JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

EXPLORING IN-SERVICE SCIENCE TEACHERS' BELIEFS ABOUT GOALS OR PURPOSES OF SCIENCE TEACHING

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Abstract. *Research indicates that teachers' beliefs about goals or purposes of science teaching, as one dimension of science teaching orientations, influence what happens in the classroom. The purpose of this research was to explore the self-reported and enacted goals or purposes of science teaching of four in-service Malawian science teachers using the curriculum emphases concept as a theoretical lens. This research used qualitative case study research design. Semi-structured interviews and classroom observations were used to explore teachers' self-reported and enacted goals or purpose of science teaching, respectively. A deductive analysis approach was used to analyze interview and classroom observation transcripts, to understand the teacher's goals or purposes. Results reveal that while teachers have multiple self-reported goals or purpose of science teaching, most of these are not enacted during teaching in the classrooms. This suggests the topic-specific nature of the goals or purposes. Results also show that all the teachers were not aware of the self-as-explainer goal or purpose of science teaching both during interviews and instruction. These findings are discussed, and implications are proposed for science in-service teacher professional development and pre-service teachers' training programs.*

Keywords: *science teachers' beliefs, curriculum emphasis, goals or purposes, science teaching orientations, teacher professional knowledge*

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Introduction

The performance of Malawian secondary school learners is poor at national-level assessments. This is especially true for science-related subjects as the chief examiners' reports for science highlight. Even though there is an improvement in the overall pass rate for learners at this level over the years (from 48% in 2006 to 60% in 2016), the situation remains worrisome since learners' performance in science remains poor. The chief examiners' reports for science have advanced several reasons. In the reports, they highlight issues such as *students' failure to apply the concepts they learn in class, students' failure to appreciate what science is, how it is conducted, poor foundation in as far as the use of other scientific skills is concerned and poor scientific skills that are displayed by the learners* during assessment (Malawi National Examinations Board, 2013, 2014, 2015). This is rather a depressing issue as it is happening when one of the objectives of science teaching at this level is to inculcate various skills that are instrumental in the learning of science such as reasoning, problem-solving and instrument manipulation skills (Ministry of Education, Science and Technology, 2013). A closer look at these highlighted factors speaks directly to the curriculum emphasis categories, developed by Roberts (2015), which in this research have been called goals or purposes of science teaching. There have been efforts by both the ministry of education and non-governmental organization to curb the issue of poor performance by learners in science. For instance, the Malawi Ministry of Education Science and Technology (MoEST), in conjunction with the Japanese International Cooperation Agency (JICA), launched a Strengthening of Mathematics and Science in Secondary Education (SMASSE) project in 2004. This Professional Development (PD) program was aimed at equipping teachers with novel techniques of effective science teaching as well as enhancing the development of their beliefs and Pedagogical Content Knowledge (PCK) (World Bank, 2010). Despite these reform efforts, Nampota (2016) noted that teaching science remains poor and that student performance in science remains largely unimpressive. The chief examiners' still highlight the same factors that lead to poor student performance in sciences. It is for this reason that the research explores the goals or purposes that Malawian science teachers set out when they are teaching science to their learners. Teachers' "goals or purposes of science teaching" are beliefs that describe the teachers' "conceptions about the function of science education in general" (Friedrichsen et al., 2011, p. 371).

https://doi.org/10.33225/jbse/21.20.456

Theoretical Framework

The curriculum emphasis concept guided this research as a theoretical framework. This was developed as a way for "understanding and distinguishing among broadly different educational objectives that have characterized school science programs in recent history" (Roberts, 2015, p. 264). The underlying assumption in this concept is that the teaching of science subjects at any school level has fundamental reasons as to why the subject is offered at that level. By examining science textbooks, "high-profile classroom materials" as well as "curriculum policy statements from North America and England" from the 1900s, Roberts identified that these documents contained groups of information that suggested the objectives why a topic is taught to the learners. He called these groups of information "curriculum emphases." For example, some curricular documents emphasize on students retaining manipulative skills. In his 1982 paper, the author defined the concept of curriculum emphasis as follows:

> "A curriculum emphasis in science education is a coherent set of messages to the student about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself- objectives which provide answers to the student question: "Why am I learning this?" The answer to that question differs significantly for the Burns text and the PSSC text just noted" (Roberts, 1982, p. 245)

From the author's perspective, the primary purpose of teaching science is not only limited to the teaching of science content that appears in various science textbooks but that there also exist several purposes for teaching science to students at a particular level. These reasons are either stated explicitly or implicitly by curriculum designers. According to Roberts (1982), the notion of curriculum emphasis is critical in both teaching and learning of science as well as the development of the curriculum. To the teaching and learning of science, it helps to respond to the frequently asked question by students; "why we are learning this subject?" On the other hand, to curriculum developers, it helps them to answer the question; "why offering this content to learners." From his analysis of the said documents, he identified seven curriculum emphases described in Table 1. As noted by Van Driel et al. (2008) the seven curriculum emphases characterize orientations to teaching. In this research, the notion of curriculum emphases was used to map the teachers' goals or purposes of science teaching.

Table 1
Curriculum Emphases Described by Roberts (1982)

No	Curriculum emphasis	Description
1.	Everyday Coping (Everyday Application)	Concerns the teaching of science so that students understand or appreciate the importance of science in everyday life.
2.	Structure of Science	This concerns the teaching of science to students in such a way that students understand and appreciate the basic nature of science e.g., what constitutes scientific knowledge, how scientific knowledge is generated etc.
3.	Science, Technology, and Decisions (STS; Science, Technology, and Society)	This concerns the teaching and learning of science to demonstrate how science relates to other fields such as technology as well as decision making.
4.	Scientific Skill Development	This concerns teaching science to students so that they develop sound scientific skills such as problem- solving or these skills are critical in scientific knowledge generation.
5.	Correct Explanation	This concerns the teaching of science so that students can explain phenomena in their environment.
6.	Solid Foundation	This concerns the teaching and learning of science as a preparatory tool for other related science courses at a higher level such as university hence teaching students science at this certain level prepares them to understand science at a higher level.
7.	Self as explainer	This concerns what the self-conveys in science learning that includes aspects such as cultural values when generating scientific knowledge

https://doi.org/10.33225/jbse/21.20.456

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

According to Roberts, the emphases described in Table 1 are choices that are influenced by "societal forces and concerns at different times in history" (Roberts, 2015, p. 264). This strongly suggests that curriculum emphases might be different from one society to the other. Considering the dynamic nature of society, they might change from time to time. In his review, he reports that some emphases that used to be more pronounced in the 1980s no longer retain the same status in the present day. For instance, *Science, Technology, Decisions* emphasis, which initially used to be more dominant and had several instances from the curricular documents no longer retain the same status (Roberts, 2015). This also brings to light the idea which Roberts also highlighted in his original publication – that the seven proposed categories are not exhaustive of the curriculum emphases that do exist. Since these curriculum emphases are either explicit or implicit, it is up to the teacher to interpret the intentions of the curriculum framers and implement the same. These interpretations might be different from teacher to teacher.

Roberts (1982) argued that the curriculum emphasis concept should be taken as "an analytical framework for understanding what is involved for policymakers, and science teachers when they shape their answers to the question: 'What counts as science education?'" (Roberts, 1988, p. 27). Against this background, several projects were conceptualized around this analytical framework. For instance, van Driel et al. (2008) reported on the curriculum emphasis of chemistry teachers in the Netherlands. Demirdöğen (2016) used the curriculum emphasis concept to analyze the teachers' "goals or purposes of science teaching" when she examined the interaction between STOs and PCK components. Hansson et al. (2021) also used the curriculum emphasis framework to research secondary science teachers' views about physics teaching. It is for this reason that this research also adopted the curriculum emphasis concept as a theoretical setting and analytical tool to underpin it. However, instead of calling them curriculum emphases, the research preferred to call them "goals or purposes of science teaching" to align with the focus of this research.

Research Aim and Research Questions

This research aimed at exploring the specific goals or purposes the science teachers do manifest when they are talking about science or teaching science. The following research questions guided this research:

1. What beliefs about goals or purposes of science teaching (if any) do the science teachers have?
2. Which of the self-reported goals or purposes of science teaching are enacted during teaching by the science teachers?

Research Methodology

Research Design

Science teachers' beliefs and classroom practices have always been researched qualitatively. This research also utilized a qualitative research design stemming from the interpretivist paradigm (Creswell, 2012) and used a case study design (Hancock, 2006) to allow for exploration and analysis of science teachers' beliefs about goals or purposes of teaching science. Data collection ran for the whole of the third term of the 2019 academic year (from September 2019 to December 2019).

Participants

Four Physical Sciences teachers were purposively sampled to take part in this research. These teachers were sampled because they had been teaching Physical Sciences at least for the past 5 years hence they had considerable experience in teaching sciences at this level. The other reason for selecting the teachers was that they had physics or chemistry as one of their majors in their teaching qualification. The assumption was that this would resemble a good understanding of the teaching and learning process. Table 2 illustrates the profile of the teachers and their contexts.

https://doi.org/10.33225/jbse/21.20.456

Table 2
Profile of the Participants

Participant	Code	Gender	Experience (years)	Grade (form)	Majors	**Qualification**	Subject
Teacher 1	T1	M	6	1	PHY/MAT	Diploma	PHY
Teacher 2	T2	M	12	2	CHE/BIO	Degree	CHE
Teacher 3	T3	M	6	4	PHY/CHE	Degree	PHY
Teacher 4	T4	M	10	3	PHY/MAT	Diploma	CHE

Key: PHY—Physics, CHE—Chemistry, BIO—Biology, MAT—Mathematics, Sch—school
As can be seen in Table 2, all teachers are trained to teach physics and/or chemistry.

These teachers were selected from three different secondary schools (see Table 3) within Zomba urban education district. Two of these schools were Conventional Secondary Schools (CSS), and one was a Community Day Secondary School (CDSS). The difference between CSS and CDSS schools in Malawi is that CSSs are better resourced than CDSSs in terms of teaching resources and infrastructure for learning, such as laboratories. For instance, the two CSSs had laboratories with running water and power sockets and well-stocked libraries as shown in Table 3.

Table 3
Description of the Schools from which the Teachers were Sampled

School	Secondary school type	Description	Duration of a single lesson
School 1	Conventional Secondary School (CSS)	• Has laboratories • Has boarding facilities	40 minutes
School 2	Community Day Secondary School (CDSS)	• No labs • No boarding facilities • Double shift school (schools that have a different set of pupils in the mornings and afternoons) • Students commute from home	30 minutes
School 3	Conventional Secondary School (CSS)	• Has laboratories • No boarding facilities • Double shift school • Students commute from home	30 minutes

Instruments

Interviews

Semi-structured interviews were used to gather data (Cohen et al, 2007). Using an interview schedule that was adapted from Demirdöğen (2016), interviews were conducted with each of the four teachers that took part in this research. The interview schedule was piloted with three science teachers who did not form part of the sample to test its reliability in this context. The piloting exercise allowed us to rephrase some of the unclear phrases. At first, questions were asked as presented in the adopted interview schedule. However, it was realized that it was imperative to provide more information about the questions to the teachers so that they understand the questions. This led to the production of a valid instrument for use in the research (Cohen et al., 2007). The interview schedule had seven questions that interrogate the teachers' beliefs about their goals or purposes while they teach science to

https://doi.org/10.33225/jbse/21.20.456

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

their learners. These interviews were conducted individually at the teachers' appropriate time and place and they all lasted between 60 minutes to 80 minutes. Teachers were asked to articulate issues such as their purposes when they teach science, the things that their students should know when they learn science, the kind of knowledge and capabilities students should learn when they learn science etc.

Classroom observations

To examine evidence of the goals or purposes of science teaching during the actual teaching, classroom observations were conducted. The four teachers were asked to be observed on a topic of their choice during the data collection phase. Each teacher was observed two times to get an overview of which of their beliefs (as self-reported) about the "goals or purposes of science teaching" are displayed in their classrooms during teaching. Table 4 below shows the observed lessons per teacher.

Table 4
Summary of Lessons Observed for all the Teachers

Teacher and school	Lesson topic and duration
Teacher 1 (School 1)	1. Energy (40 minutes) 2. Electric current (80 minutes)
Teacher 2 (School 3)	1. Specific heat capacity (30 minutes) 2. Machines (60 minutes)
Teacher 3 (School 3)	1. Magnetism (60 minutes) 2. Electricity, magnetism and electric induction (60 Minutes
Teacher 4 (School 2)	1. Electricity—electrical energy and power (30 minutes) 2. Electricity—electromagnetic induction (60 minutes)

As can be seen in Table 4, the four teachers were teaching different topics during the observation period. The duration of each observed lesson depended on the school's timetable structure (see Table 3). To capture the teachers' voices and actions for analysis of the episodes that demonstrate teachers' goals or purpose of science teaching during instruction, the lesson observations were video-recorded.

Data Analysis

Audio-recorded interviews, as well as classroom observations, were transcribed verbatim for analysis. Using deductive data analysis approach (Patton, 2002), the two authors first discussed the analytical framework (*components of curriculum emphasis*) to have a common understanding. They then coded the first interview transcript separately using the pre-determined themes developed by Roberts (1982, 1988, 2015) then came together to discuss the assigned codes in transcripts. There were some differences which they had to discuss and iron out. Thereafter, they coded the second transcript from classroom observations to familiarize and acquaint with the coding process discussed and agreed upon and compared the coding again and there was a 90% agreement. In the observation transcript, the interest was on the evidence from teachers' talk or episodes during teaching that aligns with the descriptions of curriculum emphases by Roberts (1982). After the coding of the second transcript, the first author then coded the rest of the transcripts (both from the interviews and the observations). Each transcript was assessed for evidence for any of the seven curriculum emphases—referred to as "goals or purposes of science teaching" in this research. Responses were given a number from 1-7 representing the seven goals or purposes of science teaching. The number of instances where each teacher showed evidence of each of the seven categories of goals or purposes in both the interview and observation transcripts were counted.

https://doi.org/10.33225/jbse/21.20.456

Research Results

The results for each teacher in terms of the goals or purposes of science teaching they self-reported and displayed during teaching are presented below.

Teacher 1

Table 5 below illustrates the number of instances Teacher 1 referred to each of the seven categories of goals or purposes of science teaching during the interviews (self-reported) and how frequent the self-reported goals or purposes of science teaching manifested during teaching.

Table 5
Summary of Teacher 1's Self-reported and "enacted" Goals or Purposes about Science Teaching

No.	Category of goals or purposes to science teaching	Frequency as self-reported	Frequency of "episodes" during teaching
1.	Everyday coping	2	2
2.	Structure of Science	1	1
3.	Science, Technology, and Decisions (STS; Science, Technology, and Society)	1	0
4.	Scientific skill development	1	0
5.	Correct explanation	1	0
6.	Solid foundation	1	3
7.	Self as explainer	0	0

As can be seen in Table 5, Teacher 1 revealed awareness of almost all the categories of the goals or purposes to science during interviews except for self as explainer. For instance, in terms of everyday coping, the teacher held a view that the purpose of science teaching was to help students get familiar with everyday occurrences by stating "*you want to instil skills to the students so that these students when they acquire these skills, knowledge, they utilize it in their everyday life*." He believed that once students learn and master the various skills in science, they will be able to live and cope with what the environment demands of them. Furthermore, concerning solid foundation goal, the teacher also held the view that science teaching should prepare students for science courses that they are going to do at a later stage as he states:

> We talk about different courses in colleges, whereby these courses also require the Physics/Chemistry which we are talking about. It's like we are teaching science so that we prepare these students so that they achieve their goals, they achieve their dreams and also instilling the pre-requisite knowledge there which is going to be used at a later stage after they finish secondary school.

In contrast, most of Teacher 1's self-reported goals or purposes did not manifest during his teaching. As seen in Table 5, only three of the categories (i.e., *everyday coping, structure of science, and solid foundation* goals or purposes manifested at least once). The manifestation of everyday coping was in such a way that the teacher tended to ask questions that required the students to link what they have learnt to everyday life. For instance, when he was teaching about electric current, towards the end of the lesson, he asked the students to explain how electric current relates to their everyday life. *Additionally*, when he was teaching about energy—specifically renewable sources of energy, he tended to ask students to relate each source of energy to everyday life. Concerning solid foundation, the teacher used a variety of techniques to ensure that students understand the concepts. For instance, he varied the pace of his lessons—to cater for slow learners and repeat what he had just said or use sometimes vernacular language—to cater for students who had language deficiencies. He claimed that the use of these techniques helped to take into consideration the weaknesses of a particular technique hence ensure that every student understands what he was saying.

https://doi.org/10.33225/jbse/21.20.456

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Teacher 2

Table 6 summarises the frequency where goals or purposes of science teaching for both reported and enacted were coded for Teacher 2.

Table 6
Summary of Teacher 2 Self-reported and "enacted" Goals or Purposes about Science Teaching

No.	Category of goals or purposes to science teaching	Frequency as self-reported	Frequency of "episodes" during teaching
1.	Everyday coping	1	5
2.	Structure of Science	0	0
3.	Science, Technology, and Decisions (STS; Science, Technology, and Society)	1	0
4.	Scientific skill development	1	1
5.	Correct explanation	1	2
6.	Solid foundation	0	3
7.	Self as explainer	0	0

Except for self as explainer, the teacher seemed to be aware of almost all the goals or purposes of science teaching as shown in Table 6. The teacher claimed that the teaching of science should be conducted in such a way that *"…students master the basic concepts in science, such as theories, laws, etc."*. What is coming out from this utterance is that by learning about the various theories, laws, facts and principles, students will understand how things work and be able to explain phenomena. As a result, students will achieve the correct explanation goal of science teaching. To ensure that students achieve both correct explanation and solid foundation, the teacher said that there is a "*need to vary instruction process so to ensure that they cater for the deficiencies of a particular strategy*."

During teaching, some of the goals manifested themselves more than they were said in the interviews as shown in summarising the frequency where goals or purposes of science teaching for both reported and enacted were coded for Teacher 2. For this teacher, the entire teaching process appeared to be driven by *everyday coping* goal or purposes of science teaching as several episodes were illuminating this belief. For instance, to achieve this everyday coping goal or purposes, the teacher tended to pull examples that students were familiar with as shown in the extract below:

1	-	Teacher	:	So, let's look at the types of simple machines. So, the first category is force multipliers […] This machine has the duty of multiplying this small load to become a significant force […] lift this massive load. For example, a **car jack** […]
2	-	Teacher	:	Can somebody try to describe how a car jack works?
3	-	Student	:	A car jack works by winding [*he demonstrates what he means by winding*] – so there it multiplies the force.
4	-	Teacher	:	Now you will see that you will use only one hand – just only one hand whether he is winding or trying to put it up or down. But what comes out of this using just one hand, you will see a car being lifted. So, you see that is why we say this car jack is multiplying the force that you are applying.
5	-	Student	:	Listen
6	-	Teacher	:	[*having discussed the previous examples at length, the teacher moved to a second example*] … Let's go to the second category – distance multipliers. As the name suggests, there is a movement or some kind of movement … for a movement within a small distance moves through a large distance. Do you understand why it is called a distance multiplier?

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7	-	Students	:	Yes
8	-	Teacher	:	What do you think can be a good example of a distance multiplier?
9	-	Student	:	Oxcart
10	-	Teacher	:	Not really. But a good example is the bicycle axle.

In turn 1, the teacher is illustrating that a car jack is a good example of simple machines that belong to the category of simple machines. He used examples of bicycles just outside the classroom. Since this was CDSS (see Table 3), most learners commute from their homes to school using bicycles which may have prompted the teacher to mention this example. This signifies the critical role of context in the teaching and learning of science.

Teacher 3

Table 7 summarises the frequency where goals or purposes of science teaching for both reported and enacted were coded for Teacher 3.

Table 7
Summary of Teacher 3 Self-reported and "enacted" Goals or Purposes about Science Teaching

No.	Category of goals or purposes to science teaching	Frequency as self-reported	Frequency of "episodes" during teaching
1.	Everyday coping	3	0
2.	Structure of Science	1	0
3.	Science, Technology, and Decisions (STS; Science, Technology, and Society)	4	0
4.	Scientific skill development	1	3
5.	Correct explanation	1	2
6.	Solid foundation	0	2
7.	Self as explainer	0	0

Just like the two other teachers reported above, Teacher 3 also demonstrated to have multiple goal or purposes of science teaching during interviews of which some were manifested during teaching. Concerning science, technology, decisions, goal or purposes of science teaching, his narration suggested that he teaches science so that students utilize the science knowledge to solve various problems affecting their lives. He expressed how satisfied he becomes whenever students utilize scientific knowledge to develop products that could be used to solve various problems as shown below:

> I become thrilled when learners come back, 'sir, you taught us this, now we have used this idea to produce this item'. I become pleased, and I follow those, those productions from the learners … they have done some materials which are in the lab, the materials [things] which I could not think that they can produce, but they produce the materials just because, to me, it was like feedback, to say 'ok you taught us this now we have produced this. So, to me, that's ok and for a learner to say 'ok I have produced this thing from the knowledge I had, to me, what it applies is that, ok, it means this learner understood what I taught yea and then can apply because to reach an application-level, it means that you have theoretically understood the concept

Furthermore, the teacher's sentiments suggested that he teaches science to the students to enhance their understanding of the nature of science or structure of science in the process:

https://doi.org/10.33225/jbse/21.20.456

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

> …the other thing is that, aaa the little part I can assist the learners to learn the discipline of science, they may help them to live or to sustain, they may help to themselves to sustain in the communities.

While the teacher talked more concerning *science, technology, decisions,* goal or purposes of science teaching (see Table 7), he did not show any evidence of this goal or purposes during teaching. On the contrary, the teacher focused on achieving goals such as scientific skills development and solid foundation goal or purposes. For instance, to ensure that students develop scientific skills (*measurement, observation recording and calculations*), the teacher planned to use practical work where students would determine the behaviour of resistance in both series and parallel circuits as shown in the extract below:

1	-	Teacher	:	Now I want you to divide yourselves into two groups. I want you to have the two kinds of circuits…series and parallel as shown on the board
2	-	Student	:	Students listen to the instructions of the teacher
3	-	Teacher	:	So, in series circuit what you are going to have is the cells arranged like this [*he points to the board*], You can use maybe two cells and then from the two cells you will have two resistors—two resistors like this [*he points to the board again*] and then you will also have an ammeter here and then a voltmeter here. So, this one is voltmeter 1 on resistor 1 and then on resistor 2, you will have voltmeter 2.
4	-	Student	:	Students listen to the instructions of the teacher
5	-	Teacher	:	What is the behaviour of current in a series circuit? [*teacher asks a question for the students to recall the previous knowledge*]
6	-	Students	:	Current is the same at any point in the series circuit.
7	-	Teacher	:	Therefore, construct a circuit as shown on the board [he points at a circuit on the board] take the necessary measurements and record the findings
8	-	Student	:	In their groups, students construct the circuits, take measurements of current and then record their findings
9	-	Teacher	:	Once you have recorded your findings, determine V1 and V2 [he explain this as he points at a circuit diagram on the board]
10	-	Student	:	Students determine the values of both V1 and V2 from their recordings
11	-	Teacher	:	…so, for part two instead of having these voltmeters, you are going to have one voltmeter across all the two resistors.
12	-	Student	:	Students listen to further instructions from the teacher
13	-	Teacher	:	Now let's have representatives from each group—from group 1 and group 2 give us the values; can I have the values for the first part in the series circuit what do we have. You can come here and write.
14	-	Student	:	Representatives from each group present their findings
15	-	Teacher		Now, what about resistance—resistance for R1 and resistance for R2? And what can you about the behaviour of resistance in both types of circuits? [*Teacher further asks probing questions for students to interrogate their results*]
16	-	Student	:	Students present the **calculated** values of R1 and R2

https://doi.org/10.33225/jbse/21.20.456

In the above extract, we see how the teacher strived to achieve critical scientific skills. In turns 1 and 3, the teacher told the learners the aim of the lesson which was about the behaviour of resistance in both types of circuit. Specifically, the teacher wanted the students to learn about total resistance for both series and parallel. Such kind activities, the teacher believes, enhanced students' development of scientific skills such as interaction with the materials, recording as well as measurements (turn 8) and calculation (turn 16). Similarly, towards the end, students were asked to present their findings. It is believed that this gave the students a chance to hone their presentation skills. All these are scientific skills that students need to learn as they learn science.

Teacher 4

Table 8 summarises the frequency where goal or purposes of science teaching for both reported and enacted were coded for Teacher 4.

Table 8
Summary of Teacher 4 Self-reported and "enacted" Goals or Purposes about Science Teaching

No	Category of goals or purposes to science teaching	Frequency as self-reported	Frequency of "episodes" during teaching
1.	Everyday coping	3	0
2.	Structure of Science	0	0
3.	Science, Technology, and Decisions (STS; Science, Technology, and Society)	2	0
4.	Scientific skill development	3	0
5.	Correct explanation	0	3
6.	Solid foundation	2	4
7.	Self as explainer	0	0

Just like the other three teachers, Teacher 4 was aware of almost all the goals or purposes of science teaching except for self as explainer goal. For instance, during interviews, he narrated that teaching and learning science helps learners to understand their surroundings. He explained the applicability of scientific knowledge to everyday life by citing simple everyday life phenomena that can be explained using scientific knowledge, as shown in the quote below:

> … For example, at home, there is the application of science, it's when they are cooking, there is a lot of science there. Yeah so, even as an individual, walking you know from one place to the other, there is a lot of application of science. And the commodities that being produced nowadays, there is a lot of science in there. Yeah, so we cannot run away from that. Yeah, those are just a few examples

This extract provides evidence of the teachers' orientations regarding *everyday coping* goal or purpose of science teaching. The teacher's comment suggests that science teaching is connected to our everyday lives, hence the teacher considers that science teaching is not an isolated aspect divorced from everyday life, but something that directly relates to and is applicable in explaining aspects about people's surroundings. He also went further to explain that the teaching and learning of science help "*our students to grow in science because wherever they go, they will apply that science…*". This suggests a solid foundation goal of science. Once students have a solid foundation, they will be able to use that knowledge when learning science courses in higher education.

Some of the goals of science the teacher elucidated during interviews manifested in the classroom during teaching. For instance, while teaching about chemical reactions, and despite being the least talked about the goal or purposes of science teaching, solid foundation goal manifested itself. The teacher used POE teaching strategy to ensure that students understand the concepts he was teaching. Predict Observe Explain (POE) is an active teaching strategy that was developed by Gunstone and White (1992). This strategy accords students a chance to observe and

https://doi.org/10.33225/jbse/21.20.456

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

then explain what they are observing or make a prediction and then explain their reasoning. Using this strategy, the teacher asked the students to predict what would happen to the mass (of both reactants and products) during a chemical reaction and to further support their guess with a scientific explanation as shown below:

1	-	Teacher	:	If the reactants form a new product like this one [*points at a chemical equation on the board*] … do we expect the mass of the reactants to be different from those of the products?
2	-	Students	:	Yes [*Students responded*]
3	-	Teacher	:	A chemical reaction is the rearrangement of atoms to form a new substance. Here we have reactants and, of course, products. Now, if a new substance is formed, is the mass of reactants different from the mass of products? [*teacher tries to rephrase the question so that students understand it*]
4	-	Student	:	Yes, it is different? [*one student responds*]
5	-	Teacher	:	Who else? Are they different? Why do you think the mass of reactants will be different from the mass of the products?
6	-	Student	:	Yes. Because they have rearranged themselves to form a new substance
7	-	Teacher	:	In fact, during a chemical reaction, no atoms are formed, and also no single atom is destroyed

In the course of achieving a solid foundation goal of science teaching, the teacher aims to ensure that students have a good understanding of the concepts in science. One way of achieving this is through the use of active teaching strategies where learners are engaged in the thinking process. By using the POE strategy above, the teacher engaged the student's minds-on. This is in the sense that students were encouraged, through questioning, to reason through their ideas which they have presented to the class as shown in turn 5.

Table 9 illustrates an overview of the prevalence of the self-reported and enacted goals or purposes of science teaching" for each teacher. The table below is used to discuss the findings below.

Table 9
Summary of Teachers' Self-reported or Enacted Categories of Goals or Purposes of Science Teaching

Category of goals or purposes of science teaching	Number of instances for each teacher as self-reported and enacted							
	Teacher 1		Teacher 2		Teacher 3		Teacher 4	
	R	E	R	E	R	E	R	E
Everyday coping	2	2	1	5	3	0	3	0
Structure of Science	1	1	0	0	1	0	0	0
Science, Technology, and Decisions	1	0	1	0	4	0	2	0
Scientific skill development	1	0	1	0	1	3	3	0
Correct explanation	1	0	1	2	1	2	0	3
Solid foundation	1	3	0	3	0	2	2	4
Self as explainer	0	0	0	0	0	0	0	0

Key: R – Self-reported; E – Enacted during teaching

https://doi.org/10.33225/jbse/21.20.456

Discussion

In the previous section, the findings for individual teachers in terms of the categories of goals or purposes of science teaching as self-reported and seen during teaching were presented. For discussion purposes, the findings are summarised in Table 9 above.

The research showed that all four teachers had multiple self-reported goals or purposes of science teaching. This is consistent with previous studies. For example, Friedrichsen and Dana (2005) found that teachers held multiple goals or purposes of science teaching. The most self-reported goal of science teaching is everyday coping. Although some teachers reported on the correct explanation goal, Teacher 4 did not report on any. Likewise, Teachers 2 and 3 did not report on solid foundation goal or purpose although it manifested in the classroom portraying the teachers as those that aim to prepare their students for the next levels in terms of content knowledge. The prevalence of everyday coping could mean that their purposes of teaching science are mostly about teaching the content knowledge as prescribed by the instructional materials like textbooks. The findings suggest that the teachers believed that using everyday examples could equip students with the necessary scientifically correct knowledge to use outside the classroom. Ekiz-Kiran and Boz (2020) also found the same pattern with chemistry teachers – teachers reporting mostly on everyday coping as their goals of teaching science. The dominance of everyday coping and solid foundation purposes as shown in this research may be due to the overemphasis of this goal of science teaching in both curricular, other government official documents and the media could explain this observation. For instance, in documents such as the Malawi Growth and Development Strategy (MGDS 1, 2, 3), Millennium Development Goals (MDG), National Science and Technology Policy (NSTP), they treat science as that subject that prepares students' survival in the society. This is because they acquire various critical skills that enable them to 'identify and solve current as well as emergent problems' (Ministry of Education, Science and Technology [MoEST], 2013). Such presentation of science in critical documents, it is believed, creates an impression amongst science teachers to the extent that other equally important aspects about the goals and purpose of science teaching seem subsumed into this. As argued by Azam (2020) and Friedrichsen and Dana (2005), contexts such as curriculum materials, school ethos, etc., play a significant role in shaping the beliefs of the teachers which they articulate or manifest during teaching. Similarly, Suh and Park (2017) indicate that the policies and socio-political priorities that teachers are exposed to tend to influence what teachers conform to in terms of beliefs.

The fact that other goals like structure of science and scientific skills development purposes as proposed by Roberts (1988) are less reported on, raises concerns about the teaching and learning of science. The teachers showed less awareness of *structure of science* as the goal of teaching science. The structure of science is complex emphasis where teachers who possess such goals would move from just focusing on providing correct content to conceptualizing and analyzing the content as a conceptual system (Roberts, 1988). Since research indicates that beliefs about science teaching are influenced by the school contexts in which teachers teach in (e.g., Mavuru & Ramnarian, 2018), the expectation was that Teachers 2 and 3 should have scientific skills development because they are teaching in a well-resourced school (availability of well-resourced laboratories – see Table 3 for the school context) and Teacher 1 to seldom report on this goal. Furthermore, this goal seldom manifested during their teaching excerpt for Teacher 3. The research showed the opposite – that the context in which one is teaching may not necessarily influence the orientations that teachers have. However, Teacher 4, who is also teaching at a school with laboratories illustrated having this goal, but this did not manifest at all during his teaching. As argued by Ekiz-Kiran and Boz (2020) and van Driel et al. (2008), science teachers should show evidence of having more goals of teaching science that resemble emphasis on scientific inquiry and process skills.

An interesting finding to observe in this research is that while all the teachers had multiple self-reported and enacted goals of science teaching, *self as an explainer* was neither self-reported nor manifested during teaching. This was a quite surprising finding since all the teachers did not talk about it nor manifest it during instruction despite being in the teaching service for more than 7 years on average. Ekiz-Kiran and Boz (2020) also indicated that self as explainer was not observed with the in-service chemistry teachers. One reason that potentially explains this observation is the structure of the science curriculum in Malawi. Again, a close examination of the documents revealed that neither the role of students' cultural background nor the history of science is explicitly discussed in the curriculum (see MoEST, 2013). While the curriculum is

https://doi.org/10.33225/jbse/21.20.456

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

explicit about other goals such as structure of science, everyday coping, scientific skills development solid foundation, on the contrary, it is mute about the role of the learners, the role of the cultural background of the learners and the history of science in the learning process.

While teachers had multiple self-reported goals or purposes of science teaching, most of these goals did not manifest themselves during instruction (e.g., STS goal). While this might be taken as a misalignment of goals of science, the general view is that this observation suggests that goals of science are topic-specific. Azam (2020) noted that teachers' approach to teaching science must necessarily be different due to the demands of the nature of the concepts inherent in each topic as shaped by the curriculum and context. What this means is that for specific topics, a researcher would be able to observe specific goals being manifested during teaching. For instance, some topics are traditionally inclined to everyday coping purpose of science teaching than others. Topics such as electricity or power and machines offer more chances to link the concepts to everyday life than would be the case with other topics (see Kapucu, 2016). On the other hand, teachers did not report some goals or purposes of science teaching but were seen manifesting in their classrooms. The lack of proper language by the teachers to express themselves offers some insights in this regard. Baxter and Lederman (1999) argued that sometimes teachers do not know how to articulate the things that they do and why they take certain decisions when teaching science. This is because they simply do not have a proper language that they can use to express themselves. This could explain the observation. Furthermore, this is substantiated by the fact that although some teachers did not infer anything about solid foundation or correct explanation, the two categories of goals or purposes to science teaching frequently manifested in their classrooms. This does not demonstrate that teachers did not have these goals at the back of their minds, rather it signifies a lack of proper language to express themselves that they hold those beliefs.

Conclusions and Implications

This research was about exploring the in-service science teachers' self-reported and enacted goals or purposes of science teaching as one dimension of the STOs. Although the focus of the research was not on the alignment of goals when self-reported and seen during teachers' practice, the findings reveal some insights about what is claimed by the teacher and their practices in the classrooms. This insight is that teachers may voice out certain goal not to show that during teaching. Similarly, they may not self-report on certain goals of science teaching but still, show evidence of those in their classrooms during teaching. This demonstrates the fact that sometimes what teachers lack is the language to articulate their beliefs, adding to the complex nature of beliefs. An interesting finding in this research is the fact that all the teachers did not talk about self as explainer purpose that scientific skills development and STS did not manifest in most of the classrooms. This finding is concerning in terms of the quality of science teaching in the context of Malawi as it reveals a gap in the teachers' knowledge of the teaching orientations.

The findings have implications for the professional development of both in-service and pre-service teachers. In-service teachers should be professionally developed to enhance their knowledge about goals or purposes of science teaching. Instead of the widely known and held professional developments where an academic would 'lecture' science teachers on how to display the goals or purposes of science teaching in the classrooms, the suggestion in this research is that the professional developments should be characterized by teachers collaborating and reflecting on their planning of lessons and teaching such that this reveals their beliefs. The revelation of their beliefs may lead to how they can be challenged to have quality teaching and learning of science. For pre-service teachers, teacher training institutions could embed and discuss some of these issues with the teachers on the importance of making goals or purposes of science teaching explicitly. Spending considerable time discussing these issues with pre-service teachers during training would develop their belief systems.

Limitations and Future Studies

This research was conducted in the Malawian context with only four teachers. This is a small sample to conclude about the nature of science teaching and learning in Malawi but provides considerable insights

https://doi.org/10.33225/jbse/21.20.456

for future studies. The main limitation of this research points to the data collection methods used. Since there was no post-observation interview with the teachers, the four teachers' classroom actions may not necessarily be directly related to specific goals or purposes of science teaching. It is for this reason that the research suggests more similar research and incorporate post-observation interviews to get teachers' reasoning behind their actions. In this research, the teachers were observed teaching different topics. Drawing from how teacher thinking and beliefs can vary across topics, the research suggests that more research needs to look at teachers' goals or purposes to science teaching across a particular topic.

Declaration of Interest

Authors declare no competing interest.

References

Azam, S. (2020). Locating personal Pedagogical Content Knowledge of science teachers within stories of teaching force and motion. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(12), ARTICLE em1907. https://doi.org/10.29333/ejmste/8941

Baxter, J. A., & Lederman, N. G. (1999). Assessment and measurement of Pedagogical Content Knowledge. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining Pedagogical Content Knowledge* (pp. 147–161). Springer Netherlands. https://doi.org/10.1007/0-306-47217-1_6

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed). Routledge.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed). Pearson.

Demirdöğen, B. (2016). Interaction between science teaching orientation and Pedagogical Content Knowledge Components. *Journal of Science Teacher Education*, *27*(5), 495–532. https://doi.org/10.1007/s10972-016-9472-5

Ekiz-Kiran, B., & Boz, Y. (2020). Interactions between the science teaching orientations and components of pedagogical content knowledge of in-service chemistry teachers. *Chemistry Education Research and Practice*, *21*(1), 95–112. https://doi.org/10.1039/C9RP00092E

Friedrichsen, P. M., & Dana, T. M. (2005). Substantive-level theory of highly regarded secondary biology teachers' science teaching orientations. *Journal of Research in Science Teaching*, *42*(2), 218–244. https://doi.org/10.1002/tea.20046

Friedrichsen, P., Van Driel, J. H., & Abell, S. K. (2011). Taking a closer look at science teaching orientations. *Science Education*, *95*(2), 358–376. https://doi.org/10.1002/sce.20428

Gunstone, R., & White, R. T. (1992). *Probing understanding* (1st ed.). Falmer Press.

Hancock, D. R. (2006). *Doing case study research: A practical guide for beginning researchers*. 122.

Hansson, L., Hansson, Ö., Juter, K., & Redfors, A. (2021). Curriculum emphases, mathematics and teaching practices: Swedish upper-secondary physics teachers' views. *International Journal of Science and Mathematics Education*, *19*(3), 499–515. https://doi.org/10.1007/s10763-020-10078-6

Kapucu, S. (2016). Identification of the physics subjects that are liked/disliked and why these subjects are liked/disliked by student teachers. *Journal of Theory and Practice in Education, 12*(4), 827–843.

Malawi National Examinations Board. (2013). *Chief examiners' reports for junior certificate examinations and Malawi senior certificate physics examinations.* Unpublished annual report.

Malawi National Examinations Board. (2014). *Chief examiners' reports for junior certificate examinations and Malawi senior certificate physics examinations*. Unpublished annual report.

Malawi National Examinations Board. (2015). *Chief examiners' reports for junior certificate examinations and Malawi senior certificate physics examinations*. Unpublished annual report.

Ministry of Education, Science and Technology. (2013). *Republic of Malawi syllabus for Physics forms 3 and 4.* Zomba: Malawi Institute of Education.

Nampota, D. C. (2016). Students' perspectives on teacher practices in Physical Science and their implications on inquiry-based instruction. In W. Mwakapenda, T. Sedumedi, & M. Makgato (Eds.), *Researching a sustainable environment and sustaining research in Mathematics, Science and Technology Education* (pp. 405–416). Routledge, Taylor & Francis Group.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Sage Publications.

Roberts, D. (2015). Curriculum emphasis. In R. F. Gunstone (Ed.), *Encyclopedia of science education* (pp. 264–279). Springer Reference.

Roberts, D. A. (1982). Developing the concept of "curriculum emphases" in science education. *Science Education*, *66*(2), 243–260. http://onlinelibrary.wiley.com/doi/10.1002/sce.3730660209/full

Roberts, D. A. (1988). What counts as science education? In P. J. Fensham (Ed.), *Development and dilemmas in science education* (pp. 27–54). Falmer Press.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Roberts, D. A. (1995). Junior high school science transformed: Analyzing a science curriculum policy change. *International Journal of Science Education*, *17*(4), 493–504. https://doi.org/10.1080/0950069950170408

van Driel, J. H., Bulte, A. M. W., & Verloop, N. (2008). Using the curriculum emphasis concept to investigate teachers' curricular beliefs in the context of educational reform. *Journal of Curriculum Studies*, *40*(1), 107–122. https://doi.org/10.1080/00220270601078259

World Bank (Ed.). (2010). *The education system in Malawi*. World Bank.

Received: *February 28, 2021* Accepted: *May 23, 2021*

Cite as: Maseko, B., & Khoza, C. H. (2021). Exploring in-service science teachers' beliefs about goals or purposes of science teaching. *Journal of Baltic Science Education*, *20*(3), 456-470. https://doi.org/10.33225/jbse/21.20.456

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