Development of flipped classroom math learning instruments with advocacy-sociograph

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Abstract: The research project described aims to create a Math learning media with a flipped classroom model on “Polyhedron of Cube and Block” for grade VIII Junior High School students. This device uses the advocacy-sociograph approach. This research uses three stages of development, namely Defining, Designing, and Developing. After conducting data analysis, it can be concluded that the results of the validation of the lesson plan are valid, indicating that it is well-designed and suitable for teaching the targeted mathematics content. Similarly, the e-LKPD (e-worksheet) also received very valid validation results, indicating that the e-LKPD is very suitable and adequate to facilitate student learning. These positive validation results indicate that the learning tools in lesson plans and LKPDs (worksheets) based on the flipped classroom approach with advocacy-sociographs are valid and feasible for further testing. The researchers recommend this learning tool as a reliable reference source for mathematics learning in Junior High School.

Keywords: Advocacy, Development, Flipped classroom, Learning tools, Sociograph


INTRODUCTION

Education plays a crucial role for everyone to acquire knowledge and skills in order to achieve desired goals (Hesse et al., 2015; Puspita et al., 2022). Education can be one way for individuals to avoid ignorance. Mathematics is one of several subjects that play an important role in education and is a field of study that contributes to the advancement of science and technology (Ernest et al., 2016; Sintema, 2020). The existence of mathematics aims to develop students’ critical thinking, logical, systematic, analytical, and creative abilities (Widana et al., 2018; Kusumaningrum et al., 2020).

According to Lase (2019), it is necessary to have an education system that can shape a creative, innovative, and competitive generation to face the era of the 4th industrial revolution. In response to COVID-19, the Indonesian government has adopted a ‘new normal’ approach (Nugroho, 2020). One ideal learning method in the new normal era is the application of blended learning approach (Graham et al., 2013; Hanafi et al., 2021; Dziuban et al., 2018). The blended learning approach is a teaching and learning method that combines traditional face-to-face instruction with online and digital resources. It is designed to leverage the advantages of both in-person and online learning to create a more flexible and effective educational experience. In this new normal era, there is a need for a learning model that can be implemented both in the classroom and at home, in other words, a learning model that combines face-to-face activities with online distance learning (Rapanta et al., 2021). The suitable learning model for the new
normal era is the flipped classroom (Olakanmi, 2017), which integrates face-to-face activities with online learning.

The flipped classroom learning model is utilized by teachers to enhance students' self-directed learning, creativity, and critical thinking, supported by the implementation of discussion methods (Khodaei et al., 2022). The application of discussion methods supplemented with advocacy activities is highly effective in improving students' self-directed learning, creativity, and critical thinking (Toh & Kirschner, 2020). The utilization of discussion with advocacy requires several groups of students to debate among themselves (Pfeifer et al., 2021). The division of groups in conducting discussions and advocacy needs to be carefully considered to create successful communication among group members (Nicolaidis et al., 2019). One alternative to understanding communication networks in the students' learning process is by analyzing the communication network using sociographs or commonly known as sociometry (Grunspan et al., 2014).

At SMP Muhammadiyah 1 Seyegan, despite implementing a blended learning approach, several challenges have emerged: (1) Student focus wavers during both online and offline sessions due to home distractions and the adjustment to self-directed learning; (2) Some students struggle to complete assignments due to the pace, content complexity, or inadequate teacher support; (3) Participation in group discussions is hindered by shyness, low confidence, and virtual or physical group dynamics; (4) Furthermore, students' unfamiliarity with each other leads to communication issues during group discussions, partly due to the absence of clear communication guidelines within the groups. These descriptions highlight the need for an effective mathematics learning tool that combines a blended learning approach with the flipped classroom model and advocacy-sociograph. Current educational tools tend to focus on individual pedagogical methods, such as traditional teaching, online learning, or flipped classrooms, overlooking the benefits of a blended approach. The advocacy-sociograph, a recent addition to the flipped classroom, fosters social interaction, group engagement, and open communication, addressing the shortcomings of existing tools in creating collaborative learning environments. This research aims to bridge this educational gap by proposing the development of a novel learning tool that integrates the flipped classroom model with advocacy-sociograph, leveraging their potential to enhance student-centered learning and collaboration in blended learning settings.

**METHOD**

The research method used in this study is Research and Development (R&D), which is a research method that aims to produce products such as learning models, learning modules, and others, with an emphasis on the effectiveness of the resulting products (Lumbantoruan & Natalia, 2021). According to Ellram et al., (2020), research and development aims to create a new product or improve existing products that can be accountable. The product developed in this research is a mathematics learning tool based on the flipped classroom approach with advocacy-sociograph, focusing on the topic of polyhedron of cubes and blocks for eighth-grade junior high school. The developed learning tools include the lesson plan and e-worksheets. The development model used is the 4-D model developed by Thiagarajan (1974). This model consists of four stages: Define, Design, Develop, and Dissemination.

In this development research, the development stage only reached the Develop stage due to limited time to carry out the Dissemination stage. The instruments in this section are necessary to measure the validity of the lesson plan and e-worksheets based on the flipped classroom approach with advocacy-sociograph, as conducted by two expert mathematics education professors. The instruments used in this research consist of validation sheets for experts to assess the lesson plan and e-worksheets. The criteria and aspects that experts would be assessing in the validation sheets for the lesson plan and e-worksheets, are: alignment with learning objectives, clarity and coherence, appropriateness of instructional strategies,
engagement and interactivity, content relevance, clarity of instructions, level of challenge, and also accessibility and user-friendliness.

In this stage, validation scores and opinions, feedback, criticism, and approval from the validators are also obtained. The lesson plan and e-worksheets, which have been prepared, are then revised based on the suggestions, criticisms, and feedback from the validators. Data analysis techniques are employed to obtain high-quality lesson plans and e-worksheets products that meet validity criteria. The validity analysis of the lesson plan and e-worksheets based on the flipped classroom approach with advocacy-sociograph, focusing on the topic of cubes and cuboids, is analyzed to determine the validity of the products.

The validity of the lesson plan is calculated using the calculation method proposed by Lawshe (1975), which involves calculating the Content Validity Ratio (CVR) and Content Validity Index (CVI). The Content Validity Ratio (CVR) is a statistical index used to evaluate the essentiality of items or elements within a given assessment tool or instrument. It helps determine whether the items in a tool are relevant and necessary for assessing the construct of interest. A value higher than half of the total evaluated items (e.g., CVR > 0.50) indicates that the majority of experts find the item to be essential for assessing the construct. This suggests that the item is likely to be relevant and necessary for the research. The Content Validity Index (CVI) assesses the relevance and clarity of items in an assessment tool or instrument. It aims to measure how well each item aligns with the construct being measured and how easily respondents can understand and respond to the items. A value of 0.80 or higher for an item indicates that the majority of experts consider it both relevant and clear. This suggests that the item is well-suited for the assessment tool and is likely to effectively measure the intended construct.

According to Lawshe’s criteria, a positive value indicates that at least half of the experts rate an item as appropriate or valid. The higher the CVR value is, the higher the content validity, and the sum of CVR is considered valid if it is more than half of the total number of evaluated items. As for the CVI (Content Validity Index), the closer the result is to 1, the higher the validity can be declared. The validity of the e-worksheets is calculated by calculating the total mean according to Subekti & Prahmana (2021). The calculation of validation scores can be done by calculating the ideal mean score and ideal standard deviation. Based on the calculation results, the criteria and value limits are presented in Table 1.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Valid</td>
<td>( \bar{X} &gt; 4,2 )</td>
</tr>
<tr>
<td>Valid</td>
<td>( 3,4 &lt; \bar{X} \leq 4,2 )</td>
</tr>
<tr>
<td>Less Valid</td>
<td>( 2,5 &lt; \bar{X} \leq 3,4 )</td>
</tr>
<tr>
<td>Invalid</td>
<td>( 1,8 &lt; \bar{X} \leq 2,5 )</td>
</tr>
<tr>
<td>Very Invalid</td>
<td>( \bar{X} \leq 1,8 )</td>
</tr>
</tbody>
</table>

**RESULTS AND DISCUSSION**

This research has produced a learning tool for mathematics subjects based on the flipped classroom approach with advocacy-sociograph, focusing on the topic of polyhedron for eighth-grade Junior High School. The results of this development research include a description of the stages of development that have been carried out.

**Results**

**Define Stage**

During the define phase, information was gathered through a combination of observations, interviews, and literature reviews (Wijayanto et al., 2022).
1. **A Curriculum Analysis**

The focus is on examining the existing curriculum documents and guidelines related to the mathematics subject, specifically the topic of polyhedron for eighth-grade Junior High School. The analysis involves reviewing the curriculum framework, content standards, learning outcomes, and sequencing of topics. The aim of the curriculum analysis is to identify the specific learning goals, concepts, and skills that need to be addressed in the development of the learning tool. It also helps in determining the alignment between the intended curriculum and the proposed flipped classroom approach with advocacy-sociograph.

2. **A Concept Analysis**

The concept analysis aims to identify and define the essential concepts that will guide the development of the learning tool. During the concept analysis, relevant literature, theories, and frameworks related to the flipped classroom and advocacy-sociograph are reviewed. This involves examining scholarly articles, books, and other relevant sources to gain insights into the theoretical foundations and practical applications of these concepts in mathematics education. This analysis helps in formulating research questions, establishing the theoretical framework, and guiding the subsequent stages of the research, such as design and development, to create a coherent and effective learning tool based on the identified concepts.

3. **The Formulation of Learning Objectives**

Learning objectives provide a clear direction and purpose for the instructional materials and help ensure that the desired learning outcomes are achieved. During this stage, the researchers analyze the curriculum requirements, standards, and specific learning goals related to the targeted topic of the learning tool. They identify the knowledge, skills, and competencies that students should acquire through the mathematics education process, specifically in relation to the topic of interest (e.g., polyhedron for eighth-grade Junior High School). By formulating clear and measurable learning objectives at the define stage, the researchers establish a solid foundation for designing and developing the learning tool. These objectives guide the selection of appropriate content, instructional strategies, and assessment methods to facilitate effective learning experiences for the students.

**Design Stage**

During the design phase, the preliminary development of e-worksheets, educational materials, and research tools was undertaken (Purwoko et al., 2023).

1. **Media Selection**

Media selection is an important process that involves choosing the most suitable and effective media to present learning materials. The main purpose of media selection is to facilitate students in completing assignments and enhancing their understanding of the subject matter. In the context of this study, the identified media used for learning include whiteboards, markers, laptops, and cellphones. These media options provide diverse ways to present information, encourage active participation, and promote student engagement. Overall, media selection is a thoughtful and strategic process that aims to enhance learning experiences by utilizing appropriate resources and technologies. The chosen media, such as whiteboards, markers, laptops, and cellphones, provide versatile tools to facilitate student engagement, comprehension, and completion of assignments.

2. **Format Selection**

The format selection at the Design Stage in development research refers to the process of determining the appropriate format or structure for presenting research findings. When selecting the format at the Design Stage, researchers consider various factors, including the
nature of the research, the objectives of the study, the target audience, and the preferences of the research community or funding organization.

An outline of the initial draft of the flipped classroom-based lesson plan with advocacy sociographs is presented in Figure 1.

<table>
<thead>
<tr>
<th>Lesson Plan</th>
<th>B. Basic Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education unit: Junior High School</td>
<td>Basic Competencies</td>
</tr>
<tr>
<td>Subject: Mathematics</td>
<td>Indicators</td>
</tr>
<tr>
<td>Class/semester: 8/2</td>
<td>3.9. Differentiate and determine the surface area and volume of polyhedron (cubes, blocks, prisms, and pyramids).</td>
</tr>
<tr>
<td>Academic year: 2022/2023</td>
<td>3.9.1. Mentioning the elements of the cube, determining the derivative of the volume formula of the cube.</td>
</tr>
<tr>
<td>Subject Matter: Polyhedron</td>
<td>3.9.2. Determine the nets of cubes, calculate the volume of cubes.</td>
</tr>
<tr>
<td>Topic: Cubes</td>
<td>4.9. Solve problems related to the surface area and volume of polyhedron (cubes, blocks, prisms, and pyramids).</td>
</tr>
<tr>
<td>Time allocation: 2x40’</td>
<td>4.9.1. Solve problems in daily life involving the surface area and volume of cuboid.</td>
</tr>
</tbody>
</table>

**Figure 1. Lesson Identity and Basic Competencies**

Lesson identity refers to the unique characteristics and features of a specific lesson or unit within the flipped classroom math learning instruments. Basic competencies refer to the foundational skills and knowledge that students are expected to develop through the flipped classroom math learning instruments. The Learning Steps and Attitude Assessment are shown in Figure 2.

<table>
<thead>
<tr>
<th>Assessment Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Affective Assessment</td>
</tr>
<tr>
<td>Attitude Assessment Journal</td>
</tr>
<tr>
<td>School Name: SMP 300, Mathematics</td>
</tr>
<tr>
<td>Subject: Mathematics</td>
</tr>
<tr>
<td>Class/semester: 8/2</td>
</tr>
<tr>
<td>Academic year: 2022/2023</td>
</tr>
<tr>
<td>Subject Matter: Polyhedron</td>
</tr>
<tr>
<td>Topic: Cubes</td>
</tr>
<tr>
<td>Time allocation: 2x40’</td>
</tr>
</tbody>
</table>

**Figure 2. Learning Steps and Attitude Assessment**

The learning steps typically involve pre-class activities, in-class activities, and post-class activities. Attitude assessment include items that gauge students' confidence in mathematics, their interest in the flipped classroom approach, their perceptions of the instruments' impact on their learning, and their overall satisfaction with the learning experiences. The results of the initial design of the Flipped Classroom e-worksheets with advocacy-sociograph are outlined in Figure 3.
Figure 3. Cover and Instructions for Learning at School

The cover includes the title of the instruments, the researcher’s or institution’s name, and relevant visual elements. Instructions for learning outline the objectives, expectations, and procedures for engaging with the materials, both before and during the classroom sessions. Distribution of Advocacy Groups are shown in Figure 4.

Figure 4. Sociograph and Advocacy Group Distribution

Sociograph provides insights into the social dynamics and interactions within the learning environment, while advocacy group distribution facilitates targeted support and collaboration among students. Advocacy group distribution arrangements are based on students’ prior knowledge, learning preferences, strengths, or specific needs. Math Problem with Advocacy are displayed in Figure 5.

Figure 5. Group Discussion

Nina was given a school assignment to make a cube net. After school, Nina bought a square piece of cardboard. Nina plans to make a cube net with side length (x cm) that is 1 ≤ x ≤ 6. Is it true that the surface area of the cube is 216 cm²? Give reasons based on mathematical concepts.

Another will store some square photo albums in a cube-shaped storage box with a cube-surface area of 1,350 cm². The photo albums have different side lengths of 15 cm, 12 cm, and 10 cm. You will store the photo albums in a stacked manner so that you can fit many photo albums in the storage box and not have much space left. Is it true that you should choose a photo album with a side length less than the side length of the storage box? Give reasons based on math concept?

Nina has a cube-shaped Rhik, the Rhik falls and makes one side of the Rhik disappear. The surface area of the Rhik, if the side is complete is 486 cm². Is the surface area of the Rhik will the same if one of its sides is missing? Give reasons according to mathematical concepts.
Discussion groups provide a platform for participants to engage in interactive and collaborative conversations, fostering a deeper understanding of the topic at hand. Home Learning Activities and Independent Practice Questions are pictured in Figure 6.

![Surface Area](image)

**Figure 6. Home Study Activities and Independent Practice Questions**

Home study activities refer to learning tasks or exercises that students are expected to complete outside of the classroom setting as part of their independent study. Independent practice questions are specific questions or exercises that students are expected to complete on their own to reinforce their understanding and mastery of the mathematical concepts.

**Develop Stage**

The develop stage of development research is dedicated to the actual creation and construction of the envisioned intervention, product, or tool, as outlined in the preceding phases (Anjelia et al., 2022). During this stage, the validation process for learning materials is being conducted by experts who assess the validity of each item based on specific criteria. Additionally, the experts provide feedback in the form of suggestions for improvement on areas that require further attention. The expert validation process for the lesson plans are categorized as relevant or less relevant. On the other hand, for the electronic learning and teaching materials employs a scoring system ranging from 1 (strongly disagree) to 5 (strongly agree), with intermediate scores of 4 (agree), 3 (moderately agree), and 2 (disagree). The outcomes of the validation analysis for the flipped classroom lesson plan with advocacy-sociograph are presented in Table 2.

<table>
<thead>
<tr>
<th>Validity Calculation</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVR = 17</td>
<td>Valid</td>
</tr>
<tr>
<td>CVI = 0.89</td>
<td>Valid</td>
</tr>
</tbody>
</table>

According to Table 2, the validity assessment reveals that the Content Validity Ratio (CVR) obtained a score of 17, indicating a valid category. Out of 19 items, only 2 were found to be irrelevant. Furthermore, the analysis indicates a Content Validity Index (CVI) result of 0.89, which falls within the valid range.

In research and measurement validation, the Content Validity Ratio (CVR) and Content Validity Index (CVI) serve as crucial indicators for assessing questionnaire or assessment tool validity. CVR gauges expert consensus on item relevance, with a score of 17 out of 19 items indicating substantial agreement among experts regarding item relevance. The Content Validity Index (CVI), on the other hand, considers both relevance and clarity, with a result of 0.89.
signifying significant expert accord on item validity. These measures play a pivotal role in affirming the robustness and reliability of the assessment tool, aligning with established research and measurement validation practices (Almanasreh et al., 2019; Shrotryia & Dhanda, 2019; Mason et al., 2020; Rathnasabapathy & Subramani, 2022).

The results of the e-worksheets validation by experts provide valuable insights into the strengths and areas for improvement of the learning materials. The results of e-worksheets validation by experts are presented in Table 3.

**Table 3. Summary of e-worksheets Validation Results**

<table>
<thead>
<tr>
<th>Aspects assessed</th>
<th>Average</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure of teaching materials</td>
<td>5.00</td>
<td>Highly Valid</td>
</tr>
<tr>
<td>Subject</td>
<td>4.40</td>
<td>Highly Valid</td>
</tr>
<tr>
<td>Topic Presentation</td>
<td>4.50</td>
<td>Highly Valid</td>
</tr>
<tr>
<td>Language and readability</td>
<td>4.67</td>
<td>Highly Valid</td>
</tr>
<tr>
<td>Average</td>
<td>4.64</td>
<td>Highly Valid</td>
</tr>
</tbody>
</table>

Table 3 presents the results of the assessment conducted on various aspects. The results suggest that the organization and arrangement of the materials align well with the desired educational objectives; the information and subject matter included in the materials are relevant and appropriate for the intended audience; the visual and auditory components, such as graphics, videos, or audio elements, effectively support the delivery of the instructional content and the language used is clear, understandable, and suitable for the target audience, facilitating comprehension and learning.

The validation process of the developed learning tool underscores its effectiveness in addressing several challenges in education. The tool prioritizes clarity and coherence in instructional materials, mitigating issues related to student focus during online and offline sessions. It also successfully addresses the challenge of incomplete assignments by being relevant, clear, and aligned with learning objectives. Furthermore, the advocacy-sociograph component fosters active participation, collaboration, and improved communication among students, tackling the issues of passive participation and poor communication during group activities. Overall, the validation results affirm the tool's ability to enhance engagement, comprehension, and interaction, making it a valuable asset in modern education.

**Discussion**

The flipped classroom with advocacy-sociograph approach aligns with contemporary pedagogical trends and educational theories, particularly in emphasizing student-centered learning, fostering collaboration, and nurturing critical thinking skills (Huang et al., 2022). It resonates with constructivist and social-constructivist theories, promoting active knowledge construction through student engagement and interaction (Hwang & Chen, 2019). The validation results further corroborate its alignment by highlighting the clarity and relevance of instructional strategies, reinforcing the tool's student-centered focus. Additionally, the approach adheres to collaborative learning theories, facilitating peer interaction and problem-solving, as validated by the advocacy-sociograph component's success in encouraging active participation. Furthermore, it promotes critical thinking by challenging students to analyze and apply knowledge effectively, supported by the tool's emphasis on clear and coherent materials. These findings directly address the initial challenges and research objectives outlined, including passive participation in group discussions and incomplete assignments due to a lack of understanding, while reaffirming the tool's contemporary relevance in modern education.

Limitations of the learning tool encompass disparities in technology access among students, the need for teacher training, adaptability to diverse learning styles and digital literacy levels, and alignment of assessments. These limitations highlight the importance of careful planning and inclusive design. Future research implications include assessing long-term impact, adaptability, teacher training, and technology integration, emphasizing the need for
comprehensive evaluation and scalability to enhance pedagogical approaches in mathematics education. Addressing limitations and pursuing further research can contribute to the effective implementation and development of the learning tool in diverse educational contexts.

CONCLUSION

The mathematics learning tool, flipped classroom with advocacy-sociograph, consists of lesson plans and e-worksheets for students on the topic of polyhedron of cubes and cuboid. The CVI resulted in 0.89, and the total validation mean score for the e-worksheets for students was 4.64. These results indicate that the mathematics learning tool, flipped classroom with advocacy-sociograph, is declared valid and highly valid with minor revisions. Therefore, the research and development outcomes demonstrate that the lesson plans and e-worksheets for flipped classroom with advocacy-sociograph in Junior High School are valid and suitable for testing and further research in terms of practicality and effectiveness.

Declarations

Author Contribution: ZW: Conceptualization, Methodology; IAR: Writing - Original Draft, Data curation, Formal analysis; BK: Writing - Review & Editing and Validation; EAP: Supervision.

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Conflict of Interest: The authors declare no conflict of interest.

Additional Information: Additional information is available for this paper.

REFERENCES


