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Zambian Pre-service Chemistry Teachers' Views on Chemistry Education Goals and Challenges for Achieving Them in Schools

Abstract

This study examined Zambian pre-service chemistry teachers' views on the goals of chemistry education, the importance of the goals, and challenges for achieving them in schools. The study sample was comprised of 59 pre-service chemistry teachers at the University of Zambia. Data were collected using a modified Likert-scale questionnaire that was initially developed by Gayon (2010). In general, teachers were positive about the goals of chemistry education in schools. However, the pre-service chemistry teachers did not rank the five goals of chemistry education equally. Instead, the pre-service chemistry teachers ranked the goals of chemistry education in the following descending order: Career awareness, Scientific method, Personal needs, Scientific knowledge, and Societal issues. A similar trend was revealed in the participants' ranking of the important goals of chemistry education in the following order of importance: Career awareness, Scientific methods, Scientific knowledge, Personal needs, and Societal issues. Teachers perceived lack of resources, and teacher preparation and development as the primary challenges for achieving the goals of chemistry education in schools. These findings have implications on chemistry teaching and learning, and teacher education.

Introduction

Scientific literacy is one of the desired outcomes of science education (Bybee, 1997; DeBoer, 2000; Chiappetta & Koballa, 2010; Loughram, Smith, & Berry, 2011). However, scientific literacy is a broad and controversial term, and no consensus has been reached on its definition (Shwartz, Ben-Zvi & Hofstein, 2005). Despite the lack of consensus on its meaning, the science education community agrees that scientific literacy involves developing a firm understanding of a range of scientific concepts and processes, as well as an awareness of the relationship between science, technology and society, and practices within and across science disciplines (Bauer, 1992; Lederman, 1992; American Association for the Advancement of Science [AAAS], 1993). Current US science education reforms define a scientifically literate person as one who is able to identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed (National Research Council [NRC], 1996). Shwartz et al., (2005) state that the common dimensions associated with scientific literacy are: understanding the nature of science, such as norms and methods of science, and the nature of scientific knowledge; understanding the key scientific concepts, principles, and theories; understanding how science and technology actually work together; appreciating and understanding the impact of science and technology on society; communication competencies in scientific contexts, such as the ability to read, write, and understand systemized human knowledge; and applying some scientific knowledge and reasoning skills to daily life. As such, the goals for science teaching are to educate students who are able to; "experience the richness and excitement of knowing about and understanding the natural world; use appropriate scientific processes and principles in making personal decisions; engage intelligently in public discourse and debate about matters of scientific and technological concern; and increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers" (NRC, 1996, p.13). These scientific literacy themes make up four goal clusters of science education namely: Personal Needs, Societal Issues, Academic Preparation, and Career Awareness (Pogge & Yager, 1987). Savellino and Hernandez (1996) expanded the Academic Preparation goal into two goals – Scientific Methods and Scientific Knowledge. Recently, Staver (2007) condensed the goals of science education into three broad goals, which are: prepare students to study science at higher levels of education; prepare students to enter the workforce, pursue occupations and take up careers; and prepare students to become more scientifically literate citizens.

Every science discipline is well embedded in these five cluster goals of science education: *Scientific Knowledge, Scientific Methods, Personal Needs, Societal Issues, and Career Awareness (*AAAS, 1993 & NRC, 1996). The *Scientific Knowledge* cluster goal emphasizes the need for students to know scientific concepts and definitions of scientific words or terms. The *Scientific Method* (i.e., methods of science) cluster goal of science education accentuates the need for students to attain an understanding of scientific inquiry as a process, develop inquiry abilities and critical thinking skills and use these skills to improve their ability to think critically about science-related problems. The *Societal Issues* cluster goal places emphasis on students learning about environmental concepts, world

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Table 1: Percentage distribution on Career Awareness

Chemistry Education should:	SA	A	N	D	SD
Emphasize importance of chemistry related careers to the advancement of science and technology	64.4	32.2	0	0	1.7
Prepare students for chemistry-related careers	64.4	23.7	0	3.4	5.1
Be geared to the training of future scientists	57.6	39.0	1.7	0	1.7
Promote awareness in chemistry-related careers	37.3	52.5	3.4	1.7	5.1
Inform students of the demand for chemists and chemistry teachers	33.9	45.8	6.8	6.8	6.8
Average	51.52	38.6	2.4	2.4	4.1

problems, and decision-making to solve such problems. Students should be able to deal with societal issues through the application of their scientific knowledge and skills. The *Personal Needs* cluster goal focuses on helping students acquire life-and-work and school-to-work skills. Thus, science courses must emphasize content and skills that are seen as useful in students' everyday living. The *Career Awareness* cluster goal focuses on schools providing information and training to students that will be useful in their future employment.

These science education goals should serve as the basis for chemistry education in schools. However, to achieve high quality chemistry education at school level, teachers should have a clear understanding of the goals for chemistry education in schools. This will help them structure their teaching in line with the goals of chemistry education. Research shows that teachers' understanding of the goals of science teaching affects the way they teach it (Wallace & Kang, 2004). However, very few studies have examined what teachers perceive to be the goals of chemistry education (Gayon, 2010; Uzuntiryaki & Boz, 2007). For example, Uzuntiryaki and Boz (2007) found that most Turkish pre-service chemistry teachers believed that the goal of chemistry teaching in high schools was for students to understand their daily life. On the other hand, Gayon (2010) reported that Philippine teachers perceived scientific knowledge and scientific methods as the most important goals of chemistry education. Gayon further stated that teachers considered personal needs and career awareness as less important goals of chemistry education. Philippine teachers perceived inadequate teacher preparation on pedagogy and lack of teacher professional development activities as the main barriers to achieving the goals of chemistry education in schools.

Chemistry teachers stand at the center of the chemical education literacy drive among students (Shwartz, Ben-Zvi & Hofstein, 2005). As such, knowing teachers' views on the goals and importance of chemistry education is essential in reforming chemistry instruction in schools. Yet, there is very little we know about teachers' understanding of or views on the goals of chemistry education. In order to start addressing this educational problem, this study examined Zambian pre-service chemistry teachers' views on the goals of chemistry education, the importance of the goals of chemistry education, and the challenges for achieving the goals of chemistry education. We focused on Zambian teachers because chemistry is one of the mandatory subjects in the Zambian national science curriculum. All high school students are required to take chemistry for three years, from grades 10-12. The findings in this study are important, not only to Zambian chemistry educators but also to other chemistry educators elsewhere, who are involved in chemistry teacher education. The findings also have implications for chemistry teaching, learning, curriculum design, and promotion of scientific literacy among students. This study was guided by the following research questions: What do Zambian pre-service chemistry teachers view to be the goals of chemistry education? What do Zambian pre-service chemistry teachers view to be the importance of chemistry education goals? What do Zambian pre-service chemistry teachers view to be the challenges for achieving chemistry education goals?

Table 2: Percentage distribution on Scientific Methods

Chemistry Education should:	SA	A	N	D	SD
Provide opportunities for students to discover chemistry concepts through laboratory activities	72.9	27.1	0	0	0
Improve students' ability to think critically about chemistry-related problems	55.9	35.6	0	1.7	5.1
Make students understand scientific inquiry as a process	54.2	39.0	0	0	1.7
Emphasize on the methods and processes of scientific investigation	37.3	52.5	1.7	0	8.5
Enable students to use the scientific method to solve daily problems	30.5	32.2	11.9	15.3	8.5
Provide students with the ability to form a hypothesis and plan an experiment to test the hypothesis	25.4	42.4	10.2	6.8	11.9
Focus upon student experiences with process skills such as inferring, identifying variables, etc.	3.4	27.1	27.1	15.3	23.7
Average	39.9	36.6	7.3	5.6	8.5

Methodology

Participants

A sample comprised 59 pre-service chemistry teachers in the science teacher education program at the University of Zambia. There were 34 males and 25 females. The pre-service chemistry teachers were training to teach chemistry at high school level, grades 10 – 12. They all studied chemistry in high school for 3 years, grades 10 – 12 before entry into the science teacher education program. The science teacher education program trains chemistry, physics, and biology high school teachers. The training period is four years and teachers are awarded bachelor degrees at the end of the program. During the training period, the pre-service teachers study chemistry, physics, and biology. The pre-service teachers also study courses

Table 3: Percentage distribution on Personal Needs

Chemistry Education should:	SA	A	N	D	SD
Provide information and training that will be useful in students' future employment	49.2	28.8	10.2	5.1	5.1
Develop intellect of students	42.4	50.8	0	0	5.1
Help create a favorable environment that will promote the development of students as human beings	35.6	40.7	6.8	6.8	8.5
Provide opportunities for the total personal development of the students	15.3	32.2	11.9	11.9	25.4
Average (%)	35.6	38.1	7.2	6.0	11.0

in educational foundations and science education. They do their student teaching in the third-year of their degree program.

Data Collection

Data were collected using a modified questionnaire that was initially developed by Gayon (2010). The modified questionnaire had three sections. In the first section, teachers were asked to rate the extent to which they agreed or disagreed with 30 items on the goals of chemical education by choosing *Strongly Agree, Agree, Neutral, Disagree,* or *Strongly Disagree.* The items on the goals of chemistry education were related to the following goal clusters of science education: scientific knowledge, scientific methods (methods of science), personal needs, career awareness, and societal issues. In the second section, the pre-service chemistry teachers were asked to rate 30 items on the importance of chemistry education goals by choosing *Not Important, Somewhat Important or Very Important*. In the third section, the pre-service chemistry teachers were asked to rate the challenges of achieving the goals of chemistry education by choosing *Not a barrier, Somewhat significant barrier or Very significant barrier.*

Data Analysis

Participants' responses on the goals of chemistry education were scored by assigning a value of 5 for *Strongly Agree,* 4 for *Agree*, 3 for *Neutral*, 2 for *Disagree*, and 1 for *Strongly Disagree*. Similarly, responses on the importance of chemistry education goals were scored by assigning a value of 3 for *Very important*, 2 for *Somewhat important*, and 1 for *Not important*. The responses on the challenges for achieving chemistry education goals were scored by assigning a value of 3 for *Very significant barrier*, 2 for *Somewhat significant barrier*, and 1 for *Not a barrier*. Then, Cronbach alpha values were computed to determine the reliability of the three sections and the entire instrument. Frequencies and percentages of respondents on each item were computed. Then t-tests were performed to find out the differences (if any) in mean rankings of chemistry education goals, mean rankings of the importance of chemistry education goals, and the mean rankings of the challenges for achieving the goals of chemistry education.

Results

Reliability Values

Data analysis revealed Cronbach's alpha values of *0.79* for goals of chemistry education section, *0.88* for importance of chemistry education goals section, and *0.80* for challenges of achieving chemistry education goals section. The entire instrument had a Cronbach's alpha value of *0.89*. According to George and Mallery (2009) and Fray (2010), Cronbach's Alpha coefficients from 0.60 to 0.79 indicate moderate reliability and from 0.80 to 0.89 good reliability. These statistics shows that the research instrument and its three sections had either moderate or good reliability.

Goals of Chemistry Education

On average, the pre-service chemistry teachers ranked the goal clusters of chemistry education in the following descending order: *Career awareness* (51.5%), *Scientific method* (39.9%), *Personal needs* (35.6%), *Scientific knowledge* (32.5%), and *Societal issues* (26.9%). Detailed explanations of pre-service chemistry teachers' views of each goal cluster of chemistry education have been provided below.

Career Awareness

On average, most teachers (90%) viewed *Career awareness* as the first goal of chemistry education in school. Table 1 shows that 64% of the pre-service teachers strongly agreed and 32.2% agreed that chemistry education should emphasize the importance of chemistry related careers to the advancement of science and technology. Similarly, most teachers (64.4%) strongly agreed that chemistry education should prepare students for chemistry related careers. On the other hand, very few teachers remained neutral (2.4%) or strongly disagreed (4.1%) with statements in this goal cluster of chemistry education.

Scientific Methods

Table 2 shows that 76.5% of teachers positively ranked this goal of chemistry education as the second goal of chemistry education. This implies that the pre-service chemistry teachers viewed the development of scientific methods among students as the second purpose of chemistry education in schools. For example, Table 2 shows that most teachers (73%) strongly agreed that chemistry

Table 4: Percentage distribution on Scientific knowledge

Chemistry Education should:	SA	A	N	D	SD
Develop fundamental understanding of chemistry concepts	55.9	35.6	1.7	0	5.1
Reflect the nature and structure of chemistry	49.2	35.6	0	1.7	8.5
Develop fundamental understanding of chemical systems	37.3	52.5	1.7	1.7	5.1
Provide opportunities for students to see connections among science disciplines and between science and other disciplines	37.3	35.6	5.1	6.8	15.3
Present chemistry as a body of scientific knowledge	28.8	52.5	8.5	0	6.8
Present fundamental knowledge	13.6	54.2	15.3	3.4	10.2
Be interdisciplinary in nature	5.1	20.3	13.6	15.3	44.1
Average percentage	32.5	40.9	6.6	4.1	13.6

Table 5: Percentage distribution on Societal issues

Chemistry Education should:	SA	A	N	D	SD
Provide students with an understanding of the crucial role of chemistry and technology in our society	49.2	33.9	3.4	5.1	6.8
Promote protection, conservation, and improvement of the environment	45.8	35.6	6.8	0	6.8
Emphasize on recognizing the moral obligation of chemistry and technology to the individual and society	23.7	44.1	10.2	6.8	11.9
Emphasize environmental concepts and world problems	23.7	33.9	13.6	11.9	13.6
Develop a sense of community from local to the international level	18.6	39.0	16.9	10.2	15.3
Present chemistry as a value-laden subject that has moral and ethical dimensions	16.9	20.3	16.9	13.6	28.8
Include contemporary social problems and solutions for those problems	10.2	15.3	22.0	30.5	18.6
Average	26.9	31.7	12.8	11.2	14.5

education should provide opportunities for students to discover chemistry concepts through laboratory activities. Furthermore, teachers strongly agreed that chemistry education should aim at improving students' critical thinking (56%), and understanding of scientific inquiry processes (54%). On the other hand, few teachers (5.6%) disagreed with the items in this goal cluster of chemistry education.

Personal Needs

This goal of chemistry education was ranked third by the pre-service chemistry teachers (73.8%). In particular, Table 3 shows that 49% agreed that chemistry education should provide information and training that will be useful in students' future employment. Similarly, 50.8% agreed that chemistry education should develop the intellect of students. On the contrary, 25.4% of the pre-service chemistry teachers strongly disagreed with the idea that chemistry education should provide opportunities for the total personal development of the students.

Scientific Knowledge

On average, scientific knowledge was ranked fourth by pre-service chemistry teachers on their views of the goals of chemistry education. As shown in Table 4 below, 56% of the pre-service chemistry teachers strongly agreed that chemistry education should develop fundamental understanding of chemistry concepts. Similarly, 54.2% simply agreed that chemistry education should present fundamental knowledge to students. However, 44.1% strongly disagreed that chemistry education should be interdisciplinary in nature.

Societal Issues

This was ranked the least important goal of chemistry education. On average very few teachers strongly agreed (27%) or agreed (32%) that chemistry education has a role in solving societal issues. However, Table 5 shows that 45.6% strongly agreed that chemistry education should promote protection, conservation, and improvement of the environment. Similarly, 44.1% simply agreed that chemistry education should emphasize recognizing the moral obligation of chemistry and technology to the individual and society. However, 28.8% strongly disagreed that chemistry education should present chemistry as a value-laden subject that has moral and ethical dimensions. Some teachers (22.0%) were indifferent on the idea of whether chemistry education should include contemporary social problems and solutions for those problems.

Differences in Teacher Ratings of the Goals of Chemistry Education

A one-way analysis of variance (ANOVA) was conducted to evaluate the difference in mean ratings of the goal clusters of chemistry education. As shown in Table 6 below, the One-Way ANOVA revealed a significant difference in teachers' rating of the five cluster goals of chemistry education, with Career awareness having the highest mean followed by Scientific methods, Personal needs, Scientific knowledge and Societal issues.

A Tukey HSD Post Hoc test indicated that the ratings were statistically significant for all the pairs except the following: scientific knowledge (M = 73.5, SD = 12.4) and scientific methods (M = 77.5, SD = 10.4), scientific knowledge (M = 73.5, SD = 12.4) and personal needs (M = 75.0, SD = 13.2), and scientific methods (M = 77.5, SD = 10.4) and personal needs (M = 75.0, SD = 13.2). These statistics suggest that the pre-service chemistry teachers' views on scientific methods, scientific knowledge, and personal needs as goals of chemistry education were similar.

Importance of the Goals of Chemistry Education

On average, the pre-service chemistry teachers ranked the importance of goals of chemistry education in the following descending order: *Career awareness* (74.6 %), *Scientific methods* (58.4%), *Scientific knowledge* (56.7%), *Personal*

Table 6: One-Way ANOVA on goals of chemistry education

Cluster Goal	*Mean*	*SD*	*F*	*df*	*p-value*
Career awareness	85.6	10.6	17.9	4	0.001
Scientific methods	77.5	10.4			
Personal needs	75.0	13.2			
Scientific knowledge	73.5	12.4			
Societal issues	67.3	13.5			

Significant at $p < 0.05$.

Table 7: Importance of the goals of chemistry education: Career awareness

Chemistry Education should:	Not Important	Somewhat Important	Very Important
Emphasize importance of chemistry related careers to the advancement of science and technology	3.4	10.2	86.4
Prepare students for chemistry-related careers	3.4	16.9	79.7
Promote awareness in chemistry-related careers	3.4	30.5	66.1
Inform students of the demand for chemists and chemistry teachers	10.2	30.5	59.3
Be geared to the training of future scientists	3.4	15.3	81.4
Average	4.8	20.7	74.6

Table 8: Importance of the goals of chemistry education: Scientific methods

Chemistry Education should:	Not Important	Somewhat Important	Very Important
Provide opportunities for students to discover chemistry concepts through laboratory activities	3.4	13.6	83.1
Improve students' ability to think critically about chemistry-related problems	3.4	20.3	76.3
Emphasize on the methods and processes of scientific investigation	3.4	30.5	66.1
Make students understand scientific inquiry as a process	8.5	25.4	66.1
Provide students with the ability to form a hypothesis and plan an experiment to test the hypothesis	10.2	44.1	45.8
Enable students to use the scientific method to solve daily problems	32.2	18.6	49.2
Focus upon student experiences with process skills such as inferring, identifying variables, etc.	44.1	33.9	22.0
Average	15.0	26.6	58.4

needs (47.9%), and *Societal issues* (42.4%). Below are the detailed explanations of pre-service chemistry teachers' views on the importance of the goals of chemistry education.

Career Awareness

The pre-service chemistry teachers viewed this goal cluster as the most important goal of chemistry education in schools. As shown in Table 7, most pre-service chemistry teachers (86%) viewed emphasizing the importance of chemistry related careers to the advancement of science and technology as a very important goal of chemistry education. Promoting awareness in chemistry-related careers (30.5%) and informing students of the demand for chemists and chemistry teachers (30.5%) were viewed as somewhat important goals of chemistry education. However, 10.2% of the pre-service chemistry teachers viewed the idea of informing students of the demand for chemists and chemistry teachers as not an important goal of chemistry education.

Scientific Methods

The pre-service chemistry teachers (58.4%) ranked scientific methods as the second most important goal of chemistry education. Some pre-service chemistry teachers (26.6%) ranked it as a somewhat important goal while 15.0% ranked it as not important. In particular, Table 8 below shows that 83.1% of the pre-service chemistry teachers viewed the provision of opportunities for students to discover chemistry concepts through laboratory activities as a very important aspect in chemistry education. Similarly, 76.3% of pre-service chemistry teachers believed that improving students' ability to think critically about chemistry-related problems was a very important goal of chemistry education. Furthermore, 44.1% of pre-service chemistry teachers subscribed to the idea of providing students with the ability to form a hypothesis and plan an experiment to test the hypothesis as a somewhat important goal of chemistry education. However, a similar percentage (44%) of pre-service chemistry teachers did view the idea of chemistry instruction to focus on providing student experiences with process skills such as inferring, and identifying variables as an important goal of chemistry education.

Scientific Knowledge

This goal of scientific knowledge was ranked the third most important goal for chemistry education. Specifically, 57% viewed it as very important, 34% viewed it as somewhat important, and 9% viewed it as not important. As shown in Table 9 below, 78.0% of pre-service chemistry teachers believed that developing fundamental understanding of chemistry concepts was a very important goal of chemistry education. Similarly, pre-service chemistry teachers believed that developing fundamental understanding of chemical systems was a very important goal of chemistry education.

Table 9: Importance of the goals of chemistry education: Scientific knowledge

Chemistry Education should:	Not Important	Somewhat Important	Very Important
Develop fundamental understanding of chemistry concepts	0	22.0	78.0
Develop fundamental understanding of chemical systems	1.7	22.0	76.3
Reflect the nature and structure of chemistry	3.4	39.0	57.6
Present chemistry as a body of scientific knowledge	3.4	39.0	57.6
Provide opportunities for students to see connections among science disciplines and between science and other disciplines	13.6	33.9	52.5
Present fundamental knowledge	11.9	40.7	47.5
Be interdisciplinary in nature	32.2	40.7	27.1
Average	9.5	33.9	56.7

Personal Needs

This was ranked as the fourth important goal of chemistry education, 48% viewed it as very important, 33% viewed it as somewhat important, and 19% viewed it as not important. As shown in Table 10, most pre-service chemistry teachers (63%) believed that providing information and training that will be useful in students' future employment was very important in chemistry education. Pre-service chemistry teachers also perceived both developing intellect of students and providing opportunities for the total personal development of the students as a somewhat important goals of chemistry education. However, some pre-service chemistry teachers (31%) did not believe providing opportunities for the total personal development of the students to be important in chemistry education.

Societal Issues

This was ranked last in importance order of goals of chemistry education. Table 11, shows that on average 42.4% of pre-service chemistry teachers ranked it as the most important goal while 30.0% ranked it as a somewhat important goal,

Table 10: Importance of the goals of chemistry education: Personal Needs

Chemistry Education should:	Not Important	Somewhat Important	Very Important
Provide information and training that will be useful in students' future employment	16.9	20.3	62.7
Develop intellect of students	5.1	40.7	54.2
Help create a favorable environment that will promote the development of students as human beings	23.7	30.5	45.8
Provide opportunities for the total personal development of the students	30.5	40.7	28.8
Average	19.1	33.1	47.9

27.6% ranked it as not an important goal of chemical education. However, 76.3% of pre-service chemistry teachers believed that providing students with an understanding of the crucial role of chemistry and technology in our society was very important in chemistry education. Similarly, teachers viewed protection, conservation, and improvement of the environment as a very important theme in chemistry education. However, more than 50% of teachers believed that the inclusion of contemporary social problems and solutions for those problems in chemistry curriculum was not an important theme for chemistry education.

Differences in Ratings on the Importance of the Goals of Chemistry Education

As shown in Table 12 One-way ANOVA revealed significant differences in teachers' ratings of goals of chemistry education.

These results suggest that most pre-service chemistry teachers perceived career awareness as the most important goal of chemistry education while societal issues was perceived as the least important goal of chemistry education.

Challenges for Achieving Chemistry Education Goals

In our data collection instrument, the challenges for achieving chemistry education in schools were put in three categories. The first category had challenge statements related to resources, the second category had challenge statements related to inadequate teacher preparation and lack of professional development activities. The third category included challenge statements related to other issues such as government policies and student matters. In general, the pre-service chemistry teachers perceived challenges for achieving chemistry education in schools in the following descending order: *Resources, Teacher preparation and development, and Others*. Detailed explanations have been provided below.

Resources

Pre-service chemistry teachers viewed the lack of resources as the most significant challenge to achieving the goals of chemistry education in schools. For example, Table 13 shows that that most pre-service chemistry teachers (61%) viewed lack of resources as a very significant challenge, 25% considered lack of resources as a somewhat significant challenge, and 14% did not view lack of resources as a challenge to achieving the goals of chemistry education in schools. Specifically, most pre-service chemistry teachers (90%) believed that lack of laboratories, poorly equipped labs, and lack of funds to buy equipment and supplies were very significant challenges for achieving the goals of chemistry education.

Teacher Preparation and Development

Teachers ranked teacher preparation and development as the second significant challenge to achieving the goals of chemistry education. In particular, 63% of pre-service chemistry teachers considered teachers being overloaded with work due to poor staffing in the science departments as a significant challenge. Table 14 also shows that 39.0% of pre-service chemistry teachers considered both teachers lacking opportunities to collaborate in looking at student work and teachers facing challenges to maintain discipline as somewhat significant challenges to achieving the goals of chemistry education. However, 39.0% of pre-service chemistry teachers considered teachers lacking time to prepare lessons as not a challenge to achieving the goals of chemistry education.

Other Challenges

"Other challenges" encompassed student related issues and government policies. Pre-service chemistry teachers ranked this as the least challenging to

Table 11: Importance of the goals of chemistry education: Societal issues

Chemistry Education should:	Not Important	Somewhat Important	Very Important
Provide students with an understanding of the crucial role of chemistry and technology in our society	5.1	18.6	76.3
Promote protection, conservation, and improvement of the environment	13.6	16.9	69.5
Emphasize on recognizing the moral obligation of chemistry and technology to the individual and society	15.3	45.8	39.0
Emphasize environmental concepts and world problems	33.9	30.5	35.6
Present chemistry as a value-laden subject that has moral and ethical dimensions	30.5	40.7	28.8
Develop a sense of community from local to the international level	40.7	37.3	22.0
Include contemporary social problems and solutions for those problems	54.2	20.3	25.4
Average	27.6	30.0	42.4

Table 12: ANOVA on importance of chemistry education goals

Goal	*Mean*	*SD*	*F*	*df*	*p-value*
Career awareness	89.9	11.4	15.3	4	<0.001
Scientific knowledge	82.2	10.8			
Scientific methods	81.0	11.9			
Personal needs	76.3	17.1			
Societal issues	71.5	15.2			

Significant at $p < 0.05$.

Table 13: Challenges for achieving chemistry education goals: Resources

Challenge	Not a barrier	Somewhat significant barrier	Very significant barrier
Schools lack laboratories for science teaching	0	10.2	89.8
Laboratories are poorly equipped	5.1	6.8	88.1
Schools lack funds to purchase equipment and supplies	8.5	8.5	83.1
Teachers lack materials to individualize instruction	6.8	30.5	62.7
Teachers lack reference materials (textbooks)	11.9	25.4	62.7
Teachers lack access to computers	23.7	35.6	40.7
Teachers lack access to the internet	25.4	44.1	30.5
Teachers lack appropriate computer software	30.5	35.6	33.9
Average	13.99	24.59	61.44

achieving the goals of chemistry education. Specifically, Table 15 shows that pre-service chemistry teachers believed that lack of student motivation to learn, lack of teacher supportive school culture, and lack of abilities among students as very significant challenges. Further, teachers ranked chemistry curriculum scope and sequence as a somewhat significant challenge to achieving the goals of chemistry education.

Differences in Rankings of the Challenges of Achieving Chemistry Education Goals

As shown in Table 16 below, One-way analysis of variance (ANOVA) revealed significant difference in the pre-service chemistry teachers' mean ranking of the challenges for achieving the chemistry education goals, with Resources having the highest mean followed by Teacher development/preparation and others. These statistics suggest that the pre-service chemistry teachers considered lack of resources as a more serious challenge than teacher preparation and development and other factors surveyed in this study.

Discussion

Results show that the pre-service chemistry teachers ranked the goals of chemistry education in the following descending order: Career awareness, Scientific method, Personal needs, Scientific knowledge, and Societal issues. A similar trend was revealed in the participants' ranking of the important goals of chemistry education in the following order of importance: Career awareness, Scientific methods, Scientific knowledge, Personal needs, and Societal issues. Teachers ranked challenges for achieving chemistry education in schools in the following descending order: Lack of resources, Teacher preparation and development, Government policies, and Student issues.

These results suggest that the pre-service chemistry teachers did not equally rank the five goals of chemistry education. Career awareness was ranked the most important goal of chemistry education and the societal issues cluster goal was viewed as the least important goal of chemistry education in schools. This finding is in contrast to the findings in previous studies (Uzuntiryaki & Boz, 2007; Gayon, 2010). For example, Uzuntiryaki and Boz (2007) found that the pre-service teachers viewed their daily life understanding of chemistry (Personal Needs) as the major goal of chemistry education. In another study, Gayon (2010) reported that teachers believed the development of scientific knowledge and scientific methods among students as the most important goals of chemistry education, while career awareness was rated as the least important goal of chemistry education. Zambian pre-service chemistry teachers' view of career awareness as the most important goal of chemistry education in school can be attributed to the way education is viewed in Zambia. Most Zambians believe that going to high school and beyond is a path towards formal employment. As such, every course or subject taught in school is considered good enough to help students find formal employment after school. Furthermore, most science teachers leave the teaching profession within five years of their teaching career, and find other jobs in industries.

Zambian pre-service chemistry teachers considered lack of resources as the major challenge for achieving the goals of chemistry education in schools. This finding is not consistent with previous studies. For example, Gayon (2010) reported that Philippine teachers perceived teacher preparation and development as the main challenge for achieving chemistry education at school level. One of the postulations for our finding could be that most schools in Zambia lack basic resources for effective science

Table 14: Challenges for achieving chemistry education goals: Teacher preparation/development

Challenge	Not a barrier	Somewhat significant barrier	Very significant barrier
Teachers face large classes	13.6	20.3	66.1
Teachers are overloaded with work due to poor staffing in the science departments	6.8	30.5	62.7
Teachers are not prepared to teach students of diverse ability levels	23.7	32.2	44.1
Teachers lack opportunities to collaborate in looking at student work	18.6	39.0	42.4
Teachers lack time to work with other teachers during the school year	23.7	33.9	42.4
Teachers lack time for professional development in chemistry	23.7	33.9	42.4
Teachers are not prepared to teach chemistry	28.8	33.9	37.3
Teachers lack time to teach and learn chemistry	35.6	28.8	35.6
Teachers face challenges maintaining discipline	27.1	39.0	33.9
Teachers lack time to prepare lessons	39.0	27.1	33.9
Average	24.1	31.9	44.1

Table 15: Challenges for achieving chemistry education goals: Others

Challenge	Not a barrier	Somewhat significant barrier	Very significant barrier
Students lack motivation to learn	16.9	35.6	47.5
Teachers lack a supportive school culture	15.3	44.1	44.1
Students lack ability/capability/potential	20.3	35.6	44.1
Chemistry curriculum scope and sequence	16.9	49.2	33.9
Students were not well prepared in prior grades	22.0	40.7	37.3
Ministry of Education's policies and practices	32.2	32.2	35.6
Average	20.6	39.6	40.4

instruction. For example, the Ministry of Education (MOE) (MOE, 1996,) observed a "distressing picture of poor in-school performance in mathematics and science and subsequent inadequacy in these areas points to deficiencies at the school level. The deficiency may be in the facilities, the resources or the teaching" (p. 66). In view of this background, it was not surprising for most pre-service chemistry teachers to rank lack of , such as science laboratories, as the main challenge for achieving chemistry education goals in schools.

The findings of this study have implications for teacher education and chemistry teaching and learning. In order to achieve the five goal clusters of chemistry education in schools, teachers should understand them. Furthermore, teachers should rank all the five goal clusters of chemistry education as equally important. For example, their rankings of chemistry education goals revealed that teachers were not well aware that chemistry has a role in solving societal issues. Based on these findings we suggest that teacher educators should provide explicit instruction on the goals of chemistry education to pre-service teachers. Such instruction should also emphasize the equality of the five cluster goals of chemistry education.

Studies have continued to show that teachers' understanding of the goals of science teaching affects their instructional planning, curriculum decisions and instructional practices (Wallace & Kang, 2004). Therefore, teachers' knowledge of the goals of chemistry education has a direct bearing on their instructional practices and the emphasis they would thrust on why learning chemistry is important. We suggest that teacher educators should clearly demonstrate the coverage of these five cluster goals of chemistry in their courses for teachers to see and learn how to address them in a chemistry course. There is no doubt that teachers' knowledge of the goals of chemistry education would help them to plan the course curriculum and instruction that will contribute to scientific literacy among students in schools. Furthermore, stakeholders should pay attention to the challenges for achieving the goals of chemistry education in schools. For example, the government and school districts need to meet their obligations in making resources available for chemistry instruction in schools.

Based on these results, we recommend that future research should examine how chemistry teachers address these five goal clusters of science education in chemistry classrooms.

Conclusions

This study examined Zambian pre-service chemistry teachers' views on the goals of chemistry education, the importance of the goals, and challenges for achieving them in schools. In general, teachers were positive about the goals of chemistry education in schools. However, the pre-service chemistry teachers did not equally rank the five goal clusters of chemistry education. Similarly, teachers did not view the five goal clusters of chemistry education as equally important. Instead, the pre-service chemistry teachers ranked the goals and importance of chemistry education in the following descending order: Career awareness, Scientific methods, Scientific knowledge, Personal needs, and Societal issues. The pre-service chemistry teachers also ranked the challenges for achieving chemistry education goals in the following descending order: Resources, Teacher preparation and Development, government policies, and student issues.

Table 16: ANOVA results on challenges of achieving chemistry education goals

Goal	*Mean*	*SD*	*F*	*df*	*p value*
Resources	82.6	12.0	11.4	2	<0.001
Teacher Development/preparation	73.4	12.4			
Others	73.1	12.5			

Significant at $p < 0.05$.

References

American Association for the Advancement of Science (AAAS) (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

American Association for the Advancement of Science (AAAS) (1996). *Benchmarks for science literacy*. New York: Oxford University Press.

Bauer, H. H. (1992). *Scientific literacy and the myth of the science method*. Urban: University of Illinois Press.

Bybee, R. (1997). Toward an understanding of scientific literacy. In W. Graber & C. Bolte (Eds.), Scientific literacy, (pp. 37 - 68). Kiel, Germany: Institute for Science Education (IPN). Carlton, R. (1963). On scientific literacy. NEA Journal, 52 (4) 33 - 35.

Chiappetta, E.L. & Koballa, T.R. (2010). *Science instruction in the middle and secondary schools* (7th ed.). Boston, MA: Allyn & Bacon.

DeBoer, G.E. (2000). Scientific Literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching, 37*(6), 582 – 601.

Fray, R. B. (2010). *Testing memo 8: Reliability of test scores*. Retrieved from http://www.testscoring.vt.edu/memo08.html

Gayon, E.E.P. (2010). Goals of chemistry education as perceived by chemistry

teachers: Implications for teacher preparation and development. *The International Journal of Learning, 16*(12), 37 – 51.

George, D., & Mallery, P. (2009). *SPSS for Windows step by step: A simple guide and reference 16.0 update*. Boston, MA: Allyn and Bacon.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science. A review of the research. *Journal of Research in Science Teaching, 29*(4), 331-360.

Loughran, J., Smith, K. & Berry, A. (2011). *Scientific literacy under the microscope*. Rotterdam, Netherlands: Sense publishers.

Ministry of Education (1996). *National Policy of Education*. Lusaka: Zambia.

National Research Council (NRC). (1996). *National science education standards.* Washington, DC: National Academy Press.

Pogge, A.F. & Yager, R.E. (1987). Citizen groups' perceived importance of the major goals for school science. *Science Education, 71*(2), 221 – 227.

Savellano, J., & Hernandez, D. (1996). *EDSC 301: History and philosophy of science and technology education*. Quezon City: University of the Philippines Open University and University of the Philippines College of Education.

Shwartz, Y., Ben-Zvi, R., & Hofstein, A. (2005). The importance of involving high-school chemistry teachers in the process of defining the operational meaning of 'chemical literacy'. *International Journal of Science Education, 27*(3), 323 – 344.

Staver, R. (2007). *Teaching science*. Retrieved from http://www.ibe.unesco.org/fileadmin/user_upload/archive/publications/EducationalPracticesSeriesPdf/Practice_17.pdf

Uzuntiryaki, E. & Boz, Y. (2007). Turkish pre-service teachers' beliefs about the importance of teaching chemistry. *Australian Journal of Teacher Education, 32*(4), 1 – 16.

Wallace, C. S. & Kang, N. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: an explanation of competing belief sets. *Journal of Research in Science Teaching*, 41(9), 936-960.

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