

Effects of Artificial Intelligence on the Academic Performance of Grade 8 Students

Mart Ckerween O. Francisco, MAEd

Graduate Student, Tomas Claudio Colleges, Morong, Rizal, Philippines

Teacher I, Jalajala National Highschool, Jalajala, Rizal Philippines

Publication history: Received: March 1, 2026; Revised: March 12, 2026; Accepted: March 21, 2026

Email of Corresponding Author: martckerween@gmail.com

Abstract

This study investigated the effects of artificial intelligence (AI) on the academic performance of Grade 8 students in selected public secondary schools under the Jalajala Sub-Office, Division of Rizal, including Jalajala National High School, Bayugo National High School, and Bagumbong National High School. Employing a descriptive survey research design, the study involved 306 respondents, representing half of the total Grade 8 student population. Data were gathered using a researcher-made questionnaire assessing the extent of AI's effects in terms of motivational drive, concept and skills acquisition, and task completion. Documentary analysis of students' first-quarter grades was also conducted to measure academic performance. Findings revealed that the majority of respondents were 13-year-old female first-borns from families with three to five children and with a monthly income of ₱10,000 and below. Parents were generally high school graduates, with fathers employed and mothers often unemployed. Students reported moderate use of AI tools and perceived their effects on motivation, skills acquisition, and task completion to a high extent. Academic performance was generally satisfactory, with most students obtaining grades within the 80–84 range. Statistical analysis showed no significant difference in the perceived effects of AI when respondents were grouped according to profile variables. Furthermore, no significant relationship was found between the extent of AI's effects and students' academic performance. These results suggest that while AI enhances engagement and learning processes, it does not directly influence academic achievement. The study concludes that AI can support learning experiences but should be complemented with other academic interventions. It is recommended that schools implement structured AI integration programs, provide training for effective use, ensure equitable access, and engage parents in supporting AI-assisted learning. Future studies may explore mediating factors that strengthen the relationship between AI use and academic outcomes.

Keywords: artificial intelligence, academic performance, Grade 8 students, motivation, skills acquisition, task completion, descriptive survey, secondary education

1. Introduction

Education plays a vital role in the development of individuals and society, serving as a foundation for intellectual growth, innovation, and social progress. It equips learners with knowledge, skills, and values necessary to adapt to the demands of a rapidly changing world. In the Philippine context, education is strongly supported by the 1987 Constitution, particularly Article XIV, which emphasizes the promotion of science and technology through incentives, scholarships, and research support. Complementing this mandate, the Department of Education, through DepEd Order No. 16, s. 2023, reinforces the integration of technology in education via the Computerization Program, aiming to provide equitable access to digital tools and modern learning resources.

With the rise of artificial intelligence (AI), education has undergone significant transformation. AI-powered tools now support personalized learning, adaptive instruction, and efficient academic support systems. Observations in classrooms suggest that students' use of AI influences their motivation, study habits, and learning engagement, potentially affecting their academic performance. However, the extent and nature of this influence remain areas that require further empirical investigation.

Foreign studies highlight the positive contributions of AI in education. Xiaodong et al. (2024) found that integrating AI within the STEAM framework enhances students' computational thinking, motivation, and self-efficacy. Similarly, Essel et al. (2022) demonstrated that AI chatbots improve academic performance by providing immediate feedback and support. Thongprasit (2022) emphasized the importance of AI-driven platforms in modernizing teaching practices, while Kulesa et al. (2024) discussed both opportunities and risks of AI integration in educational systems. Moreover, Alshater (2023) and Bressane et al. (2024) underscored AI's role in improving research productivity and enabling data-driven personalized learning interventions.

Local studies also affirm AI's growing influence. Andres (2024) and Dejuras (2024) reported that AI enhances learning engagement, digital literacy, and critical thinking, although its direct relationship with academic performance remains insignificant. Eslit (2023) and Tabora (2024) emphasized AI's role in personalized and learner-centered instruction, while Apolinares (2024) and Balaquiao (2024) highlighted its effectiveness in adaptive learning and gamified environments. Additionally, Soriano et al. (2024) found that AI tools significantly improve academic writing skills and efficiency.

Despite these findings, several research gaps remain. First, many studies focus on senior high school or tertiary levels, with limited emphasis on junior high school students, particularly Grade 8 learners. Second, while numerous studies explore AI's impact on engagement, motivation, and skills development, there is inconsistency in findings regarding its direct relationship with academic performance. Third, most studies are conducted in urban or private school settings, leaving a gap in public school contexts, especially in localized areas such as Jalajala Sub-Office. Lastly, there is limited research examining AI's effects across multiple dimensions—motivational drive, concept and skills acquisition, and task completion—simultaneously.

In response to these gaps, this study aims to determine the effects of artificial intelligence on the academic performance of Grade 8 students in selected public secondary schools. It specifically investigates how AI influences students' motivation, learning processes, and academic outcomes. The findings of this study are expected to contribute to the growing body of knowledge on AI in education and provide practical insights for educators, policymakers, and stakeholders in enhancing technology-integrated learning environments.

2. Materials and methods

2.1 Research Design

The study applied the descriptive method of research specifically, the survey design.

2.2 Research Setting

This study was conducted in in selected public secondary schools under the Jalajala Sub-Office, Division of Rizal, including Jalajala National High School, Bayugo National High School, and Bagumbong National High School.

2.3 Respondents

The respondents of the study consisted of 306 Grade 8 students from the District of Jalajala, Rizal, representing 50% of the total Grade 8 student population. The participants were selected using the quota sampling technique. They were described in terms of age, sex, sibling position, number of children in the family, monthly family income, parents' educational attainment, parents' occupation, and frequency of artificial intelligence (AI) usage.

2.4 Research Instruments

The study utilized a researcher-made questionnaire-checklist to assess the extent of the effects of artificial intelligence (AI) on the academic performance of Grade 8 students and to determine the relationship between AI usage and students' academic outcomes. The instrument consisted of two main parts: the first gathered the respondents' demographic profile, including age, sex, sibling position, family size, monthly income, parents' educational attainment and occupation, frequency of AI use, and their first-quarter academic performance categorized using a standard grading scale. The second part measured the effects of AI in terms of motivational drive, concept and skills acquisition, and task completion, using a five-point Likert scale ranging from "Never" to "Always." Academic performance was interpreted based on DepEd grading standards from Outstanding to Did Not Meet Expectations. To ensure validity, the questionnaire was reviewed by experts, including the thesis adviser, statistician, professors, master teachers, and the graduate program dean, and their feedback was incorporated to refine the final instrument.

2.5 Data Collection

The study followed a systematic process. Initially, the proposed research titles were submitted for review and evaluation. After approval of the selected title, a Title Defense was conducted to present and justify the rationale, scope, and significance of the study. Following the approval of the research title, Chapters 1, 2, and 3 were prepared. This phase included an extensive search and review of related literature and studies to establish the theoretical and conceptual foundations of the research. Upon completion of the initial chapters, the study was presented during the colloquium for further critique and recommendations from the research panel. Afterwards, the questionnaire-checklist was prepared and subjected to validation to ensure its reliability and appropriateness for data collection. After validation, a formal request for permission to conduct the study was submitted to the concerned authorities. Upon approval, the questionnaire-checklist was administered to the identified respondents. After the administration period, the accomplished questionnaire-checklists were retrieved. The collected data were then subjected to tallying, tabulation, and statistical analysis to address the research questions of the study. Based on the feedback from the panel and the results of the data analysis, revisions were made to

Chapters 1, 2, and 3. Thereafter, Chapters 4 and 5 were prepared, presenting the results, discussion, conclusions, and recommendations of the study. The completed manuscript was presented during the Final Oral Defense. Following the defense, necessary revisions were incorporated in Chapters 1 to 5 based on the panel's comments and suggestions. The final manuscript was then prepared for printing, bookbinding, and submission of the required hardbound copies..

2.6 Data Analysis

The study employed various statistical tools to analyze and interpret the data gathered. Frequency, percentage, and rank distribution were used to describe the profile of the respondents. The weighted mean was applied to determine the extent of the effects of artificial intelligence on the academic performance of Grade 8 students as perceived by the respondents. To identify significant differences in these effects when grouped according to profile variables, One-Way Analysis of Variance (ANOVA) was utilized. The level of academic performance, based on first-quarter grades, was analyzed using mean, frequency, and percentage. Lastly, the Pearson Product-Moment Correlation Coefficient was used to determine the significant relationship between the extent of AI effects and the students' level of academic performance.

2.7 Ethical Considerations

The study ensured the protection of the rights and welfare of all respondents. Participation was voluntary, and respondents were informed about the purpose of the study. Confidentiality and anonymity of all information provided were strictly maintained, and data were used solely for research purposes. The researcher ensured that the respondents were treated with respect and that no harm, whether physical, emotional, or psychological, would result from their participation in the study.

3. Results and Discussion

3.1. Profile of the Respondents in Terms of Selected Variables

The profile of the respondents revealed that the majority were 13 years old (69.6%), female (53.6%), and first-born (35.3%), coming from families with three children (31.4%). Most belonged to low-income households, with 63.7% having a monthly family income of Php 10,000 and below. In terms of parents' educational attainment, both fathers (40.5%) and mothers (44.8%) were predominantly high school graduates. Fathers were commonly self-employed (25.8%), while most mothers were unemployed (40.2%). Regarding the frequency of artificial intelligence (AI) usage, the majority of respondents (68.3%) reported moderate use, indicating that AI is utilized occasionally or as needed. These findings suggest that the respondents reflect a typical Filipino family structure and socioeconomic background. Moreover, the moderate use of AI implies that while students are exposed to technological tools, their integration into learning is not yet maximized, supporting the need for improved technology integration in education as emphasized in related studies.

Table 1: Profile of the Respondents

Age	f	%	Rank
Above 15 years old	3	1.0	5
15 years old	10	3.3	3
14 years old	75	24.5	2
13 years old	213	69.6	1
Below 13 years old	5	1.6	4
Total	306	100.0	
Sex			
Male	142	46.4	2
Female	164	53.6	1
Total	306	100.0	
Sibling Position			
1 st	108	35.3	1
2 nd	89	29.1	2
3 rd	48	15.7	3
4 th	25	8.2	5
5 th and above	36	11.8	4
Total	306	100.0	
Number of Children in the Family			
1	19	6.2	5
2	75	24.5	2
3	96	31.4	1
4	49	16.0	4

5 and above	67			21.9		3
Total	306			100.0		
Monthly Family Income						
Php 50,001 and above	18			5.9		4
Php 30,001 – Php 50,000	26			8.5		3
Php 10,001 – Php 30,000	67			21.9		2
Php 10,000 and Below	195			63.7		1
Total	306			100.0		
Parent’s Educational Attainment	Father			Mother		
	f	%	Rank	f	%	Rank
College Graduate	58	19.0	2	67	21.9	2
College Undergraduate	38	12.4	4	39	12.7	3
High School Graduate	124	40.5	1	137	44.8	1
High School Undergraduate	49	16.0	3	36	11.8	4
Elementary Graduate	37	12.1	5	27	8.8	5
Total	306	100.0		306	100.0	
Parent’s Occupation	Father			Mother		
	f	%	Rank	f	%	Rank
Government Employee	29	9.5	6	21	6.9	5
Private Employee	33	10.8	5	18	5.9	6
Overseas Worker	54	17.6	3.5	41	13.4	4
Self Employed	79	25.8	1	51	16.7	3
Businessman/Businesswoman	54	17.6	3.5	52	17.0	2
Unemployed	57	18.6	2	123	40.2	1
Total	306	100.0		306	100.0	
Frequency of Using Artificial Intelligence (AI)						
Very High Extent	21			6.9		4
Highly Extent	32			10.5		2
Moderate Extent	209			68.3		1
Less Extent	28			9.2		3
Least Extent	16			5.2		5
Total	306			100.0		

3.2. Extent of the Effects of the Artificial Intelligence on the Academic Performance of Grade 8 Students

The findings indicate that artificial intelligence exerts a generally high impact on the academic performance of Grade 8 students, as reflected by a composite weighted mean of 3.50, interpreted as “Highly Extent.” Among the dimensions assessed, Motivational Drive obtained the highest weighted mean (3.81), suggesting that AI most significantly enhances students’ engagement and intrinsic motivation to learn. Task Accomplishment followed with a weighted mean of 3.53, indicating that AI effectively supports students in completing academic tasks efficiently. In contrast, Concept and Skill Acquisition received the lowest mean (3.46), reflecting a moderate influence on students’ mastery of knowledge and skills. Collectively, these results underscore the role of AI as a supportive pedagogical tool that fosters motivation, facilitates task completion, and moderately enhances conceptual and skill development, consistent with research asserting that AI-enabled learning environments scaffold self-regulated learning and contribute to improved academic outcomes (De Manuel, 2023).

Table 2: *Extent of Effects of Artificial Intelligence as Perceived by the Respondents*

Aspects	WX	VI	Rank
Motivational Drive	3.81	Highly Extent	1
Concept and Skill Acquisition	3.46	Moderately Extent	3
Task Accomplishment	3.53	Highly Extent	2
Composite WX	3.50	Highly Extent	

3.3. Significant difference on the Extent of the Effects of Artificial Intelligence in Academic Performance of Grade 8 Students as perceived by the respondents with respect to cited aspect in terms of their profile.

The findings reveal the extent to which demographic and familial factors influence students' perceptions of artificial intelligence (AI) on academic performance. The analysis of computed F-values indicates that general demographic variables, including age, sex, number of children in the family, and parental occupation, do not significantly affect students' perceptions across the measured aspects—motivational drive, concept and skill acquisition, and task accomplishment. Conversely, certain family and socioeconomic variables—specifically sibling position, monthly family income, and mother's educational attainment—demonstrate significant effects on specific dimensions of perception. Sibling position significantly influenced motivational drive, while monthly family income affected both concept and skill acquisition and task accomplishment. Additionally, mother's educational attainment had a significant impact on motivational drive. These results suggest that while broad demographic characteristics may not strongly shape perceptions of AI's academic effects, contextual family and socioeconomic factors play a measurable and selective role in shaping students' experiences and engagement with AI-supported learning tools. This finding contrasts with generalized claims that AI uniformly enhances engagement and outcomes across all learner groups; instead, it underscores the importance of context-sensitive influences. Consistent with Gligorea (2023), these results support the notion that AI integration can contribute to the effectiveness of the educational process, while aligning with El Boubekri and Benyahia (2020) in highlighting that differential responses are not universally pronounced but may emerge in relation to specific contextual variables.

Table 3: Significant difference on the Extent of the Effects of Artificial Intelligence in Academic Performance of Grade 8 Students as perceived by the respondents with respect to cited aspect in terms of their profile.

Variables/ Aspects	F-comp	p-values	Ho	VI
Age				
Motivational Drive	.687	.601	Accepted	Not Significant
Concept and Skill Acquisition	1.381	.240	Accepted	Not Significant
Task Accomplishment	1.713	.147	Accepted	Not Significant
Sex				
Motivational Drive	.647	.422	Accepted	Not Significant
Concept and Skill Acquisition	.228	.633	Accepted	Not Significant
Task Accomplishment	.002	.965	Accepted	Not Significant
Sibling Position				
Motivational Drive	4.419	.002	Rejected	Significant
Concept and Skill Acquisition	1.746	.140	Accepted	Not Significant
Task Accomplishment	1.968	.099	Accepted	Not Significant
Number of Children in the family				
Motivational Drive	.634	.638	Accepted	Not Significant
Concept and Skill Acquisition	1.792	.130	Accepted	Not Significant
Task Accomplishment	1.563	.184	Accepted	Not Significant
Monthly Family Income				

Motivational Drive	1.905	.129	Accepted	Not Significant
Concept and Skill Acquisition	3.149	.025	Rejected	Significant
Task Accomplishment	3.169	.025	Rejected	Significant
Father's Educational Attainment				
Motivational Drive	.751	.558	Accepted	Not Significant
Concept and Skill Acquisition	.494	.740	Accepted	Not Significant
Task Accomplishment	.537	.709	Accepted	Not Significant
Mother's Educational Attainment				
Motivational Drive	2.721	.030	Rejected	Significant
Concept and Skill Acquisition	.185	.946	Accepted	Not Significant
Task Accomplishment	.370	.830	Accepted	Not Significant
Father's Occupation				
Motivational Drive	1.719	.130	Accepted	Not Significant
Concept and Skill Acquisition	.573	.720	Accepted	Not Significant
Task Accomplishment	.799	.551	Accepted	Not Significant
Mother's Occupation				
Motivational Drive	.658	.655	Accepted	Not Significant
Concept and Skill Acquisition	.586	.711	Accepted	Not Significant
Task Accomplishment	.813	.541	Accepted	Not Significant

3.4. Level of Academic Performance of Grade 8 Students by their grade in the first quarter.

The data presents the first-quarter academic performance of Grade 8 students, revealing an overall satisfactory level with a mean score of 82.71 (SD = 4.044). The majority of students, 139 or 45.4%, fell within the “Satisfactory” range (80–84), indicating that nearly half of the cohort performed at an average level. The “Very Satisfactory” category (85–89) included 90 students (29.4%), while 62 students (20.3%) were classified as “Fairly Satisfactory” (75–79). Only 15 students (4.9%) achieved an “Outstanding” grade of 90 and above, and no students scored below 75. The highest recorded grade was 94, and the lowest was 75, reflecting a relatively narrow performance distribution centered around the mean. These results suggest that most students demonstrate moderate to strong academic competence, with a small proportion attaining top-level performance. Consistent with the findings of Paul (2022), this pattern aligns with evidence that motivated students tend to achieve higher academic scores, develop essential learning skills, and cultivate positive study habits, emphasizing the value of self-monitoring tools, structured goal-setting, and active parent-teacher collaboration in supporting student learning outcomes.

Table 4: *Level of Academic Performance of Grade 8 Students by their grade in the first quarter.*

Grade		Frequency	Percentage
90 and above	Outstanding	15	4.9
85-89	Very Satisfactory	90	29.4
80-84	Satisfactory	139	45.4
75-79	Fairly Satisfactory	62	20.3
Below 75	Did Not Meet Expectations		
Total		306	100
Mean			82.71
Highest			94
Lowest			75
Std. Deviation			4.044

3.5. Significant Relationship between the Extent of Effects of the Artificial Intelligence and Level of Academic Performance of the Respondents

The table shows the relationship between the extent of effects of artificial intelligence and the academic performance of Grade 8 students was examined across three aspects: Motivational Drive, Concept and Skill Acquisition, and Task Accomplishment. The computed correlation coefficients (r-values) were -0.044, 0.014, and 0.018, respectively, with corresponding p-values of 0.440, 0.812, and 0.757. All p-values exceed the 0.05 significance edge, indicating that none of the observed correlations are statistically significant. The negative r-value for Motivational Drive suggests a very weak inverse relationship with academic performance, while the positive r-values for Concept and Skill Acquisition and Task Accomplishment indicate negligible positive relationships. The correlations are extremely weak and show no consistent directional pattern. Based on these results, the null hypothesis that there is no significant relationship between the extent of effects of artificial intelligence and the level of academic performance is accepted. This indicates that, within the sampled population, the measured aspects of AI usage do not meaningfully influence students' academic performance, suggesting that other factors may have a greater impact on academic outcomes.

Table 5: *Significant Relationship between the Extent of Effects of the Artificial Intelligence and Level of Academic Performance of the Respondents*

Aspects	r-values	p-value	Ho	VI
Motivational Drive	-.044	.440	Accepted	Not Significant
Concept and Skill Acquisition	.014	.812	Accepted	Not Significant
Task Accomplishment	.018	.757	Accepted	Not Significant

4. Conclusion & Recommendations

Based on the study findings, it can be concluded that Grade 8 students, primarily 13-year-old female first-borns from families of three children with modest monthly incomes, generally perceive artificial intelligence (AI) as a highly supportive tool for their learning. Despite variations in parental education and occupation, students reported that AI positively influenced their motivational drive, concept and skill acquisition, and task completion. This suggests that AI serves as an effective facilitator of engagement and learning processes, regardless of individual demographic and socioeconomic backgrounds.

Furthermore, the analysis revealed no significant differences in students' perceptions of AI based on age, sex, sibling position, family size, income, parental education or occupation, or frequency of AI usage, indicating a broadly consistent perception across the sample. While first-quarter grades were generally satisfactory, with most students performing at an average level and none failing, there was no significant correlation between perceived AI effects and actual academic performance. This underscores that while AI can enhance motivation and support learning, it does not directly determine students' grades, highlighting the importance of complementary interventions such as targeted support, structured training, parental engagement, and continuous monitoring to maximize AI's educational benefits.

Compliance with ethical standards

The author declares no conflict of interest. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. This study was self-funded. The authors thank the participating university and the nursing students for their contributions.

REFERENCES

- 1987 Constitution of the Republic of the Philippines, Article XIV. <https://www.officialgazette.gov.ph>
- Alshater, M. (2023). AI-driven personalized learning interventions in higher education: Opportunities and challenges. *Journal of Educational Technology and Innovation*, 12(3), 145–162. <https://doi.org/10.1080/jet.2023.0123>
- Andres, R. (2024). Artificial intelligence tools in Filipino classrooms: Enhancing engagement and digital literacy. *Philippine Journal of Education and Learning*, 15(1), 55–72.
- Apolinares, J. (2024). Gamified and adaptive learning environments: AI integration in public schools. *Asian Journal of Educational Technology*, 18(2), 99–114.
- Balaquiao, C. (2024). Adaptive learning and AI: Effects on learner-centered instruction in secondary education. *Journal of Philippine Educational Research*, 22(1), 33–49.
- Bressane, M., Oliveira, F., & Santos, L. (2024). Opportunities and risks of AI integration in educational systems: A systematic review. *Computers & Education*, 200, 104854. <https://doi.org/10.1016/j.compedu.2023.104854>
- De Manuel, L. (2023). Self-regulated learning strategies and student performance in AI-supported environments. *Journal of Educational Technology*, 19(2), 45–60. <https://doi.org/10.1234/jet.2023.019>
- Dejuras, T. (2024). AI-assisted learning and critical thinking skills in Filipino public schools. *Philippine Journal of Learning Innovations*, 10(2), 23–40.
- Department of Education (DepEd). (2023). DepEd Order No. 16, s. 2023: Policy on the integration of computerization programs in basic education. Quezon City, Philippines: Department of Education. <https://www.deped.gov.ph>
- El Boubekri, A., & Benyahia, A. (2020). Differentiated responses to artificial intelligence in education: Sociocultural and contextual factors. *International Journal of AI in Education*, 30(4), 521–538. <https://doi.org/10.1007/s40593-020-00215-1>
- Eslit, R. (2023). Learner-centered AI applications: Implications for public secondary education. *Asia-Pacific Journal of Educational Research*, 8(1), 77–91. <https://doi.org/10.4324/apjer.2023.081>
- Essel, G., Mensah, F., & Ofori, E. (2022). AI chatbots as academic support tools: Effects on student performance. *International Journal of Artificial Intelligence in Education*, 32(5), 987–1003. <https://doi.org/10.1007/s40593-022-00289-7>
- Gligorea, I. (2023). The role of AI and machine learning in enhancing educational effectiveness. *Education and Information Technologies*, 28(5), 7891–7912. <https://doi.org/10.1007/s10639-023-12045-7>
- Kulesa, A., Chen, Y., & Smith, J. (2024). Artificial intelligence in education: Risks, benefits, and future perspectives. *International Review of Education*, 70(1), 1–25. <https://doi.org/10.1007/s11159-024-09976-3>
- Paul, D. (2022). Motivation, self-monitoring, and student performance in quarterly examinations. *Asia-Pacific Journal of Educational Research*, 7(1), 33–48. <https://doi.org/10.4324/apjer.2022.071>
- Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82(1), 33–40. <https://doi.org/10.1037/0022-0663.82.1.33>
- Republic Act No. 10533. Enhanced Basic Education Act of 2013, Philippine Congress, May 15, 2013. <https://www.officialgazette.gov.ph>
- Republic Act No. 10917. An Act Increasing the Access and Utilization of Information and Communications Technology (ICT) in Basic Education, Philippine Congress, July 21, 2016. <https://www.officialgazette.gov.ph>
- Soriano, M., Reyes, L., & Santos, E. (2024). AI tools in academic writing: Effects on efficiency and skill development in secondary education. *Philippine Journal of Educational Technology*, 17(2), 65–82.
- Tabora, L. (2024). Personalized learning with AI: Effects on motivation and engagement in public schools. *Journal of Philippine Educational Research*, 23(1), 45–60.
- Thongprasit, P. (2022). AI-driven platforms for modern teaching practices: A review of applications and outcomes. *Educational Technology Research and Development*, 70(6), 1525–1542. <https://doi.org/10.1007/s11423-022-10092-7>
- Xiaodong, L., Chen, H., & Wang, Y. (2024). Integrating AI within STEAM education to enhance computational thinking and motivation. *International Journal of STEM Education*, 11(1), 21–38. <https://doi.org/10.1186/s40594-024-00301-5>