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Development of STREAM-Based Student Worksheets for Teaching Fluid Dynamics at SMAN 14 Medan

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Abstract: The low learning outcomes of students in dynamic fluid material and the limited use of innovative instructional materials necessitate the development of learning tools that integrate 21st-century skills. This study aims to develop a Student Worksheet based on the STREAM approach that is valid, practical, and effective for Grade XI MIPA students at SMAN 14 Medan. This research employed the Research and Development (R&D) method using the 4-D model, consisting of define, design, develop, and disseminate stages. The research subjects were 36 students of class XI MIPA 3 at SMAN 14 Medan. The research instruments included expert validation sheets, a teacher response questionnaire using a Likert scale, a student response questionnaire using a Guttman scale, and a pretest-posttest assessment. Data were analyzed using Likert and Guttman scales to determine validity and practicality, and the N-Gain test to measure effectiveness. The results showed that the LKPD was highly valid, obtaining 97.90% from the material expert and 87.78% from the media expert. Practicality results indicated 93.22% from student responses and 100% from the physics teacher, both categorized as highly practical. The effectiveness test showed an N-Gain score of 0.89 (89%), indicating that the LKPD was highly effective. It can be concluded that the developed LKPD meets the criteria of being highly valid, practical, and effective, and can serve as an alternative instructional material in physics learning. Furthermore, it enhances students' learning outcomes while facilitating critical thinking, problem-solving skills, and interdisciplinary integration through the STREAM approach.

Keywords: Student Worksheet; Stream Approach; Dynamic Fluids

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Introduction

Education is fundamental to national development, with Indonesia's 1945 Constitution emphasizing the goal of enlightening the nation's life. In the Society 5.0 era, learners are expected to master 21st-century competencies (critical thinking, creativity, communication, collaboration) alongside strong character and moral values. However, Indonesia's education still faces challenges: PISA 2022 data from OECD (2023) ranked Indonesia 68th of 81 countries in science literacy, well below the OECD average. This is linked to teacher-centered learning practices that leave students passive. Observations at SMAN 14 Medan revealed similar issues teaching still relies heavily on textbooks, with limited innovative materials, while about 70% of students search for answers online without proper guidance. The problem is especially evident in dynamic fluid material, where the average daily test score (60) falls well below the school's minimum mastery criterion (75), with 69.4% of students failing to meet it. This is attributed to the material's abstract nature and the analytical demands of connecting concepts like continuity, discharge, pressure, and Bernoulli's principle to real-life phenomena. Existing worksheets (LKPD)

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function mainly as evaluation tools rather than guides for independent concept-building, and none are specifically developed for dynamic fluid material. This points to a need for contextual, problem solving oriented, creativity fostering, and character-building learning materials.

Various pedagogical approaches address 21st-century learning needs. Problem Based Learning (PBL) has proven effective for critical thinking and problem-solving (Narmaditya et al., 2018), though it doesn't explicitly integrate multiple disciplines. The STEM approach (Science, Technology, Engineering, and Mathematics) offers an interdisciplinary framework connecting science to technology and engineering (Holmlund et al., 2018; Margot & Kettler, 2019), but tends to underemphasize affective and character dimensions (Wahono et al., 2020). STEAM extends STEM by incorporating Art to foster creativity, yet neither STEM nor STEAM explicitly addresses moral and spiritual values central to Indonesia's national education goals.

STREAM (Science, Technology, Religion, Engineering, Art, Mathematics) was therefore selected, adding a Religion component to integrate moral and spiritual values into learning. Prior research supports STREAM's effectiveness: (Sa'adah & Ellianawati, 2022) found STREAM-based worksheets feasible and capable of enhancing student creativity in dynamic fluid topics. Bhakti et al. (2020) showed STEM-based materials improve both conceptual mastery and real-life application, while Shahali et al. (2016) demonstrated gains in scientific reading, critical thinking, problem-solving, and creative thinking (Rahmawati et al., 2021). Suryadi et al. (2023) found significant effects of STREAM implementation on problem solving skills in sound wave topics through quasi-experimental study. Azizah et al. (2019) showed STREAM enhances student thinking through active, collaborative learning, while Azizah et al. (2020) found STREAM integrated with PjBL effectively improved process skills (N-Gain 0.71, high category). Agustina et al. (2020) demonstrated STREAM trains scientific process skills through integrated observation, analysis, experimentation, and solution design.

The choice of STREAM is further justified by Ekici and Erdem (2020) who noted that various learning innovations (science learning models, PBL, discovery learning) have not adequately improved students' scientific process skills, while Bhakti et al. (2020) and related studies confirm STEM-based materials significantly enhance both learning achievement and real world application abilities.

STREAM's main advantage over conventional approaches lies in its comprehensive interdisciplinary nature. Shahali et al. (2016) noted that interdisciplinary approaches effectively build problem solving skills by linking subject specific expertise to real-world problems through project based learning. Safitri and Priyambodo (2016) emphasized that STREAM, as an interdisciplinary method combining art and religion, can enhance students' problem solving skills.

A key distinction of STREAM from STEM and STEAM is its integration of religious values, adding a spiritual dimension to science learning particularly relevant in the Indonesian educational context, where science and religion are viewed as interconnected. Khoiri et al. (2017) argued that integrating religious elements into science and art education helps prevent students from accepting scientific ideas that conflict with their beliefs, representing a concrete step toward producing intelligent, responsible, and morally upright individuals (Azizah et al., 2019).

Given the gap between current learning needs and available materials particularly the low achievement in dynamic fluid material, lack of innovative resources, and need for contextual, creative, character-based learning this study aims to develop a STREAM-based Student Worksheet (LKPD) on Dynamic Fluid material at SMAN 14 Medan.

Method

This study employed a Research and Development (R&D) design to develop a STREAM-based Student Worksheet (LKPD) on Dynamic Fluid material at SMAN 14 Medan. The development followed the 4D model by Thiagarajan et al. (1974), consisting of four stages: define, design, develop, and disseminate. The 4D model was selected because it is systematic and suitable for developing learning materials (Rachman et al., 2024). The subjects of this study were all Grade XI MIPA students at SMAN 14 Medan, with a sample of 18 students for the small group trial and 36 students for the large group trial, taken from Grade XI MIPA 3. Data were collected through interviews, questionnaires, validation sheets, and pre-test and post-test instruments. The validity of the LKPD was analyzed using a percentage formula, effectiveness was measured using the N-gain formula, and practicality was assessed through teacher and student response questionnaires (Rachman et al., 2024).

Development Procedure

The implementation of the four stages in this study are as follows. The define stage consisted of several analytical steps, including front-end analysis, learner analysis, task analysis, and concept analysis. The front-end analysis was conducted through interviews with physics teachers and questionnaire distribution to Grade XI MIPA 3 students at SMAN 14 Medan to identify learning problems and needs related to

Dynamic Fluid material. The learner analysis aimed to understand student characteristics, while the task and concept analyses were conducted to identify specific student skills and examine the main concepts of Dynamic Fluid material in accordance with the applicable curriculum.

The design stage focused on determining the format and design of the LKPD. The material selected was Dynamic Fluid, based on the school syllabus. The LKPD was designed using the Canva application, covering layout, images, text, font type, and font size. Questionnaire instruments were also prepared at this stage for material experts, media experts, subject teachers, and students.

The develop stage produced the STREAM-based LKPD as the final teaching material. Validation was carried out by two physics education experts. Following validation and revision, the LKPD was questionnaires, and pre-test and post-test instruments to measure validity, practicality, and effectiveness of the LKPD (Rachman et al., 2024).

The disseminate stage was conducted by distributing the final LKPD to physics teachers at SMAN 14 Medan for broader use in learning activities. The activities in this STREAM-based LKPD were presented using the Project-Based Learning (PjBL) framework. PjBL is a learning model that uses projects as a medium to achieve attitudinal, knowledge, and skill competencies (Nababan et al., 2023) and is recognized as a creative and innovative approach that actively engages students in solving real-world projects through collaboration and inquiry (Khairani et al., 2024). PjBL was selected for three reasons: it facilitates the integration of multiple disciplines in a single real project, aligning with the interdisciplinary nature of the STREAM approach (Hakim et al., 2025); it is student-centered and supports critical thinking, problem-solving, creativity, communication, and collaboration skills required in the 21st century (Muhibbullah et al., 2024); and each PjBL stage provides space for students to explore STREAM elements in a gradual and integrated manner. The PjBL syntax used in this LKPD refers to six stages adapted from Muhibbullah et al. (2024) as presented in Table 1.

Tabel 1. PjBL Syntax and Its Integration with STREAM Elements in the LKPD

No	PjBL Syntax	Activities in LKPD	STREAM Elements
1	Start with the Essential Question	Students observe water flow phenomena (fountains, rivers, hydropower) and formulate questions about the relationship between height, velocity, and fluid pressure in real life	Science, Technology
2	Design a Plan for the Project	Students design a dynamic fluid experiment and a recycled waterwheel, including tools, materials, and group task distribution	Engineering, Mathematics
3	Create a Schedule	Students arrange a project schedule for waterwheel construction and scientific physics storyboard writing	Art, Engineering
4	Monitor the Progress	Teacher monitors project development; students record experiment data and product progress	Science, Engineering
5	Assess the Outcome	Students present experiment results, waterwheel performance, and storyboard; perform mathematical analysis using Bernoulli and continuity equations	Science, Mathematics, Art
6	Evaluate the Experience	Students reflect on the project process, including spiritual reflection on the regularity of natural laws as an expression of gratitude to God	Religion

Source: adapted from Muhibbullah et al. (2024)

Subject

The subjects for the product trial were 36 Grade XI MIPA 3 students at SMAN 14 Medan. The subjects were selected using purposive sampling method.

Data Collection Technique and Instruments

The data for the STREAM-based LKPD were collected using the following techniques: (1) interviews with physics teachers at SMAN 14 Medan regarding the use of teaching materials and student learning outcomes; (2) assessment of LKPD validity using expert validated questionnaires by material and media experts; (3) assessment of LKPD practicality through teacher and student response questionnaires; and (4) assessment of LKPD effectiveness using pre-test and post-test instruments consisting of five essay questions on Dynamic Fluid concepts.

Data Analysis Technique

Data analysis in this study focused on four aspects: validity, practicality, effectiveness, and STREAM element achievement of the LKPD.

LKPD Validity Analysis

The validity of the LKPD was analyzed based on scores from expert validators using the following formula (Rachman et al., 2024):

$$\textbf{Validity Score} = \frac{\textit{Total score obtained}}{\textit{Maximum total score}}\ x\ \mathbf{100}\%$$

The validity categories are presented in Table 2.

Table 2. Validity Categories

Validity Category	Percentage Range (%)
Very Valid	85% – 100%
Valid	70% – 84%
Sufficiently Valid	50% – 69%
Not Valid	< 50%

LKPD Practicality Analysis

The practicality of the LKPD was assessed based on teacher and student response questionnaires. The student questionnaire used Yes/No response options with the scoring guidelines presented in Table 3.

Table 3. Student Questionnaire Scoring Guidelines

Response	Positive	Negative
Yes	1	0
No	0	1

The practicality score was calculated using the following formula (Rachman et al., 2024);

$$\textbf{Practicality Score} = \frac{\textit{Total score obtained}}{\textit{Maximum total score}}\ x\ \mathbf{100}\%$$

The practicality categories are presented in Table 4.

Table 4. LKPD Practicality Categories

Practicality Category	Percentage Range (%)
Very Practical	85% – 100%
Practical	70% – 84%
Sufficiently Practical	50% – 69%
Not Practical	< 50%

LKPD Effectiveness Analysis

The effectiveness of the LKPD was evaluated through the improvement of student learning outcomes using the normalized gain (N-gain) formula (Rachman et al., 2024);

$$N - gain = \frac{\textit{Posttest score} - \textit{Pretest score}}{\textit{Maximum score} - \textit{Pretest score}}$$

N-gain categories are presented in Table 5. If data were normally distributed, a t-test was applied; otherwise, the Wilcoxon test was used (Rachman et al., 2024);

Table 5. LKPD Effectiveness Criteria

N-gain Category	N-gain Range
High Effectiveness	N-gain > 0.7
Moderate Effectiveness	0.3 ≤ N-gain ≤ 0.7
Low Effectiveness	N-gain < 0.3

STREAM Element Achievement Analysis

In addition to effectiveness measured through N-gain, this study also analyzed the achievement of each STREAM element (Science, Technology, Religion, Engineering, Art, and Mathematics) in the learning process based on student responses. The percentage formula used is as follows (Rachman et al., 2024);

$$\text{Percentage} = \frac{\textit{Score obtained}}{\textit{Maximum score}} X\ 100\%$$

The STREAM achievement categories are presented in Table 6.

Table 6. STREAM Element Achievement Categories

Category	Percentage Range (%)
High Effectiveness	85% – 100%
Moderate Effectiveness	70% – 84%
Low Effectiveness	50% – 69%

Result and Discussion

This study successfully developed a Student Worksheet (LKPD) based on the STREAM approach (Science, Technology, Religion, Engineering, Art, and Mathematics) for Dynamic Fluid material in Grade XI at SMAN 14 Medan. The development followed the 4D model by Thiagarajan et al. (1974), consisting of the define, design, develop, and disseminate stages. The following section presents the results obtained at each stage.

Define Stage

Front-End Analysis.

The front-end analysis revealed several learning problems in physics education at SMAN 14 Medan. Teaching activities were still dominated by the lecture method with textbooks as the primary learning resource. Teachers had not yet utilized interactive and contextual supporting materials. Interview results indicated that the limited availability of learning references was one of the factors causing less varied instruction. Student questionnaire data from Grade XI MIPA 3 showed that approximately 70% of students searched for learning materials online without systematic guidance, resulting in potential misconceptions. Students also tended to be passive during lessons and experienced difficulty understanding the abstract concepts of Dynamic Fluid material. The average score on Dynamic Fluid assessments remained at or below the Minimum

Mastery Criterion (KKM) of 75, with 69.4% of students failing to meet the KKM (OECD, 2023).

Learner Analysis

Learner analysis was conducted to identify student characteristics as a basis for developing an appropriate LKPD. Results showed that students had a high dependence on the internet as a learning resource, with around 70% searching for answers and materials online without adequate filtering skills. Students tended to be passive during learning due to teacher-centered instruction and limited teaching materials. Based on interviews, students were more interested in learning that involved practical activities, group discussions, and technology-based media. They also found it easier to understand material when presented with visual illustrations and connected to real-life phenomena. In terms of technology skills, students demonstrated sufficient ability to access digital information, which could be utilized in the development of the STREAM-based LKPD.

Task Analysis

Task analysis was conducted to identify the learning activities students needed to perform in understanding Dynamic Fluid material. Based on classroom observations, students rarely conducted experiments and more frequently completed practice problems from textbooks. Through task analysis, students were expected to observe fluid phenomena, conduct simple experiments, analyze data, and draw conclusions. Students were also expected to connect Dynamic Fluid concepts with real-life applications through project-based learning activities. The integration of the STREAM approach in learning tasks enabled students to develop critical thinking skills, creativity, engineering ability, and religious values.

Concept Analysis

Concept analysis was conducted to identify and examine the main concepts of Dynamic Fluid material to be developed in the STREAM-based LKPD. Based on the applicable curriculum, Dynamic Fluid material covers ideal fluid dynamics, fluid flow rate, continuity equation, Bernoulli's law, and its real-life applications. These concepts have a high level of abstraction requiring learning that connects theory with real phenomena. The integration of STREAM elements into learning objectives ensured that students not only understood the concepts theoretically, but also applied them in daily life, developed creativity, critical thinking, and religious values. The concept integration with STREAM elements and learning objectives is presented in Table 7.

Table 7. Integration of Concept Analysis with STREAM-Based Learning Objectives

STREAM Element	Focus in LKPD	Achievement Indicator
Science	Continuity Principle and Bernoulli's Law	Analyze the relationship between water height, flow velocity, and projection distance through experiments; draw conclusions based on Continuity and Bernoulli principles
Technology	Hydroelectric Power Plant (PLTA)	Explain the working principle of PLTA based on fluid dynamics; connect PLTA utilization with community energy needs
Religion	Spiritual values & moral responsibility	Show appreciation for the regularity of fluid laws as God's creation; recognize the importance of water conservation
Engineering	Design of a waterwheel from recycled materials	Design and assemble a simple waterwheel model; evaluate performance based on rotation speed and tool stability
Art	Scientific fiction storyboard	Produce a storyboard incorporating fluid dynamics principles logically and imaginatively; integrate physics concepts without losing scientific clarity
Mathematics	Mathematical equations of fluid dynamics	Use mathematical relationships between cross-sectional area, velocity, and fluid pressure to analyze flow in narrowing pipes and venturimeters

Design Stage

The design stage aimed to determine the initial design of the STREAM-based LKPD for Dynamic Fluid material. Dynamic Fluid was selected as the material based on the school's Merdeka Curriculum syllabus. The LKPD was designed using the Canva application, covering layout, images, text, font type, and font size. The LKPD structure included: (1) a cover page with the title "*Hydrotech Heroes: Petualangan Fluida Dinamis,*" subject identity, and STREAM elements; (2) usage instructions based on PjBL model; (3) a concept map to help students understand the interrelationships of Dynamic Fluid concepts; and (4) a learning mission based on a real-world problem scenario in which students were challenged to design a mini hydroelectric power plant using Dynamic Fluid principles. The initial draft of the LKPD was completed with research instruments including expert validation sheets, student activity observation sheets, and pre-test and post-test questions.

Figure 1. LKPD Cover

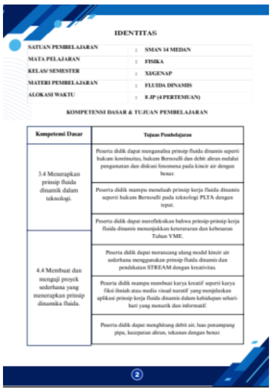

Figure 2. LKPD Identity Section

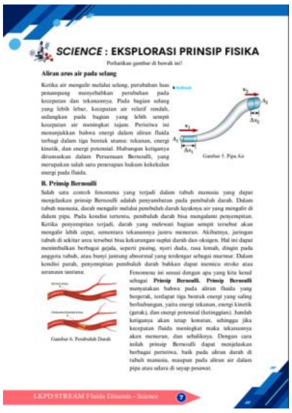

Figure 3. Science Section

Figure 4. Technology Section

Develop Stage

Validity of the LKPD

Material Expert Validation. Material expert validation assessed five aspects: content feasibility, presentation feasibility, language feasibility, contextual assessment, and STREAM approach relevance. The validation results are presented in Table 8.

Table 8 shows that the overall mean percentage of material expert validation was 97.90%, placing the LKPD in the very valid category. The content feasibility aspect obtained 98.34%, indicating that the material was accurate, up-to-date, and aligned with the Basic Competencies of Dynamic Fluid material. The presentation feasibility aspect reached 96.00%, reflecting systematic and structured sequencing of concepts and learning activities.

Table 8. Material Expert Validation Results

Aspect	Percentage (%)	Category
Content Feasibility	98.34%	Very Valid
Presentation Feasibility	96.00%	Very Valid
Language Feasibility	100.00%	Very Valid
Contextual Assessment	90.00%	Very Valid
STREAM Approach Relevance	98.00%	Very Valid
Overall Mean	97.90%	Very Valid

The language feasibility aspect achieved a perfect score of 100.00%, confirming that the language used was clear, communicative, and adaptive to students' cognitive development. The contextual assessment aspect obtained 90.00%, demonstrating that the material was connected to real-life phenomena relevant to students' environment. Finally, the STREAM approach relevance aspect reached 98.00%, confirming that all six STREAM elements were explicitly and systematically integrated throughout the learning activities. Material expert suggestions included increasing question-and-answer activities during learning and adding a glossary to help students understand key terms.

Media Expert Validation**.** Media expert validation assessed three aspects: LKPD size, cover design, and content design. The results are presented in Table 9.

Table 9. Media Expert Validation Results

Aspect	Percentage (%)	Category
LKPD Size	90.00%	Very Valid
Cover Design	90.00%	Very Valid
Content Design	86.67%	Very Valid
Overall Mean	88.89%	Very Valid

Table 9 shows that all media aspects were rated very valid. The LKPD size obtained 90.00%, confirming that the dimensions were appropriate and comfortable for classroom use. The cover design also obtained 90.00%, reflecting good color selection, title proportion, legibility, and illustration relevance to both Dynamic Fluid material and the STREAM approach. The content design aspect obtained 86.67%, indicating that the layout, typography consistency, image placement, and systematic material presentation were well-proportioned. The media expert suggested standardizing all image captions in Indonesian, which was subsequently revised. Overall, the LKPD was declared very valid and ready for the product trial stage.

LKPD Revision Based on Expert Suggestions.

Table 10. LKPD Revision Based on Media Expert Suggestions

Aspect	Before Revision	After Revision
Content Design	Some image captions were in English while others were in Indonesian	All image captions have been standardized in Indonesian

Practicality of the LKPD

Small Group Trial (Student Response). The small group trial was conducted with 18 students from Grade XI MIPA 3. Students were given the LKPD to use, after which they completed an 18-item response questionnaire covering three aspects: attractiveness, LKPD presentation, and STREAM-based learning components. The results are presented in Table 11.

Table 11. Small Group Trial Results (n=18)

Aspect	Percentage (%)	Category
Attractiveness	98.15%	Very Good
LKPD Presentation	84.13%	Very Good
STREAM Learning Components	90.34%	Very Good

Table 11 shows that the attractiveness aspect obtained 98.15%, indicating a very high level of student interest in both reading the material and completing tasks in the LKPD. The LKPD presentation aspect obtained 84.13%, reflecting clear instructions, illustrations, and task items that facilitated students in following the learning sequence. The STREAM learning components aspect obtained 90.34%, demonstrating that students perceived a clear integration of all six STREAM elements throughout the learning activities. Based on small group feedback, students suggested that more answer space be provided. This revision was implemented before the large group trial.

Table 12. LKPD Revision Based on Small Group Trial

Aspect	Before Revision	After Revision
Presentation	Answer space was too limited, causing confusion for students (page 9)	Additional answer space has been provided in the LKPD

Large Group Trial (Student Response). The large group trial was conducted with 36 students. The results are presented in Table 13. Table 13 shows that all aspects improved compared to the small group trial results, with an overall mean of 93.22% (very practical category). This increase confirmed that the revisions made after the small group trial positively impacted the quality of the LKPD. The high attractiveness score of 99.08% indicated that the LKPD design effectively motivated students to engage with the material. The STREAM learning components score of 94.11% confirmed that students clearly perceived the interdisciplinary integration throughout all learning activities.

Table 13. Large Group Trial Results (n=36)

Aspect	Percentage (%)	Category
Attractiveness	99.08%	Very Practical
LKPD Presentation	89.69%	Very Practical
STREAM Learning Components	94.11%	Very Practical
Overall Mean	93.22%	Very Practical

Teacher Response**.** The physics teacher's response was assessed across three aspects: time efficiency, ease of use, and usefulness. The results are presented in Table 13.

Table 14. Teacher Response Results

Aspect	Percentage (%)	Category
Time Efficiency	100.00%	Very Practical
Ease of Use	100.00%	Very Practical
Usefulness	100.00%	Very Practical
Overall Mean	100.00%	Very Practical

Table 14 shows that the teacher rated all aspects at 100.00%, placing the LKPD in the very practical category. The time efficiency score indicated that the LKPD effectively helped the teacher manage classroom time. The ease of use score reflected clear and communicative language and instructions. The usefulness score confirmed that the LKPD was aligned with the curriculum and supported meaningful learning that fostered students' critical and creative thinking skills.

Effectiveness of the LKPD

The effectiveness of the STREAM-based LKPD was evaluated through pre-test and post-test scores of 36 students in the large group trial. The results are presented in Table 15.

Table 15. Pre-Test and Post-Test Results (n=36)

Large Group (36 Students)	**Learning Outcomes Score**	
	Ideal Score (100)	
	Pretest	**Posttest**
Total Score	1.906	3.475
Average Score	52,92	96,53
N-Gain Score		0,89
N-Gain Criteria		High Effectiveness

Table 15. shows that the mean pre-test score was 52.92, reflecting that students' initial understanding of Dynamic Fluid material was at a medium-to-low level.

After learning using the STREAM-based LKPD, the mean post-test score increased significantly to 96.53, representing an improvement of 43.61 points. The normalized gain (N-Gain) score was 0.89, equivalent to 89%, which falls in the high effectiveness category.

STREAM Element Achievement

In addition to the N-Gain analysis, this study also analyzed the achievement of each STREAM element based on student responses. The results are presented in Table 16.

Table 16. STREAM Element Achievement Results

STREAM Element	Total Score	Percentage (%)	Category
Science	154	85.56%	High Effectiveness
Technology	162	90.00%	High Effectiveness
Religion	161	89.44%	High Effectiveness
Engineering	162	90.00%	High Effectiveness
Arts	163	90.56%	High Effectiveness
Mathematics	152	84.44%	High Effectiveness

Table 16. shows that all STREAM elements fell in the high effectiveness category. The Arts element achieved the highest percentage at 90.56%, indicating that the LKPD successfully provided space for students to express creativity and innovative ideas, particularly in design and visualization activities. The Technology and Engineering elements both achieved 90.00%, confirming that the LKPD effectively connected Dynamic Fluid concepts with real-world technology applications and encouraged students to understand simple design processes. The Religion element obtained 89.44%, demonstrating that the integration of religious values was well-received by students, encouraging them to reflect on the greatness of God through natural phenomena. The Science element obtained 85.56%, showing that the LKPD supported students in observing phenomena, analyzing problems, and understanding basic fluid dynamics concepts through experiments and discussion. The Mathematics element obtained the lowest percentage at 84.44%, though still in the high effectiveness category, reflecting that some students still encountered difficulty in mathematical calculations such as computing flow rate, fluid velocity, and applying Bernoulli's equation.

Disseminate Stage

The disseminate stage was conducted offline at SMAN 14 Medan by introducing the final LKPD to physics teachers as an alternative teaching material for use in other classes. This stage was carried out after the product had undergone development, expert validation, and field trials, and had been declared valid, practical, and effective. The dissemination stage serves a strategic role in ensuring that the developed product is not limited to the trial class but can be more broadly implemented in physics learning practice.

Steps in Developing the STREAM-Based LKPD

The development of the STREAM-based LKPD for Dynamic Fluid material adopted the 4D model by Thiagarajan et al. (1974). The define stage revealed that learning at SMAN 14 Medan still relied heavily on textbooks, with limited interactive and contextual teaching materials. Nurlaili et al., (2024) stated that instructional materials that are less flexible in accommodating differences in students' abilities, interests, and learning readiness may limit the implementation of differentiated learning and lead to low student engagement in the learning process. The design stage structured the LKPD with integrated STREAM components in a single problem-based learning activity. This aligns with the principle proposed by Bhakti et al. (2020) that STREAM integration is most effective when concepts are not taught separately but woven into one authentic problem, significantly improving both mastery and real-world application abilities.

Validity of the LKPD

The LKPD obtained an overall material validation score of 97.90% and a media validation score of 88.89%, both in the very valid category. High validity scores across all aspects confirm that the LKPD met the standards for content accuracy, systematic presentation, communicative language, contextual relevance, and STREAM integration. These results are consistent with Sa'adah and Ellianawati (2022) who found that STREAM-based worksheets were feasible and effective in enhancing student creativity in Dynamic Fluid topics.

Practicality of the LKPD

The LKPD demonstrated very high practicality, with a large group student response mean of 93.22% and a teacher response of 100.00%. The high attractiveness scores in both the small group (98.15%) and large group (99.08%) trials indicate that the STREAM-based LKPD design effectively motivated students and increased learning interest. The improvement between small group and large group results confirms that product revisions had a positive impact. The teacher's perfect score of 100.00% across all practicality aspects further validates that the LKPD is efficient, easy to use, and pedagogically beneficial.

Effectiveness of the LKPD

The LKPD achieved an N-Gain score of 0.89 (high category), with mean scores improving from 52.92 to 96.53. This significant improvement demonstrates that the STREAM approach effectively facilitated active student engagement. Integration of Science and Mathematics strengthened conceptual and quantitative understanding; Engineering and Technology encouraged real-world application; while Art and Religion provided space for creativity and value reflection. These findings support Azizah et al. (2020), who showed that STREAM integrated with Project-Based Learning effectively improved student process skills with an N-Gain of 0.71. The higher N-Gain obtained in this study (0.89) suggests that the STREAM-PjBL combination in the LKPD format yielded even stronger learning outcomes.

STREAM Element Achievement

All six STREAM elements achieved high effectiveness, with percentages ranging from 84.44% (Mathematics) to 90.56% (Arts). The high Arts score indicates students' enthusiasm for creative activities. The relatively lower Mathematics score suggests that some students still face challenges in mathematical computation, particularly in applying Bernoulli's equation and continuity formulas. This finding is consistent with Agustina et al. (2020), who found that STREAM effectively trained scientific process skills through integrated observation, analysis, experimentation, and solution design, though mathematical components may require additional scaffolding.

Conclusion

Based on the research and development activities that have been conducted, the following conclusions can be drawn:

The STREAM-based Student Worksheet (LKPD) developed for Dynamic Fluid material in Grade XI at SMAN 14 Medan demonstrated strong potential for practical use in physics learning. Material expert validation yielded an overall percentage of 97.90% and media expert validation obtained 87.78%, both placing the LKPD in the very valid category. In the practicality evaluation, the teacher response reached a perfect score of 100%, while student responses showed 88.89% in the small group trial, increasing to 93.22% in the large group trial, confirming that the LKPD is very practical and accessible as a teaching material. In terms of effectiveness, the comparative analysis of pre-test and post-test scores yielded an N-Gain score of 0.89 (89%), which falls in the high effectiveness category, indicating a significant improvement in student learning outcomes after using the LKPD.

These findings suggest that the STREAM-based LKPD, which integrates Science, Technology, Religion, Engineering, Art, and Mathematics, not only meets content and media quality standards but also supports active, contextual, and meaningful learning. Furthermore, its implementation aligns with broader national education goals, including the development of students' critical thinking, creativity, and character. Overall, the LKPD shows significant promise as an effective and innovative instructional tool that contributes meaningfully to the quality of physics teaching and learning.

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