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The Influence of Implementing Process-Oriented Guided Inquiry Learning (POGIL) Model With Website Assistance To Improve Students' Logical Thinking

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Abstract

This study designed and evaluated the impact of the Process-Oriented Guided Inquiry Learning (POGIL) model, supported by the XPOGIEDU website, on enhancing logical thinking skills in programming (branching, looping) among 37 students of 10th-grade vocational high school. Using the ADDIE framework, the intervention integrated collaborative group work with rotating roles, guided inquiry via worksheets, and iterative problem-solving. Data from pre/post-tests, projects, and Technology Acceptance Model (TAM) surveys were analyzed using Excel and SPSS. Results revealed significant improvements in logical thinking, with an overall normalized gain of 0.71, particularly benefiting lower-ability students (e.g., 0.83 gain in logic tests vs. 0.61 for high performers). TAM evaluations reflected strong student acceptance, with perceived usefulness (87.75%), ease of use (85.59%), and positive attitudes (87.57%), validating the platform's usability. However, limitations such as the short study restricted deeper trend analysis and engagement. Beyond programming, this study underscores POGIL's potential as a scalable, equity-focused pedagogy for STEM disciplines requiring structured problem-solving (e.g., engineering, data science). The findings advocate for policy reforms prioritizing technology-enhanced inquiry models in vocational and general STEM curricula to bridge skill gaps. Educators should adopt flexible grouping strategies and digital tools to cater to diverse learner needs, while institutions must invest in teacher training for guided inquiry methods. Future research should extend intervention timelines, incorporate adaptive learning technologies, and explore cross-disciplinary applications to optimize long-term outcomes. By aligning pedagogical invention with stoner-centered design, this approach addresses global demands for critical intellects complete at navigating complex STEM challenges.

Keywords: *Process-Oriented Guided Inquiry Learning (POGIL), Website-assisted Learning, Logical Thinking Improvement, Inquiry-based Learning, Educational Technology Integration.*

INTRODUCTION

Basic programming is an education that emphasizes the development of a person's mindset to develop effective and effective programs by providing the basics of universal logic, to be suitable to apply these introductory generalities to any programming language, whenever and wherever the language is used. Understanding basic programming concepts is key role in computer education (Broy et al., 2025). Basic programming also aligns with broader STEM goals to cultivate transferable skills such as abstraction, systematic analysis, and iterative design (Surpare & Klinieam, 2020). A wide range of abilities are required when one is programming. One of them is logical thinking. Logic is needed to analyze problems, formulate plans, code solutions, evaluate programs, and justify decisions (Kahl, 2021). Logical thinking, also known as analytical

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reasoning, abstract thinking, or critical thinking, is an important trait for programmers. Individuals who can think logically and effectively dissect problems and find solutions to those problems (O`ljayevna & Shavkatovna, 2020).

The importance of logical thinking for vocational school students lies in its ability to enhance essential skills such as reading comprehension and problem-solving, which are critical in vocational education (P.-Y. Lin et al., 2024). Furthermore, logical thinking plays a key role in developing critical thinking, an important skill for tackling real-world challenges in technical and vocational fields. According to the Law of the Republic of Indonesia Number 20 of 2003 regarding the National Education System Article 18, it is stated that the purpose of vocational secondary education is not only to change students in the development of personality and potential but also the preparation and provision by teachers to students to be better prepared to face the world of work with a professional attitude in the field of expertise they are interested in.

Students' logical thinking skills can be measured through their ability to express ideas or concepts in a structured manner in a sequence of words or sentences so that their arguments can be accepted (Bacci et al., 2021). In this context, logical thinking consists of three interrelated components, namely understanding or ideas, decisions or opinions, and reasoning (Kozedub et al., 2024). This shows that students who are suitable to link generalities with rational arguments and logical thinking have strong critical thinking skills. (Cresswell & Speelman, 2020). Thus, understanding and mastering these three components is key to developing students' logical thinking skills (Pressman et al., 2022).

Logical thinking drives computational thinking by enabling systematic problem-solving, such as breaking down complex tasks into algorithms or identifying patterns in data analysis (Piedade et al., 2020). It underpins abstraction, allowing students to model real-world systems through code or simulations. These skills are critical across STEM disciplines (such as Computer Science and Engineering), from debugging software to optimizing scientific experiments, fostering precision and adaptability in technology-driven innovation.

An interview with a teacher at Daarut Tauhid Boarding Vocational High School Bandung Indonesia revealed that many students, particularly those at the grade 10 level, face challenges in understanding the subject matter concepts. This problem is caused by several factors, including a significant change in material load when students move up to vocational high school level from junior high school. This change in material load can make some students feel overwhelmed and struggle to grasp new concepts. In addition, students' lack of attention and interest in learning can also contribute to this problem. When scholars are less motivated or interested in literacy, they tend to have a lower position of understanding of the material.

Informal learning environments like libraries and museums provide valuable opportunities to enhance children's computational and logical thinking through structured activities involving caregivers (Campana & Elizabeth, 2023). These settings use scaffolding and collaborative approaches to engage children in complex tasks, fostering logical reasoning (Campana et al., 2024). Beforehand exposure to logical problem-working in similar surroundings is vital for promoting stronger experimental issues. Such approaches also advance equity in STEM by providing accessible pathways for underrepresented groups to develop analytical skills, a critical policy focus in nations striving to diversify their technical workforce.

Additionally, organizing logical tasks within educational settings is crucial for fostering children's cognitive development (Kyshtoobaeva et al., 2024). By integrating learning with play, educators can create environments that encourage active cognitive engagement, helping children overcome challenges in logical thinking (Nasution et al., 2024). These findings show that early interventions, such as inquiry-based learning, significantly improve children's critical thinking and reasoning skills (X. Lin et al., 2021). Structured tasks in formal and informal settings lay the root for more complex cognitive assignments in unborn educational stages (Kyshtoobaeva et al., 2024).

Several factors contribute to students' lack of interest in literacy, such as a lack of literacy models and media that can be applied (Taub et al., 2020). Many teachers still struggle to implement innovative learning approaches that engage students effectively. This incapability to appertain ultramodern, student-centered tutoring styles impacts learners' provocation and attention (Al-khresheh, 2022). Consequently, their academic performance and thinking skills decreased. Innovative models and media can promote active learning and help improve these outcomes (Lombardi et al., 2021). Thus, educators are likely to be required to adopt the latest teaching strategies and resources to overcome this challenge.

The importance of designing classroom learning by utilizing a variety of activities that stimulate students to think actively and give them control over the formation of their knowledge, which is by the constructivist learning theory paradigm (Dörnyei & Muir, 2019). They argue that this approach encourages students to play an active role in the learning process and addresses STEM's demand for active learning, in which in constructivism theory, students are expected to observe, discover, and then transform and interpret information independently. On the other hand, the conception of a learning model is a plan or pattern used in planning classroom learning (Shepard, 2019). One of the learning models that support the constructivist approach is Process Oriented Guided Inquiry Learning (POGIL), where students are actively involved in the learning process.

The Process Oriented Guided Inquiry Learning (POGIL) model is a learning approach that emphasizes student cooperation in creating activities that can improve various aspects of cognitive and social skills (Aiman et al., 2020). During the POGIL learning process, students work together to develop their understanding of the material by crossing through structured activity stages, such as Orientation, Exploration, Concept Formation, Implementation, and Closure (Putri et al., 2020). This method focuses on active learning, critical thinking, effective communication, and the development of students' metacognitive skills, thus helping them not only understand the subject matter, but also develop logical thinking, problem-solving, and positive social attitudes in the context of learning (Purnama & Rahayu, 2023).

The POGIL model can be effectively used as a learning method to improve students' logical thinking ability during the learning process (Andriani et al., 2019). The findings revealed that students taught using the POGIL model demonstrated significantly better logical thinking skills compared to those taught through conventional methods. This suggests that the POGIL model is an effective and innovative approach to enhancing logical thinking in mathematics education.

Web learning media use is one of the potential solutions to solving educational problems (Dwijayani, 2019). The Process Oriented Guided Inquiry Learning (POGIL) model can be combined with interactive media that combines various elements, such as text, images, animation, graphics, audio, and video, as well as interactive delivery methods. This approach has proven to be quite effective in improving the achievement of students' cognitive learning outcomes, as it provides a learning experience that is close to the real world and allows students to be actively involved in the learning process (Asrowi et al., 2019).

Based on various studies on existing problems, the solution that will be held is to look for the influence of implementing the Process-Oriented Guided Inquiry Learning (POGIL) model assisted by a website. Therefore, to facilitate students' understanding abilities related to logical thinking, research was conducted on "The Influence Of Implementing Process-Oriented Guided Inquiry Learning (POGIL) Model With Website Assistance To Improve Students' Logical Thinking".

Research Objectives:

This research aims to design learning using a website as a tool in the POGIL process. Moreover, this research also evaluates the effect of applying the Process-Oriented Guided Inquiry Learning (POGIL) model assisted by a website on improving students' logical thinking skills. The specific research questions are as follows:

1. How is the influence of the Process Oriented Guided Inquiry Learning (POGIL) model assisted by a website in the Basics for Software and Game Development course on students' logical thinking skills? [RQ1]
2. How do students respond to the Process Oriented Guided Inquiry Learning (POGIL) model assisted by a website in the Basics for Software and Game Development course? [RQ2]

LITERATURE REVIEW

POGIL Model with Website Assistance

The Process Oriented Guided Inquiry Learning (POGIL) model is a learning approach that emphasizes student cooperation in creating activities that can improve various aspects of cognitive and social skills (Haryati, 2018). The educational method known as Process Oriented Guided Inquiry Learning (POGIL) involves a combination of cooperative learning and guided inquiry to help students acquire independent learning skills (Simonson, 2023). This model aligns with the core principles of STEM pedagogy, which prioritize active, collaborative, and inquiry-driven learning to develop critical thinking and problem-solving skills (Luo et al., 2023). So, it can be concluded that in general, the POGIL learning model is learning to work in groups that encourage mastery of concepts and development of skills, thinking, problem-solving, communication, management, and assessment.

The POGIL model learning design is based on a learning cycle that involves Exploration, Concept Invention, and Application (Rodriguez et al., 2020). From the same source, it is also stated that each group in the POGIL learning model consists of 3-4 people who have several tasks, including:

1. The manager is responsible for ensuring that the group works effectively and efficiently and checking all the group members contribute to the discussion and problem-solving.
2. The spokesperson is responsible for presenting the group's solution to the class and can explain the solution clearly and concisely.
3. The recorder is responsible for recording all discussions and group work clearly and neatly.
4. The strategy analyst is responsible for analyzing the group's strategy for resolving the problem and identifying the group strategy's potential strengths and weaknesses.

POGIL's emphasis on group roles, in STEM contexts, cultivates teamwork and communication skills essential for interdisciplinary STEM projects. These roles also advocate for collaborative learning environments that simulate real-world scientific and technical workflows (Simonson, 2023). A website is a collection of web pages distributed over an internet network and contains information such as text, images, animations, and videos, where it has a URL domain configured for HTTP and can be accessed through software (Leshchuk et al., 2021). Students can easily access the website anytime and anywhere, which makes learning easier. In addition, the use of websites can break the static learning atmosphere and can increase students' motivation to learn. This learning media consists of various applications and learning materials connected to the internet and equipped with various other facilities that facilitate interaction between students or users and educators (Nicolaou et al., 2019).

The combination of POGIL and media-assisted learning also advances equity in STEM education (Howley, 2020), especially with websites. The various components of the POGIL model can be linked to the features of the learning website, allowing for customized development (Kussmaul, 2022). In the POGIL model, the Orientation component aligns with the website's introduction feature, using motivational media like videos to convey learning objectives. Exploration is enhanced through interactive activities such as simulations, while Concept Formation is supported by discussion forums for collaborative analysis. The Application component is realized through problem-solving features or case studies, allowing students to apply their knowledge. Finally, the Closure component is linked to a feedback feature, enabling students to reflect on their learning and receive constructive input.

RESEARCH METHOD

Participants

This study involved 37 students from the 10th-grade Software and Game Development program at Vocational High School 2 Bandung, selected based on their engagement in basic programming topics such as branching and looping. The class consisted of male and female students, who exhibited a range of abilities and learning styles, thus providing a balanced representation of students in technical education. The sampling criteria ensured the participants were familiar with basic programming concepts, focusing on maintaining gender diversity to gain insight into different approaches to complex programming topics. This approach aimed to reflect a typical classroom environment in schools so that the findings can be applied to similar educational settings and facilitate the examination of diverse attitudes and learning outcomes.

Setting

This research was conducted in the software engineering laboratory on the 2nd floor of Vocational High School 2 Bandung, a space designed to facilitate technology-based learning and programming with access to diverse software, learning materials, and internet-connected devices (including personal laptops, cell phones, and lab computers), enabling students to engage interactively with online coursework, assignments, quizzes, and exercises. The lab's collaborative seating arrangement placed students close to stimulating teamwork, idea-sharing, and joint problem-solving, fostering social interaction and strengthening communication and cooperation skills essential for modern workplaces, all within a hands-on environment tailored to technical and interpersonal skill development.

Website Learning

XPOGIEDU, a custom learning website for grade 10 students, was developed using PHP for server-side data processing and dynamic functionality, alongside CSS and HTML to create a responsive, user-friendly interface with intuitive navigation for accessing learning materials, practice questions, and quizzes. Structured around the POGIL (Process-Oriented Guided Inquiry Learning) model, the platform fostered collaborative group work and inquiry-based learning, encouraging students to actively solve problems, explore concepts in depth, and develop critical thinking and analytical skills. This website development uses the ADDIE instructional design model (Analysis, Design, Development, Implementation, Evaluation). By merging ADDIE's systematic framework with PHP/CSS/HTML technical execution, XPOGIEDU combined hands-on exploration, peer-driven problem-solving, and structured content delivery to deepen conceptual understanding and engagement.

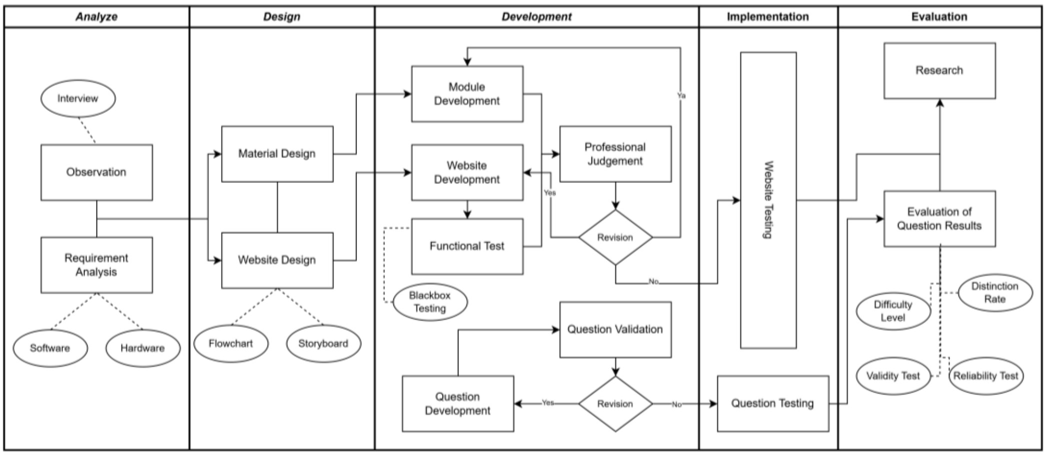


Figure 1. ADDIE Instructional Design Framework for Website Development. The five-phase ADDIE model (Analysis, Design, Development, Implementation, Evaluation) was applied to create XPOGIEDU.

There are several key features within the XPOGIEDU website that support the stages of the POGIL learning model. These features include group discussion spaces, tasks structured according to the stages of POGIL, as well as quizzes designed to measure student understanding after a learning session. Each feature serves to strengthen student collaboration, help them develop problem-solving skills, and improve the effectiveness of student-centered learning.

(a) XPOGIEDU's user interface features modules and tests designed for POGIL activities.

(b) Students engage with the platform during the learning.

Figure 2. Website Interface and Classroom Implementation.

Data Collection

Data collection was conducted through pre-tests and post-tests as primary instruments, administered before and after the learning process to gauge students' initial understanding and subsequent improvement, respectively, with both tests structured into three categories—logic (20 questions), branching (25 questions), and looping (25 questions)—to assess specific competencies tied to the curriculum. Supplementary data was gathered via learner worksheets, which enabled practical application of concepts, and project assignments that evaluated students' ability to translate theory into practice and hone problem-solving skills. All test items have undergone validation by expert lecturers and rigorous validity testing to ensure alignment with learning objectives, reliability, and measurement accuracy so that this measurement tool can effectively record students' progress in conceptual understanding and applied technical skills.

Data Analysis

Data analysis in this study employed Microsoft Excel for calculating normalized gain scores (to quantify improvement in students' logical thinking under the web-assisted POGIL model) and SPSS version 26 for statistical tests, including the Shapiro-Wilk normality test (selected due to the sample size of 30 participants, <50) and paired-sample t-tests. A 5% significance threshold ($\alpha = 0.05$) was applied: if the Shapiro-Wilk test yielded a significance value > 0.05, the data were considered normally distributed, permitting parametric analysis. For hypothesis testing, if the paired t-test significance value exceeded 0.05, the null hypothesis (H_0, which indicating no significant pre-post difference) was retained, while values ≤ 0.05 led to its rejection in favor of the alternative hypothesis (H_a), confirming statistically meaningful changes in performance. This dual-tool approach ensured rigorous, methodologically sound evaluation of the intervention's impact on skill development.

Students were stratified into upper, middle, and lower groups using z-score transformations based on pre-test and post-test results. This division is done to make it easier for researchers to identify things that need to be improved in the future. In this analysis, the data required were the average test score and standard deviation. The calculations used to determine which students belonged to the upper group used the formulas "mean + standard deviation" and "mean + (1.5*standard deviation)". Students in the middle group were determined through the calculation of "average - (0.5*standard deviation)", "average", and "average + (0.5*standard deviation)". Meanwhile, students in the lower group were calculated using the formulas "average - standard deviation" and "average - (1.5*standard deviation)". With this division, the number of students in each group on the logic, branching, and looping tests will be different, so as to provide a more detailed overview of students' abilities and the effectiveness of the application of the POGIL learning model assisted by the website in improving their logical thinking skills.

Procedure

A multiple baseline design across participants was used to examine the effect of implementing a website-assisted Process-Oriented Guided Inquiry Learning (POGIL) model to improve students' logical thinking skills. The baseline data was collected for each subject pre-intervention to understand their initial characteristics or attitudes. This step is essential to establish a reference point for comparison. The intervention itself was conducted over four sessions, totaling eight lessons.

After the initial baseline measurement, the intervention was introduced at different times for each subject to observe its effects gradually. At the end of the intervention, baseline measurements were conducted again to evaluate any changes in students' logical thinking abilities. This design allowed for a clear analysis of the effects of the POGIL model on each subject by comparing performance before and after the intervention.

Baseline-1. The pre-test was conducted to assess students' initial logical thinking skills and understanding of branching and looping concepts before using the POGIL model assisted by the website. Therefore, baseline-1 played an important role in identifying the initial characteristics of each student's logical thinking ability. The first stage of the POGIL model, Orientation, was also introduced to familiarize students with the guided inquiry approach. The pre-test results will be compared with post-test outcomes to evaluate improvements in students' logical thinking and understanding of branching and looping concepts after the intervention.

Intervention Website. During the intervention phase, key stages of the POGIL model, such as Exploration, Concept Formation, and Application, were implemented, along with the website's introduction designed to support the learning process. The website provided a structured platform aligned with POGIL's inquiry-based approach, which enhanced students' understanding of logical thinking and programming concepts. Students were guided to use the website to access learning materials, submit assignments, and take tests, encouraging active learning and allowing them to engage with the content at their own pace.

The website encouraged independent learning by offering flexibility in navigating lessons and completing assignments. It also enables students to retake assignments or tests to improve their results. A sequential access system is used, so students cannot proceed to the next test until they complete the previous one, ensuring mastery of each topic and providing a more personalized learning experience.

Baseline-2. During Baseline 2, the Closure stage of the POGIL model was conducted, where a post-test measured students' logical thinking skills after the intervention. The post-test results, compared with the pre-test, highlighted any changes in students' logical reasoning, specifically on branching and looping topics. This phase also allowed students to reflect on the learning process, consolidate their understanding, and synthesize the knowledge gained during the previous stages, helping them evaluate how well they could apply logical thinking in problem-solving scenarios.

Below is a table outlining how the website was used in the different stages of POGIL, including Orientation, Exploration, Concept Formation, and Closure. The integration of this technology ensured that students had continuous access to interactive learning materials and quizzes, helping them stay engaged and focused throughout the learning process.

Table 1. Implementation of POGIL Model Assisted by Website in Learning. Alignment of POGIL steps and Logical Thinking indicator with website features.

POGIL Model Steps	Logical Thinking Indicator	Explanation
Orientation	Orderly thinking	Students watch motivational videos on the learning website as initial guidance in learning branching and looping content.
	Orderly thinking and inference	Students take the logic, branching, and looping pre-tests on the learning website.
Exploration	Orderly thinking	Students access the branching and looping learner worksheets on the learning website.
Concept Formation	Orderly thinking	On the learning website, students watch learning videos and read modules that the teacher has uploaded.
Closure	Orderly thinking and inference	Students take the logic, branching, and looping post-tests on the learning website.

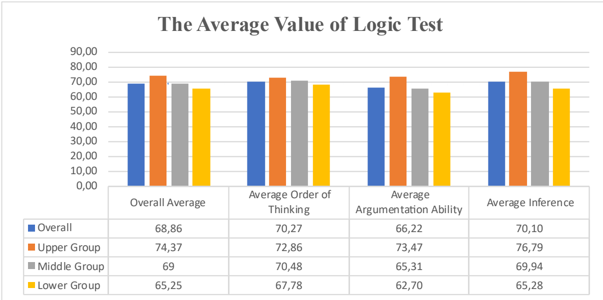
FINDING AND DISCUSSION

Findings

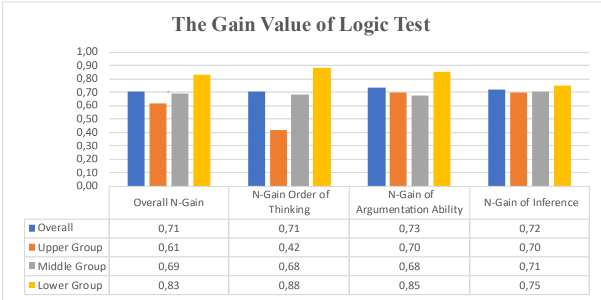
[RQ 1]: How is the influence of the Process Oriented Guided Inquiry Learning (POGIL) model assisted by a website in the Basics for Software and Game Development course on students' logical thinking skills?

The results of the gain logic test analysis showed that the average value of the students' pre-test was 51.38 with a standard deviation of 8.24. Based on this analysis, students were grouped into three categories. The upper group consisted of 3 students, the middle group of 24 students, and the lower group of 10 students. So, the total number of students was 37.

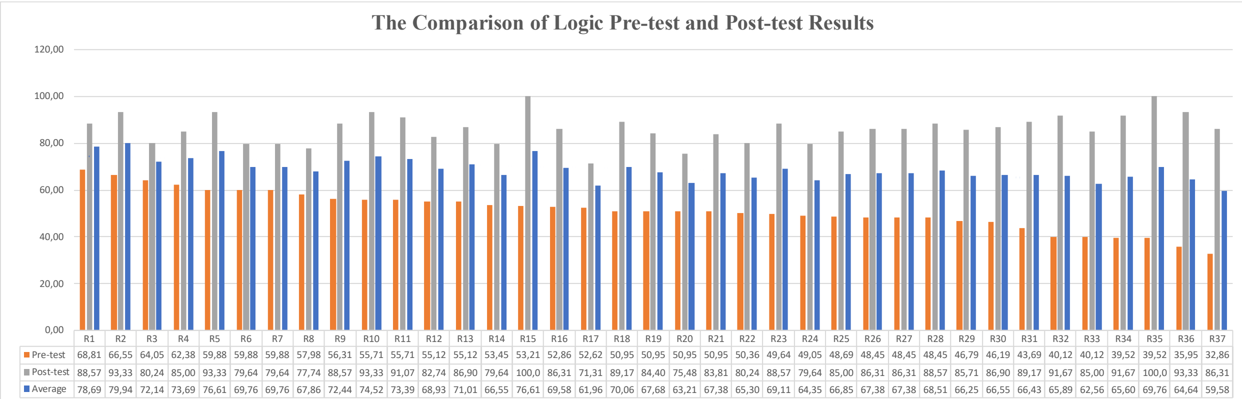
According to Figure 3, students achieved an average learning outcome of 68.86, with distinct improvements across the logical thinking indicators: order of thinking (average 70.27), argumentation skills (66.22), and conclusions (70.10). The overall normalized gain of 0.71 highlighted significant progress, particularly among lower-group students (gain = 0.83 vs. upper group = 0.61, middle group = 0.69).



(a) Average Scores of Logic Test: Displays the overall mean value of pre-test and post-test results across questions assessing logical thinking indicators.



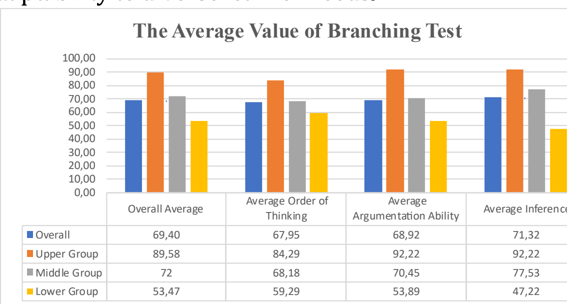
(b) Normalized Gain (n-gain) of Logic Test: Illustrates the average improvement in logical thinking skills, calculated from pre-test to post-test scores.



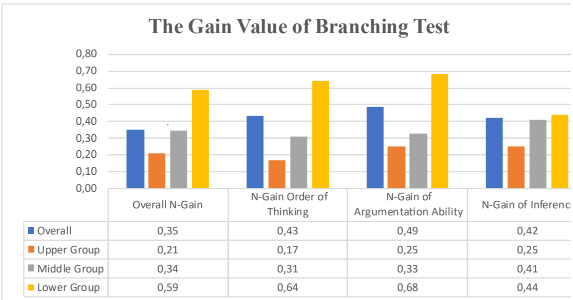
(c) Pre-test vs. Post-test Comparison: A flow diagram comparing individual student performance, highlighting increases or decreases in logical thinking proficiency after the intervention

Figure 3. Logic Test Performance Analysis.

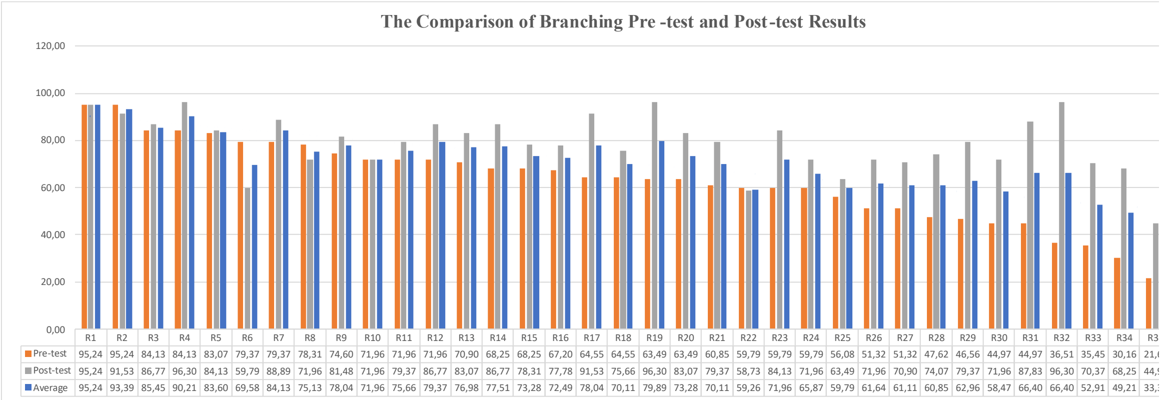
For specific indicators, order of thinking showed gains of 0.42 (upper), 0.68 (middle), and 0.88 (lower); argumentation ability improved by 0.70 (upper), 0.68 (middle), and 0.85 (lower); and inference increased by 0.70 (upper), 0.71 (middle), and 0.75 (lower), underscoring the model's efficacy in elevating logical reasoning, especially for struggling learners. In the branching test, a pre-test average of 60.53 (Standard Deviation = 20.12) categorized students into upper (n=5), middle (n=22), and lower (n=10) groups, with post-intervention analysis revealing marked conceptual comprehension gains across all proficiency levels, validating the approach's adaptability to diverse learner needs.



(a) Branching Test Average Score: This is the average score of the initial and final test results to evaluate the understanding of the branching concept.



(b) Normalized Gain (n-gain) of Branching Test: Quantifies the average skill improvement in branching concepts across all assessment items.



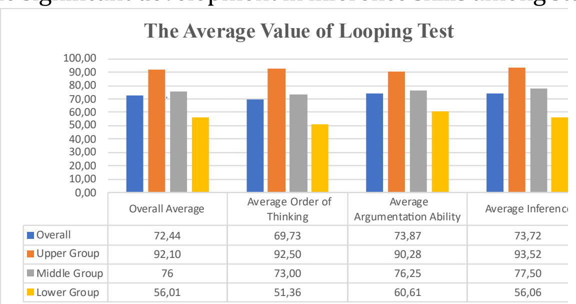
(c) Pre-test vs. Post-test Comparison: Visualize individual student progress through a flow diagram, contrasting pre-intervention and post-intervention performance in branching tests.

Figure 4. Branching Test Performance Analysis.

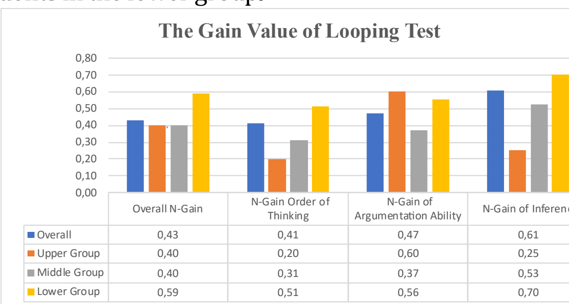
According to Figure 4, the analysis revealed an average score of 69.40 across the three logical thinking indicators—order of thinking (67.95), argumentation ability (68.92), and inference (71.32)—reflecting students' grasp of branching logic and structured reasoning.

The overall normalized gain was 0.35, with the lower group showing the most improvement (0.59 vs. upper = 0.21, middle = 0.34). For order of thinking, gains were 0.17 (upper), 0.31 (middle), and 0.64 (lower); argumentation ability improved by 0.25 (upper), 0.33 (middle), and 0.68 (lower); and inference increased by 0.25 (upper), 0.41 (middle), and 0.44 (lower), highlighting differential progress across proficiency levels. In looping concepts, the pre-test mean of 63.27 (SD = 20.86) categorized 37 students into upper (n=6), middle (n=20), and lower (n=11) groups. Post-intervention, the overall average rose to 72.44, with scores for orderly thinking (69.73), argumentation ability (73.87), and inference (73.72), demonstrating the POGIL model's efficacy in enhancing logical reasoning, particularly in iterative problem-solving tasks.

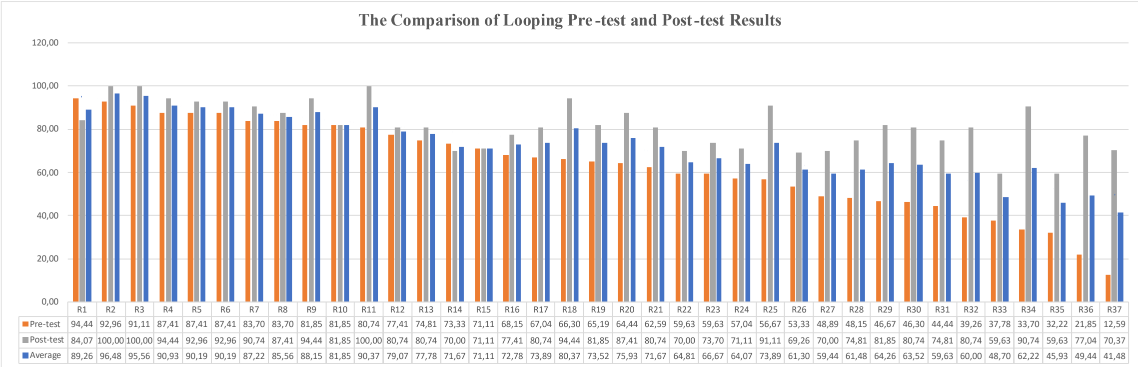
According to Figure 5, the overall average gain value was 0.43, with the upper and middle groups achieving a gain of 0.40, while the lower group achieved a higher gain of 0.59. For the orderly thinking indicator, the overall gain was 0.41, with the upper group recording a gain of 0.20, the middle group 0.31, and the lower group 0.51, indicating more significant improvement in the lower group. For argumentation ability, the overall gain was 0.47, with the upper group reaching 0.60, the middle group 0.37, and the lower group 0.56. The inference indicator showed the highest overall gain of 0.61, with the lower group demonstrating the most improvement at 0.70, followed by the middle group at 0.53 and the upper group at 0.25. These results highlight the significant development in inference skills among students in the lower group.



(a) Looping Test Average Score: This shows the mean pre-test and post-test scores for questions targeting looping concept comprehension.



(b) Normalized Gain (n-gain) of Looping Test: Reflects the average enhancement in looping skills derived from pre-post test comparisons.



(c) Pre-test vs. Post-test Comparison: A flow diagram mapping individual student trajectories, demonstrating shifts in looping proficiency after using the POGIL-assisted platform.

Figure 5. Looping Test Performance Analysis.

Based on the result, the analysis suggests that the POGIL model, supported by website assistance, effectively enhances students' logical thinking skills. However, there are areas for improvement to ensure more equitable benefits across all student groups, particularly for high-ability students. While the model has generally had a positive impact, these findings point to the potential for further refinement to optimize the learning method. Focusing on the development and optimization of this approach could ensure that all student groups experience more significant benefits, promoting a more balanced improvement in logical thinking skills across different levels of student ability.

[RQ 2]: How do students respond to the Process Oriented Guided Inquiry Learning (POGIL) model assisted by a website in the Basics for Software and Game Development course?

To determine the effectiveness and acceptance of students towards the use of websites in the research conducted, researchers distributed questionnaires by polling and analyzing the results of student response questionnaires using the Technology Acceptance Model (TAM) model. This model helps evaluate the factors that influence students' decisions to accept or reject the use of technology, including perceived ease of use and perceived benefits. The data indicated that users' perception of the website's usefulness in learning was 87.75%, reflecting a high level of confidence that the website provides significant benefits in the learning process.

Table 2. Student Feedback on XPOGIEDU. Survey responses (n=37) were rated on a 5-point Likert scale.

Aspects	Percentage (%)
Perceived Usefulness	87,75
Perceived Ease of Use	85,59
Attitude	87,57
Average	**86,97**

On the other hand, the perceived ease of use of the website reached 85.59% which shows that students felt the website was relatively easy to use and did not hinder their learning process. Students' attitudes towards the use of the website were also highly positive, with a score of 87.57% which shows that students have an excellent view of the use of the website as a learning medium. Overall, the average is 86.97%, which is considered very good, these results indicated that students generally felt that the website was a useful and easy-to-use tool, and had a positive attitude towards its use in education.

DISCUSSION

The findings of this study align with Öztop's (2023) meta-analysis, which emphasized the substantial impact of digital technology-assisted STEM education on academic achievement (d = 2.582). Both studies highlight the efficacy of technology integration in enhancing logical thinking skills, particularly among lower-ability groups. For instance, Oztop observed that high school students exhibited the highest gains in STEM outcomes, mirroring this study's results where lower-group students in logic, branching, and looping tests showed the most significant normalized gains (for example, 0.83 in logic for lower-group vs. 0.61 for upper-group). However, while Oztop's work focused broadly on STEM disciplines, this study narrows the scope to programming concepts, revealing nuanced challenges in mathematics integration (for example, lower gains in branching tests compared to inference skills), which Oztop similarly identified as a persistent issue in interdisciplinary STEM practices.

Öztop (2023) underscored the importance of user-friendly digital tools in sustaining engagement, a finding corroborated by this study's Technology Acceptance Model (TAM) results, where students rated the website's ease of use at 85.59% and perceived usefulness at 87.75%. Both studies stress that digital platforms must balance pedagogical rigor with accessibility to maximize adoption. However, this study extends Oztop's framework by explicitly linking the POGIL model's collaborative inquiry structure to gains in argumentation (66.22 → 73.87 post-intervention) and inference skills (70.10 → 73.72), demonstrating how guided inquiry synergizes with technology to deepen conceptual mastery. Oztop's meta-analysis, while validating the broad effectiveness of digital tools, did not explore specific instructional models like POGIL, making this study a critical complement to understanding how technology-enhanced pedagogy drives skill development.

Both studies identify equity gaps in STEM education. (Öztop, 2023) noted weaker effects in primary education and mathematics, paralleling this study's finding that upper-group students saw smaller gains (for example, 0.21 gain in branching for the upper group vs. 0.59 for the lower group). This suggests that while digital tools democratize access, they may inadvertently widen gaps if not tailored to diverse proficiency levels. Oztop advocated for longitudinal studies to track sustained impacts, a recommendation echoed here, as this study's short duration limited insights into long-term retention. Future research should merge Oztop's macro-level insights with micro-level interventions like the POGIL model, prioritizing adaptive designs that address variability in prior knowledge and engagement, particularly in underperforming subgroups.

CONCLUSION

The successful implementation of the POGIL model, enhanced by a structured ADDIE-designed website, underscores its potential as a transformative pedagogical framework not only for programming but across STEM disciplines, where collaborative inquiry and problem-solving are critical. By demonstrating significant gains in logical thinking (overall gain = 0.71) and equitable progress among lower-ability students (for example, 0.83 gain in logic tests), this study advocates for policy reform prioritizing inquiry-based, technology-integrated curricula to bridge skill gaps and foster inclusive learning environments. The high student acceptance of the platform (86.97% average TAM score) further highlights the necessity of investing in user-friendly digital tools that align with 21st-century educational demands. These findings urge educators and policymakers to adopt POGIL-inspired strategies in national STEM frameworks, emphasizing teacher training in guided inquiry methods and scalable digital resources to cultivate adaptable, critical thinkers capable of addressing complex global challenges.

LIMITATION & FURTHER RESEARCH

This study encountered limitations, including its short duration, which restricted the depth of data collection and obscured long-term trends or nuanced shifts in student attitudes. The lack of varied group compositions contributed to declining engagement, as participants reported boredom, potentially skewing participation levels and learning outcomes. Additionally, inconsistent task management—evidenced by late submissions and incomplete quizzes—compromised data reliability, hindering accurate assessment of student comprehension. These constraints highlight implications for future research: extending the study timeline to track sustained progress, diversifying group dynamics to foster engagement, and integrating digital tools or incentive systems to ensure timely task completion. Addressing these factors could enhance the validity of findings and the effectiveness of pedagogical interventions, promoting deeper learning and consistent student involvement.

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