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Graduate Perception-Based Evaluation of the Philippines Senior High School Science, Technology, Engineering, and Mathematics Curriculum Adequacy: Domain Analysis of Core, Specialized and Contextualized Subjects

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ABSTRACT

Purpose of the study: This study aimed to determine the level of adequacy of the Senior High School Science,Technology, Engineering, and Mathematics curriculum in the Philippines by evaluating its three curricular domains: core subjects, specialized subjects, and contextualized subjects, based on the perceptions of college students who completed the Science, Technology, Engineering, and Mathematics strand.

Methodology: A quantitative research design was employed using a structured survey questionnaire with a 4-point Likert scale, with reliability established through Cronbach's alpha (α = 0.87). A total of 159 college Science, Technology, Engineering, and Mathematics students in Benguet, Philippines were selected through random sampling. Data were analyzed using weighted mean and standard deviation, while differences among curriculum domains were examined using the Friedman test, with post hoc pairwise comparisons conducted using the Wilcoxon signed-rank test with Bonferroni correction. Interpretation was guided by established curriculum evaluation frameworks.

Main Findings: Core subjects were rated as adequate (M = 3.16, SD = 0.44), specialized subjects as highly adequate (M = 3.60, SD = 0.45), and contextualized subjects as adequate (M = 3.18, SD = 0.50). Mathematics and science-related subjects received higher ratings, whereas contextualized and humanities-related subjects showed greater variability in perceived relevance to Science,Technology,Engineering, and Mathematics preparation. The Friedman test revealed a statistically significant difference among the three domains ($\chi^2 = 75.77$, $p < 0.001$), with specialized subjects rated significantly higher than both core and contextualized subjects.

Novelty/Originality of this study: This study provides a domain-based evaluation of Science,Technology,Engineering, and Mathematics curriculum adequacy by separately examining core, specialized, and contextualized subjects through the perspective of college-level Science, Technology, Engineering, and Mathematics Senior High School graduates. It advances existing knowledge by offering empirical evidence on curriculum alignment and perceived preparedness, helping inform targeted curriculum refinement within the Philippine K–12 Science, Technology, Engineering, and Mathematics framework.

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1. INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) education has become a global priority due to its central role in innovation, economic growth, and workforce development in knowledge-based societies. International reports consistently emphasize that strengthening Science, Technology, Engineering, and Mathematics education systems is essential for achieving sustainable development goals and responding to rapid technological transformation [1]-[5]. The Organisation for Economic Co-operation and Development (OECD) further highlights that student performance in mathematics and science is strongly associated with national productivity, technological advancement, and long-term economic resilience [4], [6], [7]. In addition, contemporary research underscores that effective Science, Technology, Engineering, and Mathematics education enhances learners' scientific literacy, problem-solving ability, and adaptability in complex and rapidly changing environments [5], [8]-[10]. Central to achieving these outcomes is curriculum coherence, which ensures alignment among learning objectives, instructional practices, and assessment, as well as the integration of real-world applications and interdisciplinary competencies [5], [8], [10], [11].

In Southeast Asia and other developing education systems, recent reforms have focused on improving Science, Technology, Engineering, and Mathematics curriculum quality through competency-based approaches, interdisciplinary integration, and stronger alignment with higher education and labor market demands [4], [12], [13]. Despite these efforts, studies across the region continue to report persistent challenges, including gaps in foundational competencies, uneven implementation of inquiry-based learning, and limited integration of technology-enhanced instruction [9], [14], [15]. These findings suggest that while curriculum frameworks have evolved, their effectiveness depends not only on design but also on the quality of implementation, alignment, and contextual relevance.

In the Philippines, the implementation of the K to 12 Basic Education Program through Republic Act No. 10533 introduced the Senior High School system as a major reform aimed at improving academic preparedness and aligning basic education with international standards [16]. Within this system, the Science, Technology, Engineering, and Mathematics strand is designed to prepare learners for tertiary education in science-related fields through a structured curriculum consisting of core subjects, specialized subjects, and contextualized subjects [17]. This structure is grounded in established curriculum theories. Tyler's model emphasizes the alignment of objectives, learning experiences, and evaluation [18], while Biggs' theory of constructive alignment highlights the importance of coherence among intended learning outcomes, teaching strategies, and assessment practices [19]. Supporting these perspectives, contemporary research affirms that alignment and coherence are critical determinants of student learning outcomes and effective knowledge transfer [8], [11]. Furthermore, experiential and inquiry-based learning approaches have been shown to enhance conceptual understanding and student engagement when appropriately scaffolded and guided [8], [20].

Despite these reforms, international large-scale assessments continue to raise concerns about learning outcomes in the Philippines. Results from the Programme for International Student Assessment (PISA) 2022 indicate that Filipino learners perform significantly below the global average in mathematics and science, reflecting persistent challenges in both foundational knowledge and higher-order thinking skills [6], [21]. Similar patterns have been observed in other developing education systems, where gaps between intended and implemented curricula contribute to low performance levels [3], [13], [15]. Recent research also highlights issues such as weak mastery of foundational concepts, limited opportunities for inquiry-based and problem-based learning, and insufficient preparation for the academic demands of higher education [9], [22]. These challenges suggest that while the curriculum structure is theoretically aligned with global standards, its adequacy in practice remains uncertain.

To address these concerns, systematic evaluation frameworks are necessary. The Context, Input, Process, and Product (CIPP) evaluation model provides a comprehensive approach for assessing curriculum effectiveness in terms of design, implementation, and outcomes [23]. Recent studies emphasize that curriculum adequacy should be evaluated not only in terms of content coverage but also in relation to learner experiences, transition to higher education, and perceived preparedness [24], [25]. In this regard, graduate perspectives are particularly valuable, as they provide insight into how well the curriculum supports actual academic demands, bridging the gap between intended and achieved learning outcomes.

However, existing studies on the Philippine K to 12 reform have largely focused on implementation challenges, teacher readiness, and general stakeholder perceptions, with limited attention to a domain-specific evaluation of the Science, Technology, Engineering, and Mathematics curriculum. Most studies treat the curriculum as a single construct, without examining how its individual components, core subjects, specialized subjects, and contextualized subjects differentially contribute to student preparedness. Furthermore, there is a lack of recent empirical studies capturing the perspectives of graduates who have transitioned from Senior High School to college Science, Technology, Engineering, and Mathematics programs. This gap limits a more precise understanding of which curriculum domains effectively support learning and which require improvement.

This study addresses these gaps by conducting a domain-based evaluation of the Science, Technology, Engineering, and Mathematics curriculum, focusing on its core, specialized, and contextualized components. The novelty of this research lies in its disaggregated analysis, which enables a more detailed assessment of curriculum adequacy across different domains. The urgency of this study is underscored by the continued low performance of Filipino learners in international assessments and ongoing curriculum review initiatives aimed at strengthening Senior High School programs [6], [16]. Generating empirical evidence at this stage is critical to informing policy decisions and improving alignment between secondary education and higher education requirements.

Therefore, this study aims to determine the level of adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum in the Philippines in terms of (a) core subjects, (b) specialized subjects, and (c) contextualized subjects. In addition, the study seeks to examine the differences in perceived adequacy across these three curriculum domains. By providing a comprehensive, domain-based analysis grounded in learner perceptions, the study aims to generate empirical evidence that can inform curriculum enhancement and strengthen the alignment between secondary education and the academic demands of college-level Science, Technology, Engineering, and Mathematics programs.

2. RESEARCH METHOD

2.1. Research Design

This study employed a quantitative research design to examine the adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum in the Philippines. A quantitative approach was utilized to gather numerical data that could be analyzed statistically, providing an objective basis for describing respondents' assessments [26]. The design allowed for the systematic assessment of respondents' perceptions regarding the adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum without manipulating variables.

Specifically, this design enabled the researcher to determine the level of adequacy of the curriculum in terms of core subjects, specialized subjects, and contextualized subjects, thereby providing an evidence-based understanding of how these curricular domains are perceived in relation to their intended educational purposes. In addition, the design supported comparative analysis to determine whether there are significant differences in the perceived adequacy among these three curriculum domains, allowing for a more comprehensive evaluation of how each domain contributes to overall curriculum effectiveness.

2.2. Research Procedure

The research procedure followed a systematic and structured sequence of steps to ensure methodological rigor and the reliability of the findings. The process began with the identification of the research problem, which focused on evaluating the adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum in preparing students for higher education. This was followed by a comprehensive review of related literature, which provided the theoretical and empirical foundation of the study and guided the development of the research framework.

Identification of Research Problem
↓
Review of Related Literature
↓
Development of Research Instrument
↓
Validation and Reliability Testing
↓
Selection of Respondents (Sampling)
↓
Data Collection (Survey Administration)
↓
Data Coding and Organization
↓
Statistical Analysis (Descriptive + Friedman test)
↓
Interpretation of Results
↓
Conclusion and Recommendations

Figure 1. Research Procedure Flowchart

Subsequently, the research instrument was developed based on the identified domains of curriculum adequacy, namely core subjects, specialized subjects, and contextualized subjects. The instrument underwent validation and reliability testing to ensure that it accurately measured the intended constructs and produced consistent results. Reliability analysis yielded an acceptable level of internal consistency, supporting the use of the instrument for data collection.

Following instrument preparation, the selection of respondents was conducted using a random sampling technique. Eligible participants were identified based on predefined inclusion criteria, ensuring that only individuals who had completed the Senior High School Science, Technology, Engineering, and Mathematics strand and were currently enrolled in higher education were included in the study.

The next phase involved data collection through survey administration, during which respondents were provided with clear instructions and sufficient time to complete the questionnaire. Ethical considerations, including voluntary participation and confidentiality of responses, were strictly observed throughout the process.

After data collection, the responses were subjected to data coding and organization to prepare them for statistical analysis. The cleaned and organized data were then analyzed using both descriptive and inferential statistical techniques, including the computation of weighted means, standard deviations, and the Friedman test to examine differences in perceived adequacy across curriculum domains.

Finally, the results were interpreted in relation to the study objectives, leading to the formulation of conclusions and evidence-based recommendations. This systematic procedure ensured that the study was conducted in a logical, transparent, and replicable manner, thereby enhancing the validity and credibility of its findings.

2.3. Research Subjects and Sampling Procedure

The target population of this study consisted of approximately 445 alumni of the Senior High School Science, Technology, Engineering, and Mathematics strand from selected institutions in Benguet, Philippines. Alumni were chosen as respondents because they have completed the curriculum and transitioned to higher education, allowing them to provide informed evaluations of how well the curriculum prepared them for college-level academic demands. From this population, a total of 159 college students were selected as respondents. The sample size was deemed sufficient for statistical analysis and representation of the population.

A random sampling technique was employed to ensure that all qualified alumni had an equal chance of being selected. This method helped minimize selection bias and enhance the representativeness of the sample. The inclusion criteria required that participants must have completed the Senior High School Science, Technology, Engineering, and Mathematics strand and must be currently enrolled in a college program.

2.4. Research Instrument

The primary instrument used in this study was a survey questionnaire designed to gather data on the perceived adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum. The instrument demonstrated acceptable internal consistency, obtaining a Cronbach's alpha value of 0.87, indicating good reliability for measuring the constructs under investigation [27]. The questionnaire was divided into two parts: the first part consisted of items related to the respondents' demographic profile, while the second part included a series of indicators aimed at evaluating the respondents' perceptions of how adequate the Senior High School Science, Technology, Engineering, and Mathematics curriculum is, particularly in relation to its core subjects, specialized subjects, and contextualized subjects. This structure allowed the researcher to collect both background information and standardized evaluative responses necessary for quantitative analysis.

Table 1. Part II of the Research Instrument

Domain	Number Of Items	Cronbach's Alpha Value
Core Subjects	18	0.87
Specialized Subjects	9	
Contextualized Subjects	7	

2.5. Data Collection Procedure

The data collection process was carried out systematically to ensure the accuracy and reliability of the information gathered. Before data gathering, the researcher prepared the survey questionnaire and secured the necessary permissions to conduct the study. Potential respondents who met the study criteria were identified and informed about the purpose and nature of the research.

The survey questionnaire was then administered to college students who previously completed the Senior High School Science, Technology, Engineering, and Mathematics strand. Participants were provided with clear instructions on how to answer the instrument and were given sufficient time to complete it, ensuring that responses were based on their honest perceptions and experiences. Participation was voluntary, and confidentiality of responses was assured to promote openness and accuracy in answering.

After the administration process, the completed questionnaires were collected, reviewed for completeness, and organized for data coding and statistical analysis. This structured procedure ensured that the data gathered were consistent, reliable, and suitable for assessing the adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum.

2.6. Data Analysis Techniques

The data were analyzed using both descriptive and inferential statistical techniques. For descriptive analysis, the weighted mean was used to determine the level of perceived adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum across the domains of core subjects, specialized subjects, and contextualized subjects. The standard deviation was computed to assess the variability and consistency of the responses.

For inferential analysis, the Friedman test was employed to determine whether there are statistically significant differences in the perceived adequacy among the three curriculum domains. The level of significance was set at 0.05. When a significant difference was identified, a post hoc pairwise comparisons conducted using the Wilcoxon signed-rank test with Bonferroni correction to determine which specific domains differed from one another.

These statistical procedures ensured both a descriptive understanding and a comparative evaluation of curriculum adequacy, aligning with the objectives of the study and providing a robust basis for interpreting differences across curriculum domains [28], [29].

3. RESULTS AND DISCUSSION

3.1. The Level of Adequacy of the Core Subjects of Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Table 2 presents the respondents' assessment of the adequacy of the core subjects included in the Senior High School Science, Technology, Engineering, and Mathematics curriculum. The results show an overall mean of 3.16 with a standard deviation of 0.44, interpreted as Adequate. Beyond indicating general sufficiency, the relatively low variability suggests a convergence of experiences among respondents, where smaller standard deviations indicate more consistent responses across participants [30], implying that the perceived adequacy of the core curriculum is not isolated to specific contexts but reflects a broadly shared educational experience. This consistency supports the intended role of core subjects as foundational components of the K–12 framework, which aim to develop general competencies necessary for lifelong learning and academic transition [16], [17].

Table 2. The Level of Adequacy of Core Subjects of Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Core Subjects	Level of Adequacy		
	Mean	SD	DI
Personal Development/Pansariling Kaunlaran	3.14	0.74	A
Oral Communication	3.29	0.63	HA
Komunikasyon At Pananaliksik Sa Wika At Kulturang Pilipino	3.00	0.72	A
General Mathematics	3.62	0.61	HA
Physical Education And Health	2.99	0.83	A
Earth And Life Science	3.45	0.70	HA
Disaster Readiness And Risk Reduction	3.29	0.74	HA
Reading And Writing	3.17	0.72	A
Pagbasa At Pagsusuri Ng Iba`t Ibang Teksto Tungo Sa Pananaliksik	2.90	0.79	A
21st Century Literature From The Philippines And The World	3.04	0.82	A
Statistics and Probability	3.55	0.64	HA
Physical Education And Health	3.03	0.82	A
Media And Information Literacy	3.21	0.68	A
Physical Education And Health	3.05	0.84	A
Introduction To Philosophy Of The Human Person	3.09	0.85	A
Understanding Culture, Society And Politics	3.09	0.79	A
Contemporary Philippine Arts From The Regions	2.97	0.85	A
Physical Education And Health	3.02	0.85	A
Overall	3.16	0.44	A

Legend: 3.26 – 4.00 (Highly Adequate); 2.51 – 3.25 (Adequate); 1.76 – 2.50 (Inadequate); 1.00 – 1.75 (Highly Inadequate)

A closer examination of individual subjects reveals that General Mathematics (M = 3.62, SD = 0.61) and Statistics and Probability (M = 3.55, SD = 0.64) obtained the highest ratings. This pattern is not merely indicative of preference but reflects the functional role of mathematical competence in Science, Technology, Engineering, and Mathematics learning. Mathematics operates as a foundational language of Science, Technology, Engineering, and Mathematics disciplines, enabling abstraction, modeling, and analytical reasoning required in higher education. At the same time, mathematics learning is cognitively demanding, and difficulties in foundational numerical and problem-solving skills can lead to persistent low achievement if not adequately addressed [31]-[33]. The relatively low dispersion further indicates that this perception is widely shared, suggesting that the mathematics components of the curriculum are both relevant and consistently delivered across different learning environments. This points to effective alignment between intended learning outcomes and the cognitive demands of tertiary Science, Technology, Engineering, and Mathematics education, consistent with the principles of constructive alignment [19].

Similarly, science-oriented core subjects such as Earth and Life Science (M = 3.45, SD = 0.70) and Disaster Readiness and Risk Reduction (M = 3.29, SD = 0.74) were evaluated as Highly Adequate. These findings suggest that respondents recognized the value of these subjects in building foundational scientific literacy. Scientific literacy is not limited to content knowledge but includes the ability to interpret data, evaluate evidence, and apply scientific reasoning in real-world contexts [8], [11], [34]. However, the slightly higher variability compared to mathematics subjects indicates that the quality or depth of learning experiences in these subjects may differ across contexts, reflecting broader systemic disparities in learning conditions and instructional support [15], [21].

Communication-oriented subjects, including Oral Communication (M = 3.29, SD = 0.63) and Reading and Writing (M = 3.17, SD = 0.72), were also perceived as adequate to highly adequate. While these subjects are not directly associated with technical content, their role in Science, Technology, Engineering, and Mathematics education is increasingly recognized as essential. Effective communication skills are necessary for articulating complex ideas, engaging in collaborative problem-solving, and disseminating scientific knowledge [34], [35]. The moderate variability in responses suggests that students may differ in how they perceive the relevance of these skills to their Science, Technology, Engineering, and Mathematics experiences, which may depend on the extent to which communication tasks are integrated into discipline-specific contexts. This reflects a broader issue in Science, Technology, Engineering, and Mathematics education, where transferable skills are often undervalued when not explicitly connected to technical applications [35].

In contrast, humanities-oriented subjects such as Contemporary Philippine Arts from the Regions (M = 2.97, SD = 0.85) and Pagbasa at Pagsusuri ng Iba't Ibang Teksto (M = 2.90, SD = 0.79) received comparatively lower mean scores and exhibited higher variability. This pattern suggests not only lower perceived relevance but also a lack of consensus among respondents. The higher dispersion indicates that students' experiences with these subjects are more heterogeneous, likely influenced by individual interests, instructional methods, or perceived alignment with their academic goals. From a cognitive and motivational perspective, learners tend to assign higher value to subjects that demonstrate clear utility in achieving their academic objectives. In Science, Technology, Engineering, and Mathematics pathways, this often translates to prioritizing subjects that directly support technical competence and measurable academic performance, such as mathematics and science [6], [7]. However, this perception may overlook the broader role of the humanities in fostering critical thinking, ethical reasoning, and creativity, competencies that are increasingly recognized as essential in addressing complex, real-world Science, Technology, Engineering, and Mathematics challenges [2], [36].

Overall, the results indicate that while core subjects are generally perceived as adequate, their perceived effectiveness is not uniform across domains. Subjects that demonstrate direct and visible connections to Science, Technology, Engineering, and Mathematics competencies, particularly mathematics and science, are evaluated more positively and consistently, whereas subjects with more indirect or implicit contributions exhibit lower ratings and greater variability. This pattern highlights the multidimensional nature of curriculum adequacy, where perceived relevance plays a critical role in shaping both the level and consistency of student evaluations. Within the CIPP evaluation framework, this suggests that while the input (curriculum design) is structurally sound, variations in process (implementation and contextualization) may influence how different components are experienced by learners, consistent with evidence that learning outcomes depend heavily on how effectively curricula are enacted in practice [15], [23].

These findings point to a need for stronger integration across subject domains. The lower perceived relevance of humanities and some communication-oriented subjects does not necessarily indicate a deficiency in content but rather a gap in how these subjects are connected to Science, Technology, Engineering, and Mathematics learning. Curriculum coherence theory emphasizes that learning is most effective when connections between subjects are explicit and systematically reinforced, as weak or implicit connections can limit learners' ability to recognize the relevance of different subjects within STEM contexts [37], [38]. When such connections are weak or implicit, students may fail to recognize the relevance of certain subjects, leading to uneven perceptions of adequacy.

The results underscore the importance of interdisciplinary integration within the Science, Technology, Engineering, and Mathematics curriculum. International frameworks advocate for the embedding of nontechnical competencies, such as communication, ethical reasoning, and cultural awareness, within Science, Technology, Engineering, and Mathematics learning contexts rather than treating them as isolated domains [2], [11]. Without deliberate integration, these subjects risk being perceived as peripheral rather than integral to Science, Technology, Engineering, and Mathematics education. Strengthening contextualization through strategies such as interdisciplinary projects, applied learning tasks, and real-world problem-solving may enhance both the perceived and actual contribution of core subjects to Science, Technology, Engineering, and Mathematics readiness.

3.2. The Level of Adequacy of the Specialized Subjects of the Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Table 3 presents the respondents' assessment of the adequacy of the specialized subjects in the Senior High School Science, Technology, Engineering, and Mathematics curriculum. The overall mean of 3.60 with a standard deviation of 0.45 indicates that the specialized subjects were perceived as highly adequate. Beyond a favorable evaluation, the relatively low dispersion suggests a high degree of convergence in student experiences, implying that the perceived effectiveness of specialized subjects is not context-specific but consistently recognized across respondents. This consistency is significant because it reflects not only curriculum design strength but also a level of implementation stability across different learning environments. In practical terms, students who have transitioned to higher education appear to regard specialized subjects as the most reliable component of their prior academic preparation, aligning with the intended function of the K–12 Science, Technology, Engineering, and Mathematics strand as a preparatory bridge to tertiary Science, Technology, Engineering, and Mathematics programs [4], [16], [17].

Table 3. The Level Adequacy of the Specialized Subjects of Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Specialized Sibjects	Level of Adequacy		
	Mean	SD	DI
Pre-Calculus	3.69	0.53	HA
General Biology 1	3.60	0.64	HA
Basic Calculus	3.69	0.53	HA
General Biology 2	3.57	0.65	HA
General Chemistry 1	3.57	0.73	HA
General Physics 1	3.60	0.62	HA
General Chemistry 2	3.56	0.70	HA
General Physics 2	3.62	0.60	HA
Research	3.49	0.78	HA
Overall	3.60	0.45	HA

Legend: 3.26 – 4.00 (Highly Adequate); 2.51 – 3.25 (Adequate); 1.76 – 2.50 (Inadequate); 1.00 – 1.75 (Highly Inadequate)

Among the subjects, Pre-Calculus (M = 3.69, SD = 0.53) and Basic Calculus (M = 3.69, SD = 0.53) received the highest ratings, indicating both strong perceived utility and consistent agreement among respondents. This pattern reflects more than preference; it reveals the central role of advanced mathematics as a gatekeeper discipline in STEM education, as difficulties in mastering foundational mathematical concepts can hinder progression to more advanced topics and negatively affect long-term achievement [32], [33], [39], [40]. This reflects effective vertical alignment, where prior knowledge structures are directly transferable to subsequent learning tasks. Within the framework of constructive alignment, the strong evaluation of calculus subjects suggests that intended learning outcomes, instructional activities, and future academic demands are closely matched, resulting in higher perceived adequacy [19].

Science-oriented specialized subjects, including General Physics and Biology, also received consistently high ratings with moderate variability. This indicates that while students generally recognize their importance, there is some variation in how effectively these subjects are experienced. Disciplinary depth in science education is critical because it allows learners to move beyond surface-level understanding toward conceptual mastery and scientific reasoning. Science, Technology, Engineering, and Mathematics education literature emphasizes that deep engagement with disciplinary content is necessary for developing the ability to apply knowledge in novel and complex situations [8], [13], [41]. The relatively consistent ratings suggest that these subjects successfully provide a shared cognitive foundation; however, the presence of moderate variability points to differences in instructional quality, laboratory exposure, or contextual resources that may influence how students internalize these concepts.

In contrast, the chemistry subjects exhibit slightly higher variability despite being rated as highly adequate. This pattern is particularly revealing because it suggests that while the curriculum content is perceived as relevant, the learning experience itself is less uniform. Chemistry is widely recognized as a cognitively demanding subject due to its abstract representations and the need to integrate multiple levels of understanding (macroscopic, microscopic, and symbolic). As a result, student perceptions of adequacy may be more sensitive to instructional strategies, availability of laboratory resources, and clarity of conceptual explanations [42]. The wider dispersion in responses, therefore, signals not a weakness in curriculum design but a potential inconsistency in pedagogical delivery, where some students experience effective learning conditions while others encounter barriers to understanding.

The subject Research (M = 3.49, SD = 0.78) presents the most notable variation among the specialized subjects. Although still rated as highly adequate, the larger standard deviation indicates less agreement among respondents, suggesting that research experiences differ significantly across contexts, as inquiry-based approaches require structured guidance and clear scaffolding to be effective, which may not be consistently provided across learning environments [43]. This finding is particularly important because research and inquiry are central to Science, Technology, Engineering, and Mathematics education, serving as the primary means through which students engage in authentic knowledge construction. Inquiry-based learning has been shown to enhance critical thinking, problem-solving, and scientific reasoning; however, its effectiveness is highly dependent on implementation conditions, including mentorship quality, access to resources, and opportunities for sustained investigation [8], [11], [43]. The observed variability implies that while the curriculum includes research as a key component, its impact is mediated by contextual factors, leading to uneven learning experiences. In this sense, the issue is not the inclusion of research in the curriculum but the degree to which it is meaningfully enacted in practice. This aligns with the view that educational outcomes are shaped by the dynamic interaction between curriculum design, teacher learning, and instructional contexts, rather than by curriculum structure alone [44].

Taken together, the pattern across specialized subjects reveals a strong alignment between curriculum design and student-perceived academic preparation. Unlike core subjects, which provide generalized competencies, specialized subjects offer direct and visible connections to the knowledge and skills required in higher education. This direct relevance enhances their perceived value, as students are able to immediately recognize the applicability of what they have learned. From a motivational perspective, learners are more likely to value and engage with subjects that demonstrate clear utility in achieving their academic goals, particularly within structured pathways such as Science, Technology, Engineering, and Mathematics [31], [45]. This helps explain why specialized subjects not only receive higher ratings but also exhibit greater consistency in perception.

At the same time, the differences in standard deviation across subjects highlight an important dimension of curriculum evaluation: consistency of experience. While mean scores reflect overall effectiveness, variability reveals disparities in how that effectiveness is realized across contexts. According to evaluation frameworks such as the CIPP model, such variability is indicative of differences in process and implementation rather than input or design [23]. The higher variability observed in research and chemistry subjects suggests that certain areas of the curriculum are more sensitive to contextual conditions, including teacher expertise, resource availability, and instructional approaches.

Overall, the findings confirm that specialized subjects represent the strongest component of the Senior High School Science, Technology, Engineering, and Mathematics curriculum in terms of perceived adequacy and alignment with higher education demands. However, the presence of variability in certain subjects indicates that curriculum effectiveness is not solely determined by content structure but also by the consistency of its implementation. This distinction is critical because it shifts the focus of improvement from curriculum design to instructional support systems. Research in Science, Technology, Engineering, and Mathematics education consistently shows that even well-designed curricula require adequate teacher preparation, laboratory infrastructure, and pedagogical support to achieve intended outcomes [9], [44], [46].

These results underscore the need to strengthen implementation mechanisms to ensure equitable learning experiences across contexts. Investments in teacher training, particularly in inquiry-based and laboratory-intensive instruction, as well as improvements in resource provision and research mentoring, are essential for maximizing the effectiveness of specialized subjects. International evidence suggests that improving Science, Technology, Engineering, and Mathematics education outcomes requires a systemic approach that integrates curriculum reform with capacity building and learning environment enhancement [25], [47]. Without such support, disparities in implementation may persist, limiting the overall impact of otherwise well-designed curricula.

3.3. The Adequacy of the Contextualized Subjects of the Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Table 4 presents the respondents' assessment of the adequacy of the contextualized subjects in the Senior High School Science, Technology, Engineering, and Mathematics curriculum. The results indicate an overall mean of 3.18 (SD = 0.50), interpreted as Adequate. While this suggests that contextualized subjects generally support student learning, their comparatively lower mean relative to specialized subjects points to a weaker perceived alignment with the academic demands of tertiary Science, Technology, Engineering, and Mathematics education. The moderate standard deviation indicates that, although there is a general consensus among respondents, variations in experience remain evident. This pattern reflects the inherent nature of contextualized subjects, which emphasize transferable competencies such as research, communication, and applied learning rather than direct disciplinary mastery [2], [11]. As a result, their contribution to Science, Technology, Engineering, and Mathematics preparedness may be less immediately visible to learners, particularly when compared with content-intensive subjects.

Table 4. The Level of Adequacy of the Contextualized Subjects of Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Contextualized Subjects	Level of Adequacy		
	Mean	SD	DI
Entrepreneurship	2.94	0.78	A
Practical Research 1	3.42	0.72	HA
Practical Research 2	3.47	0.74	HA
English For Academic And Professional Purposes	3.21	0.71	A
Filipino Sa Piling Larangan - Akademik	2.85	0.77	A
Empowering Technologies	3.13	0.76	A
Inquiries, Investigation And Immersion	3.21	0.90	A
Overall	3.18	0.50	A

Legend: 3.26 – 4.00 (Highly Adequate); 2.51 – 3.25 (Adequate); 1.76 – 2.50 (Inadequate); 1.00 – 1.75 (Highly Inadequate)

Among the subjects, Practical Research 2 (M = 3.47, SD = 0.74) and Practical Research 1 (M = 3.42, SD = 0.72) received the highest ratings and were interpreted as Highly Adequate. These findings suggest that students recognize the value of research-oriented learning as a preparation for higher education. Unlike other contextualized subjects, research explicitly engages students in processes that mirror authentic academic and scientific practices, including problem formulation, data analysis, and evidence-based reasoning. Such experiences reduce the gap between secondary and tertiary learning expectations by developing procedural and metacognitive skills essential for Science, Technology, Engineering, and Mathematics success. Existing literature supports this interpretation, emphasizing that inquiry-based and research-oriented learning strengthens analytical thinking, conceptual understanding, and academic readiness when students are actively engaged in authentic investigations [8]. The relatively moderate variability further indicates that, despite contextual differences, the benefits of research subjects are broadly experienced across learners.

In contrast, Entrepreneurship (M = 2.94, SD = 0.78) and Filipino sa Piling Larangan – Akademik (M = 2.85, SD = 0.77) obtained comparatively lower ratings and exhibited higher variability. These results suggest not only lower perceived relevance but also inconsistent learning experiences across respondents. From a learner perspective, these subjects may appear more peripheral to Science, Technology, Engineering, and Mathematics preparation because their connection to technical competencies is less explicit [48]. However, this perception does not necessarily reflect their actual importance. Literature on workforce development and innovation highlights that entrepreneurial thinking, communication, and interdisciplinary awareness are critical for problem-solving and adaptability in Science, Technology, Engineering, and Mathematics careers [1], [14], [49]. The discrepancy between their theoretical importance and lower perceived adequacy suggests a gap in contextualization, specifically, how effectively these subjects are linked to Science, Technology, Engineering, and Mathematics -related applications [49]. When interdisciplinary subjects are not explicitly integrated into Science, Technology, Engineering, and Mathematics contexts, students may struggle to recognize their relevance, leading to lower valuation and more varied perceptions.

English for Academic and Professional Purposes (M = 3.21, SD = 0.71) was rated as adequate, indicating that students generally acknowledge the importance of communication skills, although not uniformly. Academic communication plays a critical role in Science, Technology, Engineering, and Mathematics, particularly in writing reports, presenting findings, and collaborating within multidisciplinary teams. However, the moderate variability suggests that the extent to which students perceive its relevance may depend on how instruction is contextualized. Research indicates that communication skills are more effectively valued by students when integrated into discipline-specific tasks rather than taught in isolation [35]. When connections to

Science, Technology, Engineering, and Mathematics practices are implicit rather than explicit, students may undervalue these competencies despite their long-term importance.

Similarly, Empowering Technologies (M = 3.13, SD = 0.76) was evaluated as adequate but with noticeable variability. This finding reflects a broader issue in technology integration within education: the distinction between learning about technology and using technology as a tool for disciplinary problem-solving. Studies show that students perceive digital literacy subjects as more meaningful when technological tools are embedded within authentic Science, Technology, Engineering, and Mathematics tasks, such as data analysis, simulation, or design-based projects [46], [47], [50]. The moderate mean and variability, therefore, suggest that while students recognize the relevance of technology, its implementation may not consistently demonstrate clear connections to Science, Technology, Engineering, and Mathematics applications, limiting its perceived adequacy.

The subject Inquiries, Investigation and Immersion (M = 3.21, SD = 0.90) presents the highest variability among all contextualized subjects. While the mean indicates adequate perceived usefulness, the large standard deviation reveals highly uneven student experiences, which aligns with global findings on disparities in learning opportunities and recovery across different contexts [15]. This variability is particularly significant because immersion-based learning is inherently dependent on contextual factors such as placement quality, mentorship, institutional support, and access to authentic learning environments. Experiential learning theory posits that meaningful learning occurs when students actively engage with real-world contexts; however, the effectiveness of such experiences depends on structured guidance and reflection, as inquiry-based and experiential approaches require deliberate scaffolding to support meaningful learning [27], [43]. When these elements are inconsistently implemented, the quality of learning varies widely, leading to divergent student perceptions. The findings, therefore, point to implementation inconsistency as a key issue rather than a limitation of curriculum design.

Taken together, the results indicate that contextualized subjects fulfill a supportive but less explicitly recognized role within the Science, Technology, Engineering, and Mathematics curriculum. They contribute to the development of transferable and applied competencies, yet their impact is often mediated by how clearly they are connected to disciplinary learning. Unlike specialized subjects, where relevance is direct and immediately observable, contextualized subjects rely on integration and application, which may not be equally emphasized across instructional contexts. This creates a situation where their educational value exists but is not consistently perceived by learners.

From a curriculum perspective, this pattern highlights a structural challenge in Science, Technology, Engineering, and Mathematics education: balancing disciplinary depth with interdisciplinary and applied learning. While both are essential, their integration must be explicit and intentional. Curriculum theories emphasize that coherence is achieved not only through content alignment but also through meaningful connections across learning domains [7], [8]. When these connections are weak or implicit, students tend to evaluate subjects independently, often prioritizing those with immediate academic relevance.

Overall, while contextualized subjects are perceived as adequate, the findings reveal significant opportunities for improvement, particularly in strengthening their alignment with Science, Technology, Engineering, and Mathematics -specific applications and ensuring consistency in implementation. Enhancing the visibility of their contribution to Science, Technology, Engineering, and Mathematics readiness, through integrated tasks, project-based learning, and authentic applications, may improve both student engagement and perceived relevance. International evidence supports that when interdisciplinary and applied learning components are effectively embedded within Science, Technology, Engineering, and Mathematics contexts, student learning outcomes and engagement improve substantially [25], [51]. Thus, the key issue is not the inclusion of contextualized subjects but how effectively they are enacted as integral components of the Science, Technology, Engineering, and Mathematics learning experience.

3.4. Comparison in the Adequacy of Core, Specialized, and Contextualized Subjects in the Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Table 5 presents the results of the Friedman test examining differences in the perceived adequacy of the core, specialized, and contextualized subjects in the Senior High School Science, Technology, Engineering, and Mathematics curriculum. The analysis revealed a statistically significant difference among the three domains ($\chi^2 = 75.77$, $p < 0.001$), indicating that at least one curriculum domain is perceived differently from the others in terms of adequacy [24]. Given that the same respondents evaluated all three domains, this result reflects a systematic difference in how learners experience and value each component of the curriculum rather than random variation.

Table 5. Significant Difference in the Adequacy of Core, Specialized, and Contextualized Subjects in the Senior High School Science, Technology, Engineering, and Mathematics Curriculum in the Philippines

Domain	Mean	X^2	P- Value
Core Subjects	3.16^{ab}	75.77	<.001
Specialized Subjects	3.60^{bac}		
Contextualized Subjects	3.18^{cb}		

Note: χ^2 = Friedman test statistic; $p < 0.05$ indicates significant difference. Different superscripts (a, b, c) indicate significant pairwise differences based on Wilcoxon signed-rank test with Bonferroni correction.

In terms of mean scores, specialized subjects (M = 3.60) obtained the highest rating, followed by contextualized subjects (M = 3.18) and core subjects (M = 3.16). Post hoc pairwise comparisons using the Wilcoxon signed-rank test with Bonferroni correction indicated that specialized subjects differed significantly from both core and contextualized subjects, while no statistically significant difference was observed between core and contextualized subjects. This pattern is analytically important: the statistical difference is not evenly distributed across all domains but is primarily driven by the stronger evaluation of the specialized component.

The significantly higher rating of specialized subjects suggests that learners perceive these subjects as the most directly relevant and effective component of the Science, Technology, Engineering, and Mathematics curriculum in preparing them for higher education. This can be explained by the immediacy of knowledge transfer, wherein concepts learned in subjects such as calculus, physics, chemistry, and biology are directly encountered in college-level coursework. Empirical evidence consistently shows that early exposure to advanced mathematics and science strengthens academic readiness, improves performance, and increases persistence in Science, Technology, Engineering, and Mathematics pathways [32], [42]. Prior exposure reduces intrinsic cognitive load, allowing students to allocate more resources to higher-order thinking rather than basic comprehension. This reflects strong vertical alignment within the curriculum, where learning at the secondary level directly supports the demands of tertiary education. Constructive alignment theory further explains that when learning outcomes, instructional experiences, and future academic expectations are closely matched, students are more likely to perceive learning as meaningful and adequate [19].

In contrast, core and contextualized subjects, although both rated as adequate, were not perceived as significantly different from one another. This lack of statistical distinction suggests that learners experience these two domains as having comparable levels of contribution to their Science, Technology, Engineering, and Mathematics preparation, despite their theoretically distinct roles. Core subjects are intended to develop foundational competencies, while contextualized subjects aim to bridge theory and application. However, from the students' perspective, both domains appear to function as indirect contributors to Science, Technology, Engineering, and Mathematics readiness rather than as immediate sources of academic advantage.

This pattern can be better understood through the lens of expectancy–value theory, which posits that learners prioritize subjects based on their perceived utility in achieving academic and career goals [31]. In Science, Technology, Engineering, and Mathematics contexts, students tend to value subjects that directly support problem-solving, conceptual mastery, and assessment performance. Large-scale international assessments further indicate that learners consistently assign higher value to domains closely associated with measurable cognitive and technical competencies, particularly mathematics and science [6], [7]. Consequently, while core subjects provide essential transferable skills and contextualized subjects promote applied and interdisciplinary learning, their contributions may be less visible to students when not explicitly connected to Science, Technology, Engineering, and Mathematics -specific tasks and outcomes.

The absence of a significant difference between core and contextualized subjects also points to a potential limitation in how the intended differentiation between these domains is realized in practice. Ideally, contextualized subjects should provide a distinct layer of applied learning that complements foundational knowledge. However, when contextualization is not explicitly anchored in Science, Technology, Engineering, and Mathematics applications, these subjects may be perceived similarly to general education components. Research on experiential and inquiry-based learning emphasizes that the effectiveness of such approaches depends heavily on instructional quality, access to resources, and opportunities for authentic engagement [46], [52]. When these elements are inconsistently implemented, the added value of contextualized learning becomes less apparent, resulting in perceptions that converge with those of core subjects.

The findings reveal a concentration of perceived adequacy within the specialized domain, with core and contextualized subjects functioning as supporting components whose contributions are less distinctly recognized. This indicates that curriculum effectiveness is not solely a function of content inclusion but also of how clearly connections across domains are structured and communicated. Theories of curriculum coherence and constructive alignment emphasize that learning is optimized when relationships among subjects are explicit, cumulative, and systematically reinforced [19], [23]. When integration across domains is weak or implicit, students are more likely to evaluate subjects in isolation, leading to uneven perceptions of their value.

These results highlight a critical implication for curriculum design and implementation: the need to enhance the visibility and integration of non-specialized domains within the Science, Technology, Engineering, and Mathematics framework. International education frameworks emphasize that effective Science, Technology, Engineering, and Mathematics curricula must balance disciplinary depth with interdisciplinary competencies and real-world applications [25], [51]. Without clear integration, foundational and applied subjects risk being perceived as peripheral rather than essential components of Science, Technology, Engineering, and Mathematics preparation.

Overall, the findings provide strong empirical evidence that while the Science, Technology, Engineering, and Mathematics curriculum is generally adequate, its domains are not perceived equally in terms of their contribution to academic preparation. Specialized subjects dominate in perceived effectiveness due to their direct alignment with higher education demands, whereas core and contextualized subjects, despite their essential roles, are viewed as contributing more indirectly. Addressing this imbalance requires not only curriculum refinement but also deliberate efforts to strengthen integration, ensuring that all domains are experienced by learners as coherent and mutually reinforcing components of Science, Technology, Engineering, and Mathematics readiness.

4. CONCLUSION

This study aimed to determine the level of adequacy of the Senior High School Science, Technology, Engineering, and Mathematics curriculum in the Philippines in terms of core, specialized, and contextualized subjects, based on the perceptions of college Science, Technology, Engineering, and Mathematics students. The findings indicate that, overall, the curriculum is adequate to highly adequate in preparing students for higher education. Specifically, the core subjects were found to be adequate ($M = 3.16$, $SD = 0.44$), the specialized subjects were highly adequate ($M = 3.60$, $SD = 0.45$), and the contextualized subjects were adequate ($M = 3.18$, $SD = 0.50$). Furthermore, the results revealed a statistically significant difference among the three curriculum domains ($\chi^2 = 75.77$, $p < 0.001$). Specialized subjects were rated significantly higher than both core and contextualized subjects, while no significant difference was observed between core and contextualized subjects.

Based on the findings of the study, several recommendations are proposed. First, the integration of core and contextualized subjects within the Science, Technology, Engineering, and Mathematics framework should be strengthened, as these domains were only rated as adequate and require more explicit connections to STEM-specific applications through interdisciplinary approaches and contextualized learning tasks. Second, the implementation of specialized subjects should be sustained and further enhanced, given their high adequacy and strong alignment with higher education demands, by ensuring consistency in instructional quality, resource availability, and curriculum delivery across institutions. Third, the implementation of contextualized subjects needs improvement by emphasizing authentic applications such as research-based activities, industry exposure, and technology integration to increase their relevance to STEM preparation. Fourth, targeted instructional support and professional development for teachers should be provided to enhance their capacity in delivering inquiry-based, interdisciplinary, and applied learning, thereby improving the effectiveness and consistency of curriculum implementation. Finally, further research is recommended to involve a broader and more diverse sample across regions, apply longitudinal designs to assess long-term outcomes, and examine additional variables such as instructional practices, institutional resources, and student performance to validate and extend the findings of this study.

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