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GEOMATE PROJECT
Implementation of Project Based Learning (PjBL) with STEAM approach in producing geometry transformations totebags as fashion products

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ABSTRACT: Mix Method research to describe the implementation of the "GEOMATE PROJECT" in enhancing students motivation and conceptual understanding of geometric transformations in Matematika Tingkat Lanjut. The research employed a comprehensive methodology, including activity observation and in-depth interviews, to ensure accurate results. The study was prompted by low student motivation, with initial data showing only 52% interest in Matematika Tingkat Lanjut, largely due to the perception that the subject focuses solely on numerical calculations and rote memorization. The learning model utilized was Project-Based Learning (PjBL) integrated with a STEAM (Science, Technology, Engineering, Art, and Mathematics) approach and differentiated instruction. In this project, students designed and produced unique tote bags by applying the principles of translation, rotation, dilation, and reflection. Differentiation was implemented across three dimensions: content (freedom in sketching while maintaining geometric concepts), process (choice of conventional or digital design), and product (selection of screen printing or manual painting techniques) based on students' interests and abilities. The results indicate that the "GEOMATE PROJECT" significantly increased learning motivation, strengthened conceptual understanding of geometry, and developed essential 21st-century skills, including critical thinking, creativity, collaboration, and communication. The STEAM approach, integrated with tangible products, created a meaningful, innovative, and relevant learning experience, increasing student interest in Matematika Tingkat Lanjut to 84%. Beyond mastering geometric transformations, students gained proficiency in digital and manual arts, material science (selecting durable pigments), and textile selection. This interdisciplinary involvement fostered higher motivation, as students realized that integrating various fields of knowledge significantly enhances the quality of a final product.

Key words: Geomate Project, STEAM, PjBL, Geometry Transformations

INTRODUCTION

The current Independent Curriculum in Indonesia emphasizes educational transformation that provides flexibility for educators to adapt the learning process to the unique characteristics and needs of students. This approach enables the implementation of differentiated learning that accommodates the diversity of talents, interests, and individual potential in the classroom. However, in reality, mathematics is

still often viewed narrowly by students as a discipline focused solely on calculating numbers and memorizing formulas without practical relevance to everyday life. The Independent Curriculum is designed to provide greater flexibility for educators and students in the learning process, tailored to individual characteristics and needs. One of its main pillars is differentiated learning, which allows teachers to accommodate the diversity of talents, interests, and potential of students in the classroom. The implementation of differentiation in this study covers aspects of content (choosing the type of transformation), process (conventional or digital design methods), and product (tote bag making techniques through screen printing or manual painting).

The condition is reflected in SMA Negeri 6 Malang, where observations show that only 52% of students have high learning motivation for advanced mathematics subjects. This low motivation stems from the belief that mathematics is abstract, boring, and less functional for their real needs. One topic considered difficult and too theoretical is geometric transformations, where students tend to get stuck memorizing formulas to determine the shadow of a point or a curve. To face this challenge, an instructional innovation is needed that can contextualize abstract concepts into tangible forms while developing 21st century skills, such as critical thinking, creativity, collaboration, and communication. One potential strategy is the integration of the Project Based Learning (PjBL) model with the STEAM approach (Science, Technology, Engineering, Art, and Mathematics). STEAM according to Dewi & Sutriyani (2024) is used as a means to foster ideas through the integration of different disciplines, one of which is mathematics. This approach not only combines science, technology, engineering, arts, and mathematics in learning, but also stimulates students to think cross-disciplinarily and integrate knowledge from various fields. The STEAM approach offers a holistic learning experience by integrating five disciplines to solve real-world problems.

Project Based Learning (PjBL) is a learning model that places students in active roles through activities of certain duration to produce a product. This model is effective for transforming abstract material into something more concrete and engaging for learners. Although requiring more preparation time than conventional methods, PjBL through creating real products has proven capable of significantly increasing learning motivation. This study documents the implementation of the "GEOMATE PROJECT", a product-based learning project in which learners are asked to create a unique tote bag by applying the concept of geometric transformation. Through this project, mathematical principles are no longer learned in isolation but integrated with environmentally friendly material selection (Science), use of design software (Technology), product structure planning (Engineering), and exploration of visual aesthetics (Art). By presenting real products close to learners' daily lives, mathematics

learning is expected to become more meaningful, innovative, and able to enhance motivation and deep understanding of concepts for learners.

METHOD

This study uses a research approach that combines qualitative and quantitative (mix methods) to describe the implementation of the "GEOMATE PROJECT" in mathematics learning. The research focuses on applying the Project Based Learning (PjBL) model with a STEAM approach (Science, Technology, Engineering, Art, and Mathematics) to improve motivation and understanding of geometric transformation concepts. The subjects of this study are eleventh-grade students who are studying advanced mathematics at SMA Negeri 6 Kota Malang. The research procedures follow the syntax of the PjBL teaching model and the STEAM approach implemented in classroom learning. The research procedures start with planning, organizing, design, production, and presentation stages. Data collection techniques used include: observation to observe active student engagement and motivation during project execution, interviews to explore students' perceptions of the usefulness of mathematics in daily life and its relation to other subjects with the STEAM approach, and documentation to collect design results both digital and conventional and the final project product in the form of a geometric transformation totebag.

Research instruments supporting the implementation of the PjBL teaching model including: teaching module, student worksheets, project assessment rubrics covering STEAM components, a mathematics motivation questionnaire, and interview guidelines to explore students' perceptions of the contextualization of advanced mathematics lessons that relate to and are useful for their daily lives. The data obtained were analyzed descriptively by comparing the situation before implementing the PjBL teaching model with the reflection results on the positive impact on concept understanding and 21st-century skills that all students must possess.

RESULT AND DISCUSSION

The main success of implementing the Project Based Learning (PjBL) learning model. This PjBL implementation is the application of differentiated instruction that accommodates learning style diversity. By providing content choices in the form of types of transformations to be realized as fashion tote bag creations, and process choices for making them digitally or conventionally, teachers succeed in meeting the needs of students with different initial abilities and interests. The tangible product in

the form of a fashion tote bag transforming geometry becomes concrete evidence of learning success that is more motivating than conventional written tests.

The STEAM approach has proven to be an effective learning paradigm in responding to the demands of the Industry 4.0 era through the integration of multidisciplinary science (Sari & Setiawan, 2020). The STEAM approach has proven to be one of the brilliant innovations in education in creating students ready to face the challenges of the Industry 4.0 era; this approach successfully unites several disciplines into a cohesive learning unit. It connects various fields of knowledge to provide more meaningful learning experiences and is highly relevant to addressing the complexities of the Industry 4.0 era.

Collaborative learning with this geometry transformation fashion tote bag product has proven effective in increasing student engagement and motivation. STEAM is an educational approach that combines science, technology, engineering, arts, and mathematics in a single framework (Harahap, et al., 2021). STEAM is an integrated learning approach that encourages students to think more broadly about real-world problems. STEAM is a discipline that integrates science, technology, engineering, arts, and mathematics into an integrated approach that can be implemented in school learning. From observations and in-depth interviews conducted with students, it can be described that the advantages of the STEAM learning approach implemented together with the PjBL model in producing the fashion tote bag product include: a) showing positive results in students' science knowledge, b) teaching students to think in order to solve problems actively, creatively, and innovatively, c) through technology, students can co-create their ideas into current technology, d) students can apply the learning outcomes obtained into daily life.

The combination of PjBL and STEAM in geometry transformation learning has been shows significant results. Students not only understand the material better but also are able to apply it in a batik motif design project of quality, supported by the use of GeoGebra (Sudiasa, 2022). The topic of geometric transformation is often considered difficult and overly theoretical due to a focus on memorizing formulas to obtain the projection of points or curves. The main problem in teaching this material is the lack of student understanding of the relevance of concepts to daily life. Through a creative project, concepts such as translation, rotation, dilation, and reflection can be internalized more deeply through the creation of complex visual patterns on fashion products, one of which is through the making of a transformation geometry totebag. Here are the products resulting from the geometry transformation totebag project by several groups.

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Figure 1. Painted Tote Bag Result

Students are free to create the tote bag results in a conventional way consisting of by painting and coloring it with acrylic paint to produce a painted tote bag. Geometric transformation is no longer just a formula on paper, but an instrument to create aesthetically functional patterns in the produced product. This product proves that good mathematical mastery is directly proportional to the ability to create a structured design, while an understanding of materials science ensures the physical quality of the product. Group activities in completing the tote bag project with a geometric transformation motif successfully created an enjoyable learning atmosphere and motivated students more to follow advanced mathematics learning (Sudiasa, 2022).

Figure 2. Screen-Printed Tote Bag Result

Differentiated learning frees students to determine the process the making of tote bags to become meaningful final results. The differentiation process allows teachers to accommodate the diversity of talents, interests, and potentials possessed by students in the classroom. The content aspect of geometric transformation design is interpreted as students in groups freely choosing the type of geometric transformation such as translation, reflection, rotation, dilation, or selecting several or all types of transformations. In terms of the process aspect, students are also free to choose the conventional design method of manual painting or using a digital process with the help

of applications to create a design that matches the selected content. This flexibility is provided by the teacher and adjusted to the characteristics and individual needs of the students. According to Sekarsari & Azka (2024), students should be given the opportunity to understand abstract mathematical concepts by manipulating concrete tools. In addition to being linked to the project of making geometric transformation tote bags as a fashion product that is often used by students.

Concept of Geometric Transformation through the STEAM Approach

The concept of geometric transformation has many applications in everyday life such as in graphic design, architecture, animation, and even the arts. This material is very suitable for projects with the STEAM approach, which can develop students' visual abilities and spatial understanding, both of which are important in various fields. The STEAM approach is a learning paradigm that integrates multidisciplinary sciences to improve the quality of student learning (Ayuningsih et al., 2022). The STEAM approach combines five main disciplines: science, technology, engineering, art, and mathematics into one unity. A learning approach that combines various disciplines can develop students' critical, creative, and innovative thinking skills, thus providing a holistic and relevant learning experience for everyday life. According to Wardani et al. (2024), learning that applies the STEAM approach can provide space for students to access broad sources of knowledge, thereby fostering creativity in solving problems in learning projects.

Involving various disciplines gives students meaningful experiences through group activities in making this geometric transformation tote bag. Through science, students learn about types of environmentally friendly paints or inks that can be used on fashion products. In the use of technology and engineering, students use software or applications to create graphic designs and apply appropriate design principles to create attractive patterns. Art can develop students' creativity in combining various interesting and beautiful design elements. The mathematics material used in this project is the concept of geometric transformation, which is combined with the STEAM approach to create repeating patterns. According to Audina & Rusnilawati (2024), the STEAM approach can improve students' mathematical problem-solving abilities. In learning geometric transformations, students tend to have difficulty understanding the concepts and often confuse translation, rotation, reflection, and dilation, making it hard for them to solve geometric transformation problems.

This occurs because the learning is not taught from the most basic concepts, such as events that occur in everyday life (Mufti & Aziz, 2024). Geometric transformation is indeed an abstract and challenging material, therefore students must gain meaningful

experiences so that the concept of geometric transformation can be properly understood in applying to daily life that they experience. Based on interview results, students after completing this learning understand the trigonometry material more, after doing hands-on practice through the process of designing a tote bag about the types of geometric transformations themselves. Students carry out activities directly either through conventional drawings with manual painting or with the help of graphic design applications. The activity is considered by students as a meaningful experience in understanding the concept of geometric transformations itself.

Motivation Transformation and Learning Perception

After project implementation, learning motivation increases because students can see the direct application of the concept of geometric transformations in a real, functional product, namely a tote bag. Mathematics is no longer considered abstract, but becomes a creative tool to solve everyday design problems. According to Mayangsari (2024), motivation during mathematics learning activities becomes one of the critical aspects in teaching, especially when facing material that is considered abstract and challenging. Indicators of learning motivation include efforts to meet learning needs, showing interest and attention to tasks assigned by the teacher, perseverance in learning, and diligence.

Before Learning (%)	After Learning (%)
52	84

Table 1. Student motivation percentage

Intrinsic motivation arises from the sense of owning an original work produced by students in the form of a geometric transformation tote bag. The process of completing the desired product through several processes and activities conducted simultaneously increases their motivation because of the ownership of the produced product. Students' attention in completing the product becomes higher because the geometry transformation material is packaged in physical activity, not just teacher lectures. Motivation is fueled by components of attention, relevance, self-confidence, and satisfaction experienced by students when carrying out activities to complete the original product as a student's flagship work. The motivation formed after gaining this learning experience is ongoing. Students not only know about geometry transformation materials, but can feel its benefits in everyday life. This motivation tends to be more

ingrained because it is tied to meaningful experiences and pride in works that can be touched and used as a fashion product.

The application of the PjBL learning model with a STEAM approach in geometry transformation material has successfully transformed students' perceptions from viewing mathematics as a series of abstract formulas and boring to become a functional design tool relevant to real life. Through the creation of the final product in the form of a geometrically designed tote bag, students experience a significant shift in motivation, from extrinsic motivation that only pursues assessment scores to intrinsic motivation driven by a sense of ownership, pride in original work, and psychological satisfaction when seeing the concepts of rotation, reflection, and dilation realized precisely in the tote bag product. The integration of art and engineering elements in the process not only reduces students' anxiety about advanced mathematics lessons but also builds strong motivation because they realize that mastery of geometric transformation concepts is proportional to the aesthetic quality of the tote bag product they create. The learning experienced creates a meaningful experience that changes thinking patterns from merely memorizing procedures and concepts to learning to innovate and solve creative problems in the industrial world and in their daily lives.

CONCLUSION

Implementing the Project Based Learning (PjBL) model with a STEAM approach has proven effective in increasing students' motivation to learn, which previously only reached 52%; after implementing the PjBL model with a STEAM approach, it rose to 84%. This measures students' learning motivation as it develops better after implementing the model along with activities carried out by students in creating the tote bag product for trigonometric transformation. The conclusion is not merely repeating data, but a substantive interpretation. The differentiation-instruction strategy, which provides freedom in choosing, transformation content, design processes (digital or conventional), and production techniques (screen printing or manual painting), successfully accommodates diverse interests and initial abilities of students. This project successfully integrates critical thinking, creative, collaborative, and communication skills (the 4Cs) through a series of design, production, and product presentation processes. The STEAM approach provides a holistic learning experience by linking mathematics with science (environmentally friendly materials), technology (design software), engineering (product function planning), and art (visual aesthetics). Considering that implementing PjBL requires a relatively long time compared to conventional teaching, future researchers are advised to design more efficient time

management and teaching modules so that all learning syntax can be carried out optimally. It is recommended to continue exploring real-world contexts close to students' daily lives so that material considered abstract can be understood concretely and meaningfully. It is hoped that schools can provide broader policy support and facilities to facilitate product-based learning projects (PjBL) across various subjects to strengthen the profile of Pancasila Student Character.

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