SUPPLYING THE DEMAND FOR SUBJECT MATTER KNOWLEDGE IN JUNIOR HIGH SCHOOL PHYSICS: A CURRICULUM CONTENT ANALYSIS

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ABSTRACT: *International studies point out that Filipino students have a limited understanding of scientific concepts. Hence, this study examined how the teacher education program of the university under study is addressing the subject matter pertaining to the knowledge required by teachers of junior high school physics. 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 physics curriculum for Grades 7 to 10. The content analysis found no gap between the teacher education program and the K-to-12 junior high school physics curriculum. There was sufficient to very sufficient coverage of the content standards in the following physics learning areas: Force, Motion, and Energy. 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 physics. It is recommended that the university offer the teacher education program in its satellite campuses and strengthen it further by infusing K-to-12 identified content related to 'sound' and 'light' in the major courses, thus maximizing the level of teacher preparedness in teaching physics.*

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

Philippines

INTRODUCTION

The "Trends in International Mathematics and Science Study" [1] revealed that Filipino students have a limited understanding of scientific concepts and limited knowledge of foundational science facts. In a prior report of the Organization for Economic Cooperation and Development [2], this dire situation was already highlighted, revealing that the Filipino students' average scores in science ranked 77th out of 77 participating countries.

While there are many factors that can be attributed to students' low academic achievement in science, one significant factor relates to teaching practice. This could be a reason why the effectiveness of pre-service or initial teacher education (TE) in preparing high-quality teachers has been constantly questioned [3]. Hence, designers of TE programs continue to grapple with decisions about what knowledge, skills, and dispositions should be pursued in the TE curriculum.

In a quick survey among school heads and master teachers at different schools in Cagayan de Oro City, Philippines, where the university under study is located, subject matter or content knowledge came out as the top must-have among the competencies required of teachers in science education. Along the line of Musset's [4] recommendation that TE programs should be based on the needs of schools, the researchers found it necessary to look for gaps between the university's pre-service teacher preparation for science education vis-à-vis the K-to-12 junior high school science curriculum in terms of subject matter knowledge. Additionally, the Department of Education has long urged the modification of the pre-service teacher training or education to conform to the requirements of the K-to-12 program [5].

While the university's TE programs are assumed to be aligned with the Commission on Higher Education policies, standards, and guidelines, it was imperative to ascertain the perceived disconnect so that possible remedies may be recommended to strengthen the TE program in subject matter knowledge. As a source of subject matter knowledge, the curriculum holds the status as the "most powerful determinant affecting teacher content knowledge" [6]. Hence, this serves reason to the examination of teacher knowledge by studying the university's curriculum, represented by the course syllabi.

From among the branches of science, physics holds a certain distinction because of the high level of abstraction and idealization that it requires [7]. This could explain why most research on subject matter knowledge in science was conducted under the domain of physics, with most researchers pursuing specific concepts rather than subject matter structures [8]. Hence, this study attempts congruence to the leaning towards the examination of preparedness in physics education.

LITERATURE REVIEW

Pre-service or initial teacher education (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 [4]. Meanwhile, Darling-Hammond [9] determined three areas of knowledge that intersect in teacher education programs: (1) knowledge of learners and how they learn; (2) understanding of curriculum content and goals; and (3) understanding of and skills for teaching. These conceptualizations highlight subject matter knowledge or content knowledge as an important component in TE programs.

Subject matter knowledge has been considered the heart of the teacher's practice [10]. It refers to the understanding of facts, concepts, and practices of a scientific discipline that is a prerequisite to the development of pedagogical content knowledge [10] [11]. In many studies, subject matter knowledge has been quantified as the number of science courses taken [8] or the subject-matter course credits [6].

An earlier distinction was made by Schwab [12] which categorized subject matter knowledge into substantive and syntactic. The substantive structure relates to the organization of concepts, facts, principles, and theories. On the other hand, syntactic structures are rules of evidence and proof used to generate and justify knowledge claims in the discipline. This classification or organization provides a framework in analyzing TE programs with regard to subject matter that is studied by pre-service teachers.

There is a divergence in the literature about whether subject matter knowledge carries more weight as a predictor of student achievement compared to pedagogical content knowledge. Rollnick and Mavhunga [10] contend that there is a close relationship between the two. In terms of effect to student achievement, some studies assert that pedagogical knowledge has more impact than content knowledge [13]. This is echoing what UNESCO [14] discovered that although research findings are inconclusive, the best pre-service programs emphasize pedagogical content knowledge.

However, in a study by Schwille and Dembele [15], some scholars assert TE programs that deliver are those that focus on the subject matter. In addition, a study linking teacher professional development to student achievement pointed out that teacher knowledge shapes classroom instruction [16] and significantly affects student learning [17].

While Abell [8] claimed the gravitation of studies on subject matter knowledge to the area of physics, the search for literature yielded only a handful of sources. In the phenomenological study of Birth, Claes & Pedersen [18], the participants contend that subject matter content contributes significantly to confidence in teaching, adding further that physics is not easy to teach without adequate subject matter knowledge. Other studies focused on effective approaches in strengthening content knowledge in physics teacher education through multi-level scaffolding [19] and educative science curriculum materials [20].

METHOD

The method of curriculum content analysis [21] was employed in this research undertaking. In other recent related studies, content analysis was used in linking course topics with program outcomes [22] in looking at the appropriateness of course objectives [23] and curricular learning objectives [24]. Content analysis has likewise been used in evaluating curriculum [25, 26, 27, 28].

In this study, curriculum content analysis was used to search for the gaps between the university's TE curriculum in science education and the K-to-12 physics curriculum for Grades 7 to 10, specifically the content standards under the following learning areas: Force, Motion, and Energy. The TE program for physics of the university under study is the Bachelor of Secondary Education, Major in 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 81-unit major courses in the TE program, particularly the topics and learning outcomes, were compared against the content standards of the K-to-12 physics curriculum through a coding process. The first level of analysis entailed observing a one-to-one correspondence of text chunks or expressions. For instance, the topic "laws of motion" in the syllabus was matched with the same text chunk "laws of motion" in the K-to-12 physics curriculum content standard. This was counted and recorded in the gap analysis matrix as one unit. In the same manner, a learning outcome that had a one-to-one correspondence with a K-to-12 physics curriculum content standard had a count of one unit, given no count from the topic comparison. Meanwhile, a topic or learning outcome in the syllabus that matched two or more content standards in the K-to-12 physics curriculum at different grade levels earned a count of two or more units.

The second level of analysis involved the matching of synonymous texts or expressions between the syllabi and the K-to-12 physics 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 exposing the gaps. To determine the level of sufficiency, the researchers developed an interpretation guide based on the coverage of the content standards under the K-to-12 physics curriculum according to the topics and learning outcomes in the syllabi.

RESULTS AND DISCUSSION

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 K-to-12 curriculum follows. The analysis demonstrated that there is very sufficient coverage of the K-to-12 content standards about motion and force. Pre-service teachers are prepared to teach motion in one dimension, Newton's three laws of motion, and uniform circular motion, while they are in the second and third year of the TE program. During these years, they are enrolled in the following university Physics courses: Mechanics; Thermodynamics, Acoustics, and Optics; and Electricity and Magnetism. Meanwhile, the concepts of projectile motion, impulse and momentum, and conservation of linear momentum are likewise taught in the second and third year of study under the courses, Mechanics and Modern Physics, respectively.

Table 1: Coverage of the content standards under each learning area of physics

Learning Area	Grade Level	Content Standards	Coverage
Motion	7	Motion in one dimension	Very sufficient
	8	Newton's three laws of motion and uniform circular motion	Very sufficient
	9	Projectile motion, impulse, and momentum, conservation of linear momentum	Very sufficient

Energy	7	Waves as carriers of energy	Very sufficient
	8	Work using constant force, power, gravitational potential energy, kinetic energy, and elastic potential energy	Very sufficient
	9	Conservation of mechanical energy	Very sufficient
Sound	7	Characteristics of sound	Sufficient
	8	Propagation of sound through solid, liquid, and gas	Sufficient
Light	7	Characteristics of light	Very sufficient
	8	Properties and characteristics of visible light	Sufficient
	10	Images formed by different types of mirrors and lenses	Sufficient
Heat	7	Heat transfer	Very sufficient
	8	Heat and temperature, and the effects of heat on the body	Very sufficient
	9	Relationship among heat, work, and efficiency	Very sufficient
Electricity and Magnetism	7	Charges and the charging processes	Very sufficient
	8	Current-, voltage-resistant relationship, electric power, electric energy, and home circuitry	Very sufficient
	9	Generation, transmission, and distribution of electrical energy from power plants to home	Very sufficient
Electromagnetic Spectrum	10	Different regions of the electromagnetic spectrum	Very sufficient
		Relationship between electricity and magnetism in electric motors and generators	Sufficient

Furthermore, the analysis found evidence for substantial preparation of pre-service teachers to teach concepts in energy. As shown in the Table, there is very sufficient coverage of the K-to-12 physics curriculum content standards. Waves as carriers of energy, a content standard in Grade 7, is taught in nearly all physics courses that are offered to students during the second and third years of study. Similarly, the concepts of work using constant force, power, gravitational potential energy, kinetic energy, and elastic potential energy (Grade 8 content) and the conservation of mechanical energy (Grade 9 content) are covered very sufficiently during the second and third year of study. In addition, the analysis also revealed that the foundational concepts of energy are taught in the non-physics course titled Earth and Space Science while students are yet in the first year of study.

However, there was just enough or sufficient coverage of the characteristics of sound (Grade 7) and propagation of sound (Grade 8) through its inclusion as a topic in one second-year course titled Thermodynamics, Acoustics, and Optics. Similarly, this sufficient coverage by the same second-year course was also found in the content standards related to properties and characteristics of visible light (Grade 8) as well as those related to images formed by different types of mirrors and lenses (Grade 10).

Regarding the content standards under the learning area related to heat, there is very sufficient coverage of the content standards in Grade 7 through Grade 9. The concepts relating to the transfer of heat, heat, and temperature, the effects of heat on the body, and the relationship among heat, work, and efficiency are learned by pre-service teachers during the second and third year of study in the TE program.

As further shown in the Table, there is a mix of very sufficient and sufficient coverage of the content standards in the learning areas, Electricity, and Electromagnetism, in the university's TE program for science education. The program covers the K-to-12 science curriculum content about electrical energy, following a spiral progression at different grade levels, during the second year of study in the program.

However, the concept pertaining to the relationship between electricity and magnetism in electric motors and generators is taught solely in one course, Electricity and Magnetism, which is taken during the third year of study. While the coverage is in only one course and thus interpreted as sufficient, this could mean an expansive

exploration and understanding of the subject as the K-to-12 content standard exactly matches the course title.

Overall, the content analysis of the syllabi reveals ample preparedness by the university of pre-service teachers for teaching physics in the junior high school level. There is very sufficient coverage of 74 percent of the 19 content standards under six learning areas and sufficient coverage of 26 percent of the same content standards. Specifically, this sufficient coverage was noted in the teaching of the concepts of 'sound' and 'light' during the second year of study in the TE program for science education.

CONCLUSION AND RECOMMENDATIONS

The TE program of the university for science education teaches many of the physics concepts that are introduced at different levels in the K-to-12 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 K-to-12 curriculum content standards of the learning areas in physics. This renders the pre-service teachers at the university capable to teach physics in junior high school science, from Grade 7 until Grade 10, in terms of substantive subject matter knowledge.

In consideration of the findings, it is recommended that the TE program be offered in the university's satellite campuses thereby expanding the impact of quality teacher preparation in the countryside where university-level education is not available. Prior to this offer, it is recommended that the content standards in 'sound' and 'light' be infused in other courses during the third year of study.

Under the perspective that perhaps the course syllabi do not provide an accurate picture of what is learned from studying a subject matter, the researchers further recommend a comprehensive four-year assessment of pre-service teachers on all the content standards under the learning areas of the K-to-12 physics curriculum. This measurement will support the assertion that the demand for subject matter knowledge is supplied by the university.

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