JURNAL VARIDIKA
Vol. 38, No. 2, 2026, pp.202-218
p-ISSN 0852-0976 | e-ISSN 2460-3953
Website: https://journals2.ums.ac.id/index.php/varidika/index

Students' Perceptions of Augmented Reality Based Student Worksheets on Circle Geometry

Trisna Wulandari[1], Ely Susanti[2*], Cecil Hiltrimartin[3]
[1, 2, 3] Mathematics Education Study Program, Faculty of Teacher Training and Education, Universitas Sriwijaya, Indonesia
*Corresponding author's email: ely_susanti@fkip.unsri.ac.id

Submission Track:
Received:
31 October 2025
Final Revision:
15 February 2026
Available online:
19 February 2026

ABSTRACT

This study aimed to describe students' perceptions of the use of Augmented Reality (AR)-based student worksheets in learning circle geometry. A descriptive quantitative approach was employed. The participants were 30 eleventh-grade students from a senior high school in Palembang selected using convenience sampling, as they were directly involved in learning activities using AR-based worksheets. Data were collected through a 20-item Likert-scale questionnaire covering cognitive, affective, and psychomotor/social aspects. Students' responses were analyzed descriptively by calculating the percentage of response frequencies for each Likert-scale category and aspect to identify overall perception trends. The results indicated that most students expressed positive perceptions of AR-based student worksheets, particularly in supporting conceptual understanding, learning engagement, and classroom interaction. However, a considerable proportion of neutral responses was also observed, especially in the affective aspect, indicating variation in students' emotional engagement. Overall, AR-based student worksheets were perceived as a supportive learning medium for circle geometry learning within the context of this study.

Keywords: Augmented Reality, Student Worksheets, Student Perception, Circle

DOI: 10.23917/varidika.v38i2.13592

INTRODUCTION

The 21st century education presents new challenges for the world of education to adapt to technological developments and the increasingly complex learning needs of students (Khahro & Javed, 2022; Kies et al., 2024). Rapid changes in various fields require teachers to innovate, not only in delivering material but also in developing media and learning strategies (Almufarreh & Arshad, 2023; Hoerudin et al., 2023). One characteristic of today's education is the use of digital technology as a primary tool to facilitate active, collaborative, and contextual learning (Kalyani, 2024). This is relevant considering that the current generation is growing up in a technology-rich environment, making conventional, monotonous approaches less effective in motivating students (Bergdahl et al., 2020).

In the context of mathematics learning, innovation is becoming increasingly important because this subject is often considered difficult, abstract, and boring by some students (Husnah et al., 2021; Kunwar, 2020). The characteristics of mathematics, which is full of symbols, formulas, and abstract

concepts, require media that can visualize these concepts clearly (Dwirahayu et al., 2021). One topic that often causes difficulties is the circle (Mifetu, 2023). This material includes concepts such as radius, diameter, arc, and tangent, which require a good visual-spatial understanding (Ogunyomi, 2021). The limitations of learning media that only consist of text or static images often make it difficult for students to visualize these concepts concretely (Galu et al., 2025). Therefore, the use of interactive technology-based learning media can be an effective solution to improve student understanding and learning interest (Ilham et al., 2024; Lu'Luilmaknun et al., 2021).

Along with technological advancements, Student Worksheets have undergone a significant transformation from conventional printed forms to digitally interactive media (Novia Sari et al., 2024). Student Digital Worksheets not only contain materials and practice questions but are also equipped with various multimedia features that support active learning (Viberg et al., 2023). Previous studies have shown that interactive Student Worksheets based on real-life contexts can increase student motivation, conceptual understanding, and active participation in the learning process (Sutarni et al., 2024; Tumangger et al., 2024). The integration of technology into Student Worksheets facilitates independent exploration, access to simulations, and utilize more engaging visualizations than printed media (Cirneanu & Moldoveanu, 2024; Hidayat & Firmanti, 2024; Medina Herrera et al., 2024).

One rapidly developing technology that is beginning to be applied in learning is Augmented Reality (Al-Ansi et al., 2023; Kamińska et al., 2023). AR is a technology that combines three-dimensional virtual objects with real-time environments, allowing users to view and interact with digital content as if it were present in the real world (Arena et al., 2022; Vakaliuk et al., 2020). In mathematics learning, AR has been shown to improve visual-spatial abilities, geometric thinking skills, and student engagement (Supli & Yan, 2024). The three-dimensional visual representations presented by AR make abstract concepts easier to understand and encourage meaningful learning (Lubis et al., 2022; Ulbrich et al., 2023).

The integration of AR into student worksheets provides a significant opportunity for teachers to create learning media that is not only informative but also immersive (Kounlaxay et al., 2021; Warsito et al., 2025). Through AR, the concept of a circle can be visualized in a realistic way, for example by displaying interactive models of the radius, diameter, arc, and tangent (Tarng et al., 2024). This allows students to make direct observations, change perspectives, and understand the relationships between the elements of a circle better than through just a two-dimensional image (Raudhatul Jannah et al., 2022; Rohendi et al., 2025).

However, the success of technology implementation in learning depends not only on the quality of the media but also on the perceptions of students as users (Chugh et al., 2023). Positive perceptions of learning media influence student motivation, engagement, and learning outcomes (Salifu & Bakari, 2022; Yuliansih et al., 2021). Conversely, negative perceptions can hinder media utilization, even if the

media is technically of good quality (Dennis & Kane, 2022). Research before emphasized that student perceptions include assessments of ease of use, attractiveness, and the media's benefits to the learning process (Salifu & Bakari, 2022). Student perceptions play a crucial role in the success of a learning model, as positive perceptions are closely related to increased motivation and learning outcomes (Anwar et al., 2020; Lo et al., 2022). Students who feel comfortable and engaged with learning media will more easily absorb information and demonstrate better learning outcomes (Hasanah Lubis et al., 2023). Therefore, evaluating student perceptions of the use of AR-based student worksheets serves not only as a product evaluation but also as a basis for developing adaptive and effective learning models (Hidayani et al., 2025).

METHOD

This study employed a descriptive quantitative approach to describe students' perceptions of the use of Augmented Reality (AR)-based student worksheets in learning circle geometry. Descriptive quantitative research aims to systematically describe phenomena based on numerical data obtained at the time the study is conducted. The participants of this study were 30 eleventh-grade students from SMA Srijaya Negara Palembang. The sample was selected using convenience sampling, as the students were readily accessible and directly involved in learning activities using AR-based student worksheets during circle geometry lessons. This sampling technique was considered appropriate because the study focused on describing perceptions within a specific learning context rather than making broad generalizations.

Data were collected using a questionnaire instrument with a 5-point Likert scale, consisting of 20 statements covering three main aspects: cognitive, affective, and psychomotor/social. The cognitive aspect consisted of 6 items related to students' understanding of learning objectives, conceptual understanding, critical thinking skills, and memory of concepts. The affective aspect consisted of 9 items addressing learning interest, motivation, relevance to real-life contexts, self-confidence, responsibility, and classroom atmosphere. The psychomotor/social aspect consisted of 5 items focusing on students' activeness, collaboration, interaction with peers, and engagement during the learning process. Content validity of the questionnaire was established through expert review by mathematics education lecturers to ensure the relevance, clarity, and appropriateness of the questionnaire items for measuring students' perceptions of AR-based student worksheets. The experts provided feedback on wording, content alignment, and construct representation, which was used to refine the instrument prior to data collection.

Data collection was conducted after students completed learning activities using AR-based student worksheets. The questionnaire was administered at the end of the learning session under teacher supervision to ensure consistent conditions during data collection. The collected data were analyzed using descriptive statistical techniques. Students' responses were summarized by calculating the

percentage of response frequencies for each Likert-scale category and for each perception aspect. The percentage analysis was used to identify trends in students' perceptions rather than to make strict categorical judgments. The results of the analysis are presented in the form of tables and diagrams to provide a clear overview of students' perception patterns toward the use of AR-based student worksheets.

Furthermore, the data were analyzed using descriptive analysis technique in the form of a percentage of the total score of each statement indicator which is then categorized.The analysis results are presented in tables and diagrams to illustrate the tendency of students' perceptions of Augmented Reality-based LKPD. The formula for determining the percentage of scores from the respondent questionnaire is as follows (Riyanti et al., 2024).

$$P = \frac{F}{N} \times 100\%$$

Information :

P = Frequency whose presentation is being sought

F = Percentage number

N = Number of frequencies or respondents

The parameters used to interpret the percentage value are (Riyanti et al., 2024):

0%	: None
1% - 25%	: Fraction
25% - 49%	: Almost Half
50%	: Half of it
51% - 75%	: Most of the
76% - 99%	: Almost All

RESULTS & DISCUSSION

Students' perceptions of learning media are crucial to the success of innovations in the teaching and learning process (Barete & Taja-on, 2024). When students perceive the media as engaging, easy to understand, and relevant to their learning needs, their motivation, engagement, and conceptual understanding will increase. Conversely, if the media is not suited to student characteristics, it can create obstacles such as boredom, confusion, and even resistance to learning (Rafniwati et al., 2025). Therefore, it is important to understand how students perceive the use of Augmented Reality-based Student Worksheets in mathematics learning, particularly on the topic of circles.

The AR-based student worksheets used in this study were designed to provide a more interactive learning experience, as shown in Figure 1 below.

Figure 1. Student Worksheet

According to Figure 1, students can scan the barcodes on the student worksheets using their devices to display three-dimensional objects, such as circles, tangents, and contextual phenomena like bicycle gears and solar eclipses. These visualizations help students see and explore abstract concepts more concretely, allowing for a more concrete understanding of the material through observation and step-by-step reasoning.

Two student worksheets are used in this lesson, each with a different context. The first student worksheet, related to a total solar eclipse, explores the natural phenomenon of the path of sunlight being blocked by the moon. The augmented reality version of a total solar eclipse is shown in Figure 2.

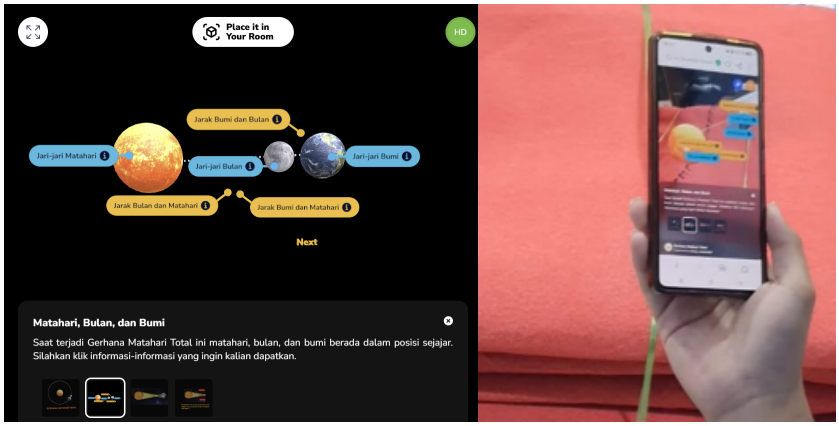

Figure 2. Augmented Reality Total Solar Eclipse

The AR visualization displays the positions of the sun, moon, and the boundary lines of light that form shadows. Students are asked to model these two circles as two circles and then draw the inner common tangent. This context helps students understand the connection between mathematical concepts and real-world scientific phenomena, making the concept of the inner common tangent more meaningful.

Meanwhile, the Bicycle Gears project addresses the problem of a bicycle chain connecting the front and rear sprockets. The augmented reality approach to a bicycle gear chain is shown in Figure 3.

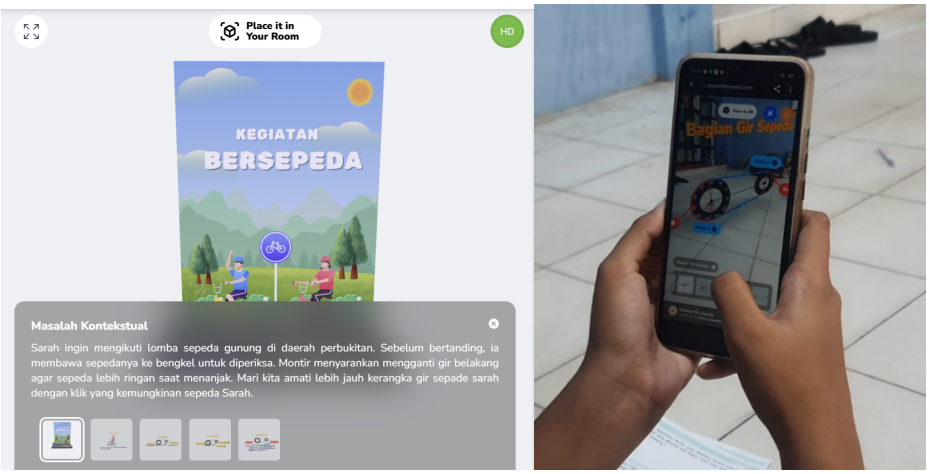

Figure 3. Augmented Reality Bicycle Gears

Based on Figure 3, through augmented reality, students can observe how the chain forms an external common tangent and then calculate the total length of the chain, consisting of arc and straight line segments. This context makes the concept of external common tangents easier to understand because it is linked to bicycle mechanics, which are close to students' lives.

Both student worksheets have the same activity structure: starting with understanding the contextual problem through AR, modeling it in a circle representation, formulating strategic guesses, implementing calculation strategies, and drawing reflections and conclusions. By utilizing AR, students are not only asked to solve problems but are also guided to observe, explore, and reason, making the learning process more meaningful and memorable.

To determine how students responded to this learning experience, a 20-item questionnaire was used with a Likert scale of 1–5. This instrument covers three main aspects: cognitive, affective, and social/psychomotor. The cognitive aspect assesses understanding of the material, the ability to remember concepts, and critical thinking skills in solving problems. The affective aspect assesses students' interest, motivation, self-confidence, and perceptions of the classroom atmosphere. Meanwhile, the social/psychomotor aspect encompasses learning responsibility, interaction with peers, and cooperation during the learning process.

The results of the descriptive analysis were then presented in tables and diagrams to demonstrate trends in students' perception scores. These findings were categorized based on percentage parameters that illustrate the extent to which students held a particular perception, ranging from "a small percentage" to "almost entirely." The following section will discuss the results of student perceptions, starting with the cognitive aspect.

This study analyzed student perceptions of the use of Augmented Reality (AR)-based Student Worksheets in circle learning, examining three main aspects that influence the student learning experience: cognitive, affective, and psychomotor/social. Data were obtained from 30 respondents through a 20-item questionnaire with a Likert scale of 1 to 5. The results were analyzed based on score trends and student perception categories.

Cognitive Aspects

The cognitive aspects of this study include students' perceptions of conceptual understanding, retention of material, and problem-solving skills after using Augmented Reality-based worksheets. Questionnaire items representing these aspects are shown in Table 1 below.

Table 1. Cognitive Aspect Statement Scores

No	Statement	Strongly Agree and Agree (SS)	Neutral (N)	Strongly Disagree and Disagree (TS)
1	Learning using Augmented Reality-based student worksheets this time made me understand the material better.	20	9	1
2	I find it easier to solve problems with this approach.	16	14	0
3	Learning using Augmented Reality-based LKPD encourages me to think critically.	21	9	0
4	I understand the learning objectives clearly through the activities in this Augmented Reality-based student worksheet.	22	8	0
5	I find it easier to remember concepts through learning activities using this augmented reality-based student worksheet.	17	13	0
6	Media or tools such as Augmented Reality in the worksheets used really helped my understanding.	19	11	0

Based on Table 1, it can be seen that the majority of students gave scores of 5 (strongly agree) and 4 (agree), as well as neutral, to the cognitive aspect statements, indicating a positive response from students to the Augmented Reality-based Student Worksheets. The results of the questionnaire will produce percentage data on the scores shown in Figure 1.

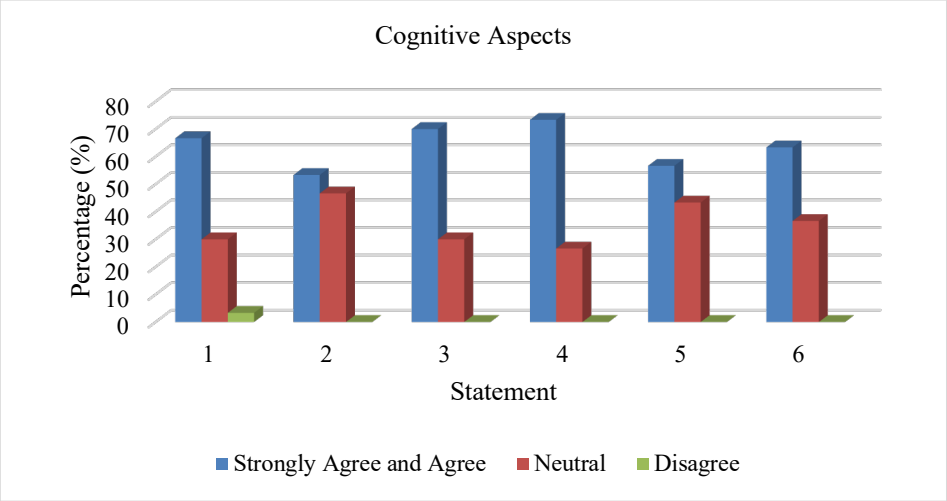

FIGURE 4. Percentage Graph of Cognitive Aspects

Based on the data in Figure 4, most students gave a positive response from the cognitive aspect to the Augmented Reality-based Student Worksheet, as seen in the majority of 63.9% who responded strongly agree and agree, and 35.6% who gave a neutral response. Although positive responses dominated the cognitive aspect, the data also show a substantial proportion of neutral responses. This indicates that while many students perceived AR-based student worksheets as supportive for understanding circle concepts, some students experienced moderate or uncertain cognitive benefits. These neutral responses reflect variation in students' learning experiences when interacting with AR-based materials. There was no significant disagreement response, indicating high acceptance from students towards this media.

The positive responses in the cognitive aspect indicate that AR-based student worksheets supported students' understanding of circle concepts by transforming abstract ideas into concrete visual representations. The three-dimensional AR visualizations enabled students to observe relationships among circle elements, such as radius, diameter, arcs, and tangents, which facilitated conceptual clarity. However, the presence of neutral responses suggests that not all students experienced the same level of cognitive benefit. This variation may be influenced by differences in prior knowledge, learning pace, or familiarity with technology-based learning environments. Previous studies also emphasize that while AR can enhance conceptual understanding, its cognitive impact may vary depending on how students interact with the technology and learning tasks.

Furthermore, students' interactions with 3D objects help develop critical thinking skills (Angraini et al., 2022). Students not only memorize concepts but also analyze the relationships between circle elements and solve contextual problems presented in the worksheet (Utama & Margunayasa, 2024). Augmented Reality learning can improve conceptual understanding skills while strengthening problem-solving abilities (Guntur & Setyaningrum, 2021).

The use of AR-based worksheets also facilitates students' visual-spatial learning styles (Guntur & Setyaningrum, 2021). When students can manipulate circular objects and view them from various angles, their understanding of the shape and properties of circles deepens. This support that Augmented Reality media helps students recognize geometric objects spatially (Gustina et al., 2025). In this context, students' logical and conceptual thinking skills improve, as they not only hear and read concepts but also see and manipulate their visual representations directly. These skills are important for linking mathematical concepts to real-world applications, such as in design, engineering, and technology (Arum Setyorini et al., 2021).

Thus, the high percentage of positive responses in the cognitive aspect shows that AR-based LKPD is not only a visual aid, but also a learning medium that is able to transform the mathematics learning process into an interactive, contextual, and meaningful experience.

Affective Aspect

The affective aspect relates to the relevance of learning to real life, learning interest and motivation, classroom atmosphere, and students' self-confidence and responsibility for learning in learning with Augmented Reality-based Student Worksheets. The questionnaire items representing this aspect are shown in Table 2 below.

Table 2. Affective Aspect Statement Scores

No	Statement	Strongly Agree and Agree (SS)	Neutral (N)	Strongly Disagree and Disagree (TS)
1	I feel that learning with Augmented Reality-Based student worksheet is related to everyday life.	12	17	1
2	I am more interested in learning with a learning model that utilizes augmented reality-based student worksheet like this.	14	15	1
3	I feel more confident in expressing my opinion.	19	10	1
4	I want the next learning to also use a model like this.	13	15	2
5	Learning using augmented reality-based student worksheet makes me more interested in this subject.	14	16	0
6	I feel that the challenges in assignments make me more enthusiastic about learning.	14	14	2
7	This learning model using augmented reality-based student worksheet makes the classroom atmosphere more enjoyable.	22	8	0
8	I feel more responsible for my own learning process.	21	9	0
9	Learning using augmented reality-based student worksheet makes me want to	11	19	0

No	Statement	Strongly Agree and Agree (SS)	Neutral (N)	Strongly Disagree and Disagree (TS)
	continue learning even outside the classroom.			

Based on Table 2, it can be seen that the majority of students gave scores of 5 (strongly agree) and 4 (agree), as well as neutral, to the affective aspect statements, indicating a positive response from students to the Augmented Reality-based Student Worksheets. The results of the questionnaire will produce percentage data on the scores shown in Figure 5.

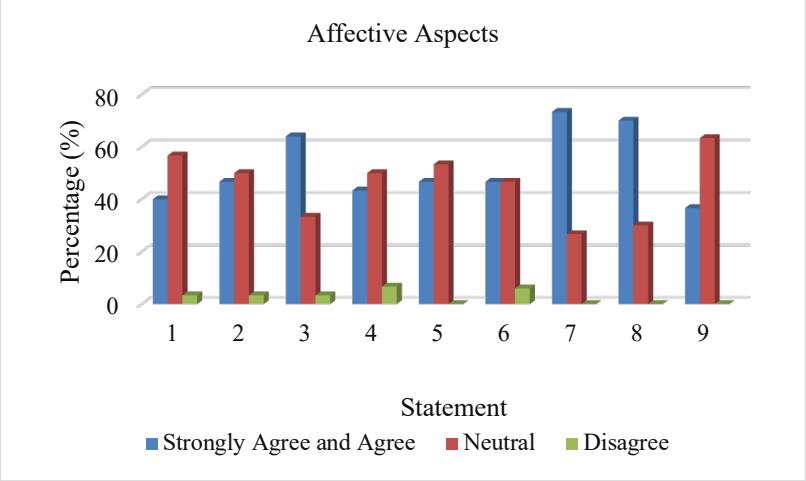

FIGURE 5. Percentage Graph of Affective Aspects

Based on Figure 5, it can be seen that most students gave a positive response to the affective aspect statement. As many as 51.9% of students gave answers "strongly agree" and "agree", and 45.6% gave a neutral response, and only a small portion "disagree". In the affective aspect, although more than half of the students expressed positive perceptions, a high percentage of neutral responses was observed. The affective findings reveal a mixed pattern of students' emotional engagement toward AR-based student worksheets. Although many students reported increased interest, motivation, and a more enjoyable classroom atmosphere, the relatively high proportion of neutral responses indicates that affective engagement was not fully experienced by all students. This condition may not only be related to students' adaptation to using AR technology but also to factors such as perceived content relevance, usability of the worksheets, and individual learning preferences. In addition, the novelty effect of introducing new technology may initially attract students' attention without immediately leading to deeper emotional involvement. This finding aligns with previous studies suggesting that sustained affective engagement requires continuous exposure and meaningful pedagogical integration of technology.

This shows that in general, the AR-based Student Worksheets was well received in terms of arousing students' interest, motivation, and positive attitudes towards learning about circles. Students felt more motivated to actively participate in the learning process because this Student Worksheets combined material with interactive displays and game-like entertainment elements. 3D visualizations of circle objects, such as radius, diameter, arc, and tangent, made learning more lively and easier to understand. Several students also mentioned that this Student Worksheets provided a fun and not boring learning atmosphere, so they were more enthusiastic about following the lesson until the end (Sholikhah & Cahyono, 2021).

Furthermore, AR-based student worksheets help students connect math material to relevant real-life situations (Arifin & Efriani, 2025). This not only makes learning more meaningful but also fosters students' curiosity. In line with that AR-based learning media can enhance students' positive emotions, such as enthusiasm and active engagement, which in turn boosts overall learning motivation (Susanto & Nurtamam, 2024). AR can influence students' positive emotions, such as enthusiasm and curiosity (Riniati et al., 2024). In this context, positive emotions also boost students' retention of the subject matter and foster learning motivation during the learning process .

Thus, the high level of positive response to the affective aspect indicates that AR-based student worksheets serve not only as teaching aids but also as triggers for students' intrinsic motivation. The combination of relevant content, engaging visuals, and opportunities for direct interaction with the learning objects are key factors in the success of this medium in fostering positive attitudes toward mathematics learning.

Psychomotor and Social Aspects

The psychomotor/social aspect encompasses how Augmented Reality based Student Worksheets facilitates physical learning activities (such as interaction with AR), group collaboration, and student engagement in discussions and collaborative tasks. Questionnaire statements supporting this aspect are shown in Table 3 below.

Table 3. Psychomotor and Social Aspect Statement Scores

No	Statement	Strongly Agree and Agree (SS)	Neutral (N)	Strongly Disagree and Disagree (TS)
1	I feel that the learning model using augmented reality-based student worksheet makes me more active.	21	9	0
2	The teacher gives students the opportunity to discuss and ask questions.	15	14	1
3	The learning time felt sufficient to complete the assigned tasks.	21	9	0
4	I can work well in groups during learning.	19	10	1
5	The teacher provides sufficient guidance during the learning process.	22	7	1

Based on Table 3, it can be seen that the majority of students gave a score of 5 (strongly agree) and 4 (agree) with, as well as neutral on the statements of the psychomotor and social aspects, which indicates a positive response from students to the Augmented Reality-based Student Worksheets. The results of the questionnaire will obtain percentage data on the scores shown in Figure 3.

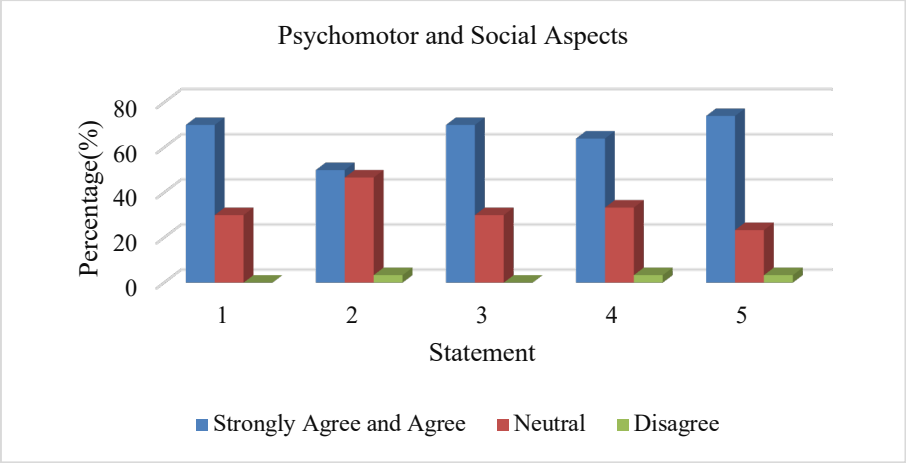

FIGURE 6. Percentage Graph for Psychomotor and Social Aspects

Based on Figure 6, most students responded positively to statements on the psychomotor and social aspects of using Augmented Reality-based Student Worksheets. A total of 65.6% of students responded "strongly agree" and "agree," while 32.7% responded neutrally, and only a small proportion "disagree." Nevertheless, the existence of neutral responses indicates that levels of activeness and collaboration varied among students during the implementation of AR-based student worksheets. These results indicate that AR-based Student Worksheets are not only beneficial for improving cognitive abilities but also effective in developing students' practical and social skills.

The positive perceptions in the psychomotor and social aspect indicate that AR-based student worksheets encouraged students to be more active and collaborative during learning activities. Students were required to interact with AR objects, discuss observations, and work together to solve contextual problems, which supported the development of communication and collaboration skills. Nevertheless, the variation in responses suggests that students' levels of participation and collaboration differed, possibly due to group dynamics, confidence in using technology, or differences in social interaction skills.

In activities designed using Augmented Reality Student Worksheets, students engage in group discussions, attempt to explain their Augmented Reality findings, and share responsibility in completing problem-based assignments. The use of this Student Worksheets requires students to actively interact, both with the media and with their group mates. Learning activities involving AR object manipulation encourage hand-eye coordination, detailed observation skills, and the ability to explain observation results. In addition, group work in solving AR based Student Worksheets problems strengthens

communication, collaboration, and role management skills within a team (Adi et al., 2025; Jampel & Antara, 2025).

During the learning process, students not only utilize technology to view 3D models of circles, but also engage in discussions, exchange ideas, and help each other understand the material. Teachers, who provide guidance throughout the activity, help ensure that each student is actively engaged and has the opportunity to practice the skills they have learned.

These findings align with research which states that AR integration in learning can improve collaborative and social skills because students are required to work together to operate the technology and solve problems together (Hidajat, 2024). Research revealed that the use of interactive media such as Augmented Reality encourages students to be socially active and improves their collaboration skills (Cevikbas et al., 2023). With elements of physical engagement (using devices, viewing 3D objects) and social engagement (discussions), Augmented Reality Student Worksheets also fulfill the principles of active learning and experiential learning (Crogman et al., 2025; Volioti et al., 2023). Thus, AR-based Student Worksheets positively contributes to the development of psychomotor and social skills, which are essential components of 21st-century competencies.

CONCLUSION

Based on the research results, it can be concluded that students generally gave positive responses to the use of Augmented Reality (AR)-based student worksheets in learning circle geometry. Most students perceived that AR-based student worksheets were visually appealing and supportive in helping them understand mathematical concepts, particularly circle material. The worksheets were also perceived as encouraging critical thinking in problem solving, helping students relate mathematical concepts to everyday contexts, and supporting concept retention. In addition, the use of AR-based student worksheets was perceived to create a more interactive and enjoyable learning atmosphere and to encourage active student involvement in discussions and group work. However, the presence of a considerable proportion of neutral responses, especially in the affective aspect, indicates that students' emotional engagement and motivation toward the learning approach varied and were not uniformly experienced by all students. Overall, AR-based student worksheets were perceived as a supportive learning medium for circle geometry within the context of this study. Nevertheless, this study is limited by the small sample size and the involvement of students from a single school. Future research is recommended to involve larger and more diverse samples, and further examine the relationship between students' perceptions and learning outcomes in AR-supported mathematics learning.

REFERENCES

Adi, N. H., Giatman, M., Huda, A., Larisang, Wahyuni, T. S., Fadillah, R., & Wahdi, Y. W. (2025). Enhancing Learning Outcomes through Cooperative Project-Based Learning with Augmented Reality Integration. Salud, Ciencia y Tecnologia, 5. https://doi.org/10.56294/saludcyt20251473

Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. In Social Sciences and Humanities Open (Vol. 8, Issue 1). Elsevier Ltd. https://doi.org/10.1016/j.ssaho.2023.100532

Almufarreh, A., & Arshad, M. (2023). Promising Emerging Technologies for Teaching and Learning: Recent Developments and Future Challenges. In Sustainability (Switzerland) (Vol. 15, Issue 8). MDPI. https://doi.org/10.3390/su15086917

Angraini, L. M., Alzaber, A., Sari, D. P., Yolanda, F., & Muhammad, I. (2022). IMPROVING MATHEMATICAL CRITICAL THINKING ABILITY THROUGH AUGMENTED REALITY-BASED LEARNING. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11(4), 3533. https://doi.org/10.24127/ajpm.v11i4.5968

Anwar, K., Asari, S., Husniah, R., & Asmara, C. H. (2020). Students' Perceptions of Collaborative Team Teaching and Student Achievement Motivation. International Journal of Instruction, 14(1), 325–344. https://doi.org/10.29333/IJI.2021.14119A

Arena, F., Collotta, M., Pau, G., & Termine, F. (2022). An Overview of Augmented Reality. In Computers (Vol. 11, Issue 2). MDPI. https://doi.org/10.3390/computers11020028

Arifin, S., & Efriani, A. (2025). Integrating Augmented Reality in RME-Based Digital Learning: Impact on Students' Problem-Solving Ability. Journal of Mathematical Society, 7. https://doi.org/10.18326/hipotenusa.v7i1.3768

Arum Setyorini, R., Permanasari, A., & Ardianto, D. (2021). Problem-Based Learning with Science, Technology, Engineering, and Mathematics (Stem) Approach to Improve Critical Thinking Skills and Conceptual Understanding of Junior High School Students (Vol. 5). https://journal.unpak.ac.id/index.php/jsep

Barete, M., & Taja-on, E. (2024). Students' Perception in Learning the Course Mathematics in the Modern World: A Qualitative Study. East Asian Journal of Multidisciplinary Research, 3(7). https://doi.org/10.55927/eajmr.v3i7.10071

Bergdahl, N., Nouri, J., & Fors, U. (2020). Disengagement, engagement and digital skills in technology-enhanced learning. Education and Information Technologies, 25(2), 957–983. https://doi.org/10.1007/s10639-019-09998-w

Cevikbas, M., Greefrath, G., & Siller, H. S. (2023). Advantages and challenges of using digital technologies in mathematical modelling education – a descriptive systematic literature review. In Frontiers in Education (Vol. 8). Frontiers Media S.A. https://doi.org/10.3389/feduc.2023.1142556

Chugh, R., Turnbull, D., Cowling, M. A., Vanderburg, R., & Vanderburg, M. A. (2023). Implementing educational technology in Higher Education Institutions: A review of technologies, stakeholder perceptions, frameworks and metrics. Education and Information Technologies, 28(12), 16403–16429. https://doi.org/10.1007/s10639-023-11846-x

Cirneanu, A. L., & Moldoveanu, C. E. (2024). Use of Digital Technology in Integrated Mathematics Education. Applied System Innovation, 7(4). https://doi.org/10.3390/asi7040066

Crogman, H. T., Cano, V. D., Pacheco, E., Sonawane, R. B., & Boroon, R. (2025). Virtual Reality, Augmented Reality, and Mixed Reality in Experiential Learning: Transforming Educational Paradigms. Education Sciences, 15(3). https://doi.org/10.3390/educsci15030303

Dennis, C., & Kane, E. (2022). PERSONAL DEVICE USE IN UNDERGRADUATE MATHEMATICS: AN INVESTIGATION INTO ACCESS, UTILIZATION, AND OUTCOMES.

Dwirahayu, G., Tantri K., D., & Afidah, A. (2021). Multimedia Assisted Analogy: Learning Approach to Developing Mathematical Representation Skills. JPI (Jurnal Pendidikan Indonesia), 10(1), 117. https://doi.org/10.23887/jpi-undiksha.v10i1.24371

Galu, A., Arifin1, S., Fitriani2, F., Aulia3, A., Awal Nur, M., Guru, P., & Dasar, S. (2025). The Influence of Visual Media on Elementary School Students' Understanding of Mathematical Concepts.

Guntur, M. I. S., & Setyaningrum, W. (2021). The Effectiveness of Augmented Reality in Learning Vector to Improve Students' Spatial and Problem-Solving Skills. International Journal of Interactive Mobile Technologies, 15(5), 159–173. https://doi.org/10.3991/ijim.v15i05.19037

Gustina, D. M., Mariana, N., & Wiryanto, W. (2025). Augmented Reality-Based Ethnomathematics Learning Media to Enhance Spatial Ability in 3D Geometry for Fifth Grade Elementary Students. Journal of Innovation and Research in Primary Education, 4(2), 273–280. https://doi.org/10.56916/jirpe.v4i2.1229

Hasanah Lubis, L., Febriani, B., Fitra Yana, R., Azhar, A., & Darajat, M. (2023). The Use of Learning Media and its Effect on Improving the Quality of Student Learning Outcomes. International Journal Of Education, Social Studies, And Management (IJESSM), 3(2), 7–14. https://doi.org/10.52121/ijessm.v3i2.148

Hidajat, F. A. (2024). Augmented reality applications for mathematical creativity: a systematic review. Journal of Computers in Education, 11(4), 991–1040. https://doi.org/10.1007/s40692-023-00287-7

Hidayani, S. M., Muchyidin, A., & Haqq, A. A. (2025). Development of an Augmented Reality-Integrated Student Worksheet (LKPD) to Enhance Mathematics Learning Outcomes. Journal of Mathematics Instruction, Social Research and Opinion, 4(2), 291–304. https://doi.org/10.58421/misro.v4i2.395

Hidayat, A., & Firmanti, P. (2024). Navigating the tech frontier: a systematic review of technology integration in mathematics education. In Cogent Education (Vol. 11, Issue 1). Taylor and Francis Ltd. https://doi.org/10.1080/2331186X.2024.2373559

Hoerudin, C. W., Syafruddin, S., Mayasari, A., Arifudin, O., & Lestari, S. (2023). E-Learning as A Learning Media Innovation Islamic Education. QALAMUNA: Jurnal Pendidikan, Sosial, Dan Agama, 15(1), 723–734. https://doi.org/10.37680/qalamuna.v15i1.4466

Husnah, A. U., Hidayat, M. A., & Jannah, M. (2021). The Journey of A Math: As a Mathematics Learning Innovation. https://doi.org/10.17509/xxxx.vxix

Ilham, I. S., Kusmiyati Arum Ningsih, Siti Rachmah, & Rasilah Rasilah. (2024). IT-Based Media in Mathematics Learning in Elementary Schools. Journal of Mathematics Instruction, Social Research and Opinion, 3(3), 285–296. https://doi.org/10.58421/misro.v3i3.273

Jampel, I. N., & Antara, I. G. W. S. (2025). Ethnomathematics-Collaborative Augmented Reality: An Innovative Framework to Enhance Problem-Solving Skills in Elementary Geometry. Jurnal Ilmiah Sekolah Dasar, 8(3), 522–528. https://doi.org/10.23887/jisd.v8i3.85666

Kalyani, L. K. (2024). The Role of Technology in Education: Enhancing Learning Outcomes and 21st Century Skills. International Journal of Scientific Research in Modern Science and Technology, 3(4), 05–10. https://doi.org/10.59828/ijsrmst.v3i4.199

Kamińska, D., Zwoliński, G., Laska-Leśniewicz, A., Raposo, R., Vairinhos, M., Pereira, E., Urem, F., Ljubić Hinić, M., Haamer, R. E., & Anbarjafari, G. (2023). Augmented Reality: Current and New Trends in Education. In Electronics (Switzerland) (Vol. 12, Issue 16). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/electronics12163531

Khahro, S. H., & Javed, Y. (2022). Key Challenges in 21st Century Learning: A Way Forward towards Sustainable Higher Educational Institutions. Sustainability (Switzerland), 14(23). https://doi.org/10.3390/su142316080

Kies, M., Sidi, U., & Abbes, B. (2024). Adapting to the Transformation of Education: New Challenges for Teachers "Foreign Languages Policy in Algeria and Teacher Professionalism" (FLPATP). Journal of Languages & Translation, 1, 80–88.

Kounlaxay, K., Shim, Y., Kang, S. J., Kwak, H. Y., & Kim, S. K. (2021). Learning media on mathematical education based on augmented reality. KSII Transactions on Internet and Information Systems, 15(3), 1015–1029. https://doi.org/10.3837/tiis.2021.03.011

Kunwar, R. (2020). Math mania: Meaning, Problems and Ways of Effective Teaching and Learning Mathematics at Basic Level Education in Nepal. Article in International Journal of Science and Research. https://doi.org/10.21275/SR20803202822

Lo, K. W. K., Ngai, G., Chan, S. C. F., & Kwan, K. P. (2022). How Students' Motivation and Learning Experience Affect Their Service-Learning Outcomes: A Structural Equation Modeling Analysis. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.825902

Lu'Luilmaknun, U., Anwar, A., Triutami, T. W., Salsabila, N. H., & Gunawan, G. (2021). Students' Responses Toward the Use of Technology Learning Media in Mathematics. Journal of Physics: Conference Series, 1933(1). https://doi.org/10.1088/1742-6596/1933/1/012076

Lubis, A. H., Dasopang, M. D., Ramadhini, F., & Dalimunthe, E. M. (2022). Augmented reality pictorial storybook: How does it influence on elementary school mathematics anxiety? Premiere Educandum : Jurnal Pendidikan Dasar Dan Pembelajaran, 12(1). https://doi.org/10.25273/pe.v12i1.12393

Medina Herrera, L. M., Juárez Ordóñez, S., & Ruiz-Loza, S. (2024). Enhancing mathematical education with spatial visualization tools. Frontiers in Education, 9. https://doi.org/10.3389/feduc.2024.1229126

Mifetu, R. K. (2023). Using activity method to address students' problem-solving difficulties in circle geometry. Contemporary Mathematics and Science Education, 4(1), ep23016. https://doi.org/10.30935/conmaths/13079

Novia Sari, R., Rosjanuardi, R., Herman, T., & Siti Balkist, P. (2024). Development of Mathematics Interactive E-Worksheet. Technology, Engineering & Mathematics (EPSTEM), 28. www.isres.org

Ogunyomi, K. O. (2021). DEVELOPMENT AND USE OF SOFTWARE PACKAGE FOR TEACHING AND LEARNING CIRCLE GEOMETRY IN SENIOR SECONDARY SCHOOLS IN IBADAN, NIGERIA.

Rafniwati, Yona S, Dekdi, & Herlinawati. (2025). The Effects of Digital Learning Media to Improve Mathematics Learning Outcomes and Motivation of Seventh Grade Junior High School Students.

Raudhatul Jannah, U., Amiruddin, M., & Nurhidayati, S. (2022). Profile of the Concept Understanding of Two-Dimensional Figure Based on Pirie Kieren's Theory Reviewed from Learning Motivation in Elementary School. Jurnal Pendidikan MIPA, 23(3), 1135–1148. https://doi.org/10.23960/jpmipa/v23i3.pp1135-1148

Riniati, W. O., Jiao, D., & Rahmi, S. N. (2024). Application of Augmented Reality-based Educational Technology to Increase Student Engagement in Elementary Schools Article Info. International Journal of Educatio Elementaria and Psychologia, 1(6), 305–318. https://doi.org/10.70177/ijeep.v1i6.1461

Riyanti, M., Khoiroh, U., Yennita, & M.Imamuddin. (2024). Persepsi Siswa Terhadap LKS Terintegrasi Islam Untuk Materi KPK Dan FPB. KOLONI: Jurnal Multidisiplin Ilmu, 3(2), 272–281.

Rohendi, D., Ramadhan, M. O., Rahim, S. S. A., & Zulnaidi, H. (2025). Enhancing student's interactivity and responses in learning geometry by using augmented reality. Eurasia Journal of Mathematics, Science and Technology Education, 21(1), em2559–em2559. https://doi.org/10.29333/ejmste/15796

Salifu, A. S., & Bakari, A. (2022). Exploring the Relationship Between Students' Perception, Interest and Mathematics Achievement. Mediterranean Journal of Social & Behavioral Research, 6(1), 13–20. https://doi.org/10.30935/mjosbr/11491

Sholikhah, B. U., & Cahyono, A. N. (2021). Augmented reality student worksheets for learning mathematics during the COVID-19 pandemic. Journal of Physics: Conference Series, 1918(4). https://doi.org/10.1088/1742-6596/1918/4/042063

Supli, A. A., & Yan, X. (2024). Exploring the effectiveness of augmented reality in enhancing spatial reasoning skills: A study on mental rotation, spatial orientation, and spatial visualization in primary school students. Education and Information Technologies, 29(1), 351–374. https://doi.org/10.1007/s10639-023-12255-w

Susanto, R., & Nurtamam, M. E. (2024). Development of AR-Based Educational Games for Mathematics Learning in Elementary Schools. Journal of Computer Science Advancements, 2(5), 273–284. https://doi.org/10.70177/jsca.v2i5.1325

Sutarni, S., Sutama, Prayitno, H. J., Sutopo, A., & Laksmiwati, P. A. (2024). The Development of Realistic Mathematics Education-Based Student Worksheets to Enhance Higher-Order Thinking Skills and Mathematical Ability. Infinity Journal, 13(2), 285–300. https://doi.org/10.22460/infinity.v13i2.p285-300

Tarng, W., Huang, J. K., & Ou, K. L. (2024). Improving Elementary Students' Geometric Understanding Through Augmented Reality and Its Performance Evaluation. Systems, 12(11). https://doi.org/10.3390/systems12110493

Tumangger, W. R., Khalil, I. A., & Prahmana, R. C. I. (2024). The Impact of Realistic Mathematics Education-based Student Worksheet for Improving Students' Mathematical Problem-Solving Skills. IndoMath: Indonesia Mathematics Education, 7(2), 196. https://doi.org/10.30738/indomath.v7i2.122

Ulbrich, E., Haas, B., ElBedewy, S., & Lavicza, Z. (2023). Amazing Walk Through Mathematics (pp. 7–31). https://doi.org/10.1007/978-981-99-4958-8_2

Utama, K. G. S., & Margunayasa, I. G. (2024). Augmented Reality Based Student Worksheets to Improve Understanding of 3D-Shapes Concepts for Fifth Grade of Elementary Schools. Thinking Skills and Creativity Journal, 7(1), 106–114. https://doi.org/10.23887/tscj.v7i1.76998

Vakaliuk, T. A., Shevchuk, L. D., & Shevchuk, B. V. (2020). Possibilities of using AR and VR technologies in teaching mathematics to high school students. Universal Journal of Educational Research, 8(11B), 6280–6288. https://doi.org/10.13189/ujer.2020.082267

Viberg, O., Grönlund, Å., & Andersson, A. (2023). Integrating digital technology in mathematics education: a Swedish case study. Interactive Learning Environments, 31(1), 232–243. https://doi.org/10.1080/10494820.2020.1770801

Volioti, C., Orovas, C., Sapounidis, T., Trachanas, G., & Keramopoulos, E. (2023). Augmented Reality in Primary Education: An Active Learning Approach in Mathematics. Computers, 12(10). https://doi.org/10.3390/computers12100207

Warsito, Nanda Kuncara, F., & Pradja, B. P. (2025). ANALYSIS OF THE USE OF AUGMENTED REALITY INLEARNING MATHEMATICS. 10, 299–313. https://doi.org/10.31943/mathline.v10i2.772

Yuliansih, E., Arafat, Y., & Wahidy, A. (2021). The influence of learning media and learning interests on student learning outcomes. JPGI (Jurnal Penelitian Guru Indonesia), 6(2), 411. https://doi.org/10.29210/021064jpgi0005