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Science, Technology, Engineering, Agriculture and Mathematics (STEAM) Education and Students' Academic Performance at Qingdao Yucai Middle School: A Correlational Study for Curriculum Enhancement Strategies

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ABSTRACT

The demand for STEAM skills sets has been driven by evolving industry needs. This study explores the relationship between Science, Technology, Engineering, Agriculture, and Mathematics (STEAM) education, highlighting the Agriculture component and its impact on students' academic performance at Qingdao Yucai Middle School. This correlational study gathered 384 students, selected through stratified sampling to ensure representative sample. The findings reveal that the student body is predominantly aged 13-15 years, with a slight female majority. Assessments of STEAM education indicate a positive reception, with an overall mean score of 3.78, classified as "Effective." Academic performance across STEAM subjects is generally high, though scores in Agriculture are slightly lower compared to other areas. Additionally, the study found no significant correlation between students' assessments of STEAM education and their academic performance, indicating that perceptions of the curriculum do not necessarily predict academic results. Overall, the findings underscore the effectiveness of the current STEAM education program at Qingdao Yucai Middle School while highlighting areas for potential improvement. The uniformity in educational experience and the lack of significant correlation between curriculum assessment and academic outcomes suggest the need for targeted interventions to further enhance the practical impact of STEAM education.

RESUMO

A demanda por competências em STEAM tem sido impulsionada pela evolução das necessidades do setor. Este estudo explora a relação com o ensino de STEAM (Ciência, Tecnologia, Engenharia, Agricultura e Matemática), destacando o componente de Agricultura e seu impacto no desempenho acadêmico dos alunos da Escola de Ensino Fundamental II Qingdao Yucai. A pesquisa, de natureza correlacional, envolveu 384 alunos selecionados por meio de amostragem estratificada para garantir a representatividade da amostra. Os resultados revelam que a maioria dos alunos tem entre 13 e 15 anos, com uma leve predominância do sexo feminino. As avaliações sobre o ensino de STEAM indicam uma recepção positiva, com uma pontuação média geral de 3,78, classificada como "Eficaz". O desempenho acadêmico nas disciplinas STEAM é, de modo geral, elevado, embora as notas em Agricultura sejam ligeiramente inferiores às das demais áreas. Além disso, o estudo não encontrou correlação significativa entre as avaliações dos alunos sobre o ensino de STEAM e seu desempenho acadêmico, indicando que a percepção do currículo não prevê necessariamente os resultados acadêmicos. Em suma, os achados reforçam a eficácia do atual programa de ensino de STEAM da Escola Qingdao Yucai, ao mesmo tempo em que apontam áreas passíveis de melhoria. A uniformidade da experiência educacional e a ausência de correlação significativa entre a avaliação do currículo e os resultados acadêmicos sugerem a necessidade de intervenções direcionadas para ampliar ainda mais o impacto prático do ensino de STEAM.

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Introduction

Science, Technology, Engineering, Agriculture, and Mathematics (STEAM) Education is an innovative, holistic educational approach that intertwines critical, analytical, and creative disciplines. This approach is pivotal for equipping students with the skills necessary to navigate and contribute to the rapidly evolving global landscape. The discussion will encompass the global context of STEAM education before delving into its specific applications and challenges within China.

Globally, the emergence of STEAM education represents a paradigm shift in response to the ever-growing need for adaptable, innovative, and problem-solving skills in the workforce. In traditional educational settings, the STEM framework does not include the subject "Agriculture" in the curriculum. Likewise, the growing focus on environmental and agricultural components in addressing global challenges is increasingly important. This includes climate change, food security, and a nation's sustainable progress and development. In addition, it embraces a more inclusive appreciation of how these areas interconnect to develop effective solutions for sustainability. STEAM education, in fact, is pivotal in making the United Nations Sustainable Development Goals (SDGs) a reality. Various goals cover Quality Education (SDG#4) and Zero Hunger (SDG 2).

In China, there is a great commitment to advancing STEAM education, emphasizing its role in economic growth and technological innovation. China's progress in science and technology is noteworthy, with a strong commitment to STEAM disciplines. Through the Chinese government's Five-Year Plans (China's State Council, 2020), STEAM fields are consistently prioritized to improve scientific exploration and innovation among the workforce.

Zhao (2016) emphasized that rote learning and exam-centered instruction may hinder the development of students' critical and creative thinking—key competencies central to STEAM education. However, ensuring equitable access to STEAM education across China, particularly in underserved and rural areas, remains a significant challenge due to the persistent urban-rural educational divide (Wang, 2018). In this context, integrating agriculture into the STEAM framework is particularly relevant, considering China's status as a major agricultural nation. Agricultural education not only prepares students for careers in the sector but also supports the development of sustainable farming practices. As Li and Zhou (2019) demonstrated, this integration meaningfully contributes to food security and environmental sustainability in China.

Furthermore, this study supports the benefits of STEAM-based approaches in the academic aspects. STEAM education significantly boosts students' academic performance and cognitive skills, particularly in science subjects (Conradty & Bogner, 2020). The results of the study by Sousa et al in 2016) reveal that the inclusion of the arts subject in the STEAM framework has a positive impact on increasing the motivation and engagement of students. This implies that it is important for assessing students' academic performance and success. Moreover, the learning atmosphere is equally a priority. Byers & Imms (2016) highlighted in their study that STEAM Education promotes students' creativity, encourages critical thinking, and collaboration among teams, which comprises the important elements of STEAM education.

While few studies have examined STEAM education, this study contributes to the existing STEAM concepts by exploring an Agriculture-integrated framework within a Chinese middle school context, providing a localized perspective on interdisciplinary education and sustainability. Unlike previous studies that focused primarily on academic achievement or student attitudes, this study focuses on students' perceptions, academic performance, demographic differences, and curriculum enhancement strategies. Overall, the study underscores the effectiveness of the current STEAM education program at Qingdao Yucai Middle School while highlighting areas for potential improvement. The uniformity in educational experience and the lack of significant correlation between curriculum assessment and academic outcomes suggest the need for targeted interventions to further enhance the practical impact of STEAM education.

Methodology

The study applied the correlational method with the purpose of examining the relationships between demographic profile of students at Yucai Midddle School in Qingdao City and their academic performance. There are 384 STEAM education students as participants identified using the Raosoft sampling calculator. Stratified sampling was employed to ensure proportional representation across demographic strata such as age, year level, and gender, as supported by Thompson (2012)..

The research instrument is composed of three parts. The first section gathered demographic profile of the respondents to analyze its correlation with STEAM-related outcomes; the second part assessed students' perceptions of STEAM education methods. Part III focused on academic performance and analyzed performance differences among demographic groups based on the assessment results. Lastly, the study explored students' insights and experiences relevant to curriculum development. To ensure the validity and reliability of the questionnaire, experts' recommendations and feedback were collected, and a pre-test was conducted.

To check the reliability of the instrument, it was evaluated using the Cronbach's alpha resulting to Cronbach's alpha of 0.91 on Assessment construct indicating excellent internal consistency, while the Curriculum Strategies obtained 0.88, indicating good internal consistency. Since both values exceed the recommended threshold of 0.70, they are considered reliable, implying that the items consistently measured their respective constructs. Future studies should incorporate qualitative data from teachers, curriculum specialists, and school administrators to strengthen the development and validation of curriculum strategies.

The study adhered to the ethical standards of the Qingdao Yucai Middle School. Before data collection, the researchers obtained permission from the officials. Participants and their parents or legal guardians received informed consent forms explaining the study's purpose, the voluntary nature of participation, the right to withdraw at any time without penalty, and the confidentiality of the information collected.

Results and Discussion

The data were presented in this chapter aligning the objectives and the statement of the problem of the study. Findings were analyzed based on theories and literature gathered.

Table 1.
Demographic Profile of the Respondents

Demographic	f	%
Age		
13-15 years old	220	**57.3%**
16-18 years old	164	**42.7%**
Gender		
Male	185	**48.2%**
Female	199	**51.8%**
Year Level		
Year 1	124	**32.3%**
Year 2	120	**31.3%**
Year 3	140	**36.5%**
Total	384	100%

The findings reveal that aged 13-15 years old with 57.3% has the higher representation in the study. This implies that junior students were exposed to STEAM subjects. It could help improve the understanding of the subject and influence career path. According to Liu and Lin (2020), the earliest exposure to STEAM core subjects will strengthen students' proficiency and interest. Likewise, age results reflect a meaningful strategy for early integration in the curriculum.

Table 1 also shows that female students slightly outnumber their male counterparts, representing 51.8% of the total respondents. While this indicates positive female participation in STEAM education at the local level, it contrasts with global trends where greater efforts are still needed to encourage female involvement in STEAM fields. This finding also contrasts with the study of Zhang et al. (2019), who emphasized that gender-balanced participation fosters more inclusive and engaging learning environments.

In addition, the third-year level has the highest frequency (36.5%) indicating that there is an increasing interest among the students' participants, thus, revealing the effectiveness of the curriculum. Its structure is better to support engagement in STEAM education. This result is aligned with the study of Wang (2018), highlighting that students perform well, motivated to do more with the understanding of STEAM concepts, impacting positively to their higher education preparedness and deciding on future career.

The study highlights various key considerations for crafting an effective curriculum with the component of STEAM education. First, it is an advantage for students to understand and appreciate if STEAM concepts will be introduced at an early age. Second, continuous improvement of curricular structures across subject areas needs to be aligned with the fast-changing educational landscape. These strategies are aligned with the existing educational reforms in China. Third, emphasis in innovative learning pedagogies and the development of practical skills will be beneficial in response to the global demands focusing on technology and engineering.

Assessment of Students on STEAM Education

Assessing the performance of the STEAM education students will help figuring out the effectiveness of policies and practices of the university such as exploring how different teaching strategies, classroom environments, and curricular integrations influence student outcomes across various demographics.

Table 2.

Assessment of Students on STEAM Education

Parameter	Mean Score	Verbal Interpretation
Content Evaluation		
1. I find the STEAM curriculum to be relevant to real-world applications.	3.55	Effective
2. The content covered in our STEAM classes is challenging and thought-provoking.	3.52	Effective
3. STEAM courses provide a balanced integration of Science, Technology, Engineering, Agriculture, and Mathematics.	3.54	Effective
4. The concepts learned in STEAM classes are interconnected and not taught in isolation.	3.60	Effective
5. The STEAM curriculum is regularly updated to reflect current scientific and technological advancements.	3.59	Effective
Overall Mean	**3.56**	**Effective**
Teaching Methodologies		
1. Teachers employ a variety of teaching methods to cater to different learning styles in STEAM subjects.	3.76	Effective
2. Collaborative projects are a regular part of our STEAM education.	3.76	Effective
3. Technology was used by my teachers to enhance learning effectviely in STEAM classes.	3.80	Effective
4. Critical thinking and problem-solving were strongly emphasized in our STEAM instruction.	3.79	Effective
5. Teachers provide hands-on activities that help me understand STEAM concepts better.	3.77	Effective

Overall Mean	**3.78**	**Effective**
Student Learning Outcomes		
1. In practical sceanrios, I am able to apply STEAM knowledge.	3.77	Effective
2. Due to STEAM educaion, my communication skills have improved.	3.84	Effective
3. My interest in STEAM careers has increased because of STEAM education.	3.81	Effective
4. I feel confident in my ability to succeed in STEAM subjects.	3.82	Effective
5. STEAM classes have taught me how to work effectively in a team.	3.85	Effective
Overall Mean	**3.82**	**Effective**
Resource Availability and Utilization		
1. Laboratory and tecnnology was provided by our school as adequate resources for STEAM learning.	3.59	Effective
2. The STEAM resources are up-to-date and well-maintained.	3.58	Effective
3. STEAM learning materials and resources outside of class are sufficieint to access.	3.54	Effective
4. In STEAM education, our school's resources have enriched my learning experience.	3.61	Effective
5. During and after classes, there are plenty of opportunities for me to engage with STEAM resources.	3.56	Effective
Overall Mean	**3.58**	**Effective**
Teacher Preparedness		
1. In STEAM subjects, teachers seem well-prepared and knowledgeable.	3.55	Effective
2. Challenging questions in STEAM sibjects were able to handled by my teachers.	3.51	Effective
3. In our school, enthusiasm was demionstrated by teachers for the subjects they teach.	3.60	Effective
4. Real-life STEAM applications were integrated by our teachers into their lessons.	3.52	Effective
5. My teachers actively continue their education in STEAM subjects.	3.51	Effective
Overall Mean	**3.54**	**Effective**
Inclusivity and Accessibility		
1. STEAM courses are designed to be accessible to students with varying abilities.	3.56	Effective
2. An inclusive environment was promoted, where all students are encouraged to participate in STEAM activities.	3.62	Effective
3. Diverse cultural perspectives were adressed in STEAM education in our school.	3.61	Effective
4. The materials used in our classes are suitable for students especailly with different learning needs.	3.54	Effective
5. Our school provides additional support to ensure all students to be successful in STEAM subjects.	3.59	Effective
Overall Mean	3.59	**Effective**
Feedback Mechanisms		
1. A timely and constructive feedback was provided by my teachers covering on my work in STEAM subjects.	3.45	Effective
2. The feedback I receive helps me understand my strengths and areas for improvement.	3.56	Effective
3. The STEAM curriculum and teaching methods were prioritized by my school.	3.55	Effective
4. To provide feedback about STEAM classes, there are established channels for students.	3.49	Effective
5. The feedback from my teachers helps me improve my problem-solving skills.	3.52	Effective
Overall Mean	**3.51**	**Effective**
Impact on Career and Skill Development		
1. STEAM education has prepared me for further education in STEAM fields.	2.47	Less Effective
2. The skills I've developed through are relevant to the current job market.	2.44	Less Effective
3. The STEAM program in our school has provided me with career guidance specially in STEAM fields.	2.49	Less Effective

4. My digital literacy and technology skills was enhanced through STEAM education.	2.40	Less Effective
5. The curriculum has improved my understanding of the STEAM skills needed for future careers.	2.45	Less Effective
	2.45	Less Effective
Overall Results	**3.45**	**Effective**
1.00 - 1-50= Not Effective / 1.51 - 2.50= Less Effective / 2.51 - 3.50= Neither Effective nor Not Effective / 3.51 - 4.50= Effective / 4.51 - 5.00= Highly Effective		

The findings on high mean ratings suggest that students viewed the STEAM curriculum

Academic Performance of Students in STEAM Education

Table 2 presents a comprehensive assessment of student perspectives on various aspects of STEAM education at their school. Students rated the content and teaching methodologies highly, with overall means of 3.56 and 3.78 respectively, indicating that the curriculum is perceived as relevant, challenging, and well-integrated across the STEAM disciplines. The high scores in teaching methodologies suggest that diverse teaching strategies and the effective use of technology are enhancing learning experiences. According to Zhao and Cziko (2001), such diverse methodologies are crucial for engaging students in multifaceted STEAM subjects, supporting the notion that varied instructional approaches cater effectively to different learning styles.

The student learning outcomes score an overall mean of 3.82, reflecting positive impacts on practical application skills, communication, interest in STEAM careers, and team-working abilities. This aligns with findings by Zhou (2018), who noted that a robust STEAM curriculum fosters not only academic skills but also essential soft skills like communication and collaboration, crucial for modern workforce demands.

In the areas of Resource Availability and Utilization, the overall result of 3.58 reflects an "Effective" interpretation underscores that STEAM curriculum offers sufficient provision of resources and teachers are prepared in its utilization. This suggests that updated and available teaching materials coupled with dedicated and prepared teachers (with an overall mean of 3.54) are vital components of successful STEAM education. This is aligned with the study of Li & Fung (2017) who emphasized that schools with complete and available resources and with enthusiastic educators is not only effective but a powerful solution in enhancing students' successful learning outcomes and engagement.

In the category of inclusivity and accessibility, the overall mean of 3.59 indicates the school is addressing students' diverse needs, varying abilities and different learning needs. This implies the educational strategies making STEAM education to be accessible to types of students regardless of their abilities or background. As mentioned by Wang (2019), this is important in promoting a supportive and inclusive culture among students with various educational needs.

On the other hand, the overall mean of 3.51 in terms of Feedback mechanism denotes to be effective. Students appreciate the remarks given to them by their teachers in STEAM education. As highlighted, this mechanism helps students to improve their skills and knowledge thus, motivated to excel. The same with the thoughts of Yang (2020) mentioning that constructive feedback to students is critical for their growth especially in STEAM subject areas.

Surprisingly, in the areas of Impact on Career and Skill Development, it is evident that it is the only domain rated as "Less Effective" with 2.45 weighted mean. The students are looking for more improvement although the delivery of STEAM education is effective in other areas. The findings reveal that students feel that STEAM education has not improved them yet for future career development and it is not necessary for the job market. This calls for room for improvement for the school administrators and educators. Supported by Zhao (2021), career preparation and orientation for students is an essential goal of STEAM education. It is important to align the educational outcomes with the current demands in the market for employability and other career opportunities.

The general assessment is rated “Effective” with an overall mean of 3.45, highlighting strengths in curriculum delivery and student engagement also pointed out the need for enhanced career and skill development focus.

Table 3.

Academic Performance of Students in STEAM Education

Subject	Weighted Mean	SD	Verbal Interpretation
Science	3.64	1.135	Good
Technology	3.63	1.112	Good
Engineering	3.61	1.119	Good
Agriculture	3.34	1.203	Average
Mathematics	3.66	1.067	Good
Overall Weighted Mean	**3.58**	**.916**	**Good**

Students’ academic performance in STEAM education basically serves as an important indicator of the effectiveness of educational pedagogies in preparing them for the complexities of the global technological landscape. It reflects their acquisition of skills and knowledge, as well as their capacity for collaboration, problem-solving, and critical thinking."

In the context of STEAM education, evaluation includes metrics such as students’ creativity, project submissions, test scores, and understanding of the lessons. These indicators help determine the curriculum's robustness and the effectiveness of teaching methods in promoting science and technology. This only proves that such evaluation supports how strategies in teaching correlate with students’ readiness for the next level in higher education.

Significant Differences in the Academic Performance of Students in STEAM Education

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Table 4.

Significant Differences in the Assessment of STEAM Education and Academic Performance of Students based on Age (Mann-Whitney U Test)

Variables		Mean Rank	U-value	p-value	Decision	Remarks
Assessment of Steam Education	13-15 years old	191.30	18304.500	.806	Accept Ho	Not Significant
	16-18 years old	194.11				
Academic Performance	13-15 years old	188.18	18991.000	.376	Accept Ho	Not Significant
	16-18 years old	198.30				

Reject Ho if $p < 0.05$

Table 4 presents results from a statistical analysis using the Mann-Whitney U Test to examine significant differences in students' assessments of STEAM education and academic performance at Qingdao Yucai Middle School, grouped by age category: 13-15 years old and 16-18 years old.

The mean ranks for the younger age group (13-15 years old) and the older age group (16-18 years old) are 191.30 and 194.11, respectively. The U-value calculated for this comparison is 18304.500 with a p-value of 0.806. Since the p-value is significantly higher than the threshold of 0.05, the null hypothesis (Ho) that there is no difference between the two age groups in terms of how they assess STEAM education is accepted. This suggests that perceptions and evaluations of the STEAM curriculum are consistent across age groups within the school.

Similarly, the academic performance comparison yields mean ranks of 188.18 for the 13-15 years old group and 198.30 for the 16-18 years old group. The corresponding U-value is 18991.000 with a p-value of 0.376. Again, the p-value exceeds the 0.05 threshold, supporting the null hypothesis and indicating no significant difference in academic performance between the two age groups.

These findings align with research in Chinese educational contexts, which often emphasizes the uniform application and assessment of educational strategies across age groups. Studies such as Zhou and Kim (2020) suggest that the standardized curriculum in Chinese schools aims to minimize disparities in educational outcomes across age groups. This may explain the lack of significant differences observed in both STEAM education assessment and academic performance across the age groups studied.

Additionally, the findings could suggest that the educational interventions and teaching strategies used at Qingdao Yucai Middle School are effectively standardized across age groups, ensuring students receive a consistent educational experience regardless of age. This aligns with the goals of equitable educational practices, which seek to provide all students with equal opportunities to succeed (H. Liang, 2019).

The lack of significant differences might be viewed positively as evidence of consistent educational quality across age groups. However, it also suggests that age-specific educational enhancements or differentiated instructional strategies might not be necessary or currently implemented at the school. Future research might explore other demographic variables, such as gender or socio-economic status, to determine whether disparities exist along these dimensions, which could inform more targeted educational strategies.

Assessment of STEAM Education and Significant Difference in Academic Performance

This finding highlights a significant difference between students' academic performance and STEAM education. It aims to analyze how various demographic factors influence learning outcomes across the STEAM disciplines. Furthermore, the results underscore the need to identify and implement targeted interventions to enhance educational effectiveness and student achievement within the STEAM framework.

Table 5.

Based on Gender: Significant Difference

Variables		Mean Rank	U-value	p-value	Decision	Remarks
Assessment of Steam Education	Male	196.67	17636.500	.478	Accept Ho	Not Significant
	Female	188.63				
Academic Performance	Male	194.82	17978.000	.692	Accept Ho	Not Significant
	Female	190.34				

Reject Ho if p < 0.05

Using the Mann-Whitney U test, Table 5 presents differences in academic performance and STEAM education by gender. The mean ranks were 196.67 for males and 188.63 for females, with a U-value of 17,636.500 and a p-value of 0.478. Since the p-value is greater than the significance level of 0.05, the null hypothesis (H0) is accepted. This indicates no significant difference in the assessment of STEAM education between genders. The result suggests a gender-neutral perception regarding the relevance and quality of STEAM education among the respondents. Traditional gender roles and cultural shifts in education in China are being challenged (Zhou et al., 2019), fostering equitable learning environments.

The U-value in Academic Performance in Table 5 is 17,978.000 with a p-value of 0.692. This implies that we accept the null hypothesis. As a result, there is no significant difference in academic performance between genders across STEAM subjects. The STEAM program at Yucai Middle School has been successfully integrated into the curriculum. The educational concepts and pedagogies are in place, supporting gender inclusivity. This implies that all students are treated equally, being successful in this field and contributing to a balanced workforce in the future.

The findings highlighted the need to standardize educational outcomes and provide equal opportunities across genders in STEAM education. Similarly, Wang & Cheng (2021) noted that the effectiveness of STEAM programs lies in offering equal access to quality education and instructional materials for students, regardless of gender, to improve academic performance.

Table 6.

Significant Differences in the Assessment Based on Year Level

Variables		Mean Rank	Chi-Square	p-value	Decision	Remarks
Assessment of Steam Education	Year 1	193.98	.385	.825	Accept Ho	Not Significant
	Year 2	187.38				
	Year 3	195.58				
Academic Performance	Year 1	187.97	.681	.711	Accept Ho	Not Significant
	Year 2	190.12				
	Year 3	198.55				

Reject Ho if p < 0.05

The Kruskal-Wallis Test in Table 6 examines whether there are significant differences in the assessment of STEAM education and academic performance among students from First Year to Third Year at Qingdao Yucai Middle School. The findings show that, by year level, the Third-Year level has the highest mean rank of 195.38, followed by the First-Year level with 187.38, and the Second-Year level has the lowest mean rank of 187.38. The p-value exceeds the standard significance level, which means the Null Hypothesis (Ho) is accepted. This implies no significant difference in how students assess their experience with STEAM education across the three-year levels. Based on the findings, student respondents are consistently satisfied with the curriculum, which aligns with Zhao et al. (2020), suggesting that this consistency provides an equitable basis for assessing student performance.

For the assessment of student performance, the mean rank for Year One is 187.97, while Year Two is 190.12 and Year Three is 198.55. The chi-square is 0.681, with a p-value of 0.700. This suggests accepting the null hypothesis because the p-value exceeds 0.05. Thus, students' assessments do not differ significantly across year levels. Monitoring students' satisfaction with their educational experiences is important (Li & Liu, 2020). Moreover, this shows that the school follows China's educational policy by providing equal opportunities for all, regardless of status (Wang & Zhou, 2018).

In summary, based on the study, Qingdao Yucai Middle School has satisfied students, as reflected in the successful implementation of the STEAM curriculum. A relevant, engaging, adaptable curriculum aligned with educational standards promotes academic success. Clear indications include a well-integrated purpose, design, and assessment aligned with the curriculum's effectiveness.

Tables 4 to 6 present the results of the Mann-Whitney U and Kruskal-Wallis tests examining differences in students' assessments of STEAM education and academic performance by age, gender, and year level. The results consistently showed no statistically significant differences ($p > .05$) across all demographic variables. These findings indicate that students' perceptions of STEAM education and their academic performance were generally comparable regardless of demographic characteristics, suggesting that the STEAM curriculum was experienced similarly across groups.

Relationship Between Assessment

To assess the relationship between STEAM education and students' academic performance, it is necessary to check the relevance of the curriculum content. Moreover, designing it is the utmost responsibility of the educators and policy makers. The team must also look into consideration the relationship of the available resources, quality of teaching and the performance outcome across the subject being assessed. Therefore, students' guaranteed experience in the curriculum highlights its strengths and should demonstrate evidence of its content and areas for intervention to improve.

Table 7 presents the results of a statistical analysis exploring the relationship between the assessment of Science, Technology, Engineering, Agriculture, and Mathematics (STEAM) education and academic performance among students, using Pearson correlation as the method of analysis.

Table 7.

Relationship Between Assessment of STEAM Education and Academic Performance

		Assessment of STEAM Education	Interpretation
Academic Performance	Pearson Correlation	.067	**No Significant Relationship**
	Sig. (2-tailed)	.189	
	N	384	

Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient between STEAM education assessment and academic performance is 0.067, with a significance (p-value) of 0.189 for a two-tailed test. Given the correlation coefficient's proximity to zero and a p-value that far exceeds the conventional threshold of 0.05 (let alone the more stringent 0.01 level mentioned in the table), the results indicate no significant relationship between how students assess STEAM education and their academic performance.

This lack of a significant correlation suggests that students' perceptions of the quality or effectiveness of their STEAM education may not directly influence their academic results in these subjects. This finding suggests that positive perceptions of curriculum implementation do not necessarily translate into higher academic achievement. As Fan & Yan (2010) note, STEAM education aims to improve understanding across multiple disciplines by building on students' prior knowledge, motivation, and external support to capture the curriculum's meaningful content. The complexity of STEAM subjects may affect the direct correlation between students' education and performance, as these require accumulating knowledge and skills over time (Zhou et al., 2019).

Both curriculum developers and educators should clearly formulate the philosophy and qualitative aspects of how STEAM education aligns with the learning needs and learning plans. Designing it will lead to more personalized learning approaches that will surely address the current needs of the students

Recommendation to Enhance the Curriculum

Strategies for developing the curriculum drive actions. Its purpose is to achieve long-term outcomes aligned with academic standards. Developing these strategies will help students develop the values and knowledge and skills that are important in the workplace. The challenge is how to include interdisciplinary topics, thus promoting creativity, critical thinking, and real-life problem-solving skills necessary for an increasingly complex world.

Curriculum development strategies should encompass a variety of key elements, including integrating innovative teaching methods, using up-to-date and relevant resources, and implementing assessment tools that accurately measure student learning and engagement. Additionally, strategies should aim to personalize learning experiences to meet diverse student needs and backgrounds, which can significantly improve engagement and academic outcomes in STEAM subjects.

Moreover, the importance of professional development for educators in effectively delivering STEAM curricula cannot be overstated. Educators need the skills and knowledge to inspire and motivate students. By focusing on these areas, the recommended curriculum development strategies will not only enhance the quality of STEAM education but also ensure students are well prepared to thrive in their future educational and career endeavors.

Table 8.

Relationship Between Assessment of STEAM Education and Academic Performance

Parameter	Mean Score	Verbal Interpretation
1. **Student-Centered Project Work**: Design projects where students have the autonomy to choose topics, fostering a sense of ownership and engagement in their learning.	3.37	Neither nor recommended
2. **Interactive Technology Integration**: Utilize interactive technology tools that captivate students' interest and make complex STEAM concepts more accessible and engaging.	3.41	Neither nor recommended
3. **Peer-to-Peer Teaching**: Encourage students to teach and learn from each other, enhancing collaborative skills and deepening understanding through peer-to-peer interaction.	3.43	Recommended
4. **Real-World Problem Solving**: Incorporate real-world problems relevant to students' lives and communities, making learning more meaningful and applicable.	3.44	Recommended
5. **Diverse Learning Resources**: Provide a variety of learning resources, including videos, games, and interactive simulations, to cater to different learning styles and preferences.	3.38	Neither nor recommended
6. **Feedback-Driven Curriculum**: Implement a feedback system where students can regularly provide input on the curriculum, ensuring it remains responsive to their needs.	3.38	Neither nor recommended
7. **Flexible Learning Spaces**: Create flexible and dynamic classroom environments that can be easily adapted for different types of STEAM activities and collaborative work.	3.39	Neither nor recommended
8. **Incorporating Student Interests**: Regularly survey students about their interests and integrate these topics into the STEAM curriculum.	3.41	Neither nor recommended
9. **Career Exploration Opportunities**: Include career exploration components, such as guest speakers from STEAM fields and career fairs, to provide insights into potential career paths.	3.42	Neither nor recommended
10. **Mentorship Programs**: Establish mentorship programs where students can receive guidance and support from professionals in STEAM fields.	3.36	Neither nor recommended
11. **Inclusion of Arts and Creativity**: Emphasize the 'A' in STEAM by integrating arts and creative subjects, which can foster innovation and creative problem-solving skills.	3.38	Neither nor recommended
12. **Hands-On Experiments and Maker Spaces**: Provide opportunities for hands-on learning through experiments, maker spaces, and DIY projects to encourage experiential learning.	3.40	Neither nor recommended
13. **Cultural and Global Perspectives**: Infuse curriculum with global and cultural perspectives, helping students appreciate the diverse applications of STEAM across the world.	3.41	Neither nor recommended
14. **Student-Led Clubs and Activities**: Support the formation of student-led STEAM clubs and activities that align with their interests, promoting extracurricular engagement.	3.38	Neither nor recommended
15. **Personalized Learning Paths**: Offer personalized learning paths within the STEAM curriculum, allowing students to delve deeper into areas of specific interest or talent.	3.45	Recommended
Overall Results	**3.40**	**Neither nor recommended**
1.00 - 1-50= Not Recommended / 1.51 - 2.50= Less Recommended / 2.51 - 3.50= Neither Recommended nor Not Recommended / 3.51 - 4.50= Recommended/ 4.51 - 5.00= Highly Recommended		

The strategies on Table 8 are rated based on their mean scores. The strategies that received a recommendation, each scoring slightly above the threshold for a neutral recommendation, are:

Peer-to-Peer Teaching (3.43): This strategy, which involves students teaching each other, is noted for enhancing collaborative skills and deepening understanding through interaction. This approach aligns with findings by Xu and Wang (2021), who emphasize the benefits of peer learning in improving comprehension and retention of complex concepts in STEAM.

Real-World Problem Solving (3.44): Incorporating practical problems relevant to students' lives enhances the applicability and relevance of STEAM education, making learning more engaging and meaningful. According to Liu and Zhou (2020), real-world applications in STEAM curricula significantly increase student motivation and interest in these subjects.

Personalized Learning Paths (3.45): Offering students the ability to explore specific areas of interest or talent within STEAM disciplines is highly recommended to cater to diverse learning preferences and boost engagement and performance.

However, most of the listed strategies received mean scores suggesting they are neither particularly recommended nor not recommended. This includes methods like integrating interactive technology, providing diverse learning resources, and incorporating student interests into the curriculum. Although these approaches are widely recognized in educational literature for their potential benefits, their middling scores may reflect a perception among respondents that, while useful, these strategies alone may not sufficiently enhance academic performance without effective implementation and integration with other educational practices.

The results suggest that while respondents generally support innovative and interactive approaches to STEAM education, they most strongly endorse strategies that directly involve students in active learning roles—either through collaboration, real-world problem-solving, or personalized learning trajectories. This underscores the importance of engaging students actively and personally in their learning processes, which is increasingly seen as crucial to effective STEAM teaching. Educators would likewise be motivated to adopt a more balanced pedagogy for focus on integrating Agriculture (Papaddodpoulou, 2024)

The findings also highlight a potential gap between the recognized value of certain educational strategies and their perceived effectiveness in practice. This may indicate a need for better implementation strategies, more robust training for educators, or further research on how best to employ these methods in diverse educational settings.

Proposed Curriculum Strategies to Enhance Academic Performance of Students in STEAM Education in Qingdao Yucai Middle School

Rationale:

The findings suggest a need for targeted interventions to further enhance the practical impact of STEAM education. This strategy aims to address these gaps by developing a curriculum that integrates real-world problem-solving, peer-to-peer teaching, and personalized learning paths to foster a deeper understanding and engagement in STEAM subjects.

Objectives:

1. To enhance student engagement and academic performance in all STEAM subjects, with a particular focus on improving outcomes in Agriculture.
2. To develop critical thinking, creativity, and problem-solving skills among students through interdisciplinary and experiential learning.
3. To ensure equitable access to quality STEAM education across different demographic groups within the school.

4. To prepare students for future career opportunities in STEAM fields by aligning the curriculum with industry needs and sustainability goals.

Implementation Strategies

Peer-to-Peer Teaching

- Develop a mentorship program where senior students guide and support junior students in STEAM projects. This will foster collaborative learning and enhance understanding through peer interaction.

Real-World Problem Solving

- Integrate project-based learning modules that focus on real-world problems, particularly in Agriculture and environmental sustainability. These modules will require students to apply interdisciplinary knowledge to develop practical solutions.

Personalized Learning Paths

- Utilize adaptive learning technologies to create personalized learning plans for students based on their strengths and areas for improvement. This approach will provide tailored resources and support to help each student achieve their full potential.

Professional Development for Teachers

- Conduct regular professional development workshops for teachers to equip them with the skills and knowledge necessary to deliver an integrated STEAM curriculum effectively. Topics will include interdisciplinary teaching methods, project-based learning, and the use of adaptive learning technologies.

Resource Availability and Utilization

- Ensure that all classrooms and laboratories are well-equipped with the necessary tools and materials for STEAM education. This includes digital resources, laboratory equipment, and access to online learning platforms.

Inclusivity and Accessibility

- Develop inclusive teaching strategies and materials that cater to the diverse learning needs of students. This includes providing support for students with disabilities and those from underrepresented groups in STEAM fields.

Monitoring Approaches

Continuous Assessment

- Implement formative assessment strategies such as quizzes, peer reviews, and self-assessments to monitor student progress continuously. These assessments will provide real-time feedback to students and teachers, allowing for timely interventions.

Performance Tracking

- Utilize a data management system to track student performance across all STEAM subjects. This system will analyze trends and identify areas where students are struggling, enabling targeted support.

Student and Teacher Feedback

- Conduct regular surveys and focus groups with students and teachers to gather feedback on the effectiveness of the STEAM curriculum and identify areas for improvement.

Periodic Review and Adjustment

- Establish a curriculum review committee that meets periodically to assess the implementation of the STEAM curriculum and make necessary adjustments based on feedback and performance data.

Reporting and Dissemination

- Prepare annual reports on the outcomes of the STEAM curriculum and share findings with stakeholders, including parents, school administrators, and the broader educational community. These reports will highlight successes, challenges, and areas for further development.

Conclusion

The STEAM education framework at Qingdao Yucai Middle School is effective but has areas for improvement. The similar experiences across different student groups and the gap between assessments and academic results highlight the complexity of STEAM education. These insights can help refine and enhance the program.

The student body's demographic composition is balanced in age and gender, with a distribution across year levels that supports a representative evaluation of the STEAM education program.

Students generally perceive the STEAM education they receive as effective, indicating that the curriculum and its delivery are well received and beneficial for most students.

Academic performance in STEAM subjects is consistently high, suggesting the curriculum successfully fosters understanding and proficiency in these critical areas, although Agriculture shows room for improvement.

Students' assessments of STEAM education and their academic performance do not differ significantly by age, gender, or year level. The program demonstrates an effective implementation.

The lack of a significant relationship between how students assess the quality of STEAM education and their academic performance suggests that subjective perceptions of the curriculum do not directly correlate with objective academic outcomes.

While the study explores several innovative strategies, it offers explicit recommendations for only a few. This implies that while these strategies are viewed positively, there is cautious optimism about their direct impact on enhancing academic performance, indicating the need for further empirical validation and effective implementation.

Future research should examine the impact of differentiated instruction and personalized learning tracks on STEAM academic performance to identify the most effective customizations. Longitudinal studies are needed to assess the long-term effects of peer-to-peer teaching and real-world problem-solving on students' preparedness for higher education and STEAM careers. Investigating the role of teacher expertise can inform improvements to curriculum and training. Additionally, exploring cultural and global perspectives in STEAM education can enhance student engagement and global preparedness. Lastly, studying the impact of technology integration will help identify the most effective tools for improving learning outcomes in STEAM subjects.

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