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USING "TANGRAM SULTAN" (FOLKSTORY GAMES) FOR INTRODUCING ANGLES AND SIDES AT ELEMENTARY SCHOOL

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Abstract

Elementary students often struggle to recognize geometric properties such as sides and angles, particularly in irregular two-dimensional figures. To address this problem, the present study developed Tangram Sultan, a culturally contextualized geometry game that integrates tangram puzzles with folklore from the Siak Sultanate in Riau, Indonesia. The study aimed to examine the effectiveness of Tangram Sultan in improving students' understanding of basic geometry through engaging and meaningful play-based learning. The game was developed using the ADDIE instructional design model and tested with second-grade students at SD IT Al-Fityah in Pekanbaru, Riau. The learning activities consisted of three phases: (1) introduction of the Tangram Sultan media, (2) implementation of the media in alignment with instructional objectives, and (3) evaluation of learning process. Results showed that 66% of students were able to accurately count the number of sides, while 69% correctly identified angles in various irregular shapes, showing measurable improvement in spatial reasoning and conceptual understanding. Moreover, the game created a more dynamic and enjoyable classroom environment that promoted active participation and collaboration. This study highlights how integrating local cultural elements into instructional media can enhance engagement and learning outcomes, while providing opportunities to design game-based tools that make abstract concepts more accessible to young learners.

Keywords: Games; Geometry; Local context; Mathematics learning; Tangram.

Abstrak

Siswa sekolah dasar sering mengalami kesulitan dalam mengenali sifat-sifat geometri seperti sisi dan sudut, terutama pada bangun dua dimensi yang tidak beraturan. Untuk mengatasi masalah ini, penelitian ini mengembangkan Tangram Sultan, sebuah permainan geometri yang diadaptasi secara budaya, yang menggabungkan teka-teki tangram dengan cerita rakyat dari Kesultanan Siak di Riau, Indonesia. Penelitian ini bertujuan untuk menguji efektivitas Tangram Sultan dalam meningkatkan pemahaman siswa tentang geometri dasar melalui pembelajaran berbasis permainan yang menarik dan bermakna. Permainan ini dikembangkan dengan menggunakan model desain instruksional ADDIE dan diuji coba dengan siswa kelas dua di SD IT Al-Fityah di Pekanbaru, Riau. Kegiatan pembelajaran terdiri dari tiga tahap: (1) pengenalan media Tangram Sultan, (2) implementasi media sesuai dengan tujuan pembelajaran, dan (3) evaluasi proses pembelajaran. Hasil penelitian menunjukkan bahwa 66% siswa dapat menghitung jumlah sisi secara akurat, sementara 69% peserta berhasil mengidentifikasi sudut pada berbagai bentuk tidak beraturan, menunjukkan peningkatan yang signifikan dalam kemampuan penalaran spasial dan pemahaman konseptual. Selain itu, permainan ini menciptakan lingkungan kelas yang lebih dinamis dan menyenangkan, yang mendorong partisipasi aktif dan kolaborasi. Studi ini menyoroti bagaimana integrasi unsur budaya lokal ke dalam media pembelajaran dapat meningkatkan keterlibatan dan hasil belajar, sambil memberikan peluang untuk merancang alat berbasis permainan yang membuat konsep abstrak lebih mudah diakses oleh siswa muda.

***Kata kunci**: Game; Geometri; Konteks lokal; Pembelajaran matematika; Tangram*

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INTRODUCTION

Geometry is one of the fundamental branches of mathematics that fosters students' logical, analytical, and spatial reasoning skills (Herawati & Hariyani, 2024). To develop these abilities effectively, learning should be systematically structured and student-centered so that students can build creativity, curiosity, confidence, and problem-solving skills (Fonte et al., 2017; Palmér & Johansson, 2018). In the 21st century, students are also expected to master essential competencies such as collaboration, creativity, critical thinking, and communication (Spies & Xu, 2018). According to Van Hiele's theory (Ma et al., 2015), students progress from visualization to formal deduction in their geometric understanding. At the elementary level, especially in second grade, students are typically in Piaget's concrete operational stage (Babakr et al., 2019) requiring tangible learning aids to comprehend concepts such as sides and angles in two-dimensional shapes.

However, research shows that many students still experience difficulties in recognizing and counting the sides and angles of shapes such as squares, rectangles, triangles, and parallelograms (Kusuma et al., 2023) These difficulties often arise because learning is still conducted abstractly, with limited use of visual or manipulative aids, and without contextual connection to students' daily lives. This condition highlights the urgency of developing instructional innovations that can help students concretize abstract geometric ideas in a way that is both engaging and developmentally appropriate.

Instructional media can serve as a bridge to address this gap. Studies have demonstrated that media use in learning can increase understanding, promote comfort, and create an enjoyable learning atmosphere (Pan et al., 2022). Similarly, Roza et al. (2017) also emphasize that media use in mathematics is both practical and effective for improving learning outcomes. Among various media forms, game-based learning stands out because it encourages active engagement while supporting critical cognitive skills. Games can help students construct mathematical understanding, stimulate creativity, and foster positive attitudes such as cooperation and persistence (Deng et al., 2020; Russo et al., 2021; Toyib et al., 2022).

Elementary students' natural tendency toward play makes game-based media highly effective for teaching geometry (Erşen & Ergül, 2022; Ulhusna et al., 2020). Games related to everyday contexts help students understand the usefulness of mathematics and apply it to solve real-life problems (Coleman & Money, 2020). As early as Ernest (1986) games were promoted as a means to make mathematics more engaging and meaningful. Game-based media can also foster collaboration, enhance comprehension, spark interest, accelerate information processing, strengthen problem-solving, and improve social awareness (Nugraheni, 2017). Khoirunnisya et al. (2024) confirmed that game-based learning can improve students' critical thinking skills.

Although numerous studies have emphasized the benefits of media (Pan et al., 2022; Roza et al., 2017) and game-based learning (Deng et al., 2020; Russo et al., 2021), few have critically examined how these approaches interact with the learner's cultural context. For instance, while Roza et al., (2017) focus on media practicality, Russo et al.

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(2021) emphasize student engagement, yet neither incorporates local values into the instructional design. In contrast, studies involving local contexts (Gaol & Simarmata, 2019; Kusumasari et al., 2020) highlight cultural relevance but rarely connect this to concrete geometry learning tools. This fragmentation suggests a need for an integrative approach that merges cognitive development theory, game-based learning, and local cultural elements to address geometric concept acquisition effectively.

Tangram is a colorful two-dimensional puzzle game originating from China, consisting of seven geometric pieces—five triangles, one square, and one parallelogram—which can be arranged into various patterns (Diandini et al., 2025; Withasari, 2018). Tangram activities promote spatial reasoning, problem-solving, and creative thinking (Diandini et al., 2025). Several studies have even adapted tangram into local contexts to create interdisciplinary and culturally meaningful learning experiences (Lutfia et al., 2023; Zulina et al., 2020).

Nevertheless, most prior studies either focus on general geometric understanding or emphasize national culture, while few incorporate local cultural narratives to concretize mathematical learning at the regional level. Gaol and Simarmata (2019) found that local-context integration increases learning activity, while Kusumasari et al. (2020) emonstrated that contextual teaching improves mathematical problem-solving skills. However, studies that merge these cultural elements with concrete geometry learning tools remain limited.

Despite these findings, there remains a lack of research focusing on instructional media that integrates local cultural narratives into concrete mathematical tools especially for geometry. To address this gap, this study proposes an innovative media: Tangram Sultan. Tangram Sultan is a tangram-based game infused with local folklore from Riau, Indonesia. This media aims to bridge abstract geometric instruction with students' concrete thinking and cultural context.

The core problem addressed in this research is the difficulty students face in understanding geometric concepts such as sides and angles, which is compounded by the abstract nature of instruction and lack of engaging media. Therefore, the objective of this study is to develop and evaluate Tangram Sultan as a culturally contextualized geometry learning media to support students' understanding of sides and angles. This contribution is novel in its integration of traditional geometric games with regional folk stories, offering a meaningful, localized, and student-centered instructional innovation.

METHODS

The present study was conducted in Alfityah IT Primary School in Pekanbaru during the 2023/2024 academic year. The study's participants were second-grade students. This decision was informed by the insights gathered from the teacher, who attested to the prevalence of comprehension challenges among students, particularly in identifying and enumerating the number of sides and angles in two-dimensional shapes. These challenges were confirmed through the results of daily evaluations, learning observations, and informal discussions with classroom teachers who were also members of the media development team.

This study uses the ADDIE model which consists of five phases namely Analysis, Design, Develop, Implemen-

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tation and Evaluation phases. In the early stages an analysis was carried out to identify the need for using media in teaching geometry to second grade students. The analysis was conducted through structured interviews and discussions with teachers to understand the challenges they faced in delivering geometry content, particularly about sides and angles. The discussion also explored the types of media previously used, their limitations, and the preferred learning styles of students. Key indicators of students' difficulties were gathered through documented classroom assessments and teacher reflections.

In the design phase, the steps carried out are : 1) designing a learning trajectory aligned with the Realistic Mathematics Education (RME) approach, consisting of real-life contexts, model-of, model-for, and formal concepts; 2) designing a tangram game combined with the local cultural narrative of Sultan Siak, later named "Tangram Sultan"; 3) preparing a narrative structure and corresponding tangram pieces to support the storyline and learning objectives. These components were aligned with the expected learning outcomes related to geometry, especially the recognition and enumeration of sides and angles.

In the development phase, the Tangram Sultan game, its components, and student activity sheets were developed based on the design blueprint. Game rules and criteria for identifying the winner were also formulated. The instruments in this study included: (a) student activity sheets to collect data on learning outcomes, and (b) observation sheets to record engagement, collaboration, and learning challenges. To ensure quality, the instruments and product were validated through expert review by two mathematics education specialists and one practitioner, assessing their relevance to the curriculum, clarity, and suitability for the learning objectives. This validation process confirmed the product's appropriateness for use in the classroom, thereby addressing the aspect of validity.

The implementation phase involved the application of the game in a real classroom setting. The participants consisted of 28 second-grade students who were divided into seven groups, each comprising four students. The teacher distributed the Tangram Sultan kits and worksheets, guiding students through the learning process. The implementation was conducted in a single class sessions lasting 70 minutes. During the sessions, the teacher facilitated discussions and ensured active student participation. Observations during this session were conducted to assess student engagement, collaboration, and difficulties in identifying geometric features. These steps provided evidence of the practicality of the media in real classroom use.

In the evaluation phase, Data were collected using two techniques. First, quantitative data were obtained from the results of the student activity sheets. The students' answers to tasks requiring identification of sides and angles were reviewed, the number of correct responses was counted, and the results were converted into percentages to describe overall achievement. Second, qualitative data were obtained from classroom observations and teacher reflections after the learning session, focusing on student engagement, collaboration, participation, and learning difficulties. The combination of these data sources enabled a comprehensive evaluation of the product's effectiveness.

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The analysis was conducted in three stages, following the ADDIE model outcomes: (1) Validity was assessed through expert review of the product and instruments; (2) Practicality was examined through the smoothness of classroom implementation, teacher facilitation, and student participation; and (3) Effectiveness was analyzed using descriptive statistics from work-sheet results combined with qualitative observation findings. These three aspects—validity, practicality, and effectiveness—were used to determine whether the developed media success-fully addressed the research problem.

RESULTS AND DISCUSSION

In this section, the research results presented based on the sequence of research stages using the ADDIE model.

A. Analysis Phase

The initial step taken at the analysis stage is a Focus Group Discussion (FGD) to gather information about students' needs and problems in learning geometry. The FGD was conducted with six elementary school mathematics teachers and three mathematics education lecturers. The teachers provide an overview of the media and learning strategies in the geometry material that has been done so far. The teachers also conveyed the basic competencies that must be mastered by second grade elementary school students in learning geometry along with the obstacles in achieving these basic competencies. The FGD was continued with the idea from the three lecturers regarding which method should be used in learning geometry.

The teacher's main problem in presenting the concepts of sides and angles is students' understanding of determining sides and angles when several shapes are combined to form a new shape. From the results of the analysis of various class conditions it was concluded that the type of media to be used was game media. This idea is in line with Tokac et al. (2019) idea that the use of video games as a medium for teaching mathematics for grades 1-12 can improve student learning outcomes in general. However, the use of game-based learning in this study was not just aimed at improving outcomes in general but specifically aligned with Van Hiele's theory of geometric understanding.

According to Van Hiele, students progress from recognizing shapes based on appearance (visual level) to analyzing their properties (analytic level). The Tangram Sultan game was designed to facilitate this shift by engaging students in tasks that move from manipulating shapes to identifying structural elements like sides and angles. Furthermore, this learning trajectory follows a concrete-to-abstract progression—starting with hands-on manipulation (concrete), followed by guided recognition (pictorial), and finally reasoning about the number of sides and angles (abstract). Increasing learning outcomes as an effect of digital technology games was also suggested by Byun and Joung (2018), from his findings games not only increased learning outcomes but were also able to increase student learning motivation which was suspected as a trigger for increased learning outcomes.

In contrast to them, this study does not use digital-based games but games with the integration of local contexts so that students can get closer to their cultural roots, this part is the novelty of this study. According to Krisdayanti et al. (2023) the use of tangrams in learning geometry can

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make learning more interesting and able to increase student interest and motivation in learning geometry. In the FGD it was concluded that the use of tangram games would help in overcoming problems, to make activities close to the daily lives of students tangram games combined with the story of Sultan Siak. The game is given the name Tangram Sultan.

The results of the FGD were used as input in the creation of Tangram Sultan. The character of Sultan Abdul Jalil Alamuddin Syah in the story is the founder of the city Pekanbaru. Many second grade students do not know the origins of the city where they live, this activity added to their insights about the city of Pekanbaru. The word PEKANBARU was given because the Sultan moved the old market place to a new area in the village of Senapelan, so that the word Pekan baru (new market) appeared as the origin of the city of Pekanbaru. Senapelan is one of the areas that are part of the city Pekanbaru. This storyline is the creation of the author based on the history of the City Pekanbaru.

B. Design Phase

The design phase begins with designing the learning trajectory that used to carry out activities during learning. Learning used a realistic mathematical approach, so the learning trajectory is designed by starting lessons with real problems in life. Students are given pictures of objects around them that have sides and angles. In the next stage they were asked to determine the sides and angles on the sultan's tangram that were used as a game. The activity is continued by determining the desired sides and angles of the two dimensional figures and ends with the concept to be achieved. The learning trajectory that has been designed can be seen in Figure 1.

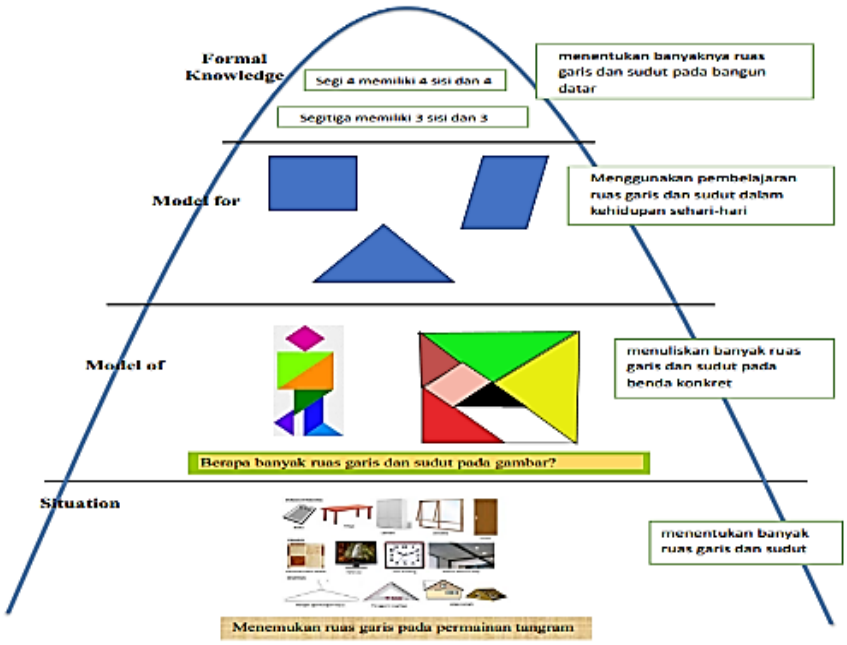

Figure 1. Learning Trajectory using Tangram Sultan

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C. The Development Phase

At this stage the researcher compiles the Tangram Sultan from 7 pieces of origami paper in the form of triangles and rectangles which can be arranged into a square as shown in Figure 1.

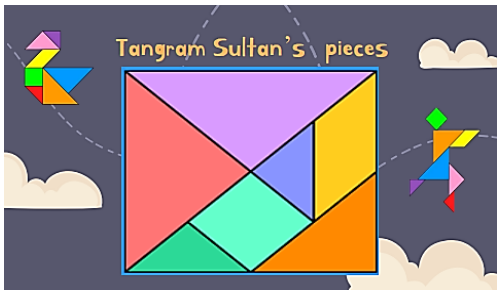

Figure 1. Design of Tangram Sultan

Based on the availability of the parts of Tangram Sultan, the researcher developed a game of Assembling shapes according to the storyline of Sultan Siak who became the founder of PEKANBARU. The storyline is the creation of the author consisting of seven figures representing seven scenes as follows. Characters in the first scene can be seen in Figure 2.

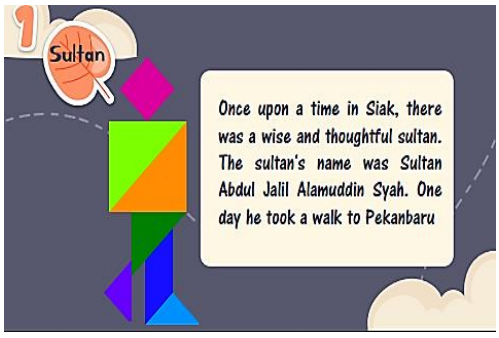

Figure 2. Introduction to Game Figure

The storyline of Tangram Sultan begins with the introduction of a Tangram Sultan character named Sultan Abdul Jalil Alamuddin Syah who is known as a wise man. In this character introduction section, students were asked to arrange the tangram pieces so that they form a human being described as Sultan Abdul Jalil Alamuddin Syah. On the student worksheet, part of the tangram arrangement is given as a key for students to arrange the tangram. Characters in the second and third scene can be seen in Figure 4 and 5.

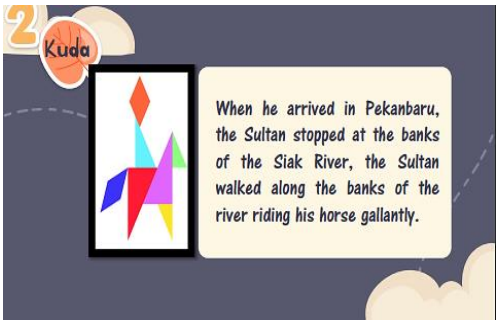

Figure 4. The Story of Sultan's visit to Pekanbaru in the second scene

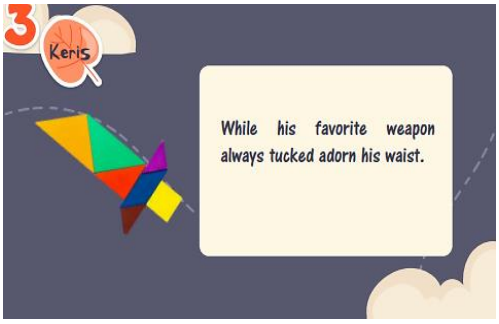

Figure 5. The Story of Sultan's visit to Pekanbaru in the third scene

It is stated that Sultan Abdul Jalil Alamuddin Syah, who came from Siak, visited Pekanbaru by riding a horse. In this section, the Tangram Sultan structured to resemble a person riding a horse. It is also stated that the sultan brought his favorite weapon like the figure of a sultan in ancient times. In this section, Tangram Sultan arranged to resemble a dagger as the sultan's favorite weapon. Characters in the fourth and fifth scene can be seen in Figure 6 and 7.

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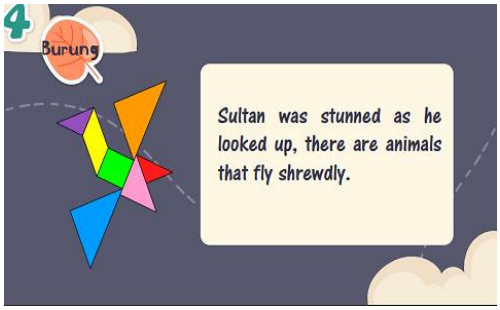

Figure 6. Nice view during visiting Pekanbaru in the fourth scene

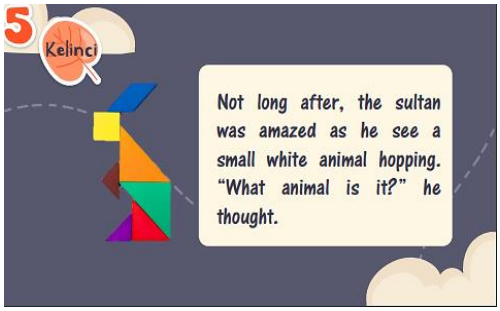

Figure 7. Nice view during visiting Pekanbaru in the fifth scene

On the way to the city of Pekanbaru, Sultan Abdul Jalil Alamuddin Syah was amazed by the natural charm around him. In the sky there are birds that fly skillfully, on the ground there are rabbits that jump around. In this section, Tangram Sultan will be shaped like a bird and a rabbit. Characters in the sixth and seventh scene can be seen in Figure 8 and 9.

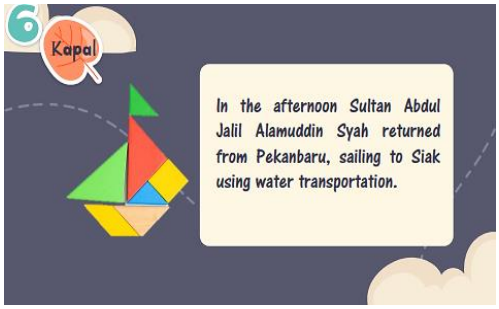

Figure 8. Nice view returned to Siak in the sixth scene

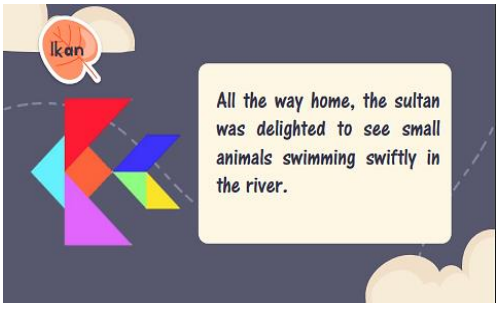

Figure 9. Nice view returned to Siak in the seventh scene

At the end of the story, Sultan Abdul Jalil Alamuddin Syah returns to Siak by sailing on a river. On the way home, from the Ship, Sultan Abdul Jalil Alamuddin Syah saw animals swimming in the river. In this section, Tangram Sultan was arranged to resemble a ship and fish.

The expert validation process confirmed that the Tangram Sultan media and its supporting instruments were aligned with the curriculum, clear in their instructions, and suitable for second-grade geometry learning. Both mathematics education specialists and the practitioner emphasized that the game was feasible to be used in class-room practice. Although no numerical validation index was calculated, the experts' consistent agreement provides evidence of the validity of the product.

Following the validator's response to the Tangram Sultan storyline, the instructor administered a trial of the game to a group of participants as part of the Tangram Sultan learning media development initiative. The results of the trial yielded a significant finding regarding the visual effects of the medium. The tangram pieces utilized in this medium were initially designed with aesthetically pleasing colors with the initial goal of increasing students' interest and engagement in learning activities. However, the findings of the observations indicated that the

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excessive utilization of colors can actually induce errors in students. It has been determined that students do not perceive the tangram figures as a single geometric composition but rather as a series of discrete images, categorized according to their respective colors.

When the tangram pieces were arranged according to the story scenario, the students experienced difficulty in identifying and counting the number of sides and angles from the formed shapes. The different colors among the tangram pieces obscure the boundaries of the basic shapes, so students' focus is interrupted on those color differences, not on the concept of lines and angles.

Based on the findings, at the implementation stage of this study using only one color for each part of the shape to minimize visual distraction and facilitate students in identifying the sides and angles of the formed shapes.

D. Implementation Phase

In the implementation phase, learning activities carried out in class 2 SD IT Alfityah Pekanbaru. Basic Competencies used is point 3.8 and 4.8 as follows:

3.8. Explaining line segments using concrete models of two-dimentional shapes and geometric shapes.
3.9. Classifying two-dimensional shapes and geometric shapes based on their characteristics.

The lesson material presented using the Tangram Sultan is to identify the number of angles and sides on a flat shape with the following learning objectives:

1. Using the game Tangram Sultan students can determine the number of sides, and the angles of two-dimensional figures.
2. Using the Sultan tangram game, student characters are formed which are discipline, respectful, cooperative, critical and self-confident as a the students.

In playing the game the students must follow the rules of the game as follows:

1. The new game can start after giving the direction by the teacher.
2. In game activities, students have to work in groups using activity sheets that have been provided.
3. The tangram must be arranged according to the storyline read by the teacher within the allocated time.
4. Each picture that is arranged correctly gets a score of 2, every angle that is correct is given a score of 1, each side that is correct is given a score of 1.
5. The winner is the group that has the highest score in compiling the image, determining the number of sides and angles of the image formed.

At the beginning of the activity the teacher explains the stages and learning objectives that will be achieved through the Tangram Sultan game. The teacher explains the rules of the game and the assessment to come out as the winner of the game. Initial activities can be seen in the Figure 10.

Figure 10. Teacher giving direction

After the initial explanation from the teacher, students are asked to sit according to the group that has been

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determined. Each group gets game equipment that used to arrange tangram figures according to the storyline and student worksheets to use to make tangrams. The activity of students working in groups can be seen in the Figure 11.

Figure 11. Student worked in group

The classroom trial also provided insights into the practicality of Tangram Sultan. The media could be implemented within the allocated 70 minutes, and students were able to follow the rules of the game, collaborate in groups, and complete the worksheets as designed. The smooth flow of classroom activities and students' active participation indicate that Tangram Sultan is practical to apply in real classroom settings.

At the time that students arrange the Tangram Sultan pieces, they are fully engaged and demonstrate a high level of enthusiasm. The students exhibited a high level of curiosity, as evidenced by their attempts to match the various pieces shapes on the auxiliary lines provided on the worksheet. This high engagement may stem from several contributing factors. First, the visual-spatial nature of the game likely appealed to students with strong spatial intelligence, enhancing their motivation and ability to recognize geometric features. Second, working in small groups may have fostered collaborative problem-solving and peer support, which are known to improve learning outcomes. Finally, the integration of local cultural elements—specifically the narrative of Sultan Abdul Jalil Alamuddin Syah—provided contextual relevance and emotional connection, which might have increased intrinsic motivation and focus during the activity.

The composition of each picture pattern in the Sultan's Tangram is followed by inquiries that direct students to enumerate and comprehend the number of sides and angles of the model they have formed. The students exhibited remarkable persistence and enthusiasm in completing the challenge, indicating the developed medium's significant appeal. However, it was noted that further refinement was necessary to enhance its visual aspects.

E. Evaluation Phase

The Tangram Sultan game is used in Geometry learning to introduce the concepts of sides and angles and to calculate the number of sides and angles that are formed after several tangram parts are combined. Learning is carried out in groups consisting of four

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students. Each group is given a Tangram Sultan activities sheet, origami paper which has been cut to form seven pieces of two-dimensional figures and glue to stick the figures according to the story. Next, the children listened to the Tangram Sultan story, then arranged the new figures on the activities by using paper according to the teacher's story. All activities have been carried out according to the scenarios that have been prepared at the design stage.

In carrying out the activity there are several obstacles faced by students and teachers. The first obstacle is managing time to carry out activities. In the early stages students lack of time to do activities, but gradually they can adjust their speed, but the teacher needs to be extra strict with their time. The next obstacle is determining the angle after the images are merged. This constraint allegedly occurred because students did not attach the paper pieces neatly, so some parts of the sides and corners were unclear and could not be calculated. The solution is to draw a line along the side of the new image that is formed and use paper of the same color. This method is quite helpful in increasing student understanding.

Once the process of learning using Tangram Sultan was completed, some student representatives were asked to present their group's work in front of the class and it turned out that some answers were not yet correct. As for the percentage of students' answers regarding multiple sides in the Tangram Sultan image is presented in Table 1 and the percentage of students' answers regarding multiple angles is presented in Table 2.

Table 1. Percentage of students' answers related to the number of sides

Groups	**Number of Sides**							**Percentage**
	Figure 1 (19)	**Figure 2 (18)**	**Figure 3 (12)**	**Figure 4 (18)**	**Figure 5 (18)**	**Figure 6 (9)**	**Figure 7 (9)**	
Correct	1	4	4	2	4	3	5	66%
Incorrect	4	1	1	3	1	2	0	34%

Table 2. Percentage of students' answers related to the number of angles

Groups	**Number of Angles**							**Percentage**
	Figure 1 (19)	**Figure 2 (18)**	**Figure 3 (12)**	**Figure 4 (18)**	**Figure 5 (18)**	**Figure 6 (9)**	**Figure 7 (9)**	
Correct	3	3	4	3	3	3	5	69%
Incorrect	2	2	1	2	2	2	0	31%

As demonstrated in Tables 1 and 2, it is evident that students possess a strong aptitude for identifying sides and angles. This is evident in that, on average, 66% of the students provided accurate responses regarding the number of sides, and 69% of the students correctly identified the number of corners of the various image patterns formed using the Sultan Tangram. These percentages reflect a promising level of initial mastery, especially considering the activity was conducted in a single session. Although the study did not include a control group or pretest-posttest design—factors that limit definitive causal claims—the results indicate meaningful short-term gains in students' ability to recognize geometric features. While benchmarks

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or effect sizes were not established, the observed outcomes provide encouraging evidence of the Tangram Sultan game's potential as an engaging tool for introducing concepts of sides and angles in early geometry learning.

To gain better insight into the types of errors students made during the learning activity, the following example illustrates common inaccuracies in identifying and calculating the number of sides and angles. These errors, as shown in Figure 12, highlight specific challenges students encountered when interpreting the geometric shapes formed using the Tangram Sultan pieces.

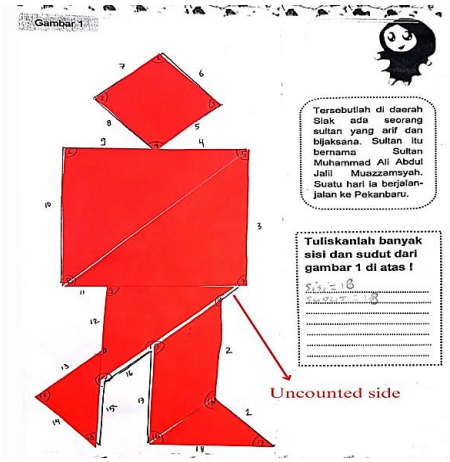

Figure 12. Students' work

In the initial scenario, students were tasked with assembling components of Sultan's Tangram to create a human figure representing Sultan Abdul Jalil Alamuddin Shah. However, a lack of rigor was observed in the identification of sides. Specifically, some sides were not designated with markers and were not included in the calculations presented in the students' worksheets.

The students' calculation errors pertaining to the number of angles, an instance is observed in the fourth tangram figure, as illustrated in Figure 10.

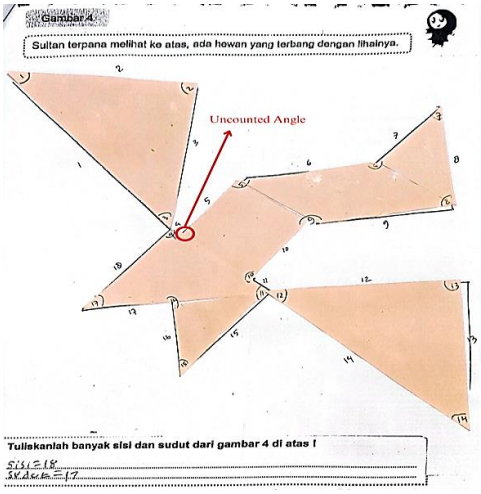

Figure 13. Students' work

In the fourth scenario, students successfully composed the Sultan Tangram pieces into the shape of a bird. However, as demonstrated in Figure 10, the arrangement of the tangram pieces by the students exhibits a lack of precision, resulting in the presence of unidentified and missed angles in the calculation. In the process of calculating angles, many students do not realize that the intersection of two lines invariably forms an angle, particularly when the angle is not immediately apparent or obscured by another element. Consequently, the responses documented on the worksheet frequently deviate from the actual number of angles and sides.

The results of this study indicate that Tangram Sultan media is effective in helping second-grade students understand the concepts of sides and angles in two-dimensional shapes. This effectiveness can be explained by the concrete nature of tangram pieces, which is in line with Piaget's theory that children in the concrete operational stage learn best through physical objects rather than abstract representations (Babakr et al., 2019). Students' increased ability to recognize sides and angles also supports Herawati and

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Hariyani (2024), who emphasized that geometry learning at the primary level plays an essential role in developing logical, analytical, and spatial thinking skills. More specifically, Tangram Sultan addressed the conceptual difficulties previously reported by Kusuma et al. (2023), who found that students often struggled to identify sides and angles due to limited understanding of geometric properties.

The positive responses observed in this study are consistent with research showing that the use of media makes learning more effective and enjoyable. Pan and Ke (2023) as well as Roza et al. (2017) found that instructional media improves comprehension and creates a comfortable classroom environment, which resonates with the enthusiastic participation of students in this study. Similarly, Deng et al. (2020) and Anggraheni et al. (2019) demonstrated that games enhance learning outcomes while fostering values such as cooperation and discipline—findings also evident in the collaborative group work during Tangram Sultan activities. Russo et al. (2021) further emphasized that game-based mathematics learning promotes exploration and concept construction; in this study, such outcomes were observed when students began creating tangram arrangements beyond those provided in the storyline.

In addition, the integration of cultural context strengthens the novelty of this research. Zulina et al. (2020) previously showed that tangram embedded with local culture is valid and effective, while several studies highlighted that learning media rooted in local contexts increases student activity and motivation noted that contextual teaching enhances mathematical problem-solving skills (Deda & Maifa, 2021; Gaol & Simarmata, 2019; Imswatama, 2023; Widyawati & Putri, 2016). Kusumasari et al. (2020) also. Building on these findings, the Tangram Sultan uniquely incorporated the folklore of Sultan Abdul Jalil Alamuddin Syah, making the learning process culturally responsive and fostering students' historical awareness in addition to mathematical understanding. This combination of cultural storytelling and student-driven exploration distinguishes the present study from previous tangram-based research, such as Krisdayanti et al. (2023) and Diandini et al. (2025), which emphasized improved student motivation and attitudes but did not embed a local cultural dimension.

The strengths of this study lie in its student-centered design, which is aligned with current pedagogical standards emphasizing inquiry, collaboration, and active engagement. Students demonstrated enthusiasm, creativity, and persistence in completing the tasks, which indicates that Tangram Sultan successfully provided both cognitive and affective benefits. Nonetheless, some limitations must be acknowledged. The validity evidence relied only on expert judgment, and practicality was inferred from a single classroom implementation without a control group, limiting the generalizability of the results. The short duration of the intervention may not fully capture long-term conceptual development, and the initial use of multiple colors in the tangram pieces caused visual distractions that sometimes hindered recognition of geometric features.

Despite these limitations, this study contributes both theoretically and practically. Theoretically, it reinforces the growing body of evidence supporting game-based and context-based learning as effective strategies in early mathematics education. Practically, it

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provides teachers with a culturally responsive instructional model that can enhance both student engagement and conceptual under-standing. The findings suggest that teachers may integrate local stories familiar to students, provide visual scaffolding such as auxiliary lines, and use monochromatic tangram pieces to avoid perceptual confusion. Future research should involve larger samples, multiple school contexts, and formal validity and practicality testing to strengthen the evidence for the broader applicability and long-term effectiveness of Tangram Sultan.

CONCLUSION AND SUGGESTION

From the activities that have been carried out in general it can be concluded that the Tangram game in learning geometry is feasible and contributes to students' understanding of the material sides and angles. In particular, the integration of local cultural elements through Tangram Sultan contributes to 1) developing problem-solving skills and logical thinking, 2) improving creative thinking skills, 3) train hand-eye coordination in carrying out activities, 4) improving motor skills, 5) increasing under-standing of geometric shapes, 6) create fun learning. This study highlights the significance of embedding culturally-relevant content in mathematics instruction, which not only enhances student engagement but also fosters a deeper connection between learners and their cultural identity. Based on these contribution, it can be suggested for grade two elementary school teachers in Pekanbaru city to use Tangram Sultan as an alternative medium for learning geometry. Teachers in other regions are encouraged to adapt tangram games by integrating them with their own local cultural narratives.

Despite these promising out-comes, this study is limited by its small sample size and short implementation period. Future research could explore the long-term impact of culturally-integrated geometry instruction across different educational settings and cultural contexts. Additionally, experi-mental studies incorporating pretest-posttest designs and control groups are needed to more rigorously validate the effectiveness of Tangram Sultan in comparison to conventional methods.

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