# PRE-SERVICE SCIENCE TEACHERS' BELIEFS OF EFFECTIVE PHYSICAL SCIENCE TEACHING

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## Abstract

The purpose of this study was to explore pre-service physical science teachers' perceptions on the types of teachers they wish to become, and to rate their personal beliefs of the characteristics of an ideal physical science teacher. The sample comprised 52 (56% female) second year Bachelor of Education science students studying towards a four year qualification in Education at a University of Technology. Pre-service physical science teachers first wrote a narrative on the type of future teachers they wish to become, and later a modified version of a questionnaire titled 'Test your effectiveness as science teacher' was used as a data collection instrument. This instrument is made up of 25 items categorized into knowledge of science, planning and organization, teaching methods, personal relations and enthusiasm. Students' perception of an ideal science teacher was measured on all the five categories using a 5-point Likert type scale ranging from 1= I really need to improve, to 5 = this is a real strength of my teaching. A relationship between the five categories and gender was also explored. The findings revealed the following: the mean score for the full scale was 3.80, for knowledge of science M = 3.35, for planning and organization M = 3.53, for teaching methods M = 3.67, for personal relations M = 4.24 and for enthusiasm M = 4.2. There was a correlation between the findings of the questionnaire and the themes that emerged from the narratives. The findings suggest that even though the pre-service physical science believe that they have good qualities and characteristics of effective future physical science teachers, they are not that confident in their content knowledge of physical science, and that they should think about how to improve this feature of their physical science teaching. The findings further revealed that male students were more efficacious than the female students in the four out of five categories. Recommendations are made to the physical science teacher education programmes to enhance the critical aspects of development towards the teaching and learning of physical science, i.e. content knowledge and pedagogical knowledge; which in turn will improve teacher quality

**Keywords**: self-efficacy, perceptions, teacher training.

## 1 INTRODUCTION

Teacher education institutions structure their provision of opportunities to learn (OTL) in a way that is consistent with their particular philosophy of what teachers need to know and be able to do (Blomeke & Kaiser, 2014). OTL according to Tatto, Schwille, Senk, Ingvarson, Peck and Rowey (2008) is defined as an experience with an anticipated or intended learning outcome (Tatto, Schwille, Ingvarson, Peck, & Rowley,

2008). This is an indication that teacher education programmes are designed in such a way that the expected final product is an ideal, pre-determined model of a teacher which in most instances does not translate into that desired picture in the real work situation.

It must be noted that OTL for teachers can occur at any point in the continuum of teacher learning, from the opportunities associated with schooling before entry into a formal teacher preparation program to the opportunities given to experienced teachers throughout their careers (Tatto, Schwille, Ingvarson, Peck, & Rowley, 2008). Similarly, pre-service teachers have been through a schooling system and taught by teachers, it is thus important to get an understanding of the type of future teachers they anticipate to become. Pre-service teachers' school years experiences may influence their beliefs as they undergo professional preparation (Thomas, Pederson, & Finson, 2001). This study is therefore intended to explore pre-service physical science teachers' actual beliefs of what an effective science teacher is.

Moreover, becoming an effective science teacher is a continuous process that stretches from pre-service experiences in undergraduate years to the end of a professional career. Science has a rapidly changing knowledge base and expanding relevance to societal issues, and teachers need ongoing opportunities to build their understanding and ability. Teachers must develop understanding of how students with diverse interests and experiences make sense of scientific ideas, and what a teacher could do to support and guide all students.

This process requires teachers who are going to meet the needs of this dynamic nature of science, i.e. competent and effective future teachers. What then is effective teaching? Effective teaching is defined as that which leads to improved students achievement using outcomes that matter to their future success. Defining effective teaching, according to Coe, Aloisi, Higgins and Major (2014) on "What makes great teaching? Review of the underpinning research", is of course problematic. Ideally, they might define effective teaching as that which leads to high achievement by students in valued outcomes, other things being equal (Coe, Aloisi, Higgins, & Major, 2014). Outcomes, with reference to Bandura's science teaching efficacy beliefs scale, form part of the two elements of science teaching efficacy beliefs, i.e. science teaching outcome expectancy and personal science teaching efficacy.

Teachers' beliefs, practices and attitudes are important for understanding and improving educational processes. They are closely linked to teachers' strategies for coping with challenges in their daily professional life and to their general well-being, and they shape students' learning environment and influence student motivation and achievement. Furthermore, they can be expected to mediate the effects of job-related policies such as changes in curricula for teachers' initial education or professional development on student learning.

Many teacher education students enter higher education classrooms with a unique set of beliefs about teaching and learning based on prior experiences. It must be noted that there is a difference between practices and beliefs. Bandura(1997) concurs with Hoy (2004) in their assertion that beliefs are the best indicators of future behavior. In this case, since the participants are still training to become teachers, the views shared in this study are based on their beliefs of what effective science teaching is. It is expected that in view of Bandura's and Hoy's assertion, this will in turn, have an effect on pre-service science teachers' future practice since beliefs play a strong role in predicting behavior.

Teachers' belief systems (how to teach and student accountability) greatly impact their abilities to create an environment where they can work collaboratively with students. That's why it is important to address teacher beliefs (Tweed, 2009). Consequently, Fishbein & Ajzen in Dunn and Rakes (20106) assert that it is important to explore individuals' beliefs because these beliefs are the basic blocks of behavior. On the contrary, Tatto and Coupland (2003) argue that there is no conclusive evidence that beliefs can be effectively influenced by teacher preparation or that they are an intrinsic characteristic of those individuals who become teachers (Tatto & Coupland, 2003). Hence the need for this study to test how pre-service teachers' beliefs can influence teacher preparation programmes. Although considerable research has been devoted to in-service teacher beliefs, less attention has been paid to pre-service teachers' beliefs on effective science teaching. This study therefore, is intended to explore and offer insight on pre-service science teachers' beliefs of effective science teaching in preparation to the envisaged future teachers they wish to become. This in turn, is expected to contribute meaningfully towards the development of pre-service science teachers' professional identity.

The purpose of this study was to explore the perceptions of pre-service science teachers' beliefs of effective science teaching. The study therefore attempted to answer the following research questions:

1. What are pre-service science teachers' perceptions of an ideal effective science teacher?

2. Is there any significant difference between males and females on the categories of effective teaching?
3. What are the implications of students' perceptions of effective science teaching for teacher educators?

# 2 METHOD

## 2.1 Research design

This study used a non-experimental, descriptive and exploratory quantitative design to determine pre-service Physical science teachers' beliefs of effective science teaching. The purpose of an exploratory approach is to use initial, qualitative phase to identify ideas and beliefs to design the quantitative part of the study, while a descriptive approach assesses the nature of existing conditions and provides a summary of an existing phenomenon by using numbers to characterize a group (McMillan & Schumacher, 2006).

## 2.2 Participants

In total, 52 second year physical science methodology course students at an institution of higher learning in South Africa participated in this study. The pre-service teachers were asked to fill out the questionnaires and to return them during class. The convenience sampling method was used.

## 2.3 Data collection

### *2.3.1 Instruments*

An open ended-questionnaire survey was administered during class. The revised questionnaire titled 'Test your effectiveness as science teacher' adopted and adapted from Trowbridge, Bybee and Sund (1981,pp 330-331) for use for quantitative data collection. This instrument is made up of 25 items. It consists of five categories, namely, knowledge of science, planning and organization, teaching methods, personal relations and enthusiasm. Students' perception of an ideal science teacher was measured on all the five categories using a 5-point Likert type scale ranging from 1= I really need to improve, to 5 = this is a real strength of my teaching. Cronbach alpha was used to compute the reliability of the instrument.

To explore in greater depth the understanding of pre-service teachers' epistemological beliefs and conceptions of teaching, they wrote narratives on the type of future teachers they wish to become. Qualitative data were generated through these written narratives.

## 2.4 Data analysis

Data were analysed using GraphPadQuickStats and Microsoft Excel. Descriptive (means and standard deviations were used to indicate the average score) and inferential statistics (t-test were used to determine if gender has any statistical significance on the five categories of the scale) were generated. Qualitative data were thematically analysed.

## 2.5 Ethical issues

Permission to conduct the study was sought from and approved by the institution. Participation in the study was voluntary. The benefits of participating in the study were explained to the participants. The respondents were also assured of the confidentiality of their responses.

# 3 RESULTS

Tables 1 and 2 give descriptive statistics on pre-service science teachers' perceptions of effective science teaching

Table 1: Pre-service science teachers' perceptions of effective science teaching (N=52)

| Statement: as a future physical science teacher: | | Mean | SD |
|---|---|---|---|
| | **Knowledge of science** | | |
| 1 | Am well read in science | 3.19 | 0.76 |
| 6 | Have a thorough knowledge of science | 3.40 | 0.77 |
| 11 | Present science concepts that are current and relevant | 3.87 | 0.83 |
| 16 | Am well informed in science related fields | 3.38 | 0.86 |
| 21 | Am knowledgeable concerning science-related social issues | 2.88 | 1.01 |
| | Overall mean | 3.35 | |
| | | | |

| | | | |
|---|---|---|---|
| | **Planning and organizing** | | |
| 2 | Have a well-organized science course | 3.65 | 0.83 |
| 7 | Always plan for and prepare for the science class | 3.94 | 0.89 |
| 12 | Recognise the need to modify daily and unit plans | 3.37 | 0.83 |
| 17 | Have thought about the long-range goals of my science class | 3.62 | 1.04 |
| 22 | Have a continuity of course material in science | 3.10 | 0.82 |
| | Overall mean | 3.53 | |
| | **Teaching methods** | | |
| 3 | Adjust my teaching to the class situation | 3.71 | 0.93 |
| 8 | Use a variety of techniques in teaching science | 3.48 | 0.93 |
| 13 | Encourage different types of learner activities in science | 3.90 | 0.93 |
| 18 | Use different curriculum materials and instructional approaches to teach science | 3.62 | 1.05 |
| 23 | Provide adequate opportunity for active work by science learners | 3.62 | 0.88 |
| | Overall mean | 3.67 | |
| | **Personal relations** | | |
| 4 | Have a good rapport with my learners | 4.40 | 0.63 |
| 9 | Recognise the unique needs of my learners | 3.88 | 0.85 |
| 14 | Relate well to learners on the individual and group level | 4.12 | 0.85 |
| 19 | Am sincere when helping my science learners | 4.27 | 0.76 |
| 24 | Listen to learners' questions and ideas | 4.54 | 0.72 |
| | Overall mean | 4.24 | |
| | **Enthusiasm** | | |
| 5 | Enjoy teaching science to learners | 4.15 | 0.91 |
| 10 | Am enthusiastic about teaching science | 3.96 | 0.92 |
| 15 | Become excited when learners learn science | 4.65 | 0.58 |
| 20 | Make an extra effort to help learners learn science | 4.08 | 0.83 |
| 25 | Am excited and energetic when teaching science | 4.15 | 1.04 |
| | Overall mean | 4.20 | |

A summary on the descriptive statistics per category is given in Table 2. The categories' ranking orders from 1 to 5 are highlighted with personal relations rated the highest and knowledge of science rated the lowest.

Table 2: Summary descriptive statistics

| Category | Mean | SD | Min | Max | Range | Rank order |
|---|---|---|---|---|---|---|
| Knowledge of science | 3.35 | 0.85 | 2.88 | 3.87 | 0.99 | 5 |
| Planning and organising | 3.53 | 0.88 | 3.10 | 3.94 | 0.84 | 4 |
| Teaching methods | 3.67 | 0.94 | 3.48 | 3.90 | 0.42 | 3 |
| Personal relations | 4.24 | 0.76 | 3.88 | 4.54 | 0.66 | 1 |
| Enthusiasm | 4.20 | 0.86 | 3.96 | 4.65 | 0.69 | 2 |

## 4 DISCUSSION

The qualitative data are in support of the findings from the quantitative data. The following were the themes from the narratives that show that pre-service teachers generally perceive effective science teaching to be influenced by adequate content knowledge, confidence to teach the subject, ability to encourage learners to pursue science related fields, being approachable, empathy and sympathy to learners. The themes that emerged from this qualitative data will be discussed in line with each of the five categories, and will be supported by excerpts from the narratives.

The discussion is arranged in line with the stated research questions:

**The first question:** What are pre-service science teachers' perceptions of an ideal effective science teacher?

From Tables 1 and 2, it can be seen that pre-service physical science teachers rank all the five categories of the scale above three, which means that all these categories are considered as good features of Physical Science teaching. The overall mean score was M=3.80, and the categories ranking from the highest score were personal relations (M=4.24); enthusiasm (M=4.20); teaching methods (M=3.67); planning and organizing (M=3.53) and knowledge of physical science (M=3.35).

The following sections look at the findings per category:

## Knowledge of science

This category involves the content knowledge of physical science. This was found to be the second lowest scored of all the five categories. It is an indication that pre-service science teachers still doubt themselves in terms of their content knowledge of physical science. This limited subject content knowledge will highly affect their confidence since content knowledge forms the basis of science teaching efficacy beliefs. Acquiring the subject content knowledge is important for pre-service teachers' success as future teachers, and this can also enhance their effectiveness in the teaching of Physical Science.

Kriek and Grayson (2009) assert that the poor state of mathematics and science education in South Africa can partially be attributed to many teachers' limited content knowledge and ineffective teaching approaches (Kriek & Grayson, 2009). This finding is consistent with the Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M) that the need to strengthen teachers' content knowledge is one of the dominant ideas that have guided reform efforts in many countries over the past years (Blomeke and Kaiser, 2014). Consequently, science and mathematics teacher preparation programmes expect their pre-service teachers to develop both a depth and breadth in the content knowledge in science and mathematics. This initial content knowledge assumes basic skills and broad general knowledge of the subject along with knowledge of inquiry in the specific discipline (Niess, 2005).

The following is an excerpt from the qualitative data supporting the knowledge of science:

"…as we know that science is regarded as a difficult subject, I want to be that confident teacher who will change that, master the content so that when I transfer the knowledge to learners, I talk about what I know…."

Item 21, "I am knowledgeable concerning science-related social issues" was the lowest scored item M=2.88. This is a clear indication that pre-service teachers cannot relate science learnt in the classroom to real life situations. It is thus imperative that the skill of applying science concepts and understandings to the new situations should be enhanced.

## Personal relations

Teachers' personal relations form part of effective teaching addressing the aspect of personal skills. This, according to Moreno (2009) involves caring, knowing the learners individually, having good and sound teacher-learners relationship and classroom management skills (Moreno, 2009). A classroom is supposed to be a conducive learning environment that allows learners to have a sense of belonging where they can freely express their views and insights without any prejudice. The pre-service physical science teachers prefer to be approachable and caring future teachers, whom learners can have confidence in. This in turn will result in motivated and inspired learners who will excel academically as expressed in the excerpt below:

"……I want to relate well with my learners, be fond of them and be patient with them…"

Personal relations was the highly ranked category with mean score M=4.24. The second highly rated item number 24 "I listen to learners' questions and ideas" (M=4.54) forms part of this category.

## Planning and organizing

A well-planned and organized lesson makes the content and session more interesting and involving, and becomes more interactive. Planning an effective science lesson can be demanding, since it requires incorporating tasks and interactions consistent with investigative science, encourages collaboration amongst learners, provides adequate time and structure for sense making

Pre-service teachers have indicated that they are going to employ constructivists classroom by considering learners' prior knowledge as their point of departure in planning and organizing their lessons. This is illustrated by the following excerpt:

"…with my learners being exposed to various means of access to information, I don't expect them to come to class empty headed, I'll tap into their existing knowledge…"

This finding is supported by Tweed (2009) by emphasizing that effective teaching also means assessing what learners know as instruction occurs and taking that information into account to adjust instruction (Tweed, 2009).

## Teaching methods

Physical science is a dynamic subject that requires a dynamic teacher. It is therefore important to encourage teaching methods that enhance inquiry. Effecting science teaching methods should help learners develop skills and attitudes from an early age, and should help them apply science concepts to new situations. This will promote inquiry based learning.

Meanwhile, learner-centered approach is encouraged in schools, whereas teacher education programmes do not allow room for inculcation of the same principles. Hence this study aims at promoting teaching methods that are accommodative of pre-service teachers' beliefs. Learner-centered instruction occurs in classrooms that emphasize opportunities for students to construct their own meanings. Instruction begins with what students think and know and bridges their ideas to the subject matter presented.

By looking at teacher effectiveness from the learners' perspectives, means that teachers need to be empowered on instructional strategies that can help learners to learn. Teaching methods were rated third highest of the five categories (M= 3.67)

## Enthusiasm

"Enthusiasm is one of those things that makes the difference between an outstanding teacher and one who is merely average". In addition, an effective teacher is responsible to create a warm classroom climate, to promote enthusiasm, motivation and an interactive teacher-student relationship. Also, it implies to be caring and understandable, and above all, to enhance learning (Moreno, 2009)

The following are the excerpts from the narratives that support pre-service teachers' enthusiasm:

"….a professional, amicable teacher, with zealous learners when they attend my lessons…."

"……a confident teacher who knows how to simplify content…"

"…an energetic, motivating and inspiring teacher, who makes science classes enjoyable and fun…"

Item 15, "I become excited when learners learn science" was the highest scored item with M=4.65. It must be emphasized that pre-service science are very enthusiastic about teaching science, but it must also be noted that this enthusiasm be nurtured through enhanced efficacy beliefs so that they can be able them to achieve desired goals.

**The second research question:** Is there any significant difference between males and females on the categories of effective teaching?

To answer research question 2, independent sample t-tests were carried out. Table 3 shows t-test results between male and female pre-service science teachers. It indicates that the perceived level of science teaching effectiveness is higher in males than in females. Consequently, there existed a statistically significant difference between the male and female pre-service science teachers at a p level of 0.05. These were identified in the two categories knowledge of science and enthusiasm as shown in Table 3 below.

Table 3: t-test results between males and females per category

| Category | Male Average Mean | Female Average mean | P-value |
|---|---|---|---|
| Knowledge of science | 3.56 | 3.18 | 0.0024 |
| Planning and organising | 3.49 | 3.57 | 0.6838 |
| Teaching methods | 3.76 | 3.59 | 0.1547 |
| Personal relations | 4.29 | 4.21 | 0.5404 |
| Enthusiasm | 4.42 | 4.03 | 0.0147 |

*p>0.05

A paired-samples t-test was conducted to compare the knowledge of science in males and females. There was a significant difference in the scores for males (M=3.56, SD=0.37) and females (M=3.18, SD=0.36); t(4)= 6.81, p=0.0024. These results suggest that males regard themselves more knowledgeable in science than females.

A paired-samples t-test was conducted to compare the enthusiasm in males and females. There was a significant difference in the scores for males (M=4.42, SD= 0.27) and females (M=4.03, SD=0.29); t(4)=4.11 , p=0.0147. These results suggest that males regard themselves more enthusiastic to teach science than females.

**Research question 3**: What are the implications of students' perceptions of effective science teaching for teacher educators?

From the analysis of both qualitative and quantitative findings, it is evident that self-confidence is the underlying factor that contributes to effective science teaching. In as much as pedagogical content knowledge needs to be emphasized, it is important that self-efficacy beliefs be embedded in teacher training programmes. This will enhance pre-service science teachers' personal science teaching efficacy beliefs and science teaching outcome expectancy, which will boast their confidence towards effective science teaching and they will approach even difficult tasks as challenges to be mastered rather than see them as limitations. It is therefore imperative that the four sources of self-efficacy beliefs as

## 5. CONCLUSION

The five categories, science knowledge, planning and organizing, teaching methods, personal relations and enthusiasm contribute meaningfully to the effective teaching of Physical Science. Pre-service teachers are the major agents of change who will reform instruction of Physical Science. Therefore, teacher education programmes need to consider all the dynamics that contribute to effective science teaching with respect to pre-service teachers' beliefs while designing teacher education curricula. This is essential to better equip teacher educators with the tools that they need to produce more efficacious teachers who will promote educational reform.

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