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STEM-7E LEARNING CYCLE LEARNING TOOLS WITH FORMATIVE ASSESSMENT TO ENHANCE CRITICAL THINKING

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ABSTRACT

Maximum learning requires planning and strategies in learning. This study aims to develop a learning tool product for dynamic fluid material based on STEM-7E Learning cycle with formative assessment to improve critical thinking skills of high school students. This research uses the research and development (R&D) method by following the stages of the 4D model and carried out until the develop stage. After the product was developed, the validity of the product was tested by two validators and 32 students of SMA Brawijaya Smart School Malang for the practicality test. The overall product validity test results were 100% and the product practicality test results were 98.25%. Based on the results of the validity and practicality tests, the developed product has a very valid and very practical category.

Keywords: STEM, 7E Learning Cycle, Formative Assessment, Critical Thinking

INTRODUCTION

Physics is an important science for life. Physics is everywhere around us (Giancoli, 2014). The science of physics is able to explain how nature works (Walker, Halliday, & Resnick, 2014). This is because physics discusses phenomena in everyday life from the smallest to the largest parts, from atoms to galaxies, from electrical circuits to aerodynamics (Young & Freedman, 2016). With physics, students can see the world with the eyes of a physicist (Giancoli, 2014).

Among all parts of physics material, there is dynamic fluid material that is interesting and important to master. This is because dynamic fluid has unlimited applications (Çengel & Cimbala, 2014). From microscopic biological systems to automobiles, airplanes, and spacecraft (Çengel & Cimbala, 2014). In everyday life, the application of dynamic fluids can be seen in carburetors, baseball curveballs, atomizers, chimneys, windmills, airflow in aerodynamic shapes on cars (Hewitt, 2006; Nurachmandani, 2009).

Based on examples of the application of dynamic fluid material which is proven to be widely used in everyday life, students need good concept mastery of the material. However, students' concept mastery of dynamic fluid material is still low (Aprita, Supriadi, & Prihandono, 2015; Samsudin et al., 2018). Low concept mastery results in low students' critical thinking skills (Sa'adah, Sudargo, & Hidayat, 2017). Therefore, if students' concept mastery is good, then students' critical thinking skills will also be good (Irawaan, 2015; Sa'adah et al., 2017).

Nowadays, critical thinking skills are important skills for every student to have (Kemendikbud, 2016; Zubaidah, 2016) in order to solve problems effectively (Snyder & Snyder, 2008). However, student achievement on critical thinking indicators is still in the range of 60% (Afiatun & Putra, 2015), so it can be concluded that some students still have low critical thinking skills (Rahayu, Harijanto, & Lesmono, 2018). This is caused by students who are not much involved in the process of constructing concepts (Husein, Herayanti, & Gunawan, 2017). Referring to the concepts taught to students, fluid dynamic material is closely related to everyday problems, but students still have an understanding that is not optimal, thus affecting their critical thinking skills.

Fluid dynamic material has been studied in research by providing learning model treatment to improve students' critical thinking, namely 1)TPS-PP model which is considered only moderately effective (Afiatun & Putra, 2015), 2)generative model focuses on constructing knowledge but has not improved C6 (creating) and lacks implementation of current technology (Uki, Saehana, & Pasaribu, 2017), 3)STEM-Schoology blended learning has implemented current technology, but has not yet demonstrated its effectiveness (Ardianti et al., 2019). Based on this, it appears that these learning treatments have not been able to optimally build students' critical thinking skills. On the other hand, learning improvement is not only done with the treatment in learning, the media and teaching materials used must also be appropriate (Indariani, Amami Pramuditya, & Firmasari, 2018).

The current pandemic requires the implementation of online learning. For online learning, electronic media and teaching materials are suitable (Andianah & Nurhidayat, 2020). Previously there was a Guided Inquiry-based worksheet development, but when tested for effectiveness, it was found that students did not improve on three problem (Apriyana, Herlina, & Abdurrahman, 2019). In addition, module development was also carried out. However, the modules that have been developed are not yet electronically based as the modules that are currently needed (Darmawan, Aminah, & Sukarmin, 2015; Madroji, Zulaiha, & Faizah, 2019). Then, based on the research that has been done, it is found that the learning tools used by teachers are still incomplete (Yerizon & Kurnia, 2018). Learning tools are an important part of learning implementation because each learning strategy requires different learning tools to achieve learning objectives (Fitriyati, Hidayat, & Munzil, 2017). Based on this, it is clear that learning devices with teaching materials in the form of electronic modules are the best alternative choice as a learning medium to build critical thinking skills.

However, to improve the critical thinking skills of high school students, the learning tools that have been developed have not discussed fluid dynamics material (Andayani, 2020; Putri, 2017). While the learning tools that have been developed by discussing dynamic fluid material have not used electronic modules as teaching materials and have not applied relevant learning models/approaches for the 21st century (Nisaa & Mu, n.d.). From this, it shows that learning devices using electronic modules as dynamic fluid teaching materials that are relevant for the 21st century and can seek to improve critical thinking skills are still rarely developed. In addition, dynamic fluids have unlimited applications (Çengel & Cimbala, 2014) and also in everyday life (Hewitt, 2006; Nurachmandani, 2009). For this reason, a solution that is able to construct student knowledge and is relevant to the current era is needed, namely the STEM approach (Ardianti et al., 2019).

Relevant updates are now known as STEM (Amatullah, Distrik, & Wahyudi, 2019). However, conventional STEM learning still leaves students behind (Mark Sanders, 2009). Therefore, in the learning tools developed, STEM is collaborated with the 7E Learning Cycle learning model which is considered capable of improving students' critical thinking skills (Husnul, Sesunan, & Rosidin, 2019). 7E Learning Cycle is needed to be integrated with STEM because learning cycle is student-centered learning and able to develop critical thinking skills so that they can answer problems and solve problems better (Bowers, Ernst, Barksdale, Magliaro, & Williams, 2015). STEM-7 E Learning Cycle has not yet implemented the assessment process as feedback during learning. Therefore, this model is integrated with formative assessment as follow-up training to help provide maximum results (Azizah, Parno, & Supriana, 2020). This formative assessment has been widely used to improve students' thinking skills and concept understanding (Ediyanto, 2015; Ilyas Ismail, 2012; Saptono, Rustaman, & Widodo, 2013; Sari, Mustikasari, & Pratiwi, 2019). Based on the description above, the purpose of this study is to develop a STEM-7E Learning cycle learning tool with formative assessment to improve the critical thinking skills of high school students.

METHOD

Part The method of this research is research and development (Research and Development). This research and development, has the aim of producing certain products and testing the validity and readability of learning device products. The model used is the 4D model. The four stages of the 4D model are 1)define, 2)design, 3)develop, and 4)disseminate (Thiagarajan, Si, Semmel, DS, Semmel, 1974) and carried out up to the develop stage.

At the define stage, gap analysis, students, concepts and tasks are carried out and the specification of learning objectives on the subject of dynamic fluids using the STEM-7E Learning cycle learning model accompanied by formative assessment. Then at the design stage, the preparation of learning indicators was carried out and studied the basic competencies 3.4 on the subject of dynamic fluids. At this stage also carried out the development of test instruments and determined the initial format of learning devices and their design. Then in the final stage of the development process carried out is the validation process by learning experts, subject matter teachers, and users or students.

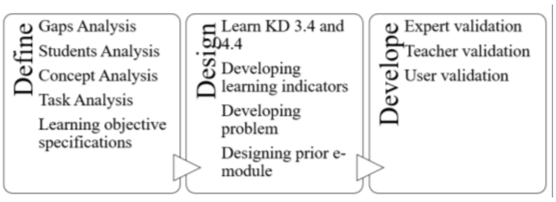


Figure 1: Flowchart of the Development Process

This research and development of learning devices has 2 types of data, namely, quantitative data and qualitative data. Quantitative data in the form of assessment scores on the validity questionnaire and readability of learning devices filled by lecturers and high school physics teachers for expert validation and students as users. The assessment for each criterion point uses a Guttman scale in the form of yes and no answers. Quantitative descriptive analysis is obtained from validation until the percentage of validity and readability of each aspect is obtained (Himah, Sudarti, & Subiki, 2016). From the total score data obtained, it is interpreted and conclusions are drawn by comparing to the product validity criteria (Arikunto, 2010). This qualitative data is obtained from comments and suggestions from validators and users and then processed to be taken into consideration in the development and improvement of the program.

Quantitative data obtained from the validity and readability questionnaires were processed by determining the percentage of validity and readability. From the results of these calculations, the validity categorization was then carried out based on Table 1 and the practicality table based on Table 2.

Table 1. Product Validity Categorization.

Percentage of Scoring Results (%)	Level of Validity
81 – 100	Very Valid
61 – 80	Valid
41 – 60	Fairly Valid
21 – 40	Invalid
0 – 20	Very Invalid

Source: Riduwan (2011)

Tabel 2. Pengkategorian Kepraktisan Produk.

Percentage of Scoring Results (%)	Level of Validity
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Fairly Practical
21 – 40	Less practical
0 – 20	Not Practical

Source: Mahadiraja & Syamsuarnis (2020)

RESULT AND DISCUSSION

The product developed is a learning tool based on STEM-7E Learning Cycle with formative assessment as an effort to improve critical thinking skills. Overall, this learning tool development product includes three subproducts, namely modules for students, teacher's manuals, and lesson plans (RPP). The module for students is in the form of a website-based electronic module. The teacher's guide module is in the form of a book that contains an explanation of the procedures for implementing learning using a web-based e-module. The teacher's guide book is also equipped with materials and answer keys for each practice question and student worksheet. Furthermore, the lesson plan contains all the details of synchronous and asynchronous learning implementation.

The first sub-product was a web-module for students. This module was developed using the Google Sites platform. This module starts from the homepage as shown in Figure 2. Then proceed with instructions for use which contains an explanation of the symbols that will be used in the module and a concept map as shown in Figure 3. Next is to enter the material cycle and product manufacturing cycle. The material delivery in this module uses text, images, and videos. Without missing the importance of experiments, this module uses PhET which is linked to the module's web page. For the collection of student work, this module uses google forms that can accommodate text, images, and videos as needed.

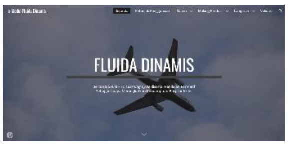


Figure 2. Student Module Homepage

Figure 3. Instructions for using the module

The first cycle is the material cycle which has a sequence of stages based on the 7E Learning Cycle learning model. The first stage starts with 'let's observe' which invites students to observe existing technology to provoke students' curiosity and analytical skills. Followed by 'let's identify' which contains learning objectives. Then, enter the 'let's explore' stage which contains the delivery of material and sample problems. Examples of problems presented in the material cycle based on critical thinking skills as in Figure 4.

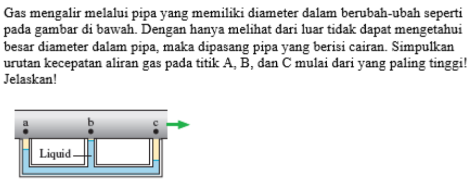

Gas mengalir melalui pipa yang memiliki diameter dalam berubah-ubah seperti pada gambar di bawah. Dengan hanya melihat dari luar tidak dapat mengetahui besar diameter dalam pipa, maka dipasang pipa yang berisi cairan. Simpulkan urutan kecepatan aliran gas pada titik A, B, dan C mulai dari yang paling tinggi! Jelaskan!

Figure 4. Sample Problem in the Student Module.

After the presentation of the material, it is continued with experimental or exploration activities in accordance with the submaterial discussed. After carrying out exploration or experimentation activities, students are invited to explain the knowledge they have gained. After being able to explain, students are invited to do exercises on critical thinking skills for analysis and evaluation indicators. With these experimental activities, exploration, and practice questions, students are able to measure their abilities. Therefore, the next stage is 'let's evaluate' as a student flashback and determines the next stage will continue or have to repeat the material again. If students are declared able to continue the next stage, then students enter the 'let's develop knowledge' stage. The series of material cycles can be explained through the flow chart in Figure 5.

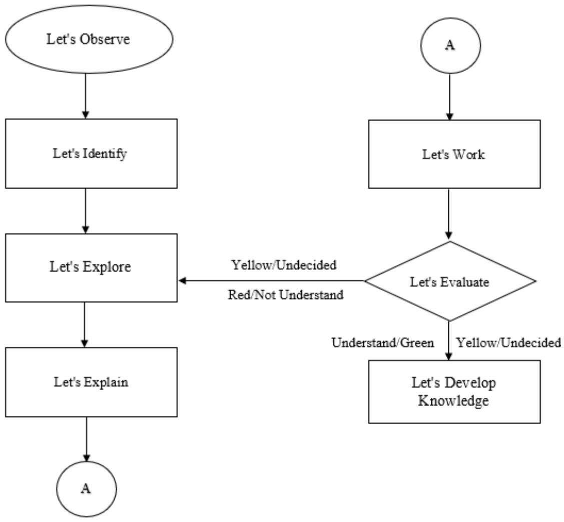


Figure 5. Flowchart of the Material Cycle.

The material presented in the material delivery cycle is divided into six submaterials. The division of submaterials refers to the Physics 2 book for SMA/MA XI (Nurachmandani, 2009) with minor changes and adjustments. The six submaterials are the principle of continuity, bernoulli's law, torricelli's principle, venturimeter and pitot tube, application of bernoulli's law in everyday life, and airplane. The six submaterials begin with an explanation of the ideal fluid requirements at the 'let's observe' stage. The delivery of the submaterial starts at the 'let's explore' to 'let's develop knowledge' stage and is repeated in each submaterial as shown in Figure 6.

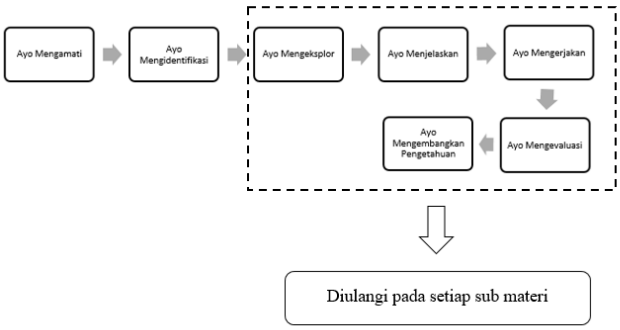
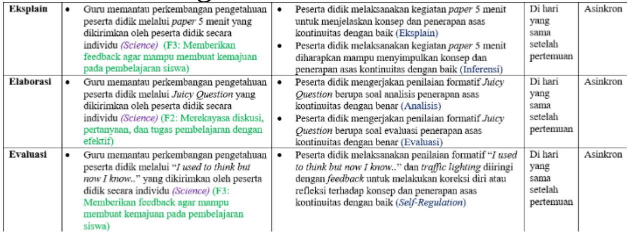


Figure 6: Submaterial delivery.

Furthermore, the product creation cycle that invites students to solve problems by applying the engineering design process (EDP) is integrated into the 7E Learning Cycle model. The first stage of product creation is 'let's observe' which contains a video about the problem of flying roofs due to strong winds. The process of observing the roof problem triggers students to observe the problems around students. With the process of observing this problem, students are trained to think critically by analyzing. After the observation, the second EDP step was to identify problems based on needs and preferences. Then proceed with finding and developing several solutions to the problems that have been found in the 'let's explore' stage. After finding solutions, students are directed to choose the best solution at the 'let's explain' stage with the direction of juicy questions. At this stage, students carry out group presentations to explain the process of selecting the selected solution and its reasons. After getting the solution, students work on the product. Then at the end, an evaluation of the product results was carried out in a presentation. From the presentation, feedback and suggestions for product improvement were obtained. Finally, product improvement is carried out at the 'let's develop the product' stage.

The second subproduct is the teacher's guidebook for implementing learning. In the teacher's guidebook there is a detailed explanation of the implementation of learning to the answer key of the student module. The teacher's guidebook consists of an introduction, learning strategy, evaluation system, achievement indicators, learning objectives, learning materials, teaching and learning activities, instructions for working on the product, and the answer key of the student module. The introduction of the teacher's guidebook explains about the description of the content of the module used. The next section is a learning strategy that explains the STEM approach, the 7E Learning Cycle learning model, formative assessment, critical thinking skills and symbols used in the module. After the explanation of the strategy, followed by an explanation of the media used. Furthermore, it explains the evaluation system of attitudes, knowledge, and skills used in learning and how to access the form that has been filled in by students. Then proceed with indicators to learning activities which are a more detailed form of the lesson plan. The final part explains about working on the product to match the dynamic fluid material.

The third subproduct is the lesson plan. The lesson plans developed consist of core competencies to learning assessment. The designed learning implementation consists of asynchronous and synchronous learning. The learning process begins asynchronously two days before the meeting at the 'let's observe' stage until the exploration stage of reading material explanations and sample problems. The exploration stage is then continued synchronously, namely the implementation of the experiment. Then it is closed with practice problems of two problems to three problems through the link given at the end of the lesson. The exploration stage until the last, 'let's develop knowledge', is carried out asynchronously on the same day after the meeting. The learning activities in this lesson plan are equipped with approaches, formative assessments, and critical thinking skills that are clearly written as in Figure 7.



Eksplain	• Guru memantau perkembangan pengetahuan peserta didik melalui *paper* 5 menit yang dikirimkan oleh peserta didik secara individu *(Science)* (F3: Memberikan feedback agar mampu membuat kemajuan pada pembelajaran siswa)	• Peserta didik melaksanakan kegiatan *paper* 5 menit untuk menjelaskan konsep dan penerapan asas kontinuitas dengan baik (Eksplain) • Peserta didik melaksanakan kegiatan *paper* 5 menit diharapkan mampu menyimpulkan konsep dan penerapan asas kontinuitas dengan baik (Inferensi)	Di hari yang sama setelah pertemuan	Asinkron
Elaborasi	• Guru memantau perkembangan pengetahuan peserta didik melalui *Juicy Question* yang dikirimkan oleh peserta didik secara individu *(Science)* (F2: Merekayasa diskusi, pertanyaan, dan tugas pembelajaran dengan efektif)	• Peserta didik mengerjakan penilaian formatif *Juicy Question* berupa soal analisis penerapan asas kontinuitas dengan benar (Analisis) • Peserta didik mengerjakan penilaian formatif *Juicy Question* berupa soal evaluasi penerapan asas kontinuitas dengan benar (Evaluasi)	Di hari yang sama setelah pertemuan	Asinkron
Evaluasi	• Guru memantau perkembangan pengetahuan peserta didik melalui "*I used to think but now I know..*" yang dikirimkan oleh peserta didik secara individu *(Science)* (F3: Memberikan feedback agar mampu membuat kemajuan pada pembelajaran siswa)	• Peserta didik melaksanakan penilaian formatif "*I used to think but now I know..*" dan *traffic lighting* diiringi dengan *feedback* untuk melakukan koreksi diri atau refleksi terhadap konsep dan penerapan asas kontinuitas dengan baik (*Self-Regulation*)	Di hari yang sama setelah pertemuan	Asinkron

Figure 7. Learning activities in the lesson plan

The clear writing is given so that teachers can directly understand the parts that must be done and focused on the learning stages. The leftmost column shows the learning model, purple writing shows the approach applied, green writing shows the formative assessment used, and dark blue writing shows the critical thinking skills trained.

Critical thinking skills implemented in learning are developed from basic competencies into achievement indicators aimed at practicing critical thinking skills. From these achievement indicators, they are developed into more specific learning objectives. The development of achievement indicators into learning objectives can be seen in Figure 8.

Pertemuan 1	**Pertemuan 1**
3.4.1 Menganalisis dan mengevaluasi konsep asas kontinuitas (Analisis, Evaluasi) 3.4.2 Menjelaskan dan menyimpulkan konsep asas kontinuitas (Eksplanasi, Inferensi) 3.4.3 Mengoreksi atau merefleksikan pengetahuan asas kontinuitas (*Self-Regulation*) 3.4.4 Menginterpretasikan masalah berdasarkan konsep asas kontinuitas (Interpretasi)	3.4.1.1 Melalui video tentang teknologi yang menerapkan prinsip fluida dinamis, peserta didik menganalisis video yang diberikan sehingga dapat memberikan pertanyaan tingkat tinggi dengan baik 3.4.1.2 Melalui penjelasan yang diberikan, peserta didik menginterpretasikan tujuan pembelajaran yang diberikan dengan baik 3.4.1.3 Melalui video dan penjelasan materi, peserta didik menganalisis konsep asas kontinuitas dengan baik 3.4.1.4 Melalui LKPD, peserta didik menganalisis konsep asas kontinuitas dengan benar 3.4.1.5 Melalui LKPD, peserta didik mengevaluasi konsep asas kontinuitas dengan benar

Figure 8. Achievement Indicators and Learning Objectives in the lesson plan

The left column is the achievement indicator and the right column is the learning objective. On the achievement indicators there is dark blue writing which is an indicator of critical thinking skills that are trained. From each achievement indicator there is an assessment that trains students' critical thinking skills.

After the achievement indicators are developed, an assessment is needed to measure student achievement. There are four kinds of assessments used, namely test assessment, performance assessment, portfolio assessment, project assessment delivered in a presentation, and product assessment. Each assessment instrument has an assessment rubric that is tailored to the characteristics of the task given. In one meeting in the material delivery cycle, there are five or six critical thinking essay questions and one student worksheet. In the product creation cycle, the assessment is carried out during the implementation of the presentation and the results of the products that have been made.

As in Figure 8. Achievement indicator 3.4.3 which trains critical thinking skills on the self-regulation indicator, the test assessment is realized in the form of essay questions as in Figure 9.

3.4.3 Mengoreksi atau merefleksikan pengetahuan asas kontinuitas	*Self-Regulation*	Diberikan fenomena , peserta didik mampu menjelaskan perkiraan jumlah kapiler dan menjelaskan relevansi penjelasannya dengan asas kontinuitas secara benar.	 Ketika ujung selang tidak ditutup, kecepatan air lambat. Namun ketika ujung selang tertutup sebagian, kecepatan fluida meningkat. Mengapa fenomena ini dapat terjadi? (Cutnell & Johnson, 2012)	Ketika ujung selang terbuka, luas penampang selang lebih lebar daripada ketika sebagian selang tertutup. Sesuai dengan asas kontinuitas $A_1 v_1 = A_2 v_2$ Maka, kecepatan aliran pada ujung yang tidak tertutup lebih lambat daripada ujung yang ditutup sebagian.

Figure 9. Development of Achievement Indicators to Questions in the lesson plan

The order from left to right column is achievement indicators, critical thinking indicators, item indicators, questions, and answers. Making critical thinking questions refers to several book sources [1]–[4], [6], [73]–[80] with necessary changes. The essay questions were assessed using a critical thinking assessment rubric according to the indicators being assessed. For example, in Figure 9, the indiator assessed is self-regulation, so the assessment rubric used is part of the self-regulation indicator as in Figure 10.

Self-Regulation	4	Diberikan fenomena atau asumsi, peserta didik mampu menjelaskan penyebab peristiwa dapat terjadi berdasarkan pengetahuan yang mereka ketahui dan menjelaskan relevansi penjelasannya dengan konsep/hukum/prinsip yang benar.
	3	Peserta didik mampu menjelaskan penyebab peristiwa tersebut dapat terjadi berdasarkan pengetahuan yang mereka ketahui namun kurang tepat dalam menjelaskan relevansi penjelasan mereka dengan yang benar konsep/hukum/prinsip.
	2	Peserta didik mampu menjelaskan penyebab peristiwa tersebut dapat terjadi berdasarkan pengetahuan yang mereka ketahui, tetapi tidak dapat menjelaskan relevansi penjelasan mereka dengan konsep/hukum/prinsip.
	1	Tidak dapat meregulasi pengetahuan

Figure 10. Critical Thinking Ability Assessment Rubric

The far left is the indicator being assessed, the center is the value/score, and the right is the criteria that must be met.

For the skills part of the material delivery cycle, the achievement indicators are implemented through experimentation and exploration activities as shown in Figure 11. The assessment used is performance assessment for experimentation activities and portfolio assessment for exploration activities.

4.4.1 Melaksanakan percobaan asas kontinuitas 4.4.2 Melaksanakan percobaan hukum bernoulli 4.4.3 Melaksanakan percobaan asas toricelli 4.4.4 Melaksanakan eksplorasi prinsip kerja dan cara menggunakan venturimeter dengan manometer	**Pertemuan 1** 4.4.1.1 Peserta didik melaksanakan percobaan asas kontinuitas menggunakan simulasi PhET dengan baik **Pertemuan 2** 4.4.2.1 Peserta didik melaksanakan percobaan hukum bernoulli menggunakan simulasi PhET dengan baik **Pertemuan 3** 4.4.3.1 Peserta didik melaksanakan percobaan asas torricelli menggunakan simulasi PhET dengan baik

Figure 11. Indicators of Achievement for the Skills Section

On the left are achievement indicators and on the right are learning objectives. For experimental activities, using performance assessment with the type of self-assessment as in Figure 12.

No.	Pernyataan	4	3	2	1
1	Saya membaca tujuan dari percobaan terlebih dahulu sebelum melakukan percobaan				
2	Saya mempelajari materi mengenai percobaan yang akan dilakukan terlebih dahulu				
3	Saya menyiapkan alat dan bahan sesuai dengan percobaan yang akan dilakukan				
4	Saya melakukan percobaan sesuai dengan langkah kerja				

Figure 12. Rubric for Assessment of Work

Students put a check mark on the score number that represents conformity with the statement. For exploration activities using portfolio assessment carried out by the teacher using a rubric as in Figure 13.

Aspek	Skor	Keterangan
Kesesuaian konsep	4	Penjelasan yang disampaikan menjawab pertanyaan dengan benar dan sesuai dengan konsep
	3	Penjelasan yang disampaikan menjawab pertanyaan kurang benar dan sesuai dengan konsep
	2	Penjelasan yang disampaikan menjawab pertanyaan benar dan kurang sesuai dengan konsep
	1	Penjelasan yang disampaikan menjawab pertanyaan dengan salah dan tidak sesuai dengan konsep
Kebenaran fakta	4	Penjelasan yang disampaikan relevan dengan pertanyaan dan sesuai dengan fakta yang terjadi
	3	Penjelasan yang disampaikan tidak relevan dengan pertanyaan dan sesuai dengan fakta yang terjadi
	2	Penjelasan yang disampaikan relevan dengan pertanyaan namun tidak sesuai dengan fakta yang terjadi
	1	Penjelasan yang disampaikan tidak relevan dengan pertanyaan dan tidak sesuai dengan fakta yang terjadi
Bahasa yang lugas	4	Penjelasan menggunakan bahasa yang baik, benar, dan mudah dipahami
	3	Penjelasan menggunakan bahasa yang baik, benar, namun kurang mudah dipahami
	2	Penjelasan menggunakan bahasa yang baik, benar, namun tidak mudah dipahami
	1	Penjelasan tidak menggunakan bahasa yang baik, benar, dan mudah dipahami

Figure 13. Portfolio Assessment Rubric

The left part is the aspect assessed by the teacher, the center is the score, and the right part is the criteria that must be met.

In the product creation cycle, the indicators of achievement were developed as in Figure 14. The assessments carried out were project assessments delivered in presentations and product assessments to assess the product as a whole.

Pertemuan 7 4.4.7 Mencari permasalahan yang sesuai dengan konsep fluida dinamis secara berkelompok (Analisis) 4.4.8 Melakukan diskusi untuk mengidentifikasi masalah yang ditemukan berdasarkan kebutuhan dan preferensi (Interpretasi) 4.4.9 Melakukan diskusi untuk mengumpulkan informasi digunakan dalam mengembangkan solusi yang memungkinkan (Analisis, Evaluasi) 4.4.10 Melakukan diskusi memilih solusi yang terbaik dan mempresentasikan pada kelompok lain melalui video presentasi tentang alasan pemilihan solusi (Eksplanasi, Inferensi)	**Pertemuan 7** 4.4.7.1 Dengan menggunakan *Juicy Question* untuk menganalisis masalah yang ditemukan, peserta didik mencari permasalahan yang sesuai dengan konsep fluida dinamis secara berkelompok dengan baik 4.4.8.1 Dengan menggunakan *paper* 5 menit, peserta didik melakukan diskusi untuk mengidentifikasi masalah yang ditemukan berdasarkan kebutuhan dan preferensi dengan baik 4.4.9.1 Dengan menggunakan *paper* 5 menit, peserta didik melakukan diskusi untuk mengumpulkan informasi digunakan dalam mengembangkan solusi yang memungkinkan 4.4.10.1 Dengan menggunakan *Juicy Question,* peserta didik melakukan diskusi untuk memilih solusi terbaik dari permasalahan yang ditemukan dengan baik 4.4.10.2 Peserta didik mempresentasikan alasan pemilihan solusi yang dipilih melalui video dengan baik

Figure 14. Achievement Indicators of the Product Creation Cycle

Indicator 4.4.10 carried out a presentation to convey the solution of the problem taken. In this presentation activity, the project assessment used is adjusted to the process of taking values. The assessment rubric used in this activity is as shown in Figure 15.

Penguasaan materi presentasi	4	Menguasai materi dengan baik dan tidak salah konsep
	3	Kurang menguasai materi namun tidak salah konsep
	2	Menguasai materi dengan baik namun ada salah konsep
	1	Kurang menguasai materi dan ada salah konsep
Kemampuan menjawab/argumentasi	4	Jawaban yang disampaikan benar, rasional, dan jelas
	3	Jawaban yang disampaikan benar, rasional, namun kurang jelas
	2	Jawaban yang disampaikan benar namun kurang rasional dan kurang jelas
	1	Jawaban yang disampaikan kurang benar, kurang rasional, dan kurang jelas
Kemampuan memanfaatkan media	4	Media yang dimanfaatkan sangat tepat, menarik, dan menunjang ketergunaan
	3	Media yang dimanfaatkan kurang tepat namun menarik
	2	Media yang dimanfaatkan tepat namun kurang menarik
	1	Media yang dimanfaatkan kurang tepat, kurang menarik, dan kurang menunjang ketergunaan

Figure 15. Project Assessment Rubric

The left part is the aspect that is assessed in the implementation of the presentation, the middle and right parts are the same as in the previous assessment. For the product assessment used is the rubric in Figure 16.

Modifikasi dan Improvisasi Produk (G)	4	Memodifikasi dan mengimprovisasi hasil produk yang telah dibuat sesuai dengan hasil uji coba, membandingkan produk, dan koreksi
	3	Memodifikasi dan mengimprovisasi hasil produk yang telah dibuat sesuai dengan hasil uji coba dan membandingkan produk, namun tidak sesuai koreksi
	2	Memodifikasi dan mengimprovisasi hasil produk yang telah dibuat sesuai dengan hasil uji coba, namun tidak sesuai membandingkan produk dan koreksi
	1	Memodifikasi dan mengimprovisasi hasil produk yang telah dibuat tidak sesuai dengan hasil uji coba, membandingkan produk, dan koreksi

Figure 16. Product Assessment Rubric

The number of aspects assessed in the product assessment is seven. The number of aspects is adjusted to the number of stages in making the product.

After carrying out the define and design stages, continue with the develope stage. At this stage, validity testing was carried out through expert validation, subject matter teachers, and users. Expert validation was carried out by one of the Malang State University lecturers, validation of the subject teacher was carried out by one of the physics subject teachers of SMA Brawijaya Smart School, and user validation or readability testing was carried out by SMA Brawijaya Smart School students. During the expert validation, there were inputs on three parts, namely the concept map, the title of the teacher's guidebook, and the learning objectives. The following is a view of the concept map, title of the teacher's guide, and learning objectives before revision and after revision.

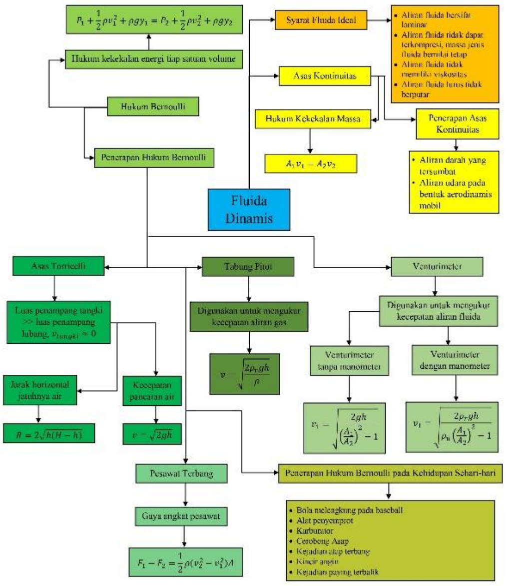


Figure 17. Concept Map Before Revision

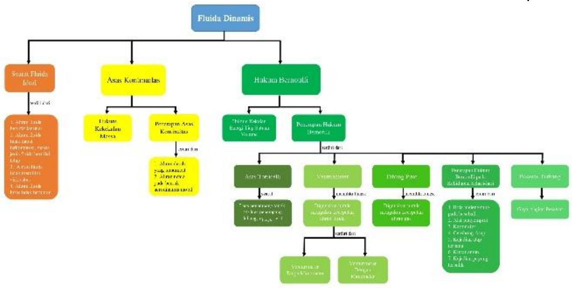


Figure 18. Revised Concept Map

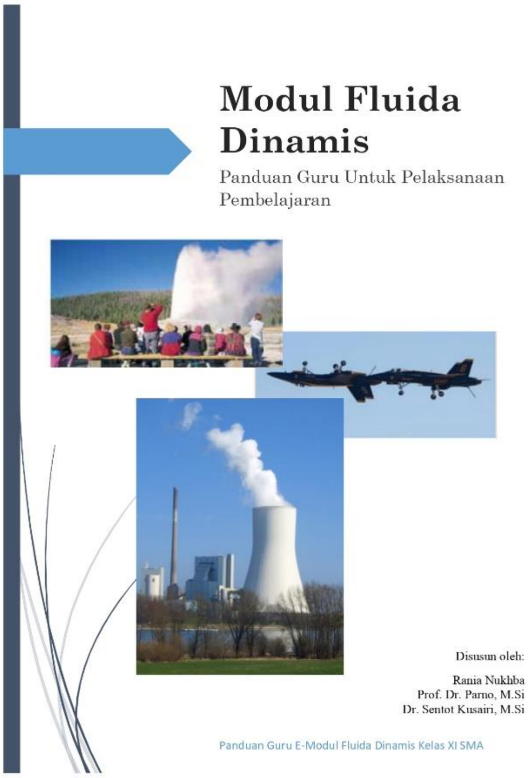


Figure 19. Cover of Teacher's Manual Before Revision

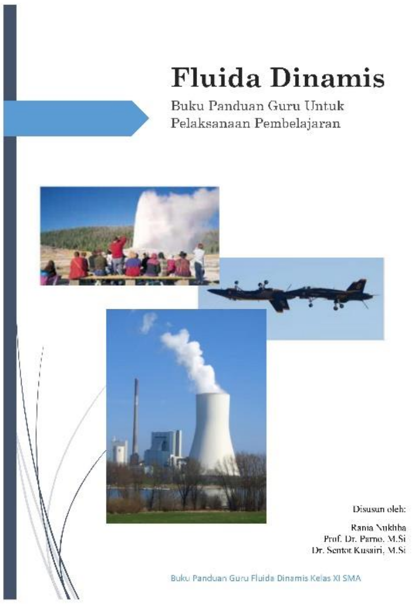


Figure 20. Cover of the Teacher's Manual After Revision

Pertemuan 2

3.4.5.1 Melalui gambar dan penjelasan materi, peserta didik diharapkan mampu menganalisis konsep hukum bernoulli dengan baik
3.4.5.2 Melalui LKPD, peserta didik diharapkan mampu menganalisis konsep hukum bernoulli dengan benar
3.4.5.3 Melalui LKPD, peserta didik diharapkan mampu mengevaluasi konsep hukum bernoulli dengan benar
3.4.5.4 Melalui penilaian formatif *Juicy Question* diiringi dengan *feedback*, peserta didik diharapkan mampu menganalisis hukum bernoulli dengan benar
3.4.5.5 Melalui *feedback* yang diberikan pada penilaian formatif *Juicy Question*, peserta didik diharapkan mampu mengevaluasi hukum bernoulli dengan baik

Figure 21. Learning Objectives Before Revision

Pertemuan 2

3.4.5.1 Melalui gambar dan penjelasan materi, peserta didik menganalisis konsep hukum bernoulli dengan baik
3.4.5.2 Melalui LKPD, peserta didik menganalisis konsep hukum bernoulli dengan benar
3.4.5.3 Melalui LKPD, peserta didik mengevaluasi konsep hukum bernoulli dengan benar
3.4.5.4 Melalui penilaian formatif *Juicy Question* diiringi dengan *feedback*, peserta didik menganalisis hukum bernoulli dengan benar
3.4.5.5 Melalui *feedback* yang diberikan pada penilaian formatif *Juicy Question*, peserta didik mengevaluasi hukum bernoulli dengan baik
3.4.5.6 Melalui kegiatan *Juicy Question*, peserta didik menganalisis fenomena yang diberikan berdasarkan konsep hukum bernoulli dengan benar

Figure 22. Learning Objectives After Revision

When validation was conducted with a physics lecturer at State University of Malang, there were three parts that received input. These were the concept map, the title of the teacher's guide, and the learning objectives. In the concept map section, there was an input. Because the concept map is a summary of the concept that shows the relationship between concepts (Chusni, Sanjaya, Assani, & Suryani, 2010), If the concept map is not in the form of a chart, it makes it difficult for the reader to know the equality and division of material. The second part that received feedback was the title of the teacher's guide, which was originally named the teacher's guide module. This is because the book serves to provide information to teachers in the form of steps in implementing learning, so it is more appropriate to be called a teacher's guide book (Bachtiar, Yudianto, & Sugiarti, 2021). The third part that received input was the sentence in the learning objectives, which eliminated the word able and went directly to the operational verbs.

In addition to the revision of these sections, expert and subject teacher validations were also carried out. The results of the expert and teacher validation of SMA BSS Malang are shown in tables IV, V, and VI. There are three parts that are carried out validity tests, namely the validity test of lesson plans, materials, and media. In the validity test part of the lesson plan, there are three aspects, namely the validity of the lesson plan components, the validity of the content, and the language. For the material validity test, there are also three aspects, namely the validity of the content in the e-module material, conformity with the STEM - 7E Learning Cycle accompanied by formative assessments, and presentation of content. For the media validity test, there is one general comment from the validator.

Table 3. Results of the lesson plan validity test

Aspects	Percentage	Category
Component validity of lesson plan	100%	Very Valid
Content Validity	100%	Very Valid
Linguistics	100%	Very Valid

Table 4. Material Validity Test Results

Aspects	Percentage	Category
Content Validity: e-Module Materials	100%	Very Valid
Conformance to STEM - 7E Learning Cycle with Formative Assessment	100%	Very Valid
Content Presentation	100%	Very Valid

Table 5. Media Validity Test Results

Aspects	Percentage	Category
Suitability of e-Module Components	100%	Very Valid
Linguistics	100%	Very Valid
Graphics	100%	Very Valid

Table 6. Media Validity Test Comments

Comments	Some formula sizes are not the same, the quality of formula images and some supporting material images look a bit blurry.

Comments, suggestions, and inputs obtained at the validation stage were general comments on the validity test of the media. The general comments are 'Some formula sizes are not the same, the quality of formula images and some supporting material images look a bit blurry'. The formula or equation displayed on the website is an equation in the form of an image. Equations are entered on the website using the Latex Equation Editor Online. This is because the way to enter formulas cannot be done by editing on website programming because it is based on drag and drop (Arif, 2021).

After validation with physics lecturers, continued validation with subject teachers and received verbal feedback. The input given is relevant to the state of learning during this pandemic. Decreased learning independence during this pandemic has been found in many schools (Etika Rahmawati et al., 2021; Maghfirin, Kurniati, & Kusumawati, 2021; Sulistyowati & Amri, 2021). With this website-based student module, it is expected to be able to increase student learning independence. However, further testing is needed to determine the effect of web-based modules on student independence. In addition to having an impact on student learning independence, this pandemic also has an impact on synchronous meetings held by schools. Therefore, it is recommended to shorten the number of meetings. However, with the delivery of fast material, other obstacles arise, namely students having difficulty in understanding the material (Noverdika, 2021).

After the validation of experts and physics teachers, it was followed by a readability test on 32 students of SMA BSS Malang. With 16 statements using a Guttman scale in the form of yes and no answers, the readability test result was 98.25%. The readability test received various comments, inputs, and suggestions from students. In general, these comments, inputs and suggestions can be summarized into six comments, inputs and suggestions as shown in table 7.

Table 7. Comments, Feedback, and Suggestions from Students

	Comments, Feedback and Suggestions
1	Coherent explanation and complete information
2	Interesting module different from others easy to understand
3	The appearance of the module and the content of the module are interesting, the language used is quite easy to understand, and the images displayed can make it easier to understand the learning material.
4	Sorry in advance, there should not be too much analysis because it is a bit confusing and makes you bored quickly, the rest is good.
5	Already good, the color selection may be made more colorful and interesting
6	The design of the website could be further enhanced

The fourth comment was 'Sorry in advance, there should not be too much analysis because it is a bit confusing and makes you bored quickly, the rest is good'. This is due to the importance of the analysis indicator, which is to develop a solution strategy (Seventika, Sukestiyarno, & Mariani, 2018). Increasing the number of analysis indicators at several stages is a form of consideration of Seventika's suggestion (Seventika et al., 2018). The fifth comment was 'It's good, the color selection might be made more colorful and interesting'. The sixth comment was 'The website design could be improved'.

Overall, the learning tools developed are better than learning tools that have been developed before. Learning devices on dynamic fluid material that have been developed previously in the last 5 years are learning devices using teaching aids (Mumu, Dungus, & Mondolang, 2021) and STEM learning tools with the help of learning videos (Aldi, Doyan, & Susilawati, 2022). The first learning device is a learning device using teaching aids getting validation results of learning device experts 98.9%, learning media experts 96.7%, material experts 86.7% (Mumu et al., 2021), and 89.4% readability validation (Mumu et al., 2021). The second learning device is a STEM learning device with the help of a learning video developed to get the results of validation of the lesson plan 85.25%, syllabus 88.25%, student worksheet 84.75%, instrument 85.50%, and video 89.50%. (Aldi et al., 2022). Overall, the learning tools that have been developed have lower validation results than this learning tool. However, the learning tools on dynamic fluid material that have been developed still do not aim to improve critical thinking skills.

CONCLUSIONS

Based on the results of research and development of STEM-7E Learning Cylce learning device products with formative assessment as an effort to improve critical thinking skills, it gets a very valid and very practical category. The results of the validity of the validation test of the lesson plan get a percentage of 100% and in a very valid category. For the results of the material validation test, the percentage is 100% and in the very valid category. For the results of the media validation test, the percentage of 100% san in the category is very valid. Then proceed with the readability test. From the readability test, the results obtained 98.25% and got a very practical category.

Based on the results of research and development that has been carried out, the learning tools developed still have shortcomings. The first suggestion is for researchers who will conduct similar research and development, namely paying attention to several aspects. The first aspect is the number of meetings that need to be adjusted to the implementation of learning in general and not too fixated on the number of hours in the semester program or annual program. The second aspect is the appearance of the module website needs to be developed to be more attractive. The third aspect is the assessment instrument, so that the validation test is carried out. The fourth aspect is to ensure that validators understand the treatment or type of product developed and increase the number of expert validators. The fifth aspect is to carry out a readability test on the product used by the teacher. The second suggestion is for the continuation of research and development, this learning tool will be maximized by continuing the effectiveness test.

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