



THE DEVELOPMENT OF STUDENTS' WORKSHEET BASED ON STEM (SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS) TO IMPROVE CRITICAL THINKING ABILITY ON HUMAN EXCRETION SYSTEM MATERIALS

¹Meiranda Simanullang, ²Halim Simatupang, and ³Abdul Pulungan

^{1,2} Science Education Study Program, Universitas Negeri Medan, Indonesia

³ Science teacher at 35th Junior High School Medan

meirandasimanullang@mhs.unimed.ac.id.

Accepted: June 8th, 2022. Published: July 8th, 2022

Abstract

This study aims to see the feasibility based on the assessment of material experts, linguists & education experts, the responses of educators and students as well as the effectiveness of the STEM (Science, Technology, Engineering, Mathematics) based students' worksheet to improve the critical thinking skills at VIII SMP students. The sample of this study was students of class VIII-10, totaling 30 people. this type of research is research and development (R&D) using the ADDIE model. The instrument used in this study consisted of a material expert validation questionnaire, linguist & education expert, a questionnaire for educators and students' responses. The test is in the form of an essay to measure the level of students' critical thinking skills on the human excretory system material. Based on the results of the study obtained data from material expert validation of 70.16, validation of linguists & education experts 69.04 with each in the appropriate category. The response of students in the small group trial with a sample of 3 people was 75.97%, while in the limited group trial the percentage of student responses with a sample of 30 people was 77.79% with each criterion very feasible, so based on the results of the students' worksheet validation This is suitable for use in the learning process. Students' worksheet which is designed effectively to improve students' critical thinking skills, the results of students' critical thinking skills are obtained with an average N-Gain value of 0.77 with high criteria.

Keywords: Students' Worksheet, STEM, Critical Thinking Ability

Introduction

The needs of the 21st century require every individual to have various skills, namely creative thinking skills, problem solving, and communication skills. Entering the era of globalization and facing challenges students can have the skills to communicate, collaborate, think critically, creatively, or what is known as the 4C skills.. (Hermansyah, 2020).

According to PISA (Program for International Student Assessment) data (2018), Indonesia ranks very low in student achievement in science at 69 out of 77 countries (PISA, 2018). Meanwhile, based on TIMSS data (Trends in International Mathematics and Science Study), Indonesia's cognitive abilities are ranked 44 out of 47 which is very low, especially in Mathematics and Science. (TIMSS, 2015). Based on these facts, it can be concluded that the knowledge of science concepts in Indonesia is very low (Walfajri and Harjono, 2019).

Many branches of knowledge are taught in schools. One of them is Natural Sciences (IPA). Natural science is one of the subjects in junior high school, in this lesson students are explained about natural and surrounding phenomena that occur and how to solve problems that exist in everyday life as well (Hutagaol, 2021). The purpose of learning science is to develop critical thinking skills, scientific skills, and conceptual knowledge. In science learning, students must be able to find relationships in equations and then connect concepts with life around them (Rohmah and Nurita, 2017). An important element in learning science is being able to obtain products and processes, so that critical thinking can be raised. An individual will be able to make and decide things through consideration with critical thinking skills. Even critical thinking skills greatly affect one's future life, so critical thinking can be used as a tool for success in this global era of the 21st century (Hidayati, Fadly and Ekapti, 2021).

The results of the pre-research through observation activities that have been carried out by researchers in class VIII science material at SMP Negeri 35 Medan using a questionnaire, it is found that the

implementation of science learning by teachers is still dominant using the lecture method and student center with the answers "Always" and "Often" got the most responses. Then students are still not familiar with the critical thinking ability test. The most responses to the critical thinking ability test carried out can be seen the results, namely "Never" and "Sometimes". This fact is also supported by the results of the critical thinking ability test for class VIII students in the first semester of science material on the Human Digestive System material by researchers, It can be seen that students' critical thinking skills are still very low. With an average value of 32,16. This indicates that science learning carried out in schools does not support students to have critical thinking skills.

Low critical thinking skills can occur because learning only focuses on material with a system of memorizing concepts but not applying them directly, so they do not have the opportunity to analyze problems, identify, summarize or propose ideas or even provide new solutions to certain problems. Learning does not encourage students to think critically (Fithri *et al.*, 2021).

Students' critical thinking skills can be improved with appropriate learning methods and approaches. Among these approaches, the STEM-based approach (Science, Technology, Engineering, and Mathematics) is able to improve individual critical thinking skills. (Changtong, Maneejak and Yasri, 2020). The STEM approach itself is an innovative learning approach with the aim of developing science skills, technology skills, engineering, and mathematics to prepare students who can compete globally (Wisudawati, 2018). To train critical thinking skills and understanding individual science material, the STEM approach is an effective and feasible way to be applied. This is because the STEM approach in the learning process trains students to develop science, technology, engineering science and mathematics skills for problem solving, building competence and tolerance (Parmin *et al.*, 2020).

Critical thinking can be developed through a STEM based approach that is integrated with Project Based Learning

(PjBL). Learning objectives can be achieved because of the following important roles such as teachers, learning media, learning resources ect. Learning media is one of these aspects. Interesting, informative and innovative media are good media to be used as learning media, (Simanullang and Simanjuntak, 2021), and one of them is students' worksheet. There are three objectives of the research conducted, namely: (1)to know the feasibility of STEM-based Student Worksheets (Science, Technology, Engineering, Mathematics) in improving critical thinking skills in the human excretory system material for class VIII SMP according to material experts, linguist & learning experts, (2)to know the teacher's response and the student's response to the STEM-based Student Worksheet (Science, Technology, Engineering, Mathematics) in improving critical thinking skills in the human excretory system material for class VIII SMP and (3)to know the effectiveness of students' worksheet based on STEM Science, Technology, Engineering, Mathematics) in improving students' critical thinking skills on excretory system material in humans.

Research Method

This research was conducted at SMP Negeri 35 Medan in the academic year 2021-2022. This type of research is Research and Development (R&D) with the ADDIE model (analysis, design, development, implementation, and evaluation). The population in this study were all eighth grade students of SMP Negeri 35 Medan and the sample was class VIII-10. The sampling technique in this study used simple random sampling. Questionnaires, interviews, test instruments with five essay questions were used as data collection techniques. Instrument validity is done first. The validity test of this instrument is given through a validity sheet to material experts, linguists & by using a Likert Scale and can be seen in table 1.

Table 1. Likert Scale Expert Team Validation Questionnaire

No	Quantitative Analysis	Statement	
		Positive	Negative
1	Strongly agree	4	1
2	Agree	3	2
3	Do not agree	2	3
4	Strongly Disagree	1	4

The questionnaire was addressed to educators and students to see the responses and feasibility of the developed worksheets. In measuring the increase in students' critical thinking skills, the pretest and posttest scores were compared through a written test with essay questions which is analyzed through a normalized gain score with the following formula:

$$(g) = \frac{100\% (S_f) - \% (S_i)}{100\% - \% (S_i)}$$

(Hake, 1999)

Description :

(g) =gain value

S_f = skor rata – rata pretest

S_i =posttest mean score

The following is a table of values from the interpretation of N-gain

Table 2. Interpretation of N-gain value

N-gain value	Interpretation
$g \geq 0.7$	Tall
$0.7g > \geq 0,3$	Currently
$g < 0.3$	Low

(Sundayana, 2014:174)

Result and Discussion

The product of this research is in the form of student worksheets to improve students' critical thinking skills on the human excretory system material for class VIII SMP. in accordance with the ADDIE stage, the activity of analyzing characteristics and analyzing the needs of students and next analyzing the needs of teachers is the first action carried out in the analysis stage. Initial analysis was conducted to find the problems faced by

students and teachers in the learning process in the four research schools.

The researchers found that the character of the students needed innovative and student-centered learning media in the implementation of science learning. But in reality, educators/teachers rarely used varied and innovative media and learning methods so that students were less enthusiastic in learning. Students need innovative learning media in the process of implementing science learning to be something that can be used because they get very high scores. In the implementation of learning, a variety of learning resources, methods and teaching strategies were needed that were able to foster the enthusiasm of students to create fun learning (Hamidah and Ratnasari, 2020). To increase effectiveness in learning, it was necessary to develop innovative and creative learning by using learning media to convey learning messages through the learning process (Miqro, Baiq and Zulandri, 2019).

Researchers also found that it was necessary to develop innovative learning, able to create and measure students' critical thinking skills. The results of the questionnaire that has been conducted to measure the ability of students by the teachers 44% and the implementation of science learning in the classroom is able to create critical thinking skills of the 44,4% students provide evidence of these facts. The ability of students to learn and make them active can be realized by using students' worksheet (Ndia et al., 2021). There are several problems and things that are needed by the teacher when carrying out the learning process and these are obtained through the interview process. The results obtained were the limited ability of educators in making learning media that is able to involve the activeness of students, educators by the teachers when carrying out the learning process and these are obtained through the interview process. Learning media that are able to measure the ability of students' critical thinking levels and educators need learning media in the form of innovative and interesting students' worksheet.

The design stage was the stage of designing the learning media that will be

developed. At this stage the learning media developed is the STEM (Science, Technology, Engineering, Mathematics)-based Student Worksheet with the same title. In the implementation of the learning process with the STEM approach, it is closely related to the STEM indicators themselves, determining the instrument for the validation sheet research of the material experts and linguist & education experts, and determining the questionnaire instrument for the responses of educators and students. The product of developing students' worksheet is useful for improving work activities such as thinking, and analysing the results of investigations in student activities (Shabila, Bhakti and Fatahillah, 2020).

The development stage is the stage where researchers produce products that have been designed. Things that are done at the development stage are:

Assessment by material experts can be seen in the results of table 3.

Table 3. Material Expert students' worksheet Validation Results.

No	Aspect	Percentage
1	Content/material Componen	35,63
2	Serving componen	41,37
3	Critical Thinking Indicator	22,98
Avarage Percentage %		70,16
Category		Worthy

The assessment by a material expert on the students' worksheet developed by the researcher obtained results that were declared eligible for use without revision. The products developed are then assessed and based on the feasibility of components/materials 35,63%, the feasibility of presentation components 41,37%, the feasibility of critical thinking indicators 22,98%. So the average percentage for assessment by material experts is 70.16% and this assessment is included in the proper category. A valid assessment from a material expert indicates that the students' worksheet developed is in accordance with the provisions and competency standards and achievement indicators that must be achieved in accordance with the applicable 2013

curriculum (Safitri, Oktaviani and Isnani, 2019).

The result of the assessment by linguist & education in table 4 below.

Table 4. Language & Education Validation Results

No	Aspect	Persentase
1	Language Component	72,41
2	Critical Thinking Indicator	27,58
Avarage Percentage %		69,04
Category		Worthy

Assessment by linguists & education experts on the worksheets developed by researchers obtained results that were declared eligible for use without revision. The assessment for the LKPD that was developed got a percentage of the feasibility of the language component 72.41%, the feasibility of the critical thinking indicator 27.58%. Then the average percentage for assessment by material experts is 69.04 and this assessment is included in the appropriate category.

Valid assessment from linguists & education experts indicates that the developed worksheets were in accordance with EYD (Perfected Spelling) which means that the sentences used are clear and do not cause confusion and ambiguity. In terms of delivering information and messages, the students' worksheet developed was interesting. The language in the students' worksheet was effective and communicative so that it was easy to understand in the learning process (Sari, Taufina and Fachruddin, 2020).

The implementation stage was carried out after the validation test from the expert has met the appropriate category. At this stage the researchers conducted small group trials and limited group trials. Taking student responses in small groups to student worksheets is carried out to obtain some information about student responses through trials. Responses were taken to 3 students of class VIII. The data in table 5 below presents the results of small group responses.

Table 5 Results of Small Group Student Responses

No	Aspek	Persentase
1	Language Component	56,64
2	Critical Thinking Indicator	19,33
Avarage Percentage %		75,97
Category		Worthy

Based on the responses of small group students to STEM-based students' worksheet (Science, Technology, Engineering, Mathematics) for the human excretory system material, the percentage of eligibility for language components was 56.64%, the percentage of eligibility indicators for critical thinking was 19.33%. So the average percentage of responses from the small group was 75.97% with a very decent category. The trial of using the product has the aim of knowing the benefits of the product, the magnitude of the attractiveness, the convenience of the product (Sumarni, Wijayati and Supanti, 2019).

Taking student responses in a limited group was carried out after a small group trial to obtain information on student responses to the students' worksheet product developed for 1 class VIII as many as 30 students. The data in table 6 presents the results of student responses in large groups..

Table 6 Responses of Limited Group Students

No	Aspek	Persentase
1	Language Component	58,14
2	Critical Thinking Indicator	19,65
Avarage Percentage %		77,79
Category		Worthy

Based on the responses of large group students to the STEM-based students' worksheet on the human excretory system material, the researchers found that the developed students' worksheet was easy to, students are trained to think critically and it is easier to understand lessons, especially the human excretory system. The students' worksheet developed was practical in terms of convenience because it was clear and attractive. The students' worksheet used makes it easier for teachers and helps students to be able to analyze, think and compile their own results from the implementation of activities through the

abilities that students have (Uum, Novaliyosi and Yani, 2020).

Products that have been declared valid are then given to educators to be asked for a response or response The results of the responses of science educators can be seen in Figure 7 below.

Table 7. Responses of science educators

Aspect	Percentage
Components of the formulation of learning objectives	8,87
Graphic component	12,09
Material Component	16,12
Language Component	16,12
Critical Thinking Indicator	12,09
Total percentage	2025
Percentage Average %	49,17
Category	Layak

Based on the results of the responses from the educators, it was found that the presentation of material on STEM-based students' worksheet on the human excretory system material that was developed makes it easier for readers to learn the material, helps students to increase critical thinking skills and was very beneficial for both educators and students. The use of STEM-based students' worksheet according to needs was helped students build knowledge that was tailored to the needs of each student (Aprilianti and Astuti, 2020).

The next stage is the evaluation stage which is carried out after the implementation stage is completed. At this stage the researcher gave a final test to students in the form of a post-test. Based on the result, it was found that there were no students who completed the pretest with the highest score of 65 and the lowest score of 15. The number of students who completed the posttest was 30 people with the highest score of 95 and the lowest score of 75. So the average value of the pretest was 32, 16% and posttest by 85%. The results of the N-Gain calculation are presented in table 8 below.

Table 8 Calculation Results of N-Gain
Score Avarage

Class	Pretest	Posttest	N-Gain	Criteria
VIII-10	32,16	85	0,77	High

The results of the pre-research that had been carried out previously saw the results of the 30 students' critical thinking ability pretest incomplete. The highest score obtained by students is 65 and the lowest score is 15. Furthermore, the posttest score obtained by students on the results of the critical thinking ability test is complete for all 30 students with the highest score being 95 and the lowest score being 75. So the average value is the average pretest is 32.16 and the posttest is 85.

N-Gain data processing presents high criteria because the students' score gets an N-Gain score of 0,77. STEM was considered to have the ability to grow students who were proficient in learning, creative, communicative and critical. LKPD developed based on STEM is able to provide a forum for students to experiment, create learning that requires students to be active and always try (Safitri, Oktaviani and Isnani, 2019)).

Conclusion

Based on the results and discussion, it can be concluded that : (1) Student Worksheets based on STEM (Science, Technology, Engineering, Mathematics) can improve critical thinking skills in the human excretory system material for class VIII SMP is categorized as suitable for use and used for learning media based on the validation of material experts and linguists & education experts.

(2) Based on the responses of educators to Student Worksheets based on STEM (Science, Technology, Engineering, Mathematics) can improve critical thinking skills in the material of the human excretory system of class VIII SMP is declared feasible to be used as a learning medium. Based on the responses of students through small group and limited group assessments, it is stated that they are very suitable for use in learning

(3)Based on the results of the N-Gain calculation, the average category "High" shows that STEM-based Student Worksheets (Science, Technology, Engineering, Mathematics) can improve critical thinking skills in the human excretory system material for class VIII

SMP has an effect on increasing ability students' critical thinking

Reference

- Aprilianti, P. P. and Astuti, D. (2020) 'Pengembangan Lkpd Berbasis Stem Pada Materi Bangun Ruang Sisi Datar SMP Kelas VIII', *Jurnal Pembelajaran Matematika Inovatif*, 3(6), pp. 653–702. doi: 10.22460/jpmi.v3i6.691-702.
- Changtong, N., Maneejak, N. and Yasri, P. (2020) 'Approaches for Implementing STEM (Science, Technology, Engineering & Mathematics) Activities among Middle School Students in Thailand', *International Journal of Educational Methodology*, 6(1), pp. 185–198. doi: 10.12973/ijem.6.1.185.
- Fithri, S. *et al.* (2021) 'Implementasi LKPD Berbasis STEM untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik', *Jurnal Pendidikan Sains Indonesia*, 9(4), pp. 555–564. doi: 10.24815/jpsi.v9i4.20816.
- Hake, R. R. 1999. Analyzing Change/Gain Scores.
- Hamidah, I. and Ratnasari, A. (2020) 'Spizaetus: Jurnal Biologi dan Pendidikan Biologi', *Spizaetus: Jurnal Biologi dan Pendidikan Biologi*, (October), pp. 21–26.
- Hermansyah, H. (2020) 'Pembelajaran IPA Berbasis STEM Berbantuan ICT dalam Meningkatkan Keterampilan Abad 21', *Jurnal Ilmiah Profesi Pendidikan*, 5(2), pp. 129–132. doi: 10.29303/jipp.v5i2.117.
- Hidayati, A. R., Fadly, W. and Ekapti, R. F. (2021) 'Jurnal Tadris IPA Indonesia Analisis Keterampilan Berpikir Kritis Siswa pada Pembelajaran IPA', *Jurnal Tadris IPA Indonesia*, 1(1), pp. 34–48.
- Hutagaol, M. W. (2021) 'Analysis of Sciences Student Problem Solving Skills At Junior High School Students Ipa Lessons', *ISER (Indonesian Science Education Research)*, 3(2), pp. 20–24. doi: 10.24114/iser.v3i2.31233.
- Miqro, L. F., Baiq, H. N. and Zulandri (2019) 'Pengintegrasian Potensi Lokal Pada Mata Kuliah Pendidikan Karakter Untuk Meningkatkan Hasil Belajar Dan Rasa Hormat Mahasiswa Terhadap Lingkungan', *JUPE: Jurnal Pendidikan Mandala*, 4(4), pp. 0–5. doi: 10.36312/jupe.v4i4.995.
- Parmin, P. *et al.* (2020) 'Indonesian science teachers' views on attitude, knowledge, and application of STEM', *Journal for the Education of Gifted Young Scientists*, 8(1), pp. 17–31. doi: 10.17478/jegys.647070.
- Rohmah, F. A. and Nurita, T. (2017) 'GELOMBANG', *E-Jurnal Pensa*, 05(03), pp. 222–225.
- Safitri, R. L., Oktaviani, D. N. and Isnani, I. (2019) 'Validasi Lembar Kegiatan Peserta Didik Dengan Pendekatan Inkuiri Berbantuan Geogebra', *JIPMat*, 4(2), pp. 163–169. doi: 10.26877/jipmat.v4i2.4216.
- Sari, L., Taufina, T. and Fachruddin, F. (2020) 'Pengembangan Lembar Kerja Peserta Didik (LKPD) dengan Menggunakan Model PJBL di Sekolah Dasar', *Jurnal Basicedu*, 4(4), pp. 813–820. doi: 10.31004/basicedu.v4i4.434.
- Shabila, R. L., Bhakti, Y. B. and Fatahillah, F. (2020) 'Pengembangan LKPD Berbasis STEM (Science, Technology, Engineering, Mathematic) Pada Materi Elastisitas Dan Hukum Hooke', *Schrodinger Jurnal Ilmiah Mahasiswa Pendidikan Fisika*, 1(2), pp. 95–100. doi: 10.30998/sch.v1i2.3081.
- Simanullang, M. Y. and Simanjuntak, P. R. N. (2021) 'the Effect of the Use of Video-Based Learning Media Light and Optical Tools on the Improvement of Students 'Learning Outcomes'', *ISER (Indonesian Science Education Research)*, 3(1). doi: 10.24114/iser.v3i1.27924.
- Sundayana, Rostina. (2014). *Statistika*

- Penelitian Pendidikan. Bandung: Penerbit Alfabeta.
- Sumarni, W., Wijayati, N. and Supanti, S. (2019) 'Analysis Kemampuan Kognitif dan Berfikir Kreatif Siswa Melalui Pembelajaran Berbasis Proyek Berpendekatan STEM [The Analysis of Cognitive and Creative Thinking Skill Through The Use of STEM Project Based Learning Model]', *Jurnal Pembelajaran Kimia OJS*, 4(1), pp. 18–30.
- Uum, U., Novaliyosi and Yani, S. (2020) 'Pengembangan lembar kerja peserta didik elektronik (e-lkpd) berbasis problem based learning pada materi pesawat sederhana di sekolah menengah pertama', *Skripsi*, 3(1), pp. 61–70.
- Walfajri, R. U. and Harjono, N. (2019) 'Peningkatan Kemampuan Berpikir Kritis Dan Hasil Belajar Tematik Muatan Ipa Melalui Model Problem Based Learning Kelas 5 Sd', *Jurnal Basicedu*, 3(1), pp. 16–20. doi: 10.31004/basicedu.v3i1.54.
- Wisudawati, A. W. (2018) 'Science Technology Engineering and Mathematics (STEM) Education Approach against a Microscopic Representation Skill in Atom and Molecule Concept', *International Journal of Chemistry Education Research*, 2(1), pp. 1–5. doi: 10.20885/ijcer.v2i1.10067.
- PISA, (2018). Data PISA. [Online] Available at :<https://www.oecd.org/pisa/data/> (20 October 2021)
- TIMSS, (2015). TIMSS 2015 Database. [Online]. Available at : <https://timssandpirls.bc.edu/timss2015/international-database/>