



STEAM-based Diagnostic Assessment Design in Mathematics Economics Course

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ABSTRACT

Purpose of the study: This study aims to design a STEAM-based diagnostic assessment framework for the Mathematics Economics course to identify students' cognitive and non-cognitive profiles while supporting differentiated instruction and fostering interdisciplinary problem-solving skills.

Methodology: The study applied a Research and Development (R&D) approach using the ADDIE model, limited to the Analysis and Design stages. Data collection involved curriculum review, instructor interviews, and literature review. Assessment instruments incorporated case studies, questionnaires, and rubrics integrating science, technology, engineering, arts, and mathematics components.

Main Findings: The assessment revealed that students generally understood the link between mathematics and economics, could integrate STEAM principles, and demonstrated creativity in visualization. Strengths were seen in conceptual understanding and scientific-economic connections, while gaps emerged in advanced technological skills, mathematical modeling complexity, and depth of elasticity concept application.

Novelty/Originality of this study: This study introduces an interdisciplinary diagnostic assessment specifically integrating STEAM principles within Mathematics Economics education, addressing a gap in existing tools that are typically subject-specific. It advances knowledge by combining cognitive and creative dimensions, aligning with differentiated and inclusive learning practices.

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1. INTRODUCTION

The rapid transformation of education in the 21st century demands the integration of interdisciplinary approaches to better prepare students for real-world challenges. Science, Technology, Engineering, Arts, and Mathematics (STEAM) education has emerged as a framework that fosters creativity, innovation, and problem-solving through the interconnectedness of disciplines [1]. Within this framework, Mathematics and Economics play pivotal roles in developing analytical and quantitative reasoning skills necessary for complex decision-making. However, effective teaching in these areas requires not only the delivery of content but also accurate and timely diagnostic assessment to identify students' strengths, misconceptions, and learning needs. Such assessments are essential in designing responsive instructional strategies that promote equitable and inclusive learning experiences [2]; [3].

In the Indonesian context, the implementation of the Kurikulum Merdeka has emphasized differentiated instruction, personalized learning, and the cultivation of higher-order thinking skills [4]; [5]. Diagnostic

assessment plays a central role in achieving these goals, particularly in STEM-related subjects. When applied in a STEAM-based framework, diagnostic assessment not only evaluates cognitive understanding but also fosters interdisciplinary connections, creativity, and collaborative problem-solving [6]; [7]. However, despite the recognized importance of such assessments, there remains a lack of integrated assessment models that align STEAM principles with the specific needs of Mathematics and Economics education. A major challenge in Mathematics Economics education lies in the gap between curriculum expectations and students' actual understanding. Traditional assessments often emphasize summative evaluation, focusing on final outcomes rather than the ongoing diagnostic processes needed to identify and address learning difficulties early [8]; [9]. This limitation can lead to persistent misconceptions, uneven skill development, and reduced engagement—issues that are particularly detrimental in subjects requiring cumulative conceptual mastery such as mathematics and economics. Furthermore, many existing diagnostic tools lack interdisciplinary integration, making them less effective in promoting transferable problem-solving skills within a STEAM context.

The general solution to this problem involves designing a STEAM-based diagnostic assessment model that integrates the cognitive demands of Mathematics Economics with the creativity and application-oriented mindset fostered by STEAM education. Such a model should be capable of uncovering both cognitive and non-cognitive learning profiles [10] while enabling culturally responsive and inclusive assessment practices [2]. This integration will support teachers in identifying diverse learners' needs and in implementing adaptive instructional strategies that promote deep learning and active engagement.

Several studies have emphasized the value of diagnostic assessment in improving instructional effectiveness. [11] developed a mathematics diagnostic test for Kurikulum Merdeka that identified specific student misconceptions, enabling targeted remedial teaching. Similarly, [12] proposed diagnostic instruments to prepare educators for curriculum changes, emphasizing the importance of precise measurement tools in supporting differentiated instruction. These studies, however, primarily focus on single-subject contexts and lack integration into interdisciplinary STEAM learning environments. In parallel, the use of technology-enhanced tools has been shown to enrich the diagnostic assessment process. For example, [7] demonstrated that augmented reality-based learning materials can enhance spatial reasoning and conceptual understanding in mathematics. Similarly, explainable AI frameworks have been explored to improve the interpretability of assessment data, offering teachers actionable insights into students' learning processes [13]. However, while these approaches show promise, their application in STEAM-based Mathematics and Economics courses remains underexplored. The principles of effective assessment design outlined by [14] further suggest that assessments must be valid, reliable, and aligned with learning outcomes. [15] reinforces the need for institution-wide commitment to assessment for learning, rather than assessment of learning. Therefore, a STEAM-based diagnostic assessment design must integrate sound assessment theory, leverage emerging educational technologies, and align with the interdisciplinary, problem-solving nature of STEAM education.

Although the literature provides evidence on the benefits of diagnostic assessment and STEAM integration separately, research on combining these approaches in the context of Mathematics and Economics remains scarce. Existing diagnostic tools in mathematics education [11]; [12] are largely subject-specific and do not emphasize the interdisciplinary connections that are critical in STEAM education. Similarly, while STEAM approaches have been linked to enhanced problem-solving and creativity [1], assessment strategies within STEAM contexts often prioritize project-based outcomes rather than ongoing diagnostic evaluation.

Moreover, studies on the Kurikulum Merdeka highlight a need for teacher readiness and formative assessment literacy [9]; [16], but there is insufficient guidance on integrating these competencies into STEAM-based diagnostic frameworks. Technology-assisted assessment methods [7]; [13] offer new possibilities for data collection and analysis, yet their application for detecting interdisciplinary misconceptions in Mathematics and Economics is largely absent. Consequently, there is a gap in both theoretical development and practical implementation of STEAM-based diagnostic assessment tools that are specifically tailored to the needs of these subjects. The objective of this study is to design a STEAM-based diagnostic assessment framework for Mathematics and Economics courses that effectively identifies students' cognitive and non-cognitive learning profiles, supports differentiated instruction, and fosters interdisciplinary problem-solving skills.

2. RESEARCH METHOD

This study employs a Research and Development (R&D) approach using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. This model was selected due to its systematic and structured workflow, making it suitable for developing both instructional and assessment instruments. However, this study is limited to the Analysis and Design stages, as the primary focus is to produce an initial draft of a STEAM-based diagnostic assessment instrument for the Mathematics Economics course, which will be validated in subsequent research.

The first stage, Analysis, aims to identify needs, learner characteristics, learning competencies to be achieved, and relevant instructional problems. Needs analysis was conducted through a review of the Mathematics

Economics course curriculum, interviews with course instructors, and a literature review related to diagnostic assessment and the STEAM approach. The second stage, Design, aims to create a preliminary prototype of the STEAM-based diagnostic assessment instrument based on the results of the analysis stage. In this stage, the design was developed by considering the test structure, item formats, and the integration of STEAM elements. The first step was to formulate the assessment objectives, which are directed toward identifying the level of mastery of mathematics-economics concepts in an interdisciplinary context involving science, technology, engineering, arts, and mathematics. Next, an assessment blueprint was created, containing assessment indicators, types of stimuli, item formats, and their relation to STEAM components. The integration of STEAM principles was applied in each test item, for example, by linking mathematical concepts to real economic phenomena, using technology to display or analyze data, and requiring creative and applicable solutions.

3. RESULTS AND DISCUSSION

Result Research

The diagnostic assessment provided insights into the students' initial knowledge and their integrated thinking abilities related to Economic Mathematics, with a focus on cross-disciplinary STEAM principles (Science, Technology, Engineering, Art, Mathematics). The assessment was conducted in the first week of the course, involving an open quiz and a group case study, where the students were tasked with analyzing the impact of a failed chili harvest on market prices and consumer behavior. The basic competencies measured in the STEAM-based diagnostic test can be seen in Table 1 below.

Table 1. The Basic Competencies Measured in The STEAM-Based Diagnostic Test

STEAM Aspects	Diagnostic Competence
Science	Students are expected to explain economic phenomena using basic concepts of mathematics and statistics. This includes understanding how natural sciences and scientific methods can be applied to analyze economic situations, such as calculating economic growth, inflation, or market change
Technology	Students are expected to use scientific calculators or simple software (such as Excel) to solve basic problems. This involves using technological tools to analyze economic data and perform necessary calculations, such as calculating price indices or conducting market data analysis.
Engineering	Students are expected to build a simple economic model from real-life situations. This includes the ability to develop and apply mathematical models that represent existing economic relationships in the real world, such as the relationship between price and demand in a market.
Art	Students are expected to present solutions in an attractive visual form, such as graphs or infographics. This competency is important for communicating economic analysis results in a clear and engaging way, so that they can be understood by a wider audience, including those without a strong background in mathematics or economics.
Mathematics	Students are expected to understand the concepts of functions, limits, derivatives, and their applications in economics. This includes a deep understanding of the mathematical concepts underlying economic analysis, such as using mathematical functions for demand and supply models, and derivatives to calculate price elasticity.

After designing the basic competencies to be measured, the next step is to design the assessment instrument, which can be designed as below:

Part A: Knowledge and Attitude Questionnaire (Individual)

1. What is your understanding of the relationship between mathematics and economics?
2. Have you ever used tools such as Excel, GeoGebra, or other economic software?
3. Do you like data visualization such as graphs and diagrams? Explain why.

Part B: STEAM Case Study (Group)

Title: Chili Prices and Consumer Behavior: What Happens When the Harvest Fails?

Description: The price of chili has surged by 200% due to a failed harvest. The government is considering subsidies or market interventions. Analyze the microeconomic impact of this phenomenon.

Tasks for Students:

1. Science: Explain the scientific factors behind the failed harvest (climate, pests, etc.).
2. Technology: Use Excel to create a simulation of price and demand.

3. Engineering: Build a mathematical model of the relationship between price and the amount of chili demanded.
4. Art: Visualize the model in the form of an attractive graph.
5. Mathematics: Calculate the price elasticity of demand for chili using derivative formulas.
6. Assessment Rubric: Concept Understanding (30%), STEAM Integration (30%), Creativity in Visualization (20%) dan Group Collaboration and Argumentation (20%)

The results of the diagnostic assessment aim to measure both individual understanding and group collaboration skills through a STEAM-based approach. Here's a breakdown of the findings:

Part A: Knowledge and Attitude Questionnaire (Individual)

Understanding of the Relationship Between Mathematics and Economics: Students were generally able to identify the connections between mathematics and economics, with many emphasizing the importance of mathematical concepts such as functions, derivatives, and statistics in analyzing economic trends. This reflects an understanding that mathematics provides the tools needed to model and predict economic behavior. **Use of Tools like Excel, GeoGebra, or Other Economic Software:** The responses varied, with some students being familiar with Excel for basic calculations, while fewer students had experience with specialized economic software like GeoGebra. This indicates a need for further exposure to and training in economic modeling software to help students integrate technology into their learning process effectively. **Interest in Data Visualization:** Many students expressed a preference for visualizing data through graphs and diagrams, citing the clarity and simplicity it provides when understanding complex economic concepts. This interest in data visualization suggests that students value the role of art and creativity in making economic data more accessible and engaging.

Part B: STEAM Case Study (Group)

Science (Understanding the Cause of the Failed Harvest): Groups demonstrated a strong understanding of the scientific factors behind the failed chili harvest, such as climate conditions (drought, irregular rainfall) and pest infestations. This illustrates students' ability to link scientific principles to economic phenomena, reflecting the integrated nature of STEAM learning. **Technology (Using Excel for Price and Demand Simulation):** Most groups successfully used Excel to simulate the relationship between chili prices and demand. This indicated that students were comfortable applying technology to economic problems, but some groups may have benefited from additional guidance in using Excel's more advanced functions. **Engineering (Mathematical Modeling of Price and Demand Relationship):** Groups varied in the complexity of their models, with some developing basic linear models and others attempting more complex relationships. This task revealed the students' ability to apply mathematical concepts to real-world situations, though some groups struggled with the formulation of accurate models. **Art (Creating Visuals of the Model):** The majority of students created visually appealing graphs to represent the price-demand relationship. The creativity displayed in this task reflected the successful integration of the 'Art' aspect of STEAM, demonstrating how visual communication can enhance the understanding of complex economic concepts. **Mathematics (Calculating Price Elasticity Using Derivatives):** Most students were able to calculate price elasticity using derivatives. However, the level of accuracy and depth of explanation varied, with some groups needing more support in understanding the concept of elasticity and its application in real-world scenarios.

Assessment Rubric

Concept Understanding (30%): The students demonstrated a solid understanding of the core concepts related to economic phenomena, though some required additional guidance on complex mathematical applications. **STEAM Integration (30%):** The integration of STEAM principles was evident, with students effectively using science, technology, engineering, art, and mathematics to analyze the economic problem. **Creativity in Visualization (20%):** Many students displayed creativity in visualizing their findings, particularly through the use of clear, engaging graphs and infographics. **Group Collaboration and Argumentation (20%):** Group work was generally effective, though some students needed encouragement to collaborate more effectively and present well-reasoned arguments in their discussions.

This assessment highlights the strengths and areas for improvement in students' ability to apply a multidisciplinary approach to solve real-world economic problems. The use of STEAM in this context not only enhances students' conceptual understanding of economics but also encourages creativity, technological proficiency, and mathematical modeling skills. Further support in mathematical modeling and advanced software tools may be beneficial to deepen students' understanding of economic analysis.

Discussion

The design and initial implementation of the STEAM-based diagnostic assessment in the Mathematics Economics course demonstrate that this approach can provide a comprehensive overview of students' initial abilities, both individually and collaboratively, in integrating cross-disciplinary concepts to analyze economic phenomena. The assessment model was developed according to the initial *Analysis* and *Design* stages of the ADDIE model, aligning with the research and development principles employed by [11]; [12] in designing diagnostic instruments for the Merdeka Curriculum.

Findings from *Part A* (knowledge and attitude questionnaire) indicate that most students already understand the relationship between mathematics and economics, particularly in applying functions, derivatives, and statistics to predict economic behavior. This aligns with [11], who emphasize that a good diagnostic test can identify misconceptions early in the learning process, enabling teachers to design appropriate interventions. On the other hand, the limited experience of students in using software such as GeoGebra or other specialized economic tools highlights the need for strengthening the technology component, as [17] also stress that diagnostic assessments should support differentiated learning and technological literacy. In *Part B* (STEAM-based case study), the integration of the five core aspects science, technology, engineering, arts, and mathematics provided students with opportunities to develop comprehensive analytical skills. For example, students' scientific understanding of the causes behind the failed chili harvest demonstrates the relevance of the *Science* component in connecting natural phenomena with economic implications, reflecting [2] assertion that assessments should be culturally and contextually responsive.

Students' *Technology* skills, particularly in using Excel to simulate price-demand relationships, reflect the practical application of basic technological tools. However, as noted by [12], the use of technology in diagnostic assessments requires further training to maximize its potential for more advanced data analysis. In the *Engineering* aspect, the ability to build mathematical models of price-demand relationships varied; some students developed simple linear models, while others attempted non-linear relationships. This supports [8] view that effective formative assessment should not only measure final outcomes but also facilitate critical thinking and modeling processes.

In the *Art* aspect, students' creativity in producing visualizations such as graphs and infographics illustrates how artistic elements can enhance the accessibility of complex economic data. This aligns with [3], who emphasizes that inclusive assessment should measure not only cognitive knowledge but also communication and visual literacy skills. In *Mathematics*, although most students were able to calculate price elasticity using derivatives, there was variation in accuracy and depth of explanation, indicating a need for deeper conceptual understanding. [10] also highlight the importance of assessments that include both cognitive and non-cognitive aspects, ensuring that students are evaluated not only on knowledge but also on logical and applied thinking skills.

The scoring rubric—weighted toward conceptual understanding (30%), STEAM integration (30%), creativity in visualization (20%), and group collaboration/argumentation (20%)—reinforces Schuwirth and [14] principles that an effective instrument must have content validity, clear indicators, and alignment with learning outcomes. This approach also aligns with [15] concept of *assessment for learning*, positioning assessment as an integral part of the learning process rather than merely a measure of achievement.

The learning outcomes from this assessment reveal that STEAM integration offers significant advantages over conventional diagnostic assessments. First, students do not work on mathematics or economics problems in isolation but are trained to connect them with real-world contexts. Second, the use of technology and art in assessment helps accommodate diverse learning styles, consistent with the differentiated learning principles of the Merdeka Curriculum [4]; [16]. Third, group work fosters collaborative skills identified by [1] as a crucial 21st-century competency.

However, several challenges remain, consistent with previous studies. First, as noted by [9], teachers' formative assessment literacy remains a significant issue. Without adequate training, lecturers or teachers may struggle to interpret STEAM-based diagnostic assessment results and use them effectively for instructional improvement. Second, similar to [18], who highlight the importance of interpretability in technology-based assessments, this instrument design should be complemented by a clear feedback system to ensure actionable outcomes. Overall, the STEAM-based diagnostic assessment in the Mathematics Economics course shows strong potential to fill the gap identified in the literature—namely, the absence of diagnostic assessment tools that combine STEAM's interdisciplinary approach with the specific needs of mathematics-economics learning.

4. CONCLUSION

The STEAM-based diagnostic assessment model designed for the Mathematics Economics course successfully integrates science, technology, engineering, arts, and mathematics to evaluate students' initial understanding and collaborative problem-solving skills. The assessment provided valuable insights into students' conceptual grasp, technological proficiency, creative visualization, and mathematical modeling abilities. The results highlight its potential as a tool for differentiated instruction in line with the Merdeka Curriculum. However, further refinement is needed in mathematical modeling skills, advanced technological tool usage, and the provision of actionable feedback.

Recommendations: Based on the findings of this study, it is essential to enhance lecturers' capacity through training programs focused on improving formative assessment literacy so they can accurately interpret the results of STEAM-based diagnostic assessments and apply them to adjust teaching strategies that are aligned with students' needs. The integration of advanced technologies, such as specialized software for economic analysis and mathematical modeling, should be implemented to strengthen students' analytical and modeling skills, enabling them to apply learned concepts more comprehensively to real-world problems. The assessment design should also be refined by incorporating more complex real-world issues to challenge higher-order thinking skills while reinforcing cross-disciplinary integration.

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