only focus on teaching preservice teachers about the use of IBI, but should also include strategies to change unsatisfactory beliefs about science teaching.

With regards to teachers' beliefs about learning generally, and particularly the learning of science, these beliefs should tie in with epistemological beliefs which also represent beliefs about how people come to know. Of particular importance are Schommer's epistemological dimensions of 'quick learning' and 'innate ability', especially as regards to teachers' beliefs about their own students' ability to learn science. As previously indicated, teachers' experiences with learning science may lead to negative beliefs about their own students ability to learn science. Also of relevance to teachers' beliefs about the teaching and learning of science are teachers' beliefs about the subject itself. The research literature has pointed to negative attitudes to science and science teaching from a significant number of elementary school teachers (E.g. [44,45,46,47]), which may be the result of negative beliefs about science developed from teachers' experiences as science students.

2.6.3 Science teaching efficacy beliefs

It was Bandura [33] who suggested that, based on various life experiences; individuals develop general expectations about their own capabilities of performing certain tasks. He referred to this as self efficacy and defined it as "a judgment of one's capability to accomplish a given level of performance" (p.391). This judgment may be based on a number of factors, which most likely would include the type of experiences an individual had relevant to the particular task in question. For example, with regards to the teaching of science, a teacher may have developed low self efficacy because of negative experiences with the learning of science as a student.

Teacher self efficacy has also been defined in relation to teachers' belief in their own ability to positively affect students' performance. Tschannen-Moran and Woolfolk-Hoy [48] described teacher self efficacy as their beliefs about their ability to teach every student, including those who may be difficult or unmotivated.

With regards to teachers' classroom behaviours, a number of researchers indicated findings showing that the levels of self-efficacy beliefs are connected to teachers' behaviours and practices in the classroom (e.g. [49,50,51,52]). Marshall et al [51] cited Hoy and Woolfolk (1993) as well as Tschannen-Moran and Woolfolk-Hoy (2001) who found that the more efficacious teachers are, the more likely they are to successfully implement new instructional strategies as well as effectively respond to classroom challenges. These findings are important when considering the implementation of IBI by teachers. More highly efficacious teachers are therefore more likely to engage and persist in IBI.

Deemer [49] provided a more detailed analysis of how teaching efficacy can influence teachers' instructional practice. Suggesting that personal teaching efficacy influences the classroom goals of teachers, she specifically indicated that low efficacious teachers spend "little effort in finding materials and planning lessons that challenge students" (p.74). These are fundamental requirements for planning inquiry-based lessons. Deemer also indicated that these teachers do not adequately persist with the students having difficulty with the concepts being covered. She also noted that the converse was true for highly efficacious teachers.

It is likely that the period of teacher training of elementary teachers may be instrumental in either the development or alteration of their educational beliefs. It is therefore important to this discussion to consider the intended as well as the actual effects of elementary teacher education experiences on the knowledge and beliefs of teachers related to their science instructional practices.

3. ELEMENTARY TEACHERS' PEDAGOGICAL TRAINING AND THEIR EDUCATIONAL BELIEFS

Initial teacher training in many jurisdictions is normally of two year duration and trainees may specialize in primary or secondary teacher education. In the primary teacher education programme, trainees are engaged in a number of content and methods courses. The content courses focus on the core areas of the primary school curriculum i.e. language arts, mathematics, science and social studies. The methods component should ideally expose student teachers to both the student centered and reform based orientations to science teaching suggested by Magnusson, Kracjik and Borko [11] or IBI approaches. Teachers should also be exposed to instructional strategies aimed at encouraging their use of IBI.

Cook, Smagorinsky, Fry, Konopak and Moore [53] identified a lack of congruence in several instructional factors associated with schools with that associated with universities and colleges offering teacher education. They identified these factors as goals for schooling, expectations of the kinds of learning that benefit students, and the means through which students acquire and represent academic knowledge. These can all be considered to be very important and even fundamental factors in the education process that may serve to determine the way students are engaged in the teaching-learning environment. The result may actually be confusion in the minds of newly trained teachers entering the classroom, and according to Cook et al. [53], they may actually abandon the teaching strategies learnt and practiced at college and gravitate to the values of the school since it is here that their teaching competence will ultimately be judged.

These differences in instructional goals of elementary schools and teachers' colleges may result in either the development or maintenance of educational beliefs which favour the goals of elementary schools. The reason for this was identified by Lortie [17] when he pointed out that the thousands of hours teachers spend in classrooms far outweigh the effects of the relatively fewer hours spent in teacher education. Although it can be argued that this is not a fair comparison since the teacher education experience is for more mature individuals and is primarily focused on teacher training, the merit in the comparison is seen when one considers that it is based on the development of beliefs which, according to Irez [8], have strong linkages to personal, episodic and emotional experiences. Rokeach [29] had actually noted that the time spent by teachers as students in primary and secondary schools are fertile ground for the development of educational beliefs. Pre-service teachers enter teacher education with these beliefs firmly in place [6,7,18] and, according to Jones and Carter [6], these beliefs act as filters for the new ideas being learnt during the teacher education process.

One set of elementary teachers' beliefs that are developed during the years of elementary and secondary education are epistemological beliefs. Since these teachers were mainly exposed to traditional approaches to science instruction, they would most likely have entered their teacher education programmes with very naïve epistemological beliefs. Since, according to Pajares [7], these beliefs tend to be relatively stable and resistant to change, they may actually persist in teachers despite their teacher education experiences. This is especially the case since, as noted by various researchers; there are several inadequacies in the teacher education process. For example, Brouwer and Korthagen [54] discussed the fragmented view of knowledge presented in teacher education curricula. In producing their national standards, the NRC [23] had noted that the preparation of pre-service primary school teachers was inadequate both in content and pedagogy. Brouwer and Korthagen [54] also expressed the widely held view that teacher educators generally do not display the best examples of good teaching. So the persistence of naïve epistemological beliefs in in-service teachers may be reflected in a predominance of traditional approaches to science instruction.

The inadequacies of the teacher education process may also result in the maintenance of low science teaching efficacy beliefs in elementary teachers. These beliefs have their background in the limited conceptual understanding of science ideas as noted by Plourde [18], and Hechter [55]. That these low science teaching efficacy beliefs persist even after pre-service teacher education has been noted by several researchers (e.g. [2, 5, 18, 56]). Abd-el-Khalick et al [2] extended this to a lack of teachers' confidence teaching science in an effective inquiry-based manner. So the low science teaching efficacy beliefs of in-service teachers may also be reflected in their persisting with traditional approaches to science instruction. It has been suggested that teachers who lack confidence teaching science give it minimal emphasis within the curriculum [6], resulting in the implementation of poorly conceptualized and ineffective learning experiences in science [18].

With regards to pre-service elementary teachers' beliefs about science teaching and learning, the assumption can also be made that, because of unsatisfactory experiences in secondary science education, these beliefs are low. For example, as suggested by Jones and Carter [6], pre-service teachers generally view teaching as a process of knowledge transmission. However, the development of positive science teaching and learning beliefs would also depend on the quality of the teacher education experiences. Researchers have provided varied reasons why teacher education may not result in the development of positive science teaching and learning beliefs, especially with regard to inquiry-based instruction and learning. Abd-el-Khalick et al [2] actually expressed doubts whether teacher development programmes can actually develop teachers' knowledge of inquiry. Cain [37] cited Doyle (1997) who observed that many pre-service teachers clung to their prior beliefs about teaching and learning even when their field experiences supported a different view. Varma et al [56] cited literature which suggested that inquiry-based instructional strategies in science are not uniformly incorporated into elementary science methods courses across the U.S. (E.g. Barrow, 2004; Smith and Gess-Newsome, 2004) and that field experiences may not provide appropriate models for IBI (Abell, 2006).

From this discussion, it seems clear that, as was noted by Pajares [7], teacher education curricula must take into consideration the entering beliefs of pre-service teachers. However, even if a teacher education programme is successful at developing more positive beliefs in elementary teachers there are contextual factors related to the school environment that may threaten the stability of that change.

4. SCHOOL CONTEXTUAL FACTORS AND ELEMENTARY TEACHERS' BELIEFS

Elementary teachers' PCK should represent a blend of their science content knowledge and general pedagogical knowledge within the unique contexts of their school and classroom situation. The development of these teachers' PCK may therefore be problematic because of their inadequate conceptual understandings of science and also, as pointed out by Fang [28], because these "contextual factors can have powerful influences on teachers' beliefs, and, in effect, affect their school practice" (p.53). The common conception that teachers do not use the IBI practiced at teachers' colleges, may be due to the influence of these contextual factors. Based on their years of experience, teachers may actually develop what the authors of this paper refer to as applicability beliefs with reference to IBI. These are teachers' beliefs of the applicability of IBI in their particular school's social, psychological and environmental contexts.

The conflict that is described by various researchers between teachers' beliefs and their practices (e.g. [6]) may actually be the result of intervening applicability beliefs developed due to contextual factors impacting their implementation of the science curriculum. In many cases, the beliefs measured by researchers are epistemological beliefs and beliefs about science teaching and learning that were developed prior to and as part of in-service experiences. Fang [28] referred to these beliefs as "situational and transferred into instructional practices only in relation to the complexities of the classroom" (p.55). Applicability beliefs, on the other hand, are directly related to teachers' experiences as classroom teachers and hence, may be more directly reflected in the classroom actions of teachers.

The social, psychological and environmental factors in schools that can be influential in the development of applicability beliefs to IBI are wide and varied. However, researchers have pointed to a number of key factors that are repeatedly raised by teachers when commenting on their implementation of the science curriculum. An important group of factors raised by a number of researchers are those related to the particular socio-cultural contexts of schools and their impact on beginning teachers. Brouwer and Korthagen [54] referred to this as the occupational socialization of teachers, and cited the view of Wideen et al. (1998) that beginning teachers may view their more experienced colleagues as more 'realistic role models' than their pre-service lecturers. They therefore tend to conform to the instructional practices of these colleagues, one of which may be the reliance on traditional approaches to science instruction. Cook et al [53] also commented on the social environment of schools, indicating that it promotes an ethic geared towards content coverage and control.

Other socio-cultural and psycho-social factors cited in the literature are:

- Attitudes of school administrators and colleagues which can "support or diminish the effectiveness of beginning teachers by influencing beliefs about themselves and their students" (Kilgore, Ross and Zbikowski; cited in [28], p.54).
- The adoption of particular instructional practices which are perceived by teachers to suit the particular characteristics of their students [5,15].

There are a number of factors related to the management of the school curriculum that may impact on the development of teachers' applicability beliefs. One that has been raised by a number of researchers (e.g. [2,5,6,18]) is an insufficient amount of time to effectively implement the science curriculum. This would directly impact on the development of applicability beliefs related to IBI since more time is needed for the implementation of IBI strategies than traditional ones. If the science curriculum is viewed as extensive, these teachers may deem traditional approaches more suitable for instruction than IBI.

Teachers' focus on preparing students for examinations may indeed be counter-productive to student learning and lead to an emphasis on traditional approaches to instruction. This is especially the case for national standardized examinations, e.g. Minimum Standards and Common Entrance and Secondary Certificate Examinations, where results may be inappropriately used for the assessment of schools and teachers. Teachers may be excessively concerned with content coverage, and hence, more likely gravitate to traditional approaches to instruction. Other factors include the greater requirement of materials and equipment for teachers implementing IBI. These may be difficult to obtain and so may deter teachers from using IBI [2,5,6,8,18]. Also, very often teachers have to use their own finances to purchase the required materials. This may be perceived by teachers as a lack of institutional support for IBI [51] and may also result in the development of negative applicability beliefs.

It is therefore the researchers' contention that teachers face a variety of contextual factors in their day to day teaching activities, which may result in the development of applicability beliefs related to a number of expectations regarding their classroom instruction. For science teaching, one such expectation is the requirement for IBI. These applicability beliefs may be strong enough to be a greater determinant of the actual teaching practices of teachers when compared to, longer established, epistemological beliefs and beliefs about teaching and learning.

5. CONCLUSIONS AND RECOMMENDATION

The nature of all the belief constructs discussed suggests the distinct possibility that teachers, to varying extents, may develop these beliefs as a result of their experiences in both formal and informal learning environments. It also suggests that these beliefs can be influential in determining the level of inquiry-based practices of teachers. It is therefore not only important to understand the nature and development of these beliefs, but also how teacher education and school authorities should deal with negative beliefs of teachers by the use of interventions for facilitating belief change.

Naive epistemological beliefs are probably the ones that would be most difficult to change because according to Pajares [7] they tend to be relatively stable. This resistance to change is most likely due to the nature of these beliefs and how they develop in individuals. Beliefs about knowledge and learning develop gradually as a result of both formal and informal learning experiences. So for example, dualist epistemological beliefs that knowledge comes from authoritative sources and is stable and unchanging may be the result of a variety of educational experiences where individuals are simply required to accept the information given from authoritative sources like teachers, parents, pastors, books, and also, as indicated by NRC [16], a lack of coherence in the k-12 science curriculum where students are expected to learn a large number of disconnected facts. Unfortunately, this is the normal way children are educated up to and including their adult life. For those who become teachers, the research literature has shown that developed naïve epistemological beliefs are reflected in the traditional content focused instructional strategies rather than inquiry based strategies.

The movement towards the development of more sophisticated epistemological beliefs in k-12 educational institutions requires a rethinking of the education process that would allow teachers to move away from the content-focused instructional practices. The idea of schools focusing on breadth rather than depth of content is not new. However this seems to have so far not gained attention from curriculum developers in many countries who continue to cram large amounts of disconnected facts into science curricula and expect students to regurgitate them in examinations. Thus teachers are constantly under pressure to cover curricula and hence resort to the traditional approaches to instruction which would most likely lead to the development of naïve epistemological beliefs. What is required instead is the in-depth coverage of a few core areas in science instruction, where students are made to see the links between concepts in science, between science and other subject areas, and between science and their everyday experiences. This can be achieve by restructuring of science curricula, inquiry-based approaches to instruction, and teachers trained to integrate the curricula of different subject areas.

With regards to teacher education, Pajares [7] pointed to a way these beliefs could be changed in preservice teachers when he cited the view of Posner, Strike, Hewson and Gertzog (1982) that their conceptual change model and Piaget's assimilation and accommodation theory can be used to explain the resiliency of epistemological beliefs. Pajares [7] reasoned that when individuals hold deep and strong epistemological beliefs, any new information contrary to these beliefs will more likely be assimilated but not accommodated. There must first be dissatisfaction with the existing belief, and then the new belief must be "intelligible and appear plausible" (p. 320) before accommodation takes place. So conceptual change strategies could be used in teacher education curricula where student teachers are provided experiences where they are dissatisfied with their existing beliefs, and the new beliefs are made to seem intelligible and plausible. The study by Kienhues et al [57] actually found that the naïve epistemological beliefs of a group of university students changed to more sophisticated beliefs using teaching strategies based on the principles of conceptual change. Deniz [58] did a similar study but with teachers as the target group, and found similar results.

Levitt [20] attributed teachers' beliefs about science teaching and learning to accumulated images of an individual's experiences with learning science in the formal school system. Teachers' experiences learning under traditional modes of instruction are most likely influential in the development of negative beliefs about science as well as the teaching and learning of science. For many elementary school teachers, these experiences also resulted in unsatisfactory levels of science content knowledge and poor attitudes to science. Since elementary science education should set the foundation for students' appreciation and understanding of science, it is imperative that appropriate strategies be implemented to change this situation. These are the same strategies that were outlined for the improvement of teachers' and students' epistemological beliefs.

The applicability belief construct was conceptualized by the authors as a possible explanation of the findings of a number of researchers that teachers were claiming various psychological, environmental and socio-cultural hindrances to their use of IBI. These beliefs about school based hindrances to IBI are important in that they may actually be intervening variables that act against teachers' implementing IBI despite the possibility that the other educational beliefs may actually facilitate IBI. Engendering positive applicability beliefs would however require widespread interventions to the management of school curricula including increased social and financial support for teachers, alteration to timetables, integration of subject curricula, and a rethinking about the purposes of examinations.

In attempting to tackle elementary teachers' low science teaching efficacy beliefs it is first important to identify the reasons for these beliefs being low for so many primary school teachers even after they have completed their teacher training. For a substantial number of these teachers, their experiences of secondary school science did not encourage the development of positive attitudes to the subject. This is most likely a key issue in the development of low science teaching efficacy beliefs. The strategies outlined earlier for the improvement in epistemological and science teaching beliefs are also applicable to improving the science teaching efficacy beliefs of teachers. However this is a long term solution. In the short term, the focus must be on teacher education, especially how the teacher education science curriculum and its implementation could be adjusted to cater for the low science teaching efficacy beliefs of students entering the programme, and turn out trained teachers with significantly improved beliefs.

To change preservice science teaching efficacy beliefs, Plourde [18] made a suggestion also utilizing similar principles to that of conceptual change models. He recommended that students be engaged in experiences in which they would be encouraged to first become aware of, and then confront their existing beliefs about their ability to teach science. Other strategies suggested by researchers ranged from effective integration of science content and pedagogy, to the use of IBI by teacher educators. Hechter [55] cited a number of studies in which the integration of science content and methods in single courses were showed to result in improved teachers' science teaching efficacy (e.g. Appleton, 1995; Cantrell et al, 2003; Palmer, 2006). Liang and Richardson [59] looked instead at the effects of IBI on teacher candidates' science teaching efficacy. They found that scaffolded inquiry techniques (where written instructional supports are provided to students during student-initiated inquiry) resulted in improved personal science teaching efficacy of teachers.

As this discussion has indicated, teachers' educational beliefs are indeed quite possibly an important factor in their science instructional decisions. However, despite being deeply held and resilient, school based interventions as well as changes to teacher education curricula could be implemented to change the beliefs that result in the implementation of unsatisfactory content focused instructional approaches. There are promising developments in the U.S. where what is referred to as 'The Next Generation Science Standards' is in the process of being developed by collaboration between the NRC, the American Association for the Advancement of Science (AAAS) and Achieve. These standards are in the final stages of public consultation and articulate the need for integrating science, technology and engineering concepts in k-12 instruction. It is indicated that these curricula should focus on a smaller number of' cross-cutting' concepts, have a greater coherence in the science concepts done across grade levels, and utilize constructivist and inquiry-based strategies in the implementation of curricula [60]. If initiatives such as these are properly implemented in k-12 education, it should be instrumental in the development of positive beliefs in the next generation of elementary science teachers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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