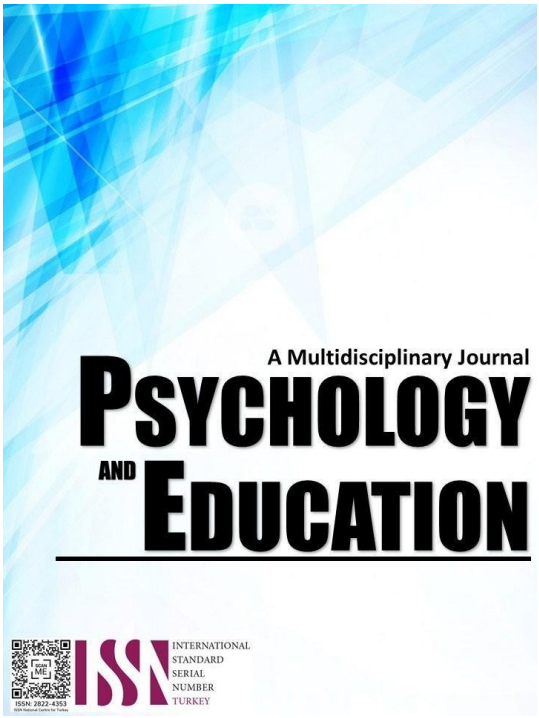
PLICKERS AND 3-2-1 JOURNAL: AN INTEGRATED APPROACH IN ENHANCING CRITICAL THINKING SKILLS IN GENERAL PHYSICS 1



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Research Article

Plickers and 3-2-1 Journal: An Integrated Approach in Enhancing Critical Thinking Skills in General Physics 1

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Abstract

In today's rapidly evolving technological landscape, strong critical thinking skills (CTS) are essential, especially in the context of 21st century science education, where students engage in analysis and reasoning beyond simple memorization. This study examined the effectiveness of integrating Plickers and the 3-2-1 journal to enhance the CTS of grade 12 STEM students. A quasi-experimental research design was employed to evaluate the enhancement of CTS through conventional approach and integrated approach. The evaluation was guided by Facione's CTS indicators: interpretation, analysis, inference, evaluation, explanation, and self-regulation. Pretest results indicated that students in both approaches initially in low level of CTS in all CTS indicators. However, the posttest showed an increase in the level of CTS across all indicators in both approaches, with the integrated approach yielding significantly higher results (M = 83.4; SD = 2.4) than the conventional approach (M = 76.1; SD = 4.09). Furthermore, the Mann-Whitney U analysis revealed a significant difference in the mean gain scores between the approaches ($p < .001$) in interpretation, analysis, evaluation, explanation, and self-regulation, suggesting the effectiveness of the integrated approach. However, the inference indicator showed no significant difference, suggesting that both approaches are similarly effective, and that further or alternative instructional interventions may be needed to improve students' inference skills. These findings suggest that integrating Plickers and 3-2-1 journals significantly enhances students' critical thinking in General Physics 1, demonstrating its effectiveness as a pedagogical tool.

Keywords: *critical thinking skills, plicker, 3-2-1 journal, integrated approach*

Introduction

Critical thinking is recognized as a fundamental skill for students in 21st century science education, a natural progression of students for metacognitive understanding. Additionally, critical thinking is a complex concept that incorporates both cognitive abilities and affective dispositions, which can affect the way certain educators communicate concepts to their students (Jasnani, 2023). It involves a deliberate effort to gather, interpret, analyze, and assess information to arrive at valid and reliable conclusions. However, Chartrand et al. (2013) points out that 70% of high school learners struggle with critical thinking skills, and among college students 9% deficient in critical thinking skills, only 28% have developed these skills after four years of study.

In Global context, Shaheen (2016) revealed that international students encounter various challenges related to critical thinking while studying at British universities. These include struggles with analyzing and assessing arguments, difficulties in making evidence-based judgments and decisions, and issues with forming logical arguments and reaching conclusions. In Suprapto et al. (2024) study involving 154 sample found that most of the learners fall under low category of critical thinking skills in physics, which emphasizes that students excel better in evaluating information, however they struggled significantly with synthesizing knowledge, a skill that is essential for effective problem-solving skills in physics. A survey conducted by the Times Education Supplement found that 85% of teachers across the globe believe their students are deficient in critical thinking skills (Pitts, 2019).

According to the Department of Education (DepEd), Filipino students were ranked last out of 79 countries in the Program for International Student Assessment (PISA), and the Philippines ranked sixth from the bottom out of 81 countries, indicating that Filipino students continue to lag in reading, math, and science (Ombay, 2024). The lack of CTS among Filipino students has been an ongoing issue in the Philippines for many years, even though experts are highly creative and innovative both locally and internationally.

Meanwhile, a scoping review of critical thinking conducted by Lopez (2023) in the Philippines from 1971 to 2017 which shows that there are a lot of studies focusing on critical thinking abilities, but there is a notable scarcity of studies related to critical thinking skills in physics education, especially in South Cotabato. Indicating a research gap that should be addressed which limits the analysis of how critical thinking are cultivated in specific context and hinders the development of tailored educational strategies that could effectively enhance these skills among students. This observation is supported by Marisda et al. (2024), who noted that while studies have examined critical thinking in science, there remains a need for more targeted research in physics classrooms to inform instructional strategies and enhance students' critical thinking profiles.

Thus, to enhance students' critical thinking (CT), and as per the recommendation of Freeman et al. (2014), utilizing effective engagement strategies such as interactive activities and active learning techniques is crucial. Innovative approaches must be presented to make the subject matter engaging and relevant (Bilir and Ozdilek, 2024). Teachers have a crucial role in honing students' critical thinking skills and are responsible for driving students' interest and cognitive abilities during the learning process. Hence, the researcher is determined to utilize and measure the effectiveness of Plickers assessment and a 3-2-1 reflective journal in developing the critical thinking skills of the grade 12 STEM students in General Physics 1. The findings of this study aimed to contribute valuable insights

into pedagogical practices that fostered CTS in Physics.

The constructivist theory played a key role in shaping how students learn by placing them at the core of the learning process (Piaget, 1952). It emphasizes how learners actively build and shape their own understanding. In General Physics 1, tools like Plickers made this possible by allowing students to respond to a question in real time, making learning more interactive and engaging. This aligns with Bruner's (1961) idea that discovery learning and collaborating are essential for deeper understanding. Within this framework, students are encouraged to ask questions and make sense of information through critical thinking (Facione, 1990).

Metacognition is the capacity to examine one's thinking, evaluate understanding, adapt strategies to improve learning outcomes (Schraw & Dennison, 1994). In this study, the 3-2-1 journal was utilized to help students reflect on their structure and build metacognitive skills including self-regulation and explanation. The relationship between metacognition and CT is well established in literature, with studies showing that reflective practices enhance learner's ability to recognize knowledge gaps and apply effective problem-solving strategies (Zohar & Dorim, 2012).

In developing students CTS largely relies on the selection of effective strategies in learning. Critical thinking is also dependent upon engaging learning environment and having metacognitive awareness and that in turn can be activated using reflective journaling coupled with technology-based assessment. Dynamic engaging learning environments are created with real time formative assessments accessible on the internet just like Plickers. This makes it easy for teachers to check students' understanding of the subject and adapt their teaching methods accordingly. This immediate feedback system not only encourages active participation by students but also facilitates effective responses to learning gaps that will go a long way to encourage exemplary critical thinking.

Specifically, the online and offline real-time assessment utilized in this study was an interactive formative tool called Plickers, which allows students to receive immediate feedback. This instant feedback was crucial for promoting self-regulation and the ongoing enhancement of their CTS. Additionally, the 3-2-1 journal enabled learners to express their thoughts, self-evaluation, experiences, and learning processes at the conclusion of each topic. By integrating these two independent variables, the approach aimed to create a synergistic effect on the enhancement of critical thinking.

Research Questions

Generally, this study aimed to determine the effectiveness of integrating Plickers and the 3-2-1 journal in enhancing the critical thinking skills of Grade 12 STEM students in General Physics 1 at Tupi National High School, Tupi, South Cotabato. Specifically, it sought to answer the following questions:

1. What is the level of student's critical thinking skills in the pre-test and post-test using conventional approach and using Plickers and 3-2-1 Journal in General Physics 1 in terms of:
    1.1. interpretation;
    1.2. analysis;
    1.3. inference;
    1.4. evaluation;
    1.5. explanation; and
    1.6. self-regulation?
2. Is there significant difference between the pre-test and posttest scores of the group who used conventional approach and integrated approach?
3. Is there significant difference in the mean gain scores of critical thinking skills between the group who used conventional approach and integrated approach?

Methodology

Research Design

The study used a quasi-experimental research design in the determination of enhanced critical thinking skills with the conventional and the integrated approach: the Plickers and the 3-2-1 journal. This design involved the presentation of the research setting through words, figures, and the present profiles and classifications of participants. It also described how to address questions concerning who, what, when, and how (Neuman, 2014).

Moreover, the design enables evaluation of changes in for conventional approach and integrated approach prior and after the intervention, therefore it was possible to gain important information concerning the effectiveness of the integrated approach in critical thinking skills of the students.

Respondents

The respondents of the study were the Grade 12 STEM students enrolled for the first semester in General Physics 1 for the School Year 2024-2025. 72 students were selected as respondents through simple random sampling, comprising two equally distributed sections: 36 from STEM A and 36 from STEM B. Critical thinking skills of Grade 12 STEM students are valuable skills in all aspects of life as

they form basis for problem solving skills and innovation especially in General Physics (Lepasana, 2018). The study employed simple random sampling, wherein the groups have an equal chance of being selected as representative sampling. To ensure homogeneity the t-test for two samples was statistically treated using their grades, where the difference is significant ($p<.05$), indicating that section A ($M=89.89$) is relatively more intelligent than section B ($M=82.50$). The 72 students were arranged from highest grade to lowest grade and from there the groupings were arranged by odd numbers (Group A: Control Group) and even number (Group B: Experimental Group). This method ensured a balanced distribution of student abilities across both groups.

Table 1. *Distribution of Respondents*

Treatment	*Sample*		*Total*
	Male	Female	
Control Group (Conventional Approach)	12	24	36
Experimental Group (Integrated Approach)	16	20	36
Grand Total	28	44	72

Instrument

The test is a researcher-made assessment which evaluates the students' critical thinking skills. Test items utilized Facione's (1990) CTS framework, specifically the six CTS indicators: interpretation, analysis, inference, evaluation, explanation, and self-regulation. A table of specifications (TOS) was created in ensuring the proper distribution of the test items which focus on CTS indicators.

The researcher-made test was evaluated and validated by 6 evaluators. The reliability process was carried out by undergoing pilot testing in Koronadal Comprehensive National High School (KCNHS). The reliability of the test was measured using Cronbach's Alpha showing reliability coefficient of 0.78, which is considered good and acceptable test items.

Procedure

The respondents were oriented before the administration of the study. The pretest was administered to the respondents. From there, the experimental group underwent treatment using conventional approach and Plickers and the 3-2-1 journal the integrated approach for a period of 8 weeks. The posttest was administered to the respondents to determine the significant difference in performance of the respondents between the pretest and posttest after the treatment. All data collected throughout the process were summarized, tabulated, analyzed, and interpreted and subsequently statistically treated.

Data Analysis

To determine the level of critical thinking skills of the respondents, the rating scale and transmutation table below, which was enclosed in DepEd order number 8, series of 2015 were adopted.

Scale	*Descriptor*
90 – 100	Outstanding
85 – 89	Very Satisfactory
80 – 84	Satisfactory
75 – 79	Fairly Satisfactory
Below 75	Did Not Meet Expectations

Since the data failed to satisfy the assumptions of normality, the Wilcoxon Signed Rank test and Mann-Whitney U were applied. To determine the significant difference in the pretest and posttest for the dependent sample, the Wilcoxon Signed Rank test was utilized. To examine the significant difference in the mean gain scores of the independent sample in the level of critical thinking skills of the students, the Mann-Whitney U was used at 0.05 level of significance.

Ethical Considerations

This study strictly complied with ethical standards throughout its implementation. Informed consent was ensured by providing participants with adequate opportunity to ask questions and address any concerns, as well as comprehensive briefing on the study's objectives and data collection methods. All procedures related to data collection, handling, and analysis were conducted adhering to the Data Privacy Act of 2012 (Republic Act No. 10173). Ethical principles such as integrity, confidentiality, fairness, and beneficence were observed to safeguard the rights and well-being of all participants

Results and Discussion

This section presents the results, analysis, and interpretation of the study presented both in tabular and textual formats.

Table 3. *Level of student's critical thinking skills in the Pretest.*

CTS indicators	*Conventional Approach*			*Integrated Approach*		
	Mean	*SD*	*Qualitative Description*	*Mean*	*SD*	*Qualitative Description*
Interpretation	68.60	2.41	Did Not Meet	68.30	2.67	Did Not Meet

			Expectations			Expectations
Analysis	67.40	2.37	Did Not Meet Expectations	72.90	2.40	Did Not Meet Expectations
Inference	66.80	2.14	Did Not Meet Expectations	72.30	4.95	Did Not Meet Expectations
Evaluation	67.90	2.74	Did Not Meet Expectations	67.70	3.08	Did Not Meet Expectations
Explanation	68.20	3.42	Did Not Meet Expectations	67.60	3.19	Did Not Meet Expectations
Self-Regulation	69.30	4.25	Did Not Meet Expectations	68.70	3.89	Did Not Meet Expectations
Overall Mean	68.00	1.46	Did Not Meet Expectations	69.60	1.60	Did Not Meet Expectations

Legend: *90-100, Outstanding; 85-89, Very Satisfactory; 80-84, Satisfactory; 75-79, Fairly Satisfactory; below 75, Did Not Meet Expectations*
N = 36

Table 3 shows that both conventional and integrated approaches were starting from a similar level of critical thinking skills with an overall mean percentage of 68.00 and 69.60, respectively. These results fall below 75, indicating that students did not meet expectations across all six critical thinking skill indicators. This finding is further supported by low standard deviations (1.40 and 1.60, respectively), suggesting consistent performance within each group. Thus, students in both groups demonstrated comparatively low levels of CTS before the intervention.

The low pretest scores indicate that students faced challenges in applying key cognitive processes to physics concepts and problem-solving skills. The data shows that students struggle to interpret physical data and concepts, analyze relationships, draw logical inferences, evaluate scientific claims, explain their reasoning, and self-regulate their thinking processes. These results reflect common gaps in higher-order thinking required for understanding complex physics topics before the targeted instruction.

These findings are supported by Lapuz and Fulgencio (2020), which reported that students' critical thinking skills were fair only before any intervention were employed and indicated that there's a need for improvement. Saputri et al. (2018) also pointed out that many students find it difficult to master some components of critical thinking simply because they are not used to experience questions that make them think critically. Limited practice, a lack of resources, and time constraints all contribute to this difficulty.

Similarly, Arifah et al. (2023) found that students scored lowest in areas like interpretation and explanation, which mirrors the results in the pretest. Altogether, these studies underline the importance of targeted instructional strategies, as they reveal that students often have foundational gaps in critical thinking, especially in challenging subjects such as physics.

Table 4. *Level of student's critical thinking skills in the Posttest.*

CTS indicators	*Conventional Approach*			*Integrated Approach*		
	Mean	*SD*	*Qualitative Description*	*Mean*	*SD*	*Qualitative Description*
Interpretation	75.6	6.42	Fairly Satisfactory	81.8	5.19	Satisfactory
Analysis	77.7	6.84	Fairly Satisfactory	86.2	4.35	Very Satisfactory
Inference	78.5	6.63	Fairly Satisfactory	84.9	4.74	Very Satisfactory
Evaluation	74.3	4.21	Fairly Satisfactory	81.8	3.23	Satisfactory
Explanation	74.9	4.33	Fairly Satisfactory	81.3	5.12	Satisfactory
Self-Regulation	75.8	5.79	Fairly Satisfactory	84.6	3.02	Very Satisfactory
Overall Mean	76.1	4.09	Fairly Satisfactory	83.4	2.4	Satisfactory

Legend: *90-100, Outstanding; 85-89, Very Satisfactory; 80-84, Satisfactory; 75-79, Fairly Satisfactory; below 75, Did Not Meet Expectations*
N = 36

The table 4 presents the posttest results of the level of critical thinking skills after the use of conventional and integrated approaches. Both approaches resulted in observable improvements in all six CTS indicators. The conventional approach shows the overall mean score of 76.1, which falls under the "Fairly Satisfactory" category. In contrast, the integrated approach led to a higher average mean score of 83.4, rated as "Satisfactory."

These findings suggest that while both methods can help strengthen students' critical thinking skills, the integrated approach has a significantly greater impact. This highlights the value of incorporating integrated instructional approach that foster better support students' cognitive development and CTS. This help students in understanding complex problem in physics, evaluate, and reflect on their thinking process in the context of physics.

The findings align with the literature review highlighting the advantage of the integrated approach in developing CTS compared to traditional instructions. Yaki (2022) pointed out that integrated instruction helps students strengthen key skills indicators such as interpretation, analysis, inference, evaluation, explanation, and self-regulation. This, in turn, leads to deeper cognitive engagement and more consistent performance.

Similarly, Aka et al. (2025) found a strong significant impact of integrated learning on students' critical thinking, with a notably large standardized mean difference favoring the integrated approach over conventional approaches. Moreover, the findings are supported by Moghadam et al. (2023) which indicated that an intervention to enhance CT capacity resulted in higher posttest scores compare to respondents receiving conventional approach.

Similarly, Arviani et al. (2023) emphasized the value of instructional strategies which promotes higher-order thinking, particularly within science education, noting that learners exposed to such strategies exhibited improvements in CTS and critical thinking dispositions. This supports the findings of Jovanov et al. (2022), that learning is significantly enhanced by integrated approaches in STEM subjects

Table 5. *Wilcoxon Signed Rank Test Analysis in the Significant difference of the student's Critical Thinking Skills in the Conventional Approach during Pretest and Posttest*

CTS indicators	*Posttest*	*Pretest*	*df*	*Statistics*	*p*
Interpretation	81.80	68.30	35	666	< .001
Analysis	86.20	72.90	35	666	< .001
Inference	84.90	72.30	35	561	< .001
Evaluation	81.80	67.70	35	666	< .001
Explanation	81.30	67.60	35	666	< .001
Self-Regulation	84.60	68.70	35	666	< .001

Note. H_o μ *Measure 1 - Measure 2 ≠ 0*

The results presented in Table 5 illustrates the significant differences in the pretest and posttest scores of students' CTS in the conventional approach using the Wilcoxon Signed Rank Test. In comparison to the pretest scores, the posttest scores are consistently higher for all CT indicators, which includes interpretation, analysis, inference, evaluation, explanation, and self-regulation. The p-values (<.001) in all CTS indicators signifies that there is a significant improvement, confirming that the students in the conventional approach experienced notable gains in their CTS over time.

Substantial increase in posttest scores suggests that the conventional approach exhibit development in their CT abilities. The results demonstrate that the conventional approach can lead to meaningful improvements in students critical thinking abilities, supporting that structured traditional methods can be effective when deliberately applied (Facione, 1990; Angelo, 1995). This finding contradicts Snyder (2008), who argued that conventional approaches may enhances critical thinking but does not ensure great improvement. In terms of substantial application, methods of instruction that favor memory do not help critical thinking. Some study suggested that specific instructional strategies could help teachers select and implement the best approach to enhance students' CT abilities (Alsaleh, 2020).

Table 6. *Wilcoxon Signed Rank Test Analysis in the Significant difference of the Student's Critical Thinking Skills in the Integrated Approach Group during Pretest and Posttest*

CTS indicators	*Posttest*	*Pretest*	*df*	*Statistics*	*p*
Interpretation	81.80	68.30	35	666	< .001
Analysis	86.20	72.90	35	666	< .001
Inference	84.90	72.30	35	561	< .001
Evaluation	81.80	67.70	35	666	< .001
Explanation	81.30	67.60	35	666	< .001
Self-Regulation	84.60	68.70	35	666	< .001

Note. H_o μ *Measure 1 - Measure 2 ≠ 0*

The data presented in Table 6 highlights the significant differences in students' CTS in the integrated approach before and after the intervention. The Wilcoxon Single rank test results indicate that the posttest scores across all CT indicators are significantly higher than the pretest scores. The p-values (< .001) across all indicators confirm that these differences are statistically significant, suggesting that the intervention applied to the integrated approach had a substantial effect of enhancing students' CTS.

The remarkable increase in posttest scores across all CTS indicators revealed the effectiveness of the integrated approach in fostering HOTS. The most notable improvement is observed in analysis (pretest: 72.9, posttest: 86.2) and self-regulation (pretest: 68.7, posttest: 84.6), suggesting that students in the integrated approach significantly enhanced their ability to critically examine information, break down complex concepts, and regulate their own learning processes. The improvements were likely driven using active learning strategies, tech-based assessments, and reflective learning

The notable increase in inference scores from 72.3 in the pretest to 84.9 in the posttest shows that the integrated approach helped students build stronger reasoning skills. They became better at drawing logical conclusions and making sound judgments based on the information provided. In comparison, while the conventional approach also led to some improvement in inference (as shown in Table 4), the gains were more modest. This suggests that the integrated approach was especially effective in helping students understand and connect ideas more deeply.

The result support the recommendation by Masita and Fitri (2020), which recommend the extended use of Plickers across different subjects, skill areas, and educational levels over a longer period to support meaningful changes in teaching and learning. In just eight weeks, students demonstrated significant improvement in their CTS in Physics. The real-time assessment feedback that Plickers offers is the major factor behind this development, which encouraged more interactive discussions. These discussions gave students the opportunity to think critically about the questions, examine their reasoning, and gain a insightful knowledge of the concepts involved (Gurisik & Demirkan, 2019).

In addition, utilizing Plickers the online and offline digital assessment tool has been shown to enhance engagement and participation, which supports the improvement of the CTS (Susilowati, 2020). Reflective journaling methods such as the 3-2-1 journal also give students a meaningful way to assess their learning and think more critically about how they process information (Alsaleh, 2020). Similarly, Septina et al. (2018) found that reflective journals play a key role in building metacognitive skills, helping learners evaluate their own understanding and identify areas of improvement.

Table 7. *Mann-Whitney U Test Analysis in Significant difference in the mean gain scores of the Critical Thinking Skills in the Conventional Approach and Integrated Approach.*

CTS indicators	*Conventional Approach*	*Integrated Approach*	*Mann-Whitney U*	*p*
Interpretation	7.08	13.5	289	< .001
Analysis	10.28	13.33	428	0.013
Inference	11.67	12.69	575	0.413
Evaluation	6.39	14.06	157	< .001
Explanation	6.67	13.69	222	< .001
Self-Regulation	6.56	15.92	200	< .001

Note: H_i μ Control ≠ μ Experimental

The integrated approach yielded a notably higher mean gains scores across all indicators of critical thinking compared to the conventional approach, which implies that integrated approach have strong positive effect on students' CTS. Interestingly, the significant improvements were seen in the CTS indicators of interpretation, evaluation, explanation, and self-regulation ($p < 0.001$), as well as in analysis ($p = .013$). This signifies that the integrated approach was especially effective in helping students strengthen these specific skills.

The results are consistent with the findings of Bilir and Ozdilek (2024), who noted that innovative teaching strategies in science are more effective in stimulating CT than traditional methods of teaching. The utilization of Plickers as a formative assessment tool in integrated approach also contributed to increased student participation and better learning outcomes, as noted by McBrunett (2019).

The results support the literature review, which highlights the value of interactive and integrative teaching tools in promoting higher-order thinking. Debora and Pramano (2021) revealed that integrated learning with a focus on STEM can significantly enhance students' critical thinking and problem-solving skills. Similarly, Struyf et al. (2019) emphasized the significance of active involvement in developing reasoning and scientific thinking. Moreover, the use of tools like Plickers and reflective journaling, as discussed by Yuliani (2020) and McGuire et al. (2009), helps improve metacognition and self-regulation. This is illustrated in the increased mean gain scores from the integrated approach. Overall, the results not only confirm the effectiveness of the integrated method but also support the best practices found in current educational research.

Conclusion

It is concluded that the integrated approach, which utilized Plickers and 3-2-1 journal, has proven to be an effective approach in enhancing critical thinking skills of Grade 12 STEM students in General Physics 1. This study provides strong evidence that integrated approach leads to significantly greater improvements in students' ability to interpret, analyze, evaluate, explain, and self-regulate compared to conventional approaches. The use of Plickers and 3-2-1 journals is a more advantageous instructional strategy for fostering critical thinking in science education. While both approaches support development of critical thinking skills of students, targeted efforts may be needed to enhance students' inference skills.

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