

SUBJECT MATTER KNOWLEDGE IN HIGH SCHOOL CHEMISTRY: AN EXAMINATION OF PRE-SERVICE TEACHER EDUCATION

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ABSTRACT: *The study is qualitative in nature, which aimed to determine if the pre-service teacher education curriculum of the University of Science and Technology of Southern Philippines complied with the requirements for the competencies needed in teaching high school chemistry of the Department of Education. Specifically, it examined the content of the teacher education program of the university in terms of subject matter knowledge in junior high school chemistry. Curriculum content analysis was employed in looking at the syllabi of the major courses of the teacher education program in relation to the required content standards in the K-to-12 chemistry curriculum for Grades 7 to 10. The content analysis found no gaps between the teacher education program and the K-to-12 junior high school chemistry curriculum. There was a very sufficient coverage of the content standards in the chemistry learning areas. The study concludes that the teacher education program of the university adequately prepares pre-service teachers for high school teaching in terms of subject matter knowledge in chemistry. It is recommended that the university offer the teacher education program in its satellite campuses.*

Keywords: science education, subject matter knowledge, pre-service teacher education, curriculum content analysis

INTRODUCTION

Chemistry is described as the central science which connects the physical sciences with the life sciences and applied sciences [1]. The universe is subject to the laws of chemistry, while human beings depend on the orderly progress of chemical reactions within their bodies. Thus, as emphasized by Khanam [2], chemistry education is important which necessitates enhancing the quality of teaching, research and development, as well as ensuring that students are equipped with good knowledge to produce intensive goods and services meeting the human need for food, health care products, and other materials aimed at improving the quality of life.

Recent results of the Program for International Student Assessment (PISA) show an alarming performance of Filipino students in the field of science. The PISA of the Organization of Economic Cooperation and Development intended to assess educational systems by measuring 15-year-old students' scholastic performance on mathematics, science, and reading. Results reveal that Filipino students' scores in science ranked 77th out of 77 participating countries [3].

Although academic achievement may be explained by various intellectual and non-intellectual factors, teaching practice has been at the forefront in studies about the influences on students' academic achievement [4, 5, 6, 7, 8]. Perhaps this is a reason why, consequently, the effectiveness of pre-service or initial teacher education (TE) in preparing high quality teachers has been pursued as subject of study [9].

Pre-service or initial TE is composed of subject-matter knowledge, pedagogical skills, capacity to be able to work with a wide range of students/ colleagues/ administrators, and a capacity for continuing these sets of knowledge and skills [10]. There is a divergence in literature about whether subject matter knowledge carries more weight as a predictor of student achievement compared to pedagogical content knowledge. Rollnick and Mavhunga [11] contend that there is a close relationship between the two. Additionally, in a study by Schwille and Dembele [12], some scholars assert TE programs that deliver are those that focus on subject-matter. Nevertheless, the need to prepare pre-service teachers with subject matter knowledge while in the TE program was highlighted in the longitudinal study of Nixon, Hill and Luft [13].

This was confirmed in the interviews among school heads and master teachers assigned at different public schools in the city of Cagayan de Oro, Philippines (where the university under study is located). They expressed their preference for subject matter or content knowledge as the top requirement among the competencies of teachers in science education. Hence, there was a need to examine the preparedness of the university's pre-service teacher in teaching chemistry.

The country's Commission on Higher Education influences the content of TE programs or the curriculum through its issuance of policies, standards, and guidelines (known in the academic community as PSGs). As a source of subject matter knowledge, the curriculum holds the status as the "most powerful determinant affecting teacher content knowledge" [14]. Hence, this serves reason to the examination of teacher knowledge by studying the university's curriculum, represented by the syllabi of the courses.

The researchers determined the need to look at the subject matter gaps between the university's pre-service teacher preparation for chemistry education vis-à-vis the high school science curriculum of the Department of Education (DepEd). This curriculum follows the spiral progression approach that highlights the building of knowledge on previously learned knowledge (i.e., constructivist in nature) under which all subjects are taught under the stages of Understanding by Design.

The desired outcomes are defined through the expectancies in the form of content and performance standards. Content standards refer to what students should know, what they do, and what understanding they construct as they process information. On the other hand, performance standards are what students do or how they use their learning and understanding. Ideally, these content and performance standards form the basis for the development of teacher education programs (www.deped.gov.ph).

METHOD

Curriculum content analysis was the method used in the study. In other recent related studies, content analysis was used in linking course topics with program outcomes [15] in looking at appropriateness of course objectives [16] and curricular learning objectives [17]. Content analysis has likewise been used in evaluating curriculum [18, 19, 20, 21, 22].

Gaps between the university's TE curriculum in science education and the DepEd chemistry curriculum for Grades 7 to 10, specifically the content standards under the learning area, "matter," was examined. The TE program for chemistry is the Bachelor of Secondary Education, Major in Science (BSED-Science), a degree which is completed after finishing 179 credit units. Thirty-six units of this requirement come from general education courses, 45 units are from professional education courses, 81 are from major courses, 14 are from mandated courses, and 3 are from elective courses.

The content in the syllabi of the major courses in the TE program, particularly the topics and learning outcomes, were compared against the content standards of the DepEd chemistry curriculum through a coding process. The first level of analysis involved determining a one-to-one correspondence of text chunks or expressions. The second level of analysis involved the matching of synonymous texts or expressions between the syllabi and the DepEd chemistry curriculum. At this point, the researcher determined if the text chunk or expression in the syllabus (topic or learning outcome) represented the content standard that was analyzed. This was the interpretation process known as latent content analysis, which focused on underlying meanings of the text chunk or expression.

After the coding was completed, the slotted units were validated with the instructor of the respective major courses through the process of member checking. The analysis produced a gap analysis matrix, which gave indications of the degree of coverage of the competencies, and thus pointing out the gaps. To determine the level of sufficiency, the researchers developed an interpretation guide based on the coverage of the content standards under the DepEd chemistry curriculum according to the topics and learning outcomes in the syllabi.

RESULTS AND DISCUSSION

Column 3 in the Table below shows the content standards in different learning areas that are listed per grade level, according to the spiral progression approach that the DepEd curriculum follows. The analysis demonstrated that there is very sufficient coverage of the DepEd content standards about "matter." This implies that pre-service teachers of the university are prepared to teach topics on "matter."

As shown in Table 1, preparation for the content about "matter" in all levels, from Grade 7 to Grade 10, was very sufficient. The common properties of acidic and common properties of acidic and basic mixtures (Grade 7) and the periodic table of elements as an organizing tool to determine the chemical properties of elements (Grade 8) were the specific content standards that have the highest coverage count. Acid and base reactions are common chemical reactions that are found in all aspects of chemistry, while the periodic table of elements is often used as reference for chemical and physical properties of elements.

Table 1.: Coverage of the content standards under the chemistry learning area, "matter"

Learning Area	Grade Level	Content Standards	Coverage	
Matter	7	Properties of solutions	Very Sufficient	
		Properties of substances, distinguished from mixtures	Very Sufficient	
		Classifying substances as elements or compounds	Very Sufficient	
		Common properties of acidic and basic mixtures	Very Sufficient	
		Properties of metals and non-metals	Very Sufficient	
	8	Particle nature of matter as basis for explaining properties, physical changes, and structure of substances and mixtures	Very Sufficient	
		Identify of substance according to its atomic structure	Very Sufficient	
		Periodic table of elements as an organizing tool to determine the chemical properties of elements		
		9	Development of atomic models that led to the description of the behaviour of electrons within atoms	Very Sufficient
			Combination of atoms through transfer and sharing of electrons	Very Sufficient

	Forces that hold metals together	Very Sufficient
	Types of bonds that carbon forms resulting to diversity in carbon compounds	Very Sufficient
	Unit and mole that quantitatively measures the number of very small particles of matter	Very Sufficient
10	Information stored in DNA as being used to make proteins	Very Sufficient
	How changes in a DNA molecule may cause changes in its product	Very Sufficient
	Behavior of gases based on the motion and relative distance between gas particles	Very Sufficient
	Structure of biomolecules, which is mostly made up of carbon, hydrogen, oxygen and nitrogen	Very Sufficient
	Chemical reactions associated with biological and industrial processes affecting life and environment	Very Sufficient

Common properties of acidic and basic mixtures, a content standard in Grade 7, is taught in nearly all chemistry courses which are offered to students during the second and third year of study. Similarly, the concepts of particle nature of matter as basis for explaining properties, physical changes, and structure of substances and mixtures (Grade 8 content) and the periodic table of elements as an organizing tool to determine the chemical properties of elements (Grade 8 content) were covered very sufficiently during the second and third year of study.

There was very sufficient coverage of 100 percent of the 18 content standards under the learning area, “matter.” Thus, the analysis found evidence for substantial preparation of pre-service teachers under the BSED-Science teacher education program to teach concepts in “matter.” There was no gap in terms of capacitating the pre-service teachers to teach the topics related to “matter.”

CONCLUSION AND RECOMMENDATION

The BSED-Science teacher education program of the university teaches the concepts related to “matter” that are introduced at different levels in the DepEd science curriculum in a spiral progression. No major gaps were found between the topics and learning outcomes of the TE program when juxtaposed with the DepEd curriculum content standards of the learning area “matter” in chemistry. This renders the pre-service teachers of the university with ample subject matter knowledge about “matter” and have the capacity to teach the related concepts from Grade 7 until Grade 10. In consideration of the findings, it is recommended that the BSED-Science teacher education program be offered in the university’s satellite campuses thereby expanding the impact of a quality teacher preparation to the region where university-level education is not available.

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