P-ISSN : 2339-2444
E-ISSN : 2549-8401
Jurnal Karya Pendidikan Matematika
Universitas Muhammadiyah Semarang
A University For The Excellence
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DEVELOPMENT OF A COMIC-BASED MATHEMATICS E-HANDOUT ON TRIGONOMETRY MATERIAL TO IMPROVE LEARNING OUTCOMES OF 10TH GRADE STUDENTS OF SMA NEGERI 5 SURAKARTA IN THE 2024/2025 ACADEMIC YEAR

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Keyword: e-handout, comic-based, Trigonometry

Abstract

This research focuses on the development of comic-based e-handouts on Trigonometry material for class X students of SMA Negeri 5 Surakarta for the 2024/2025 academic year. The main objectives of this research are to find out how the e-handout development process, the validity of the e-handou t developed, the practicality of the e-handout developed, and measure the effectiveness in improving student learning outcomes. This research uses the ADDIE development model, which consists of Analysis, Design, Development, Implementation, and Evaluation stages. The subjects of this study were 33 students of class X-E6 SMA Negeri 5 Surakarta in the 2024/2025 academic year. Data were collected through interviews, documentation, questionnaires, and tests. The results showed that: (1) the comic-based e-handout development process uses the ADDIE development model and digital platforms in the form of Canva, Heyzine, Padlet, Quizizz, and Google Forms; (2) the validity of the e-handout gets an average score of 0.9027 from the validation of material and media experts which is included in the very high validity category; (3) teacher responses have an average score with a percentage of 79.33%, included in the practical category; (4) student responses have an average score with a percentage of 83.5%, also included in the very practical category; (5) the average increase in N-Gain is 0.75 or 75.18%, classified as a high increase with sufficient effectiveness. Based on these results, it is concluded that the comic-based e-handout developed is valid, practical, and effective in improving student learning outcomes,

and is suitable for use to deepen understanding of Trigonometry concepts for grade X high school students.

1. INTRODUCTION

Article 31 paragraph 1 of the Basic Law (UUD) 1945 on the national education system states that every citizen has the right to obtain a decent and quality education. Education is an effort made with full awareness to create a learning process and atmosphere so that it can explore and develop its potential. Education shapes the current generation in order to be a good example of the learning outcomes of previous generations. The success of the learning process is strongly influenced by the supporting components used and developed in learning.

The curriculum is a guideline for implementing learning at every level of education and is also one of the tools to achieve educational goals. Permendikbudristek No.12 of 2024 officially establishes the Merdeka Curriculum as the basic framework and curriculum structure for all educational units in Indonesia. In Permendikbudristek Article 2 paragraph 4 of 2022 states that one of the subjects that must be included in the Primary and Secondary Education curriculum is mathematics. Mathematics is very important to learn, but because of its abstract nature, many students find it difficult and are afraid to learn it. Therefore, it requires maximum effort, perseverance, and an unyielding attitude. Mathematics learning that is not meaningful causes students to have difficulty in understanding the concept of the material. Learning will be meaningful when students find the knowledge they learn relevant and meaningful to them. The teaching and learning process requires teachers to improve their role and competence, because student learning outcomes are highly dependent on the role and ability of the teacher. According to Ibrahim in Imansari and Sunaryantiningsih (2017), learning outcomes or human abilities are divided into three domains, namely the cognitive domain, the psychomotor domain, and the affective domain.Competent teachers will be more effective in managing the classroom so that they can achieve optimal student learning outcomes (Arianti, 2018). Learning with a contextual approach makes it easier for teachers to deliver material that is relevant to students' real lives (Widiastuti, 2021) This helps students connect the knowledge they have with its application in everyday life.

Learning in school is certainly different from the conditions faced in real life. Therefore, it is necessary to bridge math with real life, one of which is the use of learning media. Comics are a form of graphic media that features various characters and presents a continuous story through a series of images, which aims to entertain its readers (Kristanto, 2016). Based on research conducted by Mujawal, Bani, & Nani in 2018, using comic media. In addition, a similar study was conducted by Subroto Qohar & Dwiyana in 2020, to see the effective use of comic media in learning Mathematics. Based on the results of the study, it shows that the percentage of the results of the media selection questionnaire data obtained as many as 55% of students chose to use comics as a learning medium and the percentage of the results of the student response questionnaire obtained 88.58% of positive student responses to the use of comics.

In math, many formulas make students think that math is difficult and complicated. Moreover, teaching materials that do not meet the needs of students and are monotonous make students even more difficult and their interest in learning decreases. In Anggriani et al (2022), teaching materials have an important role, especially for teachers in the learning process. Although the government has prepared teaching materials to support

curriculum policies, this does not eliminate teacher creativity in designing teaching materials. Teachers play an important role in developing appropriate teaching materials and creating effective learning. According to Ritonga et al (2022), one of the benefits of teaching materials is that the experience and knowledge of educators become deeper and broader when creating and developing teaching materials.

Observation was conducted by the researcher through an interview with one of the math teachers at SMA Negeri 5 Surakarta. According to Budiyono (2017), semi-structured interviews are interviews whose questions can be changed according to conditions in the field. The results of pre-research observations of interviews with one of the mathematics teachers at SMA Negeri 5 Surakarta, student learning outcomes in Trigonometry material were seen when the daily assessment was carried out in the odd semester 2023/2024. Based on the results of the daily assessment of class X - E 10, students who reached the Learning Objective Completeness Criteria (KKTP) were 10 students out of 36 students or 27.77%. This data shows that students' mathematics learning achievement in Trigonometry material is still relatively low. In addition, based on the results of observations, monotonous and conventional teaching materials were found so that they did not attract students' interest. Math learning uses package books in the library and Student Worksheets (LKS). These teaching materials are considered difficult for students to understand. According to Hartoyo and Rahmadayanti in (Pratiwi et al., 2023), one of the characteristics of an independent curriculum is the availability of many teaching tools. In reality, mathematics learning resources that are in accordance with the characteristics of learning in an independent curriculum, especially class X Trigonometry material, are still lacking. Mathematics learning is not optimal, one of which is due to the lack of use of learning media. In fact, the lesson material has been prepared by the teacher in the form of PowerPoint (PPT) and has been distributed to students before learning activities. The hope is that students can study the material given before it is explained by the teacher. However, many students do not study it independently.

One of the factors causing this is low student interest in learning. This can be seen during the learning process, where students who are active in the classroom are only 20% and the rest tend to be passive. One of the school teachers said that the situation of students is very heterogeneous due to the zoning system during the New Student Admission (PPDB). Various kinds of zoning rules are very normative in an area. Zoning is not only about equalizing education for students, but also the quantity of teachers in the school. Schools must keep a record of the number or quantity of teachers so that the distribution is more fair to schools that lack teachers. The very heterogeneous characteristics of students make it difficult for teachers to determine teaching materials or learning methods. In the Merdeka Curriculum, the time allocation for mathematics subjects in Senior High School (SMA) is only 4 JP in one week with 3 JP for Teaching and Learning Activities (KBM) and 1 JP for the Pancasila Student Profile Strengthening Project (P5). The amount of time allocation is relatively low, causing teachers to have difficulty in creating meaningful learning that requires students to think critically and create their own knowledge. The learning model used in the school is a conventional learning model and occasionally uses a group learning model (cooperative). Teachers are worried that if every learning is done in groups, they cannot complete the material coverage that has been determined in a timely manner.

Therefore, an innovation is needed that can overcome these problems. Teaching materials that are interactive, easy to understand, interesting, and easily accessible to students are needed. As discussed earlier, the Merdeka Curriculum requires students to actively participate in the learning process. To realize this, students' interest is needed.

Handouts are short learning materials that serve to simplify and provide information or material support to students (Roesmawati et al., 2022) . This teaching material is taken from various literatures that are in accordance with the learning outcomes. This teaching material is provided to students to make it easier for them to follow the learning process which is designed to be affordable, economical, and practical (Uge et al., 2019). The purpose of preparing handouts must be tailored to the needs of students, in order to increase learning motivation in a fun and not boring way (Indriani et al., 2020). Handouts are useful for enriching students' knowledge by increasing interest, understanding of concepts, and participation in learning (Khaerati & Syam, 2020). According to Sirumahombar et al (2023), e-handouts are teaching materials in the form of handouts that are presented electronically with visual elements such as images, audio, video, and animation to increase student interest in learning. E-handouts are summaries of various relevant literature, organized in a compact and concise manner (Sitorus et al., 2023). E-handouts are teaching materials in the form of handouts that are presented electronically with visual elements such as images, audio, video, and animation to increase student interest in learning (Sitorus et al., 2023). E-Handout is one of the teaching materials that can attract student interest and facilitate the learning process, both in class and independently (Asiyani, 2019). The scope of the e-handout includes material and discussion, practice questions, and assignments. The material and discussion section contains a summary of main ideas, keywords, concepts, and main principles. Practice questions contain various types of questions designed to help students understand and master the material. Meanwhile, the task section aims to develop and evaluate students' understanding after the learning process (Yaumi, 2018).

E-handouts are very effective in learning, especially for distance learning, because teachers can distribute them to students easily and quickly. In addition, e-handouts are also useful for face-to-face learning as it is now, because it makes it easier for students to learn independently anytime and anywhere through smartphones. Thus, smartphones do not only function as telecommunications or entertainment tools, but also as a means of learning through e-handouts. According to Febrianto (2018), the use of handout media aims to facilitate the learning process, as a student handbook and can support the delivery of material from the teacher.

The e-handout to be developed is comic-based in the form of an interactive flipbook. Comic media is a non-projection language learning tool consisting of text and interesting pictures that can be seen and read in a fun way, thus facilitating the learning process (Putra & Milenia, 2021). Comic media is expected to help students understand the content of a story so that they can convey it well (Musfiroh, 2018). Interactive in this e-handout means that students can work on questions in the form of audio and quizzes. After completing the quiz, students can see the scores obtained and get feedback (discussion) to find out where their mistakes are. If the feedback is not clear, students can access the learning video in the e-handout. In addition, students can also ask the teacher in class to gain a deeper understanding of the material. The e-handout is designed to be as interesting as possible so that students do not feel bored. Survey results that say the youth segment is still a strong base in the use of Smartphones, which is as much as 39% of the largest results in the survey, users are young people in the age range of 16 to 21 years (Rahma, 2015). So that the teaching material developed is in digital form.

Observations found monotonous and conventional learning resources. The

material and practice questions in the package book or LKS are poured into PPT and then used as learning resources in class. Media-based learning such as comics has never been used in the school. However, learning often utilizes technology by searching for material or practice questions on the internet.

Based on the characteristics of the Merdeka Curriculum, which gives independence to students, teachers, and schools in choosing appropriate learning. At SMA Negeri 5 Surakarta, one of the materials for the odd semester of the 2024/205 academic year, namely Trigonometry.

In this study, researchers wanted to develop comic-based e-handout learning media. The things that are considered in this development are validity, practicality, and effectiveness to improve student learning outcomes. Therefore, this research is expected to help students during learning. Not only that, this research can add learning resources, especially trigonometry material. Based on this description, the researcher is interested and to conduct development research entitled "Development of Comic-Based Mathematics E-Handout on Trigonometry Material to Improve Learning Outcomes of Class X Students of SMA Negeri 5 Surakarta in the 2024/2025 Study Year".

2. METHOD [11 Pt., Book Antiqua, Bold, Align Text Left]

The method used should be accompanied by references; the relevant modification should be explained.

This research was conducted in the odd semester of the 2024/2025 academic year at SMA Negeri 5 Surakarta. According to Amali et al in (Maydiantoro, 2020), research and development or known as Research and Development (R&D) is a research method that develops and test products so that they are feasible to be applied in the world of education. Research and development has four levels, namely: Research and Development at Level 1 (the lowest level) is research to produce a design without continuing with product manufacturing or testing, Research and Development at Level 2 is research that directly tests existing products without conducting preliminary research, Research and Development at Level 3 is research to develop or revise existing products, including creating new versions and testing their effectiveness, Research and Development at Level 4 is research to create new products and test the effectiveness of these products (Okpatrioka, 2023). Development is a conscious effort in formal and non-formal education with the aim of introducing, growing, guiding, and developing a balanced, whole, and harmonious personality base, as well as knowledge and skills in accordance with individual talents, interests, and abilities (Sugiyono, 2021). This research develops teaching materials in the form of e-handouts or comic-based electronic handouts as a means of supporting learning in class X Trigonometry material.

The research conducted refers to the ADDIE development research model which consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. The steps of research and development carried out by researchers can be seen in the figure below.

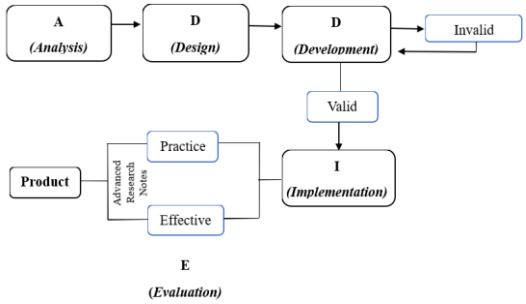

Figure 1. Flowchart of ADDIE Research Procedure

Data collection techniques used to evaluate and validate the developed e-handout are using observation sheets, questionnaires, and learning outcomes test instruments. The data analysis technique used to process the development result data is with qualitative description analysis

techniques and quantitative data analysis techniques.

The validity test of the e-handout was analyzed using an e-handout assessment questionnaire with 5 answer options consisting of Very Good (SB), Good (B), Good Enough (CB), Less Good (KB), and Very Less Good (SKB). The validity test consists of media expert validation and material expert validation. The scores obtained are then calculated to determine the validity value using the Aiken's Value validity formula, as quoted in Komaria et al (2023) used to see the validity calculation on the validation sheet which is explained as follows:

$$V = \frac{\sum(r - I_0)}{[n(c-1)]}$$

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Tabel 1. Validity Category

Interval	Category
$0.00 \leq V < 0.20$	Very Low Validity
$0.20 \leq V < 0.40$	Low Validity
$0.40 \leq V < 0.60$	Medium Validity
$0.60 \leq V < 0.80$	High Validity
$0.80 \leq V < 1.00$	Very High Validity

Description:

V = average total validity score from all validators

The practicality test of the developed e-handout was analyzed using a response questionnaire from teachers and students. The questionnaire was prepared with five answer options, namely Very Good (SB), Good (B), Good Enough (CB), Less Good (KB), and Very Poor (SKB). Based on the scores obtained, the percentage of the number of respondents' answers will be calculated using the following formula.

$$P = \frac{Total\ acquisition\ score}{Maximum\ number\ of\ scores} \text{ x } 100\%$$

The average validity score of all validators was calculated using the following formula:

$$\bar{x} = \frac{\sum_1^n P}{n}$$

Furthermore, the average score will be converted based on the practicality assessment category proposed by Budiyono (2020), as shown in Table 2.

Tabel 2. Practicality Assessment Category

Interval (%)	Category
$0 \leq \bar{x} < 20$	Not Practical
$20 \leq \bar{x} < 40$	Less Practical
$40 \leq \bar{x} < 60$	Practical enough
$60 \leq \bar{x} < 80$	Practical
$80 \leq \bar{x} < 100$	Very Practical

(Budiyono, 2020)

Description:

$\bar{x}$ = average total practicality score

Based on Table 2 above, the developed product will be considered practical if it reaches a minimum percentage of 60%.

The effectiveness of the product in improving student learning outcomes is

measured using the Gain Normality Test. According to Nisa Nuraini (2024), who quoted from Ayunani, Gain Normality is a test used to estimate the extent to which a treatment is effective in increasing concept understanding. The formula for calculating the normalized gain value is as follows:

$$N - Gain = \frac{S_{post-test} - S_{pre-test}}{S_{maks} - S_{pre-test}}$$

The interpretation of the N-Gain value in this study refers to the interpretation of the N-Gain results described by Wahab et al (2021) who cited Hake's findings, as shown in Table 3.

Tabel 3. N-Gain Interpretation

Interval	Category
$0.70 \leq N < 1.00$	High Improvement
$0.30 \leq N < 0.70$	Medium Improvement
$0.00 \leq N < 0.30$	Low Improvement

(Wahab et al., 2021)

In addition to knowing the category of improvement based on N-Gain, the interpretation of the effectiveness of N-Gain is also done in the form of a percentage, as shown in Table 4.

Tabel 4. N-Gain Effectiveness Category (Percentage)

Percentage (%)	Category
> 75	Effective
56 – 75	Effective Enough
40 – 55	Less Effective
< 40	Ineffective

(Wahab et al., 2021)

3. RESULTS AND DISCUSSION [11 Pt., Book Antiqua, Bold, Align Text Left]

The analysis stage includes analyzing student needs, student characteristics, learning materials, and the curriculum used. In the learning process, students need interactive teaching materials that can meet the characteristics of the independent curriculum, namely creating student-centered learning.

In Anggriani et al (2021), teaching materials have an important role, especially for teachers in the learning process. In addition, teaching materials also function as the main support in the success of the learning process. The implementation of learning supported by good and complete tools allows students to learn in a planned and directed manner. Conversely, the use of learning tools that are not in accordance with student characteristics can reduce activity levels and result in low learning outcomes (Wiratama, 2019). According to Wiratama (2019), who quoted Sutanto's statement, teacher-centered learning can lead to low student activity and learning outcomes. Teaching materials for high school students must be designed in accordance with the applicable curriculum. This is done by adjusting learning materials to the objectives set out in the curriculum, so that learning in high school can take place more effectively and optimally.

According to Kosasih (2021), one of the learning tools or teaching materials is handouts. The use of handouts is tailored to student conditions and designed to be in line with learning objectives. It aims to help students understand the material clearly and apply it in everyday life. According to Aziz cited by Wiratama (2019) the use of teaching materials in the form of handouts can help students understand and apply learning in accordance with the applicable curriculum. Handouts serve to complement the shortcomings that may exist in textbooks in the learning process. In its implementation, learning using handouts emphasizes ideality for educators, resulting in an effective and efficient learning process in accordance with the curriculum. With the preparation and utilization of handouts, it is hoped that students will be able to apply learning in real life and build their knowledge independently.

In the Merdeka Curriculum, one of the topics of high school / vocational high school mathematics subjects for Phase E (grade X) is Trigonometry. This topic can be related to contextual problems so that students can find solutions to these problems. Students really need teaching materials as learning tools that are tailored

to the characteristics of the independent curriculum, namely student-centered learning and provide opportunities for students to learn from the surrounding environment and use their imagination.

Once the comic-based e-handout has been developed, the next step is a validation process undertaken by experts, including materialists and media experts using angled intrums. The items in the assessment figures had previously been validated by the lecturer as instrument validators.

Tabel 5. Validity Results by Material Expert

Assessment Aspect	Average Validity Score	Validity Criteria
Content Appropriateness	0,875	Very High
Language Aspects	0,875	Very High
Presentation Appropriateness Aspect	0,917	Very High
Average Total Score Validity	**0,889**	**Very High**

Based on Table 5, the average total validity score from the material expert assessment shows a very high category, with values in the range of 0.8 to 1. Suggestions and input from material experts were used as a reference to improve the e-handout, including changing the title of contextual questions, clarifying the material and explanations in the comic section.

Tabel 6. Results of Validity by Media Experts

Assessment Aspect	Average Validity Score	Validity Criteria
Display Screen Design	0,9375	Very High
Ease of Use	0,96875	Very High
Consistency	0,95833	Very High
Graphics	0,975	Very High
Usability	0,75	Very High
Average Total Score Validity	**0,91792**	**Very High**

Based on Table 6, the average total validity score from the assessment of media experts shows a very high category, with values in the range of 0.8 to 1. Feedback from the media experts was used as a reference to improve the e-handout, including changing the character of the student, adding the θ angle on page 16, and changing the color of the triangle character.

After the comic-based math e-handout developed was validated by the validators, the next stage was the implementation of the e-handout. Implementation was carried out in class X-E6 SMA Negeri 5 Surakarta with 33 students. Practicality test assessment was conducted through a response questionnaire given to teachers and students. The results of the practicality test assessment through the teacher response questionnaire can be seen in Table 7.

Tabel 7. Results of Practicality Test by Teacher

Assessment Aspect	Score (%)	Practicality Criteria
Learning aspects	76	Practice
Quality Aspects of E-Handout	73,33	Practice
Function Aspect of E-Handout	80	Very Practice
Display Aspect of E-Handout	88	Very Practice
Average Practicality Score	79, 33	Practice

Table 7 shows that the average score is 79.33%. The percentage shows that the e-handout is included in the practical criteria.

Tabel 8. Results of Practicality Test by Students

Assessment Aspect	Score (%)	Practicality Criteria
Learning aspects	94	Very Practice
Quality Aspects of E-Handout	85	Very Practice
Function Aspect of E-Handout	90	Very Practice
Display Aspect of E-Handout	97	Very Practice
Average Practicality Score	91,5	Very Practice

From Table 8, an average score of 91.5% was obtained, which indicates that the e-handout is included in the very practical criteria with all aspects of the assessment being in the same category. Based on the results of this practicality test, it can be concluded that the average practicality test of mathematics e-handouts developed by researchers with an average score of 85.42% which means it is very practical to use in learning.

Tabel 9. N-Gain Category Percentage

	Total number of students	Percentage
High Improvement	30	69,70%
Medium Improvement	10	30,30%
Low Improvement	0	0%

Based on the pre-test and post-test results, it is known that 30 students fall into the high improvement category, while 10 students are in the medium improvement category. This shows that 69.70% of students experienced high improvement and 30.30% experienced moderate improvement. There were no students who fell into the low improvement category and no decrease in learning outcomes was found. Thus, it can be concluded that the comic-based math e-handout developed by researchers is effective in improving student learning outcomes.

In addition, the average pre-test and post-test scores also increased significantly, from 44 to 86. The average N-Gain in percentage reached 75.18%, which indicates that the product developed is quite effective. Based on the results of the N-Gain test, it can be concluded that comic-based math e-handouts are quite effective in improving student learning outcomes in Trigonometry material in class X.

The final stage is evaluation, where researchers conduct an assessment of the product during the research and development process. Evaluation is carried out by reviewing product deficiencies based on the results of student and teacher response questionnaires and the results of the e-handout effectiveness test in improving student learning outcomes. The results of this evaluation will be a reference and improvement material for further research.

Researchers realize that the developed product still has several weaknesses, namely:

1. Some features, such as learning video references from YouTube, quizzes on Quizizz, and Padlet require an internet connection to be used.
2. Accessing e-handouts requires a certain loading time, which can hinder its use.
3. The material presented in the comic-based e-handout is still too basic and less in-depth, making it less suitable for use in higher classes or levels of education.

4. **CONCLUSION [11 Pt., Book Antiqua, Bold, Align Text Left]**

Based on the results of research and discussion related to the development of comic-based math e-handouts to improve student learning outcomes on Trigonometry material, the researcher concluded the following:

1. The development of comic-based math e-handouts on Trigonometry material uses the ADDIE development model. At the analysis stage, researchers made initial observations while analyzing the needs for the basis of product development both in terms of models, methods, media, and teaching materials. In addition, researchers also analyzed student characteristics, materials, and the applied curriculum. Furthermore, at the design stage, researchers compiled a product design in the form of an outline of e-handout content consisting of an e-handout framework, e-handout learning content, e-handout selection, and e-handout format selection. At the development stage, the preparation of product prototypes begins with making the initial design of e-handouts in the form of e-handout components and the initial writing systematics of e-handouts. The e-handout development began by compiling the entire comic script and e-handout content using Microsoft Word, which was then uploaded and rearranged through the Canva application. Once the drafting was complete, the e-handout format was converted into a flipbook using Heyzine Flipbook Maker, which is integrated with Canva. In addition, researchers also prepared various instruments to test the validity, practicality, and effectiveness of the product. After the e-handout was developed, the product was validated by material experts and media experts. After the validation is done, the product is revised according to the suggestions given by the validators. The next stage is implementation, where the e-handout is tested to measure its practicality and effectiveness. The trial was conducted by teachers and all students of Class X-E6 SMA Negeri 5 Surakarta, who participated in learning using comic-based math e-handouts. The last stage, namely evaluation, focuses on assessing the final results of product development that has been implemented on 33 students of Class X-E6. Evaluation is carried out based on test results, input from teachers, and student responses to the use of e-handouts, which are used as a reference to meet the needs of learning resources at school.
2. The validation results show that the average total validity score from material experts is 0.889 and media experts is 0.93042. Based on these results, it can be concluded that the comic-based math e-handout is declared valid and feasible to use in learning.
3. The results of the product practicality test showed that the average total score of the teacher assessment reached 79.33%, while the average total score of the student assessment was 91.5%. Based on these data, it can be concluded that comic-based math e-handouts are declared practical for use in learning Trigonometry material.
4. The N-Gain test results show that the average N-Gain obtained is 0.75 which is included in the high improvement category. Meanwhile, the product effectiveness test based on the average N-Gain with a percentage of 75.18% is in the moderately effective category. Based on these results, it can be concluded that comic-based math e-handouts are effective enough to improve student learning outcomes in Trigonometry material.

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