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ChatGPT in STEM Classrooms: Students' Perceptions of Interest, Academic Proficiency, and Learning Independence

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ABSTRACT

Purpose of the study: To provide K-12 evidence from a low- and middle-income context, this study examines how basic education STEM students use ChatGPT and how it relates to their interest, academic proficiency, and learning independence.

Methodology: Design: descriptive cross-sectional survey in one large public school. Participants: 186 Grade 11–12 STEM students. Instrument: 17-item researcher-developed questionnaire, administered online during class. Tool: ChatGPT (OpenAI). Analysis: item-level frequencies and percentages; reliability and validity checks treated as supportive for a heterogeneous instrument.

Main Findings: ChatGPT use was episodic and concentrated in Research and English. Students reported greater engagement, clearer understanding, and shorter assignment time. Independence gains were modest; textbook reliance declined while tutoring reliance was largely stable. Governance practices were common, including verification and paraphrase-synthesis or inspirational use. Older students emphasized efficiency and integration; younger students reported larger conceptual gains.

Novelty/Originality of this study: This study contributes classroom-proximate, item-level evidence from Philippine basic education, an underrepresented K-12 setting. It characterizes selective, front-end deployment and widespread verification, offering rubric-ready handles for responsible use. It identifies grade-linked orchestration differences and connectivity-aware implications that can guide targeted scaffolds to translate efficiency into competence and independent learning.

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1. INTRODUCTION

Since ChatGPT's public release in late 2022, generative AI has shifted from novelty to a routine study aid. Global bodies have issued guidance for education and research [1] and described an emerging landscape of nonbinding school-level guidance alongside evolving national frameworks [2], [3]. In the Philippines, the basic education curriculum includes writing- and inquiry-intensive subjects (English for Academic and Professional Purposes and Practical Research 1) that naturally invite student use of AI for brainstorming, drafting, summarizing, and feedback [4], [5]. Classroom uptake is also shaped by infrastructure: government connectivity initiatives continue to expand, yet affordability and geographic disparities persist, especially in public schools outside major urban centers [6], [7]. Against this backdrop, rigorous evidence from Philippine basic education Science,

Technology, Engineering, and Mathematics settings remains limited relative to the higher-education literature; this study addresses that gap by documenting students' reported use of ChatGPT and their perceptions of its influence on interest, academic proficiency, and learning independence.

Grounded in established learning frameworks, we examine whether on-demand drafting, exemplars, and formative feedback afforded by ChatGPT operate as scaffolds that lower entry barriers to complex tasks, support perceived competence and autonomy, and trigger situational interest that may develop into more enduring engagement [8], [9], [10]. We also assess citation, verification, and acknowledgment practices in light of continuing K–12 uncertainty reported in recent surveys of teachers and teens, which underscores the need for explicit classroom norms and AI-literacy instruction [11], [12], [13]. Taken together, this framing clarifies how basic education students position ChatGPT as a study scaffold in writing-intensive coursework and highlights governance and assessment practices that are likely to condition its integration in everyday learning [1], [11]–[13].

Emerging evidence shows that students most often use ChatGPT for brainstorming, outlining, summarizing, and getting feedback on writing, while teachers report uneven benefits and persistent concerns about accuracy and academic integrity [12], [13]. Reviews and meta-analytic syntheses suggest potential gains for learning and study efficiency under guided conditions, but effects vary widely across designs, subjects, and measures, and misuse remains a salient risk [11], [14], [15]. At the secondary level, adoption appears to be rising among teens, yet most evidence still comes from higher education or from high-income settings, underscoring the need for context-specific studies in K–12 and in low- and middle-income countries such as the Philippines [12], [16], [17]. Building on governance-oriented guidance that emphasizes verification, transparency, and human oversight [1], [11] this study focuses on what STEM learners report about ChatGPT's role in their interest, academic proficiency, and learning independence.

Anchoring our inquiry in established learning frameworks, we interpret students' responses as theoretically grounded perceptions of three constructs: interest (motivational engagement that develops from situational to individual interest), academic proficiency (perceived competence and understanding tied to self-efficacy), and learning independence (self-directed and self-regulated study). Classic accounts remain appropriate for these anchors, and contemporary syntheses reaffirm their centrality in today's classrooms [10]. Under guided conditions, recent reviews and meta-analyses report generally positive associations between ChatGPT-supported learning and outcomes such as performance, engagement, and reduced mental effort—though effects vary by design, subject, and measures and are drawn largely from higher education samples [14], [15]. Governance guidance emphasizes that any classroom use should be paired with verification, transparency, and human oversight [11]. Finally, rising teen exposure to GenAI and mixed teacher sentiment underscore the need for context-specific K–12 evidence in low- and middle-income settings like the Philippines [13], [18].

Accordingly, this study documents how Grade 11–12 STEM students in a large Philippine public school report using ChatGPT across subjects and tasks, and how they perceive its influence on interest, academic proficiency, and learning independence. It contributes K–12 evidence from a low- and middle-income context to a literature still dominated by higher-education studies and reviews and aligns with calls to generate classroom-level evidence to guide responsible AI use in schools. We address three questions: (RQ1) How do STEM students perceive ChatGPT's influence on their interest or engagement in study? (RQ2) How do they perceive its influence on academic proficiency? (RQ3) How do they perceive its influence on learning independence?

2. RESEARCH METHOD

We used a descriptive, cross-sectional survey to estimate the prevalence of ChatGPT use and describe perceived effects on interest, academic proficiency, and learning independence among STEM students. Cross-sectional designs collect data at a single time point and are appropriate for documenting patterns and associations without inferring causality [19]. Reporting follows relevant elements of the STROBE guidance for observational studies to improve transparency of design, sampling, measurement, and analysis [20].

We analyzed survey responses from 186 STEM students drawn from a large public secondary school in Sorsogon City, Bicol Region, Philippines. The sample comprised Grade 11 (n = 139, 74.7%) and Grade 12 (n = 47, 25.3%) students. Participants identified as female (n = 104, 55.9%) or male (n = 82, 44.1%). Ages ranged from 15 to 18 years (M = 16.38, SD = 0.66). We targeted STEM students because their coursework is writing- and research-intensive, increasing the likelihood of authentic Gen-AI use in academic tasks. Eligibility required prior experience using ChatGPT for schoolwork. We employed a two-stage sampling approach: purposive eligibility (STEM students with ChatGPT exposure) followed, where feasible, by random selection within eligible classes to distribute participation across sections. School approval was obtained before data collection; participation was voluntary, with informed consent obtained via an embedded statement in the questionnaire. Responses were collected anonymously and treated as confidential.

We adopted a researcher-developed questionnaire [21] and administered 17 single-select items (Q1–Q17) plus demographics (grade level, sex). Items were written deductively to profile perceived influence across three constructs aligned with the study aims: interest/engagement, academic proficiency, and learning independence.

The instrument is descriptive; items capture self-reports of study practices and perceived changes rather than latent traits or causal effects [21], [22]. Response formats were categorical or ordered where appropriate (e.g., increased vs. no change vs. decreased; daily to never). Content validity was supported by expert review (mean rating = 4.67/5). A prior technical check computed KR-21 = .65 after dichotomizing ordered responses solely for that reliability estimate; given the instrument's heterogeneity and the study's item-level reporting, internal-consistency statistics are treated as supportive rather than definitive [22], [23].

To make the link to the research questions explicit, we use the following item–RQ map: RQ1 (interest/engagement) uses Q1–Q4, Q6, Q7, Q13, and Q14. Within RQ1, Q4 captures perceived change in engagement or interest and Q6 captures willingness to recommend; Q1–Q3 (frequency, purposes, subject areas) provide usage context; Q13 (satisfaction/quality) and Q14 (verification/credibility) are governance indicators included with RQ1 to contextualize engagement; Q7 (study time/efficiency) serves as a bridging indicator reported under RQ1 and RQ2. RQ2 (academic proficiency) uses Q5, Q7–Q9, Q15, and Q16: Q5 evaluates overall performance, Q8 conceptual understanding, Q7 study time/efficiency, and Q9 subjects where change is noticed, complemented by governance items Q15 (integration) and Q16 (citation/acknowledgment) to situate proficiency within responsible-use practices. RQ3 (learning independence) uses Q10–Q12 and Q17: Q10–Q12 capture self-reported independence and reliance on textbooks and tutoring, and Q17 captures self-regulation. This mapping is carried through in the Results and Discussion.

Data were gathered on the first quarter of 2025 via a self-administered online questionnaire during regular class time with school approval. Class advisers coordinated access, and students completed the survey individually on their own devices. An embedded consent item preceded all questions; 100% selected "I agree." Minimal identifying fields (e.g., name or username) were captured solely to manage data integrity and were dropped before analysis; analytic files contained only demographics and item responses. Responses were exported to CSV for analysis.

Item completion was essentially complete. We screened for data issues (e.g., duplicate submissions, straight-lining). One near-duplicate from the same account two seconds apart had identical answers; excluding it did not alter distributions, so primary analyses retained N = 186. Ages were parsed from text (e.g., "17 years old"), and grade level was derived from "Year & Section" (mapped to Grade 11 or Grade 12). Ordered categorical options were treated as ordinal for descriptive summaries; no causal inferences or latent scale scores were estimated, consistent with the study's descriptive, cross-sectional design [24], [25].

Demographics were summarized as counts and percentages for grade level and sex, and as mean and standard deviation for age. Each questionnaire item (Q1 to Q17) was analyzed at the item level using frequencies and percentages. The five-level satisfaction item (Very dissatisfied, Dissatisfied, Neutral, Satisfied, Very satisfied) was collapsed to three categories: dissatisfied (very dissatisfied and dissatisfied), neutral, and satisfied (satisfied and very satisfied). Summaries are unweighted and use complete-case denominators per item. Analyses are organized by the study's research questions using the pre-specified item–RQ map.

3. RESULTS

3.1. STEM students perceive ChatGPT's influence on their interest in study (RQ1)

Use of ChatGPT was present but largely episodic, with students positioning it as a tool they reach for in specific study moments rather than a constant companion. Frequency data in Table 1 show a plural profile anchored in "rarely" and "weekly" use. The largest share reported using ChatGPT rarely (Q1D, 43.0%), followed closely by weekly users (Q1B, 38.2%); monthly use accounted for 11.3% (Q1C). Only a small fraction used it daily (Q1A, 4.8%) and a similarly small fraction reported never using it (Q1E, 2.7%). Grade-level patterns suggest maturation effects. Grade 12 students were more represented among daily and weekly users (Q1A, 6.4%; Q1B, 42.6%) than Grade 11 students (Q1A, 4.3%; Q1B, 36.7%), while Grade 11 students more often selected rarely (Q1D, 45.3% vs. 36.2%). Taken together, these frequencies indicate that ChatGPT has penetrated everyday study routines but with measured intensity, consistent with selective deployment during tasks that students perceive as benefiting from assistance.

Table 1. STEM students perceive ChatGPT's influence on their interest in study (n = 186)

Questions	Options	Grade 11	%	Grade 12	%	Total	%
Q1 How often do you use ChatGPT for your academic tasks?	A. Daily	6	4.3	3	6.4	9	4.8
	B. Weekly	51	36.7	20	42.6	71	38.2
	C. Monthly	14	10.1	7	14.9	21	11.3
	D. Rarely	63	45.3	17	36.2	80	43
	E. Never	5	3.6	0	0	5	2.7
Q2 For which academic tasks do you use ChatGPT?	A. Homework	33	23.7	21	44.7	54	29
	B. Research	57	41	10	21.3	67	36

	C. Writing assignments	9	6.5	5	10.6	14	7.5
	D. Others	40	28.8	11	23.4	51	27.4
Q3 In which subject areas do you use ChatGPT?	A. English	28	20.1	19	40.4	47	25.3
	B. Sciences (Chemistry, Biology, etc.)	22	15.8	13	27.7	35	18.8
	C. Mathematics	20	14.4	4	8.5	24	12.9
	D. Social Science	5	3.6	1	2.1	6	3.2
	E. Research	64	46	10	21.3	74	39.8
Q4 Has the use of ChatGPT affected your engagement or interest in your studies?	A. Increased significantly	14	10.1	8	17	22	11.8
	B. Increased slightly	70	50.4	19	40.4	89	47.8
	C. No change	50	36	15	31.9	65	34.9
	D. Decreased slightly	4	2.9	5	10.6	9	4.8
	E. Decreased significantly	1	0.7	0	0	1	0.5
Q6 Would you recommend ChatGPT to other students?	A. Yes	58	41.7	26	55.3	84	45.2
	B. No	14	10.1	4	8.5	18	9.7
	C. Not sure	67	48.2	17	36.2	84	45.2
Q7 Have you noticed any changes in the time it takes to complete assignments since using ChatGPT?	A. Significantly less time	31	22.3	20	42.6	51	27.4
	B. Slightly less time	87	62.6	24	51.1	111	59.7
	C. No change	11	7.9	2	4.3	13	7
	D. Slightly more time	9	6.5	1	2.1	10	5.4
	E. Significantly more time	1	0.7	0	0	1	0.5
Q13 How satisfied are you with the quality and accuracy of the content generated by ChatGPT?	A. Very dissatisfied	1	0.7	0	0	1	0.5
	B. Dissatisfied	12	8.6	3	6.4	15	8.1
	C. Neutral	90	64.7	31	66	121	65.1
	D. Satisfied	35	25.2	13	27.7	48	25.8
	E. Very satisfied	0	0	0	0	0	0
Q14 How do you evaluate the reliability and credibility of the information provided by ChatGPT?	A. I do not check the sources or references used by ChatGPT.	5	3.6	1	2.1	6	3.2
	B. I check the sources or references used by ChatGPT but I do not verify them.	11	7.9	0	0	11	5.9
	C. I check and verify the sources or references used by ChatGPT.	27	19.4	7	14.9	34	18.3
	D. I check, verify, and compare the sources or references used by ChatGPT with other sources.	49	35.3	16	34	65	34.9
	E. I check, verify, compare, and critique the sources or references used by ChatGPT with other sources.	47	33.8	23	48.9	70	37.6

The distribution of task types reinforces this interpretation. When asked where ChatGPT is used, students most often chose research tasks (Q2B, 36.0%) and homework (Q2A, 29.0%), while other uses such as brainstorming, clarifying instructions, or preparing for quizzes accounted for 27.4% (Q2D). Writing assignments was least selected at 7.5% (Q2C). This pattern implies that students frequently situate ChatGPT at the front end of academic work where information gathering, comprehension, and initial structuring occur. It is less commonly positioned as a drafting engine for graded writing. The subject-area profile aligns with that task distribution. Students reported using ChatGPT most in Research (Q3E, 39.8%) and English (Q3A, 25.3%), followed by Sciences such as Chemistry and Biology (Q3B, 18.8%). Mathematics use was lower (Q3C, 12.9%), and Social Science was the least selected (Q3D, 3.2%). English and Research are language- and inquiry-intensive domains where summarizing, rephrasing, and conceptual explanation are naturally useful [26]-[28]; Mathematics often requires symbolic manipulation and stepwise reasoning that students may prefer to handle with teacher support or dedicated tools [29]. These distributions suggest that perceived utility is strongest where tasks demand reading, synthesis, and explanation.

On self-reported interest, the net effect skews positive but mostly in modest increments. A combined 59.6% reported that ChatGPT increased their engagement (increased slightly, Q4B, 47.8%; increased significantly, Q4A, 11.8%), 34.9% reported no change (Q4C), and 5.3% reported decreases (Q4D–E). Grade-level contrasts again hint at experience shaping benefit. Grade 12 students more often endorsed increased significantly (Q4A, 17.0% vs. Grade 11 at 10.1%), whereas Grade 11 students clustered in increased slightly (Q4B, 50.4%). These distributions indicate that while many learners feel more motivated when they can unblock themselves or

accelerate routine steps, the experience is not universally transformative. A sizable minority perceives no change, and a small group reports that interest decreases, which could reflect frustration with answer quality, concerns about overreliance, or misalignment with teacher expectations.

Perceived efficiency is a prominent part of the interest story. A large majority reported that assignments now take less time (significantly less, Q7A, 27.4%; slightly less, Q7B, 59.7%; combined 87.1%), while no change was 7.0% (Q7C) and more time was rare at 5.9% (Q7D–E). Grade 12 students more often selected significantly less time (Q7A, 42.6% vs. Grade 11 at 22.3%), suggesting that more experienced users translate the tool into time savings more readily. Efficiency gains can foster interest by reducing friction in preparatory tasks, which may explain why "increased slightly" is the modal response for engagement [27]. At the same time, efficiency without careful verification may temper enthusiasm, as students weigh speed against accuracy [30], [31].

That calibration is evident in quality and governance responses. Satisfaction with output quality skewed neutral (Q13C, 65.1%) with satisfied at 25.8% (Q13D) and dissatisfied at 8.6% including very dissatisfied at 0.5% (Q13A–B). No respondents chose very satisfied (Q13E, 0.0%), which underscores a cautious stance toward the reliability of generated content. Consistent with that caution, most students reported active verification behaviors. A combined 72.5% said they check, verify, and compare sources (Q14D, 34.9%) or go further to critique them (Q14E, 37.6%). Smaller shares reported verify without comparison (Q14C, 18.3%) or check without verify (Q14B, 5.9%), and very few do not check at all (Q14A, 3.2%). Grade 12 students more often selected the most advanced behavior of check, verify, compare, and critique (Q14E, 48.9% vs. Grade 11 at 33.8%). These governance patterns help explain the interest profile. Students are saving time and often feel a modest lift in motivation, yet their neutral satisfaction and deliberate verification suggest that they are balancing convenience with skepticism. This balance likely contributes to hesitation in advocacy. When asked if they would recommend ChatGPT to peers, responses split between Yes (Q6A, 45.2%) and Not sure (Q6C, 45.2%), with No at 9.7% (Q6B). Students who are uncertain may be weighing perceived benefits against quality concerns, assessment policies, or uneven teacher guidance.

Synthesizing across items for RQ1, the pattern is coherent. Students invoke ChatGPT primarily where it supports reading, idea generation, and clarification in English and Research. The tool is used episodically rather than continuously, and it is associated with substantial time savings that appear to nudge interest upward for many students, especially in Grade 12. At the same time, enthusiasm is moderated by neutrality in satisfaction and a strong emphasis on verification, which reflects realistic appraisal of limitations. Recommendation ambivalence mirrors this duality. In short, ChatGPT functions as a formative aid that can raise engagement modestly by reducing friction in front-end learning tasks, provided students continue to evaluate outputs critically and align use with classroom expectations.

3.2. Students' perceptions on ChatGPT's influence on academic proficiency (RQ2)

Perceived academic performance tilted positive, with just over half of students reporting improvement since using ChatGPT, a large minority reporting no change, and very few noting decline (see Table 2). Specifically, 53.2% indicated an improvement (Q5A), 43.5% no change (Q5B), and 3.2% a decline (Q5C). Grade-level contrasts suggest a modest advantage for older students: Grade 12 reported more improvements than Grade 11 (59.6% vs. 51.1%), and slightly fewer "no change" responses (38.3% vs. 45.3%). These distributions indicate perceived gains without masking a substantial group for whom performance is stable, a pattern consistent with heterogeneous tasks and differential fit between tool use and assignment demands.

Table 2. Students' perceptions on ChatGPT's influence on academic proficiency (n = 186)

Questions	Options	Grade 11	%	Grade 12	%	Total	%
Q5 Have you noticed any changes in your academic performance since you started using ChatGPT?	A. Improvement	71	51.1	28	59.6	99	53.2
	B. No change	63	45.3	18	38.3	81	43.5
	C. Decline	5	3.6	1	2.1	6	3.2
Q7 Have you noticed any changes in the time it takes to complete assignments since using ChatGPT?	A. Significantly less time	31	22.3	20	42.6	51	27.4
	B. Slightly less time	87	62.6	24	51.1	111	59.7
	C. No change	11	7.9	2	4.3	13	7
	D. Slightly more time	9	6.5	1	2.1	10	5.4
	E. Significantly more time	1	0.7	0	0	1	0.5
Q8 Have you noticed any changes in your understanding of new concepts since using ChatGPT?	A. Understanding significantly improved	42	30.2	8	17	50	26.9
	B. Understanding slightly improved	82	59	32	68.1	114	61.3
	C. No change	12	8.6	4	8.5	16	8.6
	D. Understanding slightly worsened	0	0	0	0	0	0
	E. Understanding significantly worsened	0	0	0	0	0	0
Q9 In which subjects have you noticed these changes?	A. Mathematics	24	17.3	8	17	32	17.2
	B. Science	25	18	17	36.2	42	22.6

	C. English	23	16.5	16	34	39	21
	D. Social Studies	6	4.3	0	0	6	3.2
	E. Research	61	43.9	6	12.8	67	36
Q15 How do you integrate the content generated by ChatGPT with your own ideas and knowledge?	A. I copy and paste the content generated by ChatGPT without any changes	1	0.7	1	2.1	2	1.1
	B. I copy and paste the content generated by ChatGPT with minor changes	0	0	1	2.1	1	0.5
	C. I paraphrase the content generated by ChatGPT	11	7.9	2	4.3	13	7
	D. I paraphrase and synthesize the content generated by ChatGPT with my own ideas and knowledge.	53	38.1	10	21.3	63	33.9
	E. I use the content generated by ChatGPT as a reference or inspiration for my own original work.	74	53.2	33	70.2	107	57.5
Q16 How do you cite and acknowledge the sources used by ChatGPT?	A. I do not cite or acknowledge the sources used by ChatGPT.	21	15.1	10	21.3	31	16.7
	B. I cite or acknowledge the sources used by ChatGPT inconsistently or incorrectly.	10	7.2	2	4.3	12	6.5
	C. I cite or acknowledge the sources used by ChatGPT consistently and correctly.	39	28.1	13	27.7	52	28
	D. I cite or acknowledge the sources used by ChatGPT and ChatGPT itself consistently and correctly.	28	20.1	9	19.1	37	19.9
	E. I cite or acknowledge the sources used by ChatGPT and ChatGPT itself and provide a rationale for using ChatGPT as a learning tool consistently and correctly	41	29.5	13	27.7	54	29

Perceived efficiency gains were widespread and substantial, reinforcing the performance signal. A combined 87.1% reported that assignments take less time with ChatGPT—27.4% significantly less (Q7A) and 59.7% slightly less (Q7B)—while 7.0% saw no change (Q7C) and 5.9% reported more time (Q7D–E). Grade 12 students more often endorsed significantly less time than Grade 11 (42.6% vs. 22.3%), consistent with more strategic deployment in capstone-style or integrative tasks. Taken together, these figures position ChatGPT as a productivity scaffold that compresses early-cycle activities (e.g., information gathering, outlining, initial drafting), which plausibly underpins the perceived performance improvements.

Perceived conceptual understanding moved strongly in the direction of improvement, with virtually no reports of worsening. In total, 88.2% indicated better understanding—26.9% significantly improved (Q8A) and 61.3% slightly improved (Q8B)—8.6% reported no change (Q8C), and 0% reported worsening (Q8D–E). Here the grade-level nuance inverts the efficiency pattern: Grade 11 were more likely to select significantly improved than Grade 12 (30.2% vs. 17.0%), whereas Grade 12 chose slightly improved more often (68.1% vs. 59.0%). This suggests that earlier learners may experience larger "conceptual jumps" as they first leverage the tool for explanation and example generation, while older students translate the same affordances into steadier, incremental understanding alongside greater time savings [12].

The subjects in which changes were noticed mirror the language- and inquiry-centric profile observed in RQ1. Reported gains clustered in Research (36.0%, Q9E), followed by Science (22.6%, Q9B) and English (21.0%, Q9C), with lower shares in Mathematics (17.2%, Q9A) and Social Studies (3.2%, Q9D). Grade-level differences were modest but illustrative: Grade 11 more frequently located changes in Research (43.9%) than Grade 12 (12.8%), consistent with earlier exposure effects and the novelty of AI-supported inquiry in Grade 11 coursework. Overall, the concentration in Research/English/Science aligns with tasks that demand reading, synthesis, and explanation—where ChatGPT's exemplars and reformulations are most directly useful—while computation-heavy or fact-recall tasks appear less affected.

Indicators of responsible-use practices contextualize these proficiency perceptions. Students overwhelmingly described higher-order integration of AI outputs: the most common behaviors were using content as reference or inspiration (57.5%, Q15E) and paraphrasing and synthesizing with one's own ideas (33.9%, Q15D). Paraphrasing only (Q15C) accounted for 7.0%, and direct copy–paste behaviors were rare (1.6% combined for Q15A–B). Grade 12 were more likely than Grade 11 to use ChatGPT as reference/inspiration (70.2% vs. 53.2%), consistent with a more mature orchestration of sources in complex tasks. These patterns suggest that students are

not simply transplanting AI text; rather, most are incorporating outputs as prompts, scaffolds, or comparators to produce their own work—an approach more likely to build competence and transfer [32], [33].

Citation and acknowledgment behaviors show progress with room for consolidation. A combined 76.9% reported consistent and correct acknowledgment at varying levels—citing sources used by ChatGPT (28.0%, Q16C), citing sources and ChatGPT itself (19.9%, Q16D), or citing both and providing a rationale for using ChatGPT (29.0%, Q16E). However, 16.7% did not cite (Q16A) and 6.5% cited inconsistently or incorrectly (Q16B). The overall profile indicates maturing governance practices that support credible learning gains, while also identifying a persistent minority who need explicit instruction on attribution standards, rationale statements, and transparency in AI-assisted academic work.

Across items, students associate ChatGPT with better performance, faster task completion, and clearer conceptual understanding, with no evidence of perceived conceptual harm. Gains are most salient in Research, English, and Science, where reading, synthesis, and explanation dominate; improvements are less pronounced in domains that emphasize computation or rote recall [34]. Most students integrate AI outputs through paraphrase–synthesis or use them as inspiration, and three in four practice some form of proper acknowledgment, conditions that plausibly convert efficiency into legitimate proficiency rather than superficial speed. Grade-level contrasts imply developmental differences in strategy—Grade 12 prioritize time savings and inspirational use, while Grade 11 report larger conceptual jumps and concentrate gains in Research—suggesting that instructional supports can be tuned by year level to convert emerging practices into durable academic competencies.

3.3. Students' perceptions on ChatGPT's influence on learning independence (RQ3)

Perceived learning independence moved in a positive direction for a majority of students, although a meaningful minority reported no change and a smaller group perceived declines (see Table 3). Overall, 44.6% selected slightly more independent (Q10B) and 10.2% significantly more independent (Q10A), while 29.0% saw no change (Q10C); decreases were less common at 16.2% combined (slightly less, Q10D, 15.1%; significantly less, Q10E, 1.1%). Grade-level contrasts suggest independence grows with experience: Grade 12 endorsed significantly more independent more frequently (19.1%) than Grade 11 (7.2%), with Grade 11 clustering in no change (33.8% vs. 14.9% for Grade 12). These patterns indicate that students commonly experience modest gains in self-direction with ChatGPT, and that older learners are more likely to attribute substantial increases in independence to their use.

Table 3. Students' perception on ChatGPT influence on learning independence

Questions	Options	Grade 11	%	Grade 12	%	Total	%
Q10 Has the use of ChatGPT helped you become more independent in your learning process?	A. Significantly more independent	10	7.2	9	19.1	19	10.2
	B. Slightly more independent	59	42.4	24	51.1	83	44.6
	C. No change	47	33.8	7	14.9	54	29
	D. Slightly less independent	21	15.1	7	14.9	28	15.1
	E. Significantly less independent	2	1.4	0	0	2	1.1
Q11 Has the use of ChatGPT decreased your dependence on textbooks?	A. Significantly decreased	14	10.1	7	14.9	21	11.3
	B. Slightly decreased	60	43.2	19	40.4	79	42.5
	C. No change	58	41.7	18	38.3	76	40.9
	D. Slightly increased	5	3.6	2	4.3	7	3.8
	E. Significantly increased	2	1.4	1	2.1	3	1.6
Q12 Has the use of ChatGPT decreased your dependence on tutoring?	A. Significantly decreased	11	7.9	3	6.4	14	7.5
	B. Slightly decreased	44	31.7	12	25.5	56	30.1
	C. No change	77	55.4	28	59.6	105	56.5
	D. Slightly increased	7	5	4	8.5	11	5.9
	E. Significantly increased	0	0	0	0	0	0
Q17 How do you monitor and regulate your own learning process when using ChatGPT?	A. I do not monitor or regulate my own learning process when using ChatGPT	13	9.4	6	12.8	19	10.2
	B. I monitor or regulate my own learning process when using ChatGPT occasionally or superficially.	20	14.4	9	19.1	29	15.6
	C. I monitor or regulate my own learning process when using ChatGPT regularly or moderately.	40	28.8	12	25.5	52	28
	D. I monitor or regulate my own learning process when using ChatGPT frequently or deeply.	24	17.3	4	8.5	28	15.1
	E. I monitor or regulate my own learning process when using ChatGPT and reflect on the strengths and weaknesses of using	0	0	0	0	0	0

ChatGPT as a learning tool frequently or deeply.

Shifts in reliance on textbooks show a complementary pattern. A slight majority perceived decreased dependence on textbooks (11.3% significantly decreased, Q11A; 42.5% slightly decreased, Q11B; 53.8% combined), while 40.9% reported no change (Q11C), and 5.4% perceived increases (Q11D–E). The decrease signal is shared across grades, with Grade 12 somewhat more likely to choose significantly decreased (14.9%) than Grade 11 (10.1%). These distributions suggest that students are substituting some portion of textbook consultation with on-demand explanations and examples from ChatGPT, although a large group still perceives their textbook use as stable, consistent with blended strategies rather than full substitution.

By contrast, reliance on tutoring was mostly unchanged. Over half of students selected no change (56.5%, Q12C), with decreases less common than for textbooks (7.5% significantly decreased, Q12A; 30.1% slightly decreased, Q12B; 37.6% combined) and increases relatively rare (5.9%, Q12D–E). Grade 11 reported decreases more often than Grade 12 (39.6% vs. 31.9% combined), suggesting that earlier students may treat ChatGPT as a partial substitute for certain help-seeking episodes, whereas older students keep their tutoring practices more stable. The asymmetry between textbooks and tutoring implies that learners view ChatGPT as a quick-reference or explainer that trims routine reading, but not as a full replacement for human scaffolding when tasks become challenging or high-stakes.

Evidence on self-regulation while using ChatGPT underscores a developing, but not yet advanced, metacognitive profile. Among respondents who answered Q17 (n = 128), 28.0% reported regular or moderate monitoring (Q17C) and 15.1% reported frequent or deep monitoring (Q17D). Meanwhile, 15.6% monitored only occasionally or superficially (Q17B) and 10.2% did not monitor at all (Q17A). Notably, no student chose the highest option that explicitly combined frequent monitoring with reflective appraisal of ChatGPT's strengths and weaknesses (Q17E, 0%). Grade-level patterns suggest that Grade 11 were somewhat more likely to report frequent/deep monitoring (17.3%) than Grade 12 (8.5%), while Grade 12 more often indicated no monitoring (12.8% vs. 9.4%). This mix points to emerging self-regulatory habits, with many learners engaging in routine checks but few reaching the reflective, critique-oriented practices that characterize mature self-regulated learning.

Synthesis for RQ3. Across Q10–Q12 and Q17, students generally perceive that ChatGPT supports greater independence and lighter reliance on textbooks, while leaving tutoring needs largely unchanged. Gains in independence are usually modest rather than dramatic, and they are more pronounced among Grade 12, which is consistent with increasing ability to orchestrate tools within complex tasks. The stability of tutoring suggests that, even as students offload some reading to AI explanations, human guidance remains important for diagnosing misconceptions, aligning with teacher expectations, and navigating assessment demands. Finally, the self-regulation profile reveals a clear developmental target: many students monitor their learning to some extent, but almost none reach the level of systematic reflection on when and why ChatGPT helps or hinders. These results justify embedding explicit self-regulation prompts and reflection rubrics in assignments that permit AI use, so that time savings and just-in-time explanations translate into durable, autonomous learning practices.

3.4 Discussion

This study shows a coherent pattern across frequency, task, and subject use that helps explain students' perceived gains. Students reported using ChatGPT episodically rather than continuously, concentrating use in research and English tasks that require reading, synthesis, and explanation, with lower intensity in mathematics and social science. Within this profile, most students perceived modest increases in interest, substantial time savings, and better conceptual understanding, although many remained neutral about output quality and almost half were unsure about recommending the tool. Governance behaviors were relatively mature for a majority, with frequent verification, comparison, and critique of sources and an emphasis on paraphrase–synthesis or inspirational use rather than copying. Grade-level contrasts suggest developmental differences in orchestration. Grade 12 students more often reported pronounced time savings and greater independence, while Grade 11 students reported larger conceptual jumps and located changes more frequently in research coursework, consistent with earlier exposure effects and the novelty of AI-supported inquiry in Grade 11.

A Philippine lens helps clarify why these effects cluster where they do and why enthusiasm remains calibrated rather than unqualified. Household internet access is not universal, and many learners depend on prepaid mobile data or shared devices, which favors short, opportunistic sessions over long, iterative exchanges at home [35]. In such conditions, it is rational for students to deploy ChatGPT at the front end of tasks where even a brief consultation pays off, such as brainstorming, obtaining quick explanations, or scoping references, and to avoid extended drafting that would demand continuous connectivity and repeated verification. The same constraints help explain the neutral satisfaction profile and the high prevalence of checking, verifying, and critiquing outputs; students appear to budget time for accuracy checks and to weigh that cost against the convenience of rapid answers. Philippine studies conducted prior to and alongside the current AI wave reported inadequate equipment and slow connections as recurring barriers in secondary education [36], [37], which aligns with the episodic use and cautious stance observed here. In related work on self-regulated learning among Filipino preservice teachers, strengths in

environment structuring and goal setting coexisted with weaker task strategies and help-seeking, a profile that resonates with our finding that routine monitoring is common while deeper, reflective monitoring of when and why ChatGPT helps or misleads is rare [35]. In short, the mix of infrastructural and metacognitive baselines in Philippine classrooms provides a concrete mechanism for the selective, front-end deployment, the neutral satisfaction, and the verification-heavy governance we document.

Interpreting the results through established learning frameworks further tightens the link between what students reported and how benefits arise. The four-phase model of interest development predicts that lowering entry barriers and providing rapid feedback will move situational interest toward more stable forms; the dominance of "increased slightly" in engagement, paired with the large efficiency gains and the high rate of improved conceptual understanding, is consistent with this mechanism [9]. Self-determination theory suggests that the perceived competence and autonomy afforded by on-demand exemplars, explanations, and outline scaffolds support motivation, provided use is paired with choice and transparent classroom norms; the combination of time savings, understanding gains, and careful verification in our data matches this pattern and helps explain why interest rises without evidence of widespread [8], [38]. Self-regulated learning models emphasize planning, monitoring, and evaluation [39]; our results indicate that many students already monitor by checking and comparing sources, yet few reach reflective appraisal that articulates when AI is appropriate, what needed correction, and how reliability was established, which marks a clear and teachable ceiling for growth [10].

The subject profile and the asymmetries across resources also follow logically from students' reported practices. Improvements were concentrated in Research, English, and Science, where reading, synthesis, and explanation dominate and where paraphrase–synthesis and "use as inspiration" are legitimate pathways to competence. Lower effects in mathematics and social science are plausible when students require stepwise reasoning or authoritative interpretations that must be triangulated with textbooks and lectures. The combination of decreased reliance on textbooks with largely unchanged reliance on tutoring suggests that ChatGPT functions as a quick explainer or comparator that trims routine reading but does not replace human scaffolding when tasks are challenging or high stakes. This configuration is compatible with international guidance that positions generative AI as formative support under human oversight and with Philippine proposals for classroom-level rules that specify permitted uses, require triangulation for factual claims, and set transparent acknowledgment norms so that speed gains convert into competence and integrity rather than superficial coverage [1], [2], [11], [38].

Grade-level contrasts underscore that orchestration skills develop with experience. Older students reported greater time savings and more frequent use of AI as reference or inspiration, which suggests a shift from tool-novelty effects to strategic integration within complex tasks. Younger students reported larger conceptual jumps and concentrated perceived changes in research coursework, a pattern consistent with first exposure to structured exemplars and reformulations that lower the barrier to inquiry writing. These differences imply that scaffolds should be adjusted by year level. For Grade 11, emphasis on concept building, structured verification checklists, and explicit modeling of paraphrase–synthesis can stabilize early gains. For Grade 12, emphasis on multi-source synthesis, documentation of verification steps, and rationale statements for AI use can translate efficiency into durable mastery and independent judgment. Dr. Funa's meta-synthesis converges on this direction of travel, recommending balanced, context-sensitive classroom guidance that integrates verification and acknowledgment into assessment while remaining attentive to inequities in access and teacher capacity [11].

The pattern of ambivalence in recommendation and neutrality in satisfaction should therefore not be read as a contradiction to the performance and understanding gains. Rather, it is evidence of sensible calibration in a context where connectivity is uneven and where verification and acknowledgment are nontrivial parts of doing the assignment well. Absent explicit instruction, efficiency gains can encourage superficial coverage, and weak attribution practices among a minority may create integrity risks. With targeted supports, however, the very behaviors students already report—checking, verifying, comparing, critiquing, and integrating outputs with their own ideas—can be formalized in rubrics and brief reflection prompts that require students to record when AI helped, what needed correction, and how claims were checked. Such designs align with international governance guidance and with Philippine scholarship [1], [11], [40], [41], and they are directly responsive to the empirical profile in this study: episodic but purposeful use, strong efficiency and understanding signals, modest independence gains, and a verification-heavy stance that is ready to be converted into mature self-regulation.

4. CONCLUSION

This study concludes that STEM students in a large Philippine public school use ChatGPT selectively and purposively, most often at the front end of academic work where reading, synthesis, and explanation are required. Use concentrates in Research, English, and Science, with lower intensity in mathematics and social science. Across the sample, students perceived modest increases in interest, substantial time savings, and clearer understanding, while maintaining a cautious stance toward quality that is reflected in high rates of checking, verifying, and critiquing outputs. Independence gains were present but usually modest, and reliance on tutoring largely persisted, indicating that students position ChatGPT as a quick explainer and comparator rather than a

substitute for human guidance. Grade-level contrasts suggest developmental differences in orchestration: Grade 12 learners more readily convert AI into efficiency and inspirational use, whereas Grade 11 learners report larger conceptual jumps, especially in research-oriented tasks. These patterns are consistent with established accounts of interest development, self-determination, and self-regulated learning, and they align with Philippine realities in which intermittent access and cost constraints favor short, goal-directed sessions at home and school. Overall, the evidence supports positioning ChatGPT as a formative, teacher-guided scaffold that can lower barriers to inquiry and writing while sustaining verification, authorship, and academic integrity.

Based on the results and discussion, instructors should explicitly permit ChatGPT for front-end tasks (brainstorming, outlining, explanation) and make verification and paraphrase synthesis graded requirements to ensure quality and authorship. Embed a brief reflection per AI-permitted task that records when the tool helped, what was corrected, and how claims were checked to strengthen self-regulation. Tune supports by year level: for Grade 11, emphasize concept building and structured verification checklists; for Grade 12, emphasize strategic efficiency, multi-source synthesis, and concise rationale or acknowledgment of AI use. Finally, design AI activities that work with intermittent access (short, chunked tasks and on-campus verification time), consistent with the Philippine context discussed.

REFERENCES

[1] F. Miao and W. Holmes, *Guidance for Generative AI in Education and Research*. Paris, France: UNESCO, 2023.

[2] OECD, *Education Policy Outlook 2024: Reshaping Teaching into a Thriving Profession—from ABCs to AI*. Paris, France: OECD Publishing, 2024.

[3] OECD, "What should teachers teach and students learn in a future of powerful AI?," *OECD Education Spotlights*, no. 20, 2025, doi:10.1787/ca56c7d6-en.

[4] Department of Education (DepEd), "K to 12 Senior High School—Applied Track Subject: English for Academic and Professional Purposes (Curriculum Guide)," 2013.

[5] Department of Education (DepEd), "K to 12 Senior High School—Applied Track Subject: Practical Research 1 (Curriculum Guide)," 2013.

[6] World Bank, *Better Internet for All Filipinos: Reforms Promoting Competition and Increasing Investment for Broadband Infrastructure (Policy Note)*, 2024.

[7] World Bank, "Unlocking the Philippines' digital transformation by increasing internet connectivity," 2025.

[8] E. L. Deci and R. M. Ryan, "The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior," *Psychological Inquiry*, vol. 11, no. 4, pp. 227–268, 2000, doi:10.1207/S15327965PLI1104_01.

[9] S. Hidi and K. A. Renninger, "The four-phase model of interest development," *Educational Psychologist*, vol. 41, no. 2, pp. 111–127, 2006, doi:10.1207/s15326985ep4102_4.

[10] E. Panadero, "A review of self-regulated learning: Six models and four directions for research," *Frontiers in Psychology*, vol. 8, Art. 422, 2017, doi:10.3389/fpsyg.2017.00422.

[11] A. A. Funa and R. A. E. Gabay, "Policy guidelines and recommendations on AI use in teaching and learning: A meta-synthesis study," *Social Sciences & Humanities Open*, vol. 11, p. 101221, 2025, doi: 10.1016/j.ssaho.2024.101221.

[12] A. A. Funa and R. A. E. Gabay, "Exploring perspectives toward artificial intelligence integration in science education: A cross-generational study," SSRN preprint, 2025, doi:10.2139/ssrn.5243807.

[13] Ofcom, "Children and parents: Media use and attitudes report 2024," Apr. 19, 2024. [Online]. Available: https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/media-literacy-research/children/children-media-literacy-report-2024/childrens-media-literacy-report-2024.pdf

[14] R. Deng, "Does ChatGPT enhance student learning? A systematic review and meta-analysis of experimental studies," *Computers & Education*, vol. 207, p. 105224, 2024, doi:10.1016/j.compedu.2024.105224.

[15] J. Wang, Y. Liu, and X. Zhang, "The effect of ChatGPT on students' learning performance, learning perception, and higher-order thinking: A meta-analysis," *Humanities and Social Sciences Communications*, vol. 12, p. 399, 2025, doi:10.1057/s41599-025-04787-y.

[16] L. Casal-Otero, A. Catala, C. Fernández-Morante, M. Taboada, B. Cebreiro, and S. Barro, "AI literacy in K–12: A systematic literature review," *International Journal of STEM Education*, vol. 10, p. 29, 2023, doi: 10.1186/s40594-023-00418-7.

[17] J. H. Kaufman, A. Woo, J. Eagan, S. Lee, and E. B. Kassan, *Uneven Adoption of Artificial Intelligence Tools Among U.S. Teachers and Principals in the 2023–2024 School Year*, RR-A134-25. Santa Monica, CA, USA: RAND Corporation, 2025, doi:10.7249/RRA134-25.

[18] O. Sidoti, E. Park, and J. Gottfried, "About a quarter of U.S. teens have used ChatGPT for schoolwork—double the share in 2023," *Pew Research Center*, Jan. 15, 2025.

[19] J. W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 5th ed. Thousand Oaks, CA, USA: SAGE Publications, 2018.

[20] E. von Elm, D. G. Altman, M. Egger, S. J. Pocock, P. C. Gøtzsche, and J. P. Vandenbroucke, "The strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies," *PLoS Medicine*, vol. 4, no. 10, e296, 2007, doi:10.1371/journal.pmed.0040296.

[21] D. F. Polit and C. T. Beck, "The content validity index: Are you sure you know what's being reported?," *Research in Nursing & Health*, vol. 29, no. 5, pp. 489–497, 2006, doi:10.1002/nur.20147.

[22] R. F. DeVellis and C. T. Thorpe, *Scale Development: Theory and Applications*, 4th ed. Thousand Oaks, CA, USA: SAGE Publications, 2016.

[23] G. F. Kuder and M. W. Richardson, "The theory of the estimation of test reliability," *Psychometrika*, vol. 2, no. 3, pp. 151–160, 1937, doi:10.1007/BF02288391.
[24] A. Agresti, *Analysis of Ordinal Categorical Data*, 2nd ed. Hoboken, NJ, USA: John Wiley & Sons, 2010, doi:10.1002/9780470594001.
[25] M. S. Setia, "Methodology Series Module 3: Cross-sectional studies," *Indian Journal of Dermatology*, vol. 61, no. 3, pp. 261–264, 2016, doi:10.4103/0019-5154.182410.
[26] A. A. Funa, "Digital badges as rewards in science education: Students' perceptions and experiences," *Dalat University Journal of Science*, vol. 14, no. 2, pp. 107–127, 2024, doi:10.37569/dalatuniversity.14.2.1212(2024).
[27] S. Noy and W. Zhang, "Experimental evidence on the productivity effects of generative artificial intelligence," *Science*, vol. 381, no. 6654, pp. 187–192, 2023, doi:10.1126/science.adh2586.
[28] A. A. Funa, L. S. Roleda, and M. S. Prudente, "Integrated science, technology, engineering, and mathematics—problem-based learning—education for sustainable development (I-STEM-PBL-ESD) framework," in *A Diversity of Pathways Through Science Education*, Singapore: Springer Nature Singapore, 2024, pp. 151–172, doi:10.1007/978-981-97-2607-3_9.
[29] H. S. Almarashdi and A. Jaber, "Unveiling the potential: A systematic review of ChatGPT in transforming mathematics teaching and learning," *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 20, no. 12, em2555, 2024, doi:10.29333/ejmste/15739.
[30] D. Ravšelj, D. Keržič, N. Tomaževič, *et al.*, "Higher education students' perceptions of ChatGPT: A global study of early reactions," *PLOS ONE*, vol. 20, no. 2, e0315011, 2025, doi:10.1371/journal.pone.0315011.
[31] L. Huang, W. Yu, W. Ma, *et al.*, "A survey on hallucination in large language models: Principles, taxonomy, challenges, and open questions," *ACM Computing Surveys*, 2025, doi:10.1145/3703155.
[32] M. T. H. Chi and R. Wylie, "The ICAP framework: Linking cognitive engagement to active learning outcomes," *Educational Psychologist*, vol. 49, no. 4, pp. 219–243, 2014, doi:10.1080/00461520.2014.965823.
[33] J. Hattie and H. Timperley, "The power of feedback," *Review of Educational Research*, vol. 77, no. 1, pp. 81–112, 2007, doi:10.3102/003465430298487.
[34] R. A. E. Gabay, A. A. Funa, and J. D. Ricafort, "Generative Artificial Intelligence (GenAI) for Academic Writing in Higher Education: A scoping review of applications, challenges, and implications," Research Square, preprint, Aug. 26, 2025, doi:10.21203/rs.3.rs-7440784/v1.
[35] A. A. Funa, E. C. B. Deblois, L. D. Lerios, F. G. J. Jetomo, and R. A. E. Gabay, "Exploring Filipino preservice teachers' online self-regulated learning skills and strategies amid the COVID-19 pandemic," *Social Sciences & Humanities Open*, vol. 7, no. 1, p. 100470, 2023, doi:10.1016/j.ssaho.2023.100470.
[36] M. A. Largo, T. M. Sederia, F. C. Villadores, and M. Andrada, "Smart chat, bright minds: Does ChatGPT propel students to academic heights?," *Journal of Education and Learning Advancements*, vol. 1, no. 1, pp. 8–21, 2024. [Online]. Available: https://jelamagste.org/journalofed/index.php/jela/article/view/14
[37] A. A. Funa and R. A. E. Gabay, "Bridging the gap among knowledge, attitudes, and behaviors toward sustainable development through I-STEM-PBL-ESD," *International Journal on Studies in Education*, vol. 7, no. 2, pp. 288–303, 2025, doi:10.46328/ijonse.317.
[38] A. A. Funa, R. A. E. Gabay, K. A. Esdicul, and M. S. Prudente, "Secondary teachers' and students' perceptions of distance education in science: Focus on learner-centered, action-oriented, and transformative learning," *Dalat University Journal of Science*, vol. 13, no. 3, pp. 156–181, 2023, doi:10.37569/DalatUniversity.13.3.1108(2023).
[39] B. J. Zimmerman, "Becoming a self-regulated learner: An overview," *Theory Into Practice*, vol. 41, no. 2, pp. 64–70, 2002, doi:10.1207/s15430421tip4102_2.
[40] N. L. Mediana Jr., A. A. Funa, and R. V. Dio, "Effectiveness of inquiry-based learning (IbL) on improving students' conceptual understanding in science and mathematics: A meta-analysis," *International Journal of Education in Mathematics, Science and Technology*, vol. 13, no. 2, pp. 532–552, 2025, doi:10.46328/ijemst.4769.
[41] J. M. Ramallosa, A. A. Funa, A. T. Geron, R. T. Ibardaloza, and M. S. Prudente, "Meta-analysis on the effectiveness of argument-based learning on students' conceptual understanding," in *Proc. 13th Int. Conf. E-Education, E-Business, E-Management and E-Learning (IC4E)*, 2022, pp. 315–323, doi:10.1145/3514262.3514305.