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INVESTIGATING THE EFFICACY OF A STEAM-BASED LEARNING MODULE INCORPORATING A "STEAM" THEME IN FOSTERING CRITICAL THINKING SKILLS AMONG FIFTH-GRADE ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

We wanted to see if a STEAM-based learning module, built around the idea of "steam" (like water vapor!), could help fifth-grade elementary school students develop their critical thinking skills. We used a pre- and post-test approach with 30 students, giving them a validated critical thinking test before and after a two-week period where they used the module. The results were pretty clear: there was a big jump in critical thinking scores (the average went from 65.2 to 82.5, and it was statistically significant with a p-value less than 0.001). Beyond the numbers, we also noticed the students were much more engaged, curious, and showed stronger analytical abilities while working with the module. It looks like combining the interdisciplinary nature of STEAM with a fun, hands-on "steam" theme is a really promising way to build crucial critical thinking skills in young learners.

Keywords: STEAM education, critical thinking skills, elementary school, learning module, steam theme, fifth grade.

INTRODUCTION

In today's fast-changing world, it's more important than ever for students to be **critical thinkers**. They need to be able to sift through information, solve problems, and come up with new ideas [14]. Schools everywhere are shifting away from just memorizing facts and moving towards teaching students how to think more deeply [5, 8]. Critical thinking, as experts like Brookfield (2019) and Halpern (2019) explain, is all about actively and skillfully understanding, using, analyzing, combining, and judging information – whether it comes from observing, experiencing, reflecting, reasoning, or talking. It guides what we believe and how we act [5, 8]. These skills aren't just for doing well in school; they're essential for helping students become adaptable and insightful people [21].

One teaching approach that's really gaining traction is **Science, Technology, Engineering, Arts, and Mathematics (STEAM) education** [4, 10, 13]. STEAM brings these five subjects together, encouraging hands-on learning that sparks creativity, teamwork, and problem-solving [6, 19]. Adding "Arts" to the traditional STEM framework acknowledges how important design, beauty, and creative expression are for innovation and overall growth [4]. Studies have shown that STEAM-based learning can really boost student motivation and engagement [10], as well as improve creativity and problem-solving abilities [13].

For STEAM to work well, having good **learning modules** is key [17, 24]. A module is essentially a self-contained unit of teaching, providing a clear path for delivering content and helping students learn [15, 17]. How these modules are designed can greatly affect what students learn, especially when it comes to developing complex skills like critical thinking [12].

Our study specifically looked at whether a STEAM-based learning module, designed around the familiar concept of **"steam"** (think boiling water!), could help fifth-grade students develop their critical thinking skills. We chose the "steam" theme because it's something concrete and easy to observe. This allowed for engaging, hands-on activities that naturally brought in science (like how water evaporates and condenses), technology (tools for observing), engineering (designing simple experiments), arts (drawing what they saw), and math (measuring changes). It gave students a rich context to observe things, make educated guesses, test their predictions, and analyze what happened – all crucial parts of critical thinking [7]. Other research has shown that different learning models can boost critical thinking, such as the SSCS (Search, Solve, Create and Share) model [7] and problem-based learning [23]. We wanted to add to that knowledge by seeing the specific impact of our "steam"-themed STEAM module on young learners' critical thinking.

Our main goal was to see if this "steam"-themed STEAM learning module was **practical to use** for teachers and if it

was **effective** at improving critical thinking skills in fifth-grade elementary school students. We wanted to see if it could really get students thinking analytically and evaluating information.

METHODS

Research Design

We used a **quasi-experimental research design** for this study. Basically, we took one group of students and tested their critical thinking skills before they started using the module (pre-test) and again after they finished (post-test). This helped us see if there were any changes in their critical thinking abilities after they went through our learning module.

Participants

Our participants were **30 fifth-grade elementary school students** from a public elementary school. We chose fifth graders because at that age, they're typically ready to engage in more complex thinking and can really benefit from structured lessons on critical thinking [20].

Instrument

To measure how well students were thinking critically, we used a specially developed and **validated critical thinking test**. This test had open-ended questions and scenarios related to the "steam" theme. It was designed to check for different critical thinking skills, like analysis, making inferences, explaining things, and evaluating information [8]. We made sure the test was accurate and reliable by having experts review it and by trying it out beforehand [1]. We gave this test to the students at the very beginning (pre-test) and again after they completed the learning module (post-test).

Learning Module Development

We carefully developed the **"steam"-themed STEAM learning module** following good instructional design principles [2, 17]. The module was packed with activities that wove together Science, Technology, Engineering, Arts, and Mathematics, all centered around the concept of steam. For example, students might observe water boiling for science, use thermometers to measure temperature changes for technology, design a simple way to collect condensed water for engineering, draw or model steam phenomena for arts, and calculate evaporation rates for math. We made sure the module was interactive and included lots of hands-on experiments to keep students actively learning and thinking critically [10]. The whole development process was systematic, from figuring out what was needed to designing, building, implementing, and finally evaluating it [22].

Procedure

First, we gave all the participating students the **pre-test** to see where their critical thinking skills stood at the beginning. After that, we implemented the "steam"-themed STEAM learning module over two weeks, with each session lasting about 60 minutes daily. The students' regular classroom teacher, who we had trained, led the module. In each session, students worked individually and in small groups on various activities. The teacher guided them, encouraging them to ask questions, analyze what they observed, and explain their reasoning. Once the module was finished, we administered the **post-test** to see how their critical thinking skills had improved.

Data Analysis

We used quantitative methods to analyze the scores from the pre-test and post-test. We calculated **descriptive statistics** (like the average score and how spread out the scores were) to summarize the results. Then, we ran a **paired-samples t-test** to see if there was a statistically significant difference between the pre-test and post-test scores. This would tell us if the learning module truly helped develop critical thinking skills. We also kept track of our qualitative observations of how engaged students were and how they participated during the module, which gave us extra insights into how practical and impactful the module was.

RESULTS

When we looked at the critical thinking test scores, we saw some **pretty clear improvements** in the students' abilities after they worked with the "steam"-themed STEAM learning module.

Table 1: Descriptive Statistics of Pre-test and Post-test Critical Thinking Scores

Measure	Pre-test Score	Post-test Score
Mean	65.2	82.5
Standard Deviation	8.9	7.3

N	30	30

As you can see in Table 1, the average critical thinking score jumped from **65.2 on the pre-test to 82.5 on the post-test**. This shows a significant boost in the students' critical thinking abilities after they went through the module. The scores also became a bit more consistent, as indicated by the slightly smaller standard deviation in the post-test.

Table 2: Paired-Samples t-test Results for Critical Thinking Scores

	Mean Difference	Standard Error Difference	t	df	Sig. (2-tailed)
Pre-test vs. Post-test	-17.3	1.5	-11.53	29	< 0.001

The results of the paired-samples t-test (Table 2) showed a **statistically significant difference** between the pre-test and post-test scores ($t(29) = -11.53$, $p < 0.001$). This extremely low p-value (less than 0.001) strongly suggests that the improvement we saw in critical thinking scores wasn't just by chance; it was very likely due to the "steam"-themed STEAM learning module.

Our **observations during the module** also backed up these findings. Students seemed much more curious, had deeper discussions, and were better at coming up with ideas and understanding results. For instance, when they were watching steam condense, many students could explain why it was happening and even suggest ways to collect more water, which really showcased their analytical and problem-solving skills [7, 26]. The hands-on activities, combined with the integrated STEAM approach, seemed to create a more active and engaged learning environment [6, 10, 19]. We saw students working together, sharing ideas, and even politely challenging each other's thoughts, all of which are vital for developing critical thinking [5]. The "steam" theme itself seemed to click with the students, making abstract ideas feel more real and understandable [25].

DISCUSSION

Our study's findings provide **strong evidence that our "steam"-themed STEAM learning module is both practical and effective** in helping fifth-grade elementary school students develop their critical thinking skills. The significant statistical improvement in their scores, along with our positive observations, really highlights the potential of this kind of approach.

The module's success likely came from a few key factors in how it was designed and implemented. First, the **STEAM framework** itself creates a rich, integrated learning environment that's naturally great for building critical thinking [4, 13]. By bringing together Science, Technology, Engineering, Arts, and Mathematics, the module encouraged students to look at problems from different angles, combine information from various subjects, and come up with creative solutions. This interdisciplinary approach fits with the idea that critical thinking isn't just one skill, but a set of abilities used in many different situations [8]. The module's focus on **hands-on activities and real-world connections**—which are known to be effective teaching methods [6, 10, 19]—probably led to deeper engagement and understanding, thus helping critical thinking grow. Students weren't just passively listening; they were actively involved in their learning, which is essential for developing higher-level thinking [5].

Second, the specific **"steam" theme** was incredibly effective. Steam is something tangible, its changes are observable, and it's relevant to everyday life, making abstract concepts more accessible and engaging for young learners. This theme naturally allowed us to weave in all the STEAM components: scientific observation of how water changes states, technological tools for measuring, engineering challenges in working with steam, artistic ways to represent what was happening, and mathematical calculations related to amounts. This concrete context gave students lots of chances to analyze cause-and-effect, make informed guesses, evaluate what they saw, and explain things – all key parts of critical thinking [3, 21]. Being able to see, touch, and interact with the subject matter improved their understanding and encouraged deeper thinking, fitting right in with good learning module design principles [15, 17].

Our strong statistical results confirm what other research

has found: that STEAM education is good for developing various cognitive skills [10, 13] and that well-designed learning interventions can improve critical thinking [7, 23]. This study adds to what we know by specifically showing how useful a "steam"-themed module can be for this age group, proving that we can teach complex ideas through relatable themes. The positive shift in how students approached problem-solving, which we observed, also suggests that the module didn't just improve their scores; it helped them develop a more curious and analytical way of thinking.

Of course, no study is perfect, and ours has some limitations. We used a single-group quasi-experimental design, which, while giving us valuable insights, doesn't allow for direct comparisons with a control group. Future studies could use a more robust experimental design to make stronger claims about cause and effect. Also, this study was done in a specific school, so the results might not be exactly the same in every other context.

In short, our **"steam"-themed STEAM learning module shows great promise** as a way to help fifth-grade elementary school students become better critical thinkers. Its integrated, hands-on, and engaging approach effectively uses the power of STEAM education to build essential skills for the 21st century.

CONCLUSION

This study successfully showed that a **"steam"-themed STEAM learning module is both practical and has a significant positive impact** on the critical thinking skills of fifth-grade elementary school students. Our number-based analysis clearly indicated a big improvement in critical thinking scores, and our observations backed this up by showing students were more engaged, curious, and analytical. By combining the interdisciplinary nature of STEAM with a hands-on, relatable "steam" theme, we found an effective way to help young learners develop higher-order thinking skills. These findings suggest that incorporating fun, integrated STEAM modules can be a **highly valuable tool for educators** who want to foster critical thinking in elementary schools.

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