

# **RESEARCH ARTICLE**

#### TEXTBOOKS BASED ON STEM-CP (SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS, AND CONTEXTUAL PROBLEMS) MATERIALS ON VIRUSES TO IMPROVE CRITICAL THINKING SKILLS FOR HIGH SCHOOL STUDENTS

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#### Abstract

..... This study aims to develop a STEM-CP based virus material textbook for grade X SMA students. The textbook is organized into a contextual textbook with problem-solving characteristics in the material "Virus". Virus material was chosen based on contextual problems that are being faced by the world community, namely the COVID-19 pandemic. Therefore, students are expected to be be able to master material regarding the structure of the virus, as well as hone students' critical thinking skills to solve problems in the right efforts to tackle the COVID-19 virus. The research method is Quasi Experiment with Pretest-Posttest without a control class. The data analysis was carried out by using mixed methods, which is the result of qualitative and quantitative data. The sample used was 30 students of class X SMA with problems. These results can be seen from the scores obtained by students. The prettest results of students 'critical thinking abilities before using STEM-CP-based virus textbooks were relatively low, namely 2,5 Unacceptable, but after using the value of students' critical thinking skills relatively increased, namely 3,8 category Acceptable. This shows that the critical thinking skills possessed by students are better after students learn viral material using virus textbooks that are applied in learning. iresults of the N-gain scores of students in the Dessiminate class with an overall average of 0.80 in the high category This shows that STEM-Cp-based viral textbooks are effective in improving students' cognitive abilities.

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Introduction:-

Biological material, namely viruses, is closely related to life and daily problems faced by society. When learning viruses, students are expected to understand the concept of viruses, so that students can participate in overcoming problems caused by viruses (Fariroh al, 2015). To understand the application of the concept to this viral material in everyday life students must also have scientific thinkingThis study aims to develop a STEM-CP based virus material textbook for grade X SMA students. The textbook is organized into a contextual textbook with problem-solving characteristics in the material "Virus". Virus material was chosen based on contextual problems that are being faced by the world community, namely the COVID-19 pandemic. Therefore, students are expected to be be able to master material regarding the structure of the virus, as well as hone students' critical thinking skills to solve problems in the right efforts to tackle the COVID-19 virus. The research method is Quasi Experiment with Pretest-Posttest without a

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The main purpose of 21<sup>st</sup> -Century learning is how to improve students' thinking skill to a higher level than before, particularly ones related to an ability to think critically in absorbing various information, think creatively in solvingproblemsbyusingtheirbackgroundknowledgeaswell asmakedecisionsincomplexsituations(Anggrainy,2016).

One approach that can be implemented to improve student learning outcomes and critical thinking skills is to use the STEM approach (Marinda, 2020). STEM education (Science, Technology, Engineering, and Mathematics) needs to be developed as a solution to the challenges of the 21st century (Beybee, 2013). STEM is an approach in the field of education that contributes greatly to helping learning in the 21st century (Dong et al., 2019). The STEM (science, technology, engineering and mathematics) approach involves the integration of several disciplines, especially the four disciplines. It is said that STEM education is very important for students to develop 21st century skills such as problem solving, innovation, creativity, communication, and collaboration (Cepni, 2018).Integrated Science, Technology, Mathematics and Engineering (STEM) education supports teaching concepts that can achieve student understanding (English & King, 2019). The STEM approach is used because (i) involves applications that connect at least two fields of science, technology, mathematics and engineering, (ii) these fields are brought together in contexts based on real-life problems, and (iii) help teach students about subject matter or enrich learning them (Kelly and Knowles, 2016)In STEM education, students seek solutions to contextual problems. Contextual problems encountered in real life are interdisciplinary and cannot be limited to the knowledge and skills of a particular discipline. Therefore, to solve these conceptual problems, students must use an interdisciplinary approach to knowledge and skills from various disciplines according to their nature (Wang, 2012; Wang et al., 2011). The purpose of STEM education is to equip students with STEM topics and practices, which can develop positive STEM attitudes, and can become life learners for students, (i) increase the potential of students who choose the STEM field as a profession, (ii) Expand employment with STEM skills, and (iii) increasing the potential of students in the STEM field (National Research Council [NRC], 2011). Therefore, Chute (2009) defines STEM as an educational

system in which students generate solutions to contextual problems faced in real life and create STEM Education as a purposeful integration of various disciplines used in solving real contextual problems. Sanders (2009).

Based on this, it can be seen that learning research uses STEM textbooks by using contextual problems. Virus material is material that requires deep understanding, so it is necessary to have a STEM approach by combining contextual problems in the way it is conveyed to students. Several studies have shown that the STEM approach and contextual problems are very effective in learning. Based on this, this research is a combination of STEM approaches and contextual problems or abbreviated as STEM-CP packaged in the form of textbooks with viral material. so it is hoped that in this STEM-CP learning activity it can teach students about viruses that are not only theoretical but can affect the handling of problems around them.

Textbooks are a type of teaching material that is indispensable in learning. Textbooks serve as a basic reference in starting, implementing, evaluating, and developing the learning process (Suwarni, 2015). Textbooks are a set of lesson substances that include curriculum content that students must achieve in learning activities and are arranged systematically and attractively so that they can attract students' interest in learning (N Hasanah, 2021).

### **ResearchMethod:-**

This type of research is a quasi experimental research method with one group pretest postest. Quasi experiment (pseudo-experiment) is used with the aim of indicators of the influence of the independent variables and the dependent variable after being influenced by direct influence (cause-effect) (Yustyan, et.al, 2015). The sample used in this study only used one treatment class without a control class. The research development design uses a 4-D model consisting of Define, Design, Develop, and Disseminate (Thiagarajan, Semmel and Semmel). This development research aims to develop a textbook for high school viruses x material based on the STEM-CP Biology approach in high school.

### Textbook validity analysis

The analysis of the validity of the textbook is obtained from expert validation and validationuser. Expert validity results are obtained from expert responses (validators) to the feasibility of STEM-Cp-based optical instrument textbooks, while the user validityobtained from the responses of users (teachers). The contents of the validation sheet consist of assessment of the feasibility of content, language, presentation, and graphics of optical instrument textbooksbased on STEM-Cp. The research data on the validity of the textbooks were analyzed using descriptive analysis, with the following data processing formula:

$$v = \frac{\sum x_1}{\sum x_2} \times 100$$

V= textbook validity level  $\sum_{x1}$  = total score of answers from validator  $\sum_{x2}$  = total score of answers from validator (Suprapto, 2011)

Level of Validity	Criteria	Description
85.01 - 100.00	Very valid	No revision
70.01 - 85.00	Fairly valid	Needs a little revision
50.01 - 70.00	Less valid	Needs major revision
01.00 - 50.00	Invalid	Not allowed to use

### Criteria score validity

Students' critical thinking skills are classified into several criteria. The following is the data on the criteria for students' critical thinking skills in Table 1.2

**Table 1.2:-** Criteria for students' critical thinking skills scores.

Skor	Criteria for critical thinking skills
4	Strong
3	Acceptable
2	Unacceptable
1	Weak

(Facione, 2009)

The textbook is said to be effective if the student's test answers are at leastget a score of 3 or in the acceptable category.

For test data on learning outcomes in the realm of knowledge in the form of pretest scores andstudent posttest, analyzed using N-gain analysis to determine improvement of learning outcomes, with the following formula:

$$g = \frac{s_{post} - s_{pre}}{s_{max} - s_{pre}}$$

With :

g	= Normalized Gain Value (N-gain)
S <sub>post</sub>	= Posttest score
S <sub>pre</sub>	= Pretest Value
S <sub>max</sub>	= Maximum Value
Furthermo	re, the N-gain value is translated into the following criteria:

1.3N-gain criteria

Skor	Normalized Gain Criteria
$0,70 \le N$ -gain	high
$0,30 \le N$ -gain $\le 0,70$	medium
N-gain $\leq 0.30$	low

(Ahmad, 2010)

# FindingsandDiscussion:-

Results Development stage (Develop)

The development stage is carried out with the aim of measuring the feasibility of the viral textbook that has been developed. After an evaluation by the validator will be made improvements to the parts of the textbook that are not appropriate according to the validator so that the virus textbook product is valid, practical and effective. The results of the validation of the STEM-Cp-based virus textbook aim to measure the validity of the developed textbook, so that valid results are obtained and can be used in field tests. The data from the validation of the textbooks are presented in table 1.5

 Table 1.4: Textbook
 ValidationResult
 Data

Penilaian	Aspek	Skor (skor	Nilai	Krieria
		maksimum =4)		
Expert Validaor 1	Content eligibility	47	87,0	Very Valid
	Eligibility ofcreativity	32	80,0	Very Valid
	Language eligibility	41	85,4	Very Valid
	Serving eligibility	33	91,6	Very Valid
Average Value			86,0	Very Valid
Expert Validaor	Content eligibility	48	85,7	Very Valid
	Eligibility ofcreativity	32	80	Very Valid
	Language eligibility	40	83,3	Very Valid
	Serving eligibility	31	86,1	Very Valid
Average Value			83,7	Very Valid
Ave	rage Number of Expert Validat	or Scores	84,8	Very Valid

User validaor 1	Content eligibility	49	87,5	Very Valid
	Eligibility ofcreativity	39	87,5	Very Valid
	Language eligibility	43	89,6	Very Valid
	Serving eligibility	35	97,2	Very Valid
Average Value			90,4	Very Valid
User validaor 2	Content eligibility	41	91,0	Very Valid
	Eligibility ofcreativity	39	97,5	Very Valid
	Language eligibility	41	85,4	Very Valid
	Serving eligibility	34	94,4	Very Valid
Average Value			92,0	Very Valid
User validaor 3	Content eligibility	53	94,6	Very Valid
	Eligibility ofcreativity	39	97,5	Very Valid
	Language eligibility	42	87,5	Very Valid
	Serving eligibility	35	97,2	Very Valid
Average Value			94,2	Very Valid
User validaor 4	Content eligibility	51	91,0	Very Valid
	Eligibility ofcreativity	39	97,5	Very Valid
	Language eligibility	41	85,4	Very Valid
	Serving eligibility	35	97,2	Very Valid
Average Value			92,7	Very Valid
Av	erage Number of User Validator	Values	92,37	Very Valid

Based on Table 1.4, it can be seen that the average validation of STEM-Cp-based virus textbooks by two expert validators namely lecturers is 84.4% and can be said to have a very valid category. high school biology. The average validation of the STEM-Cp virus textbook by four users was 92.3% with a very valid category.

Results and Analysis of the Dessimination School Trial

The participants of this study were 125 students of class X SMA majoring in science from SMA Negeri 2 (Class A, SMA Negeri 1 Kalisat (Class B) and SMA Argopuro (Class C) Jember batch 2021/2022. Measurement students' critical thinking skills depend on the results of posttest and pretest tests according to critical thinkin indicators. Students' critical thinking skills are classified into several criteria.

The following is the data on the criteria for students' critical thinking skills in Table

1.5Data on the results of the pretest-posttest scores of students in the dissemination class

No	Critical Thinking Skills Indicator	Average Score Each Meeting SMAN 2 JEMBER					
		Perter	nuan 1	Pertemuan 2		Pertemuan 3	
		Pre	Post	Pre	Post	Pre	Post
1	Intepretasi	2,9	4	2,9	4	3	4
2	Analisis	2,4	3,9	2,5	4	3	4
3	Infrensi	2,2	3,9	2,2	3,9	2,9	4
4	Evaluasi	2	3,9	2,1	3,8	2,8	3,9
5	Eksplanasi	2,3	3,4	2,2	3,8	2,6	3,7
6	Pengaturan Diri	1,6	3	2	3,1	2,3	3,6
Rerata 2,		2,2	3,7	2,3	3,7	2,7	3,8
		SMAN 1	KALISAT				
1	Intepretasi	2,9	4	2,9	4	3	4
2	Analisis	2,5	3,9	2,5	4	3	4
3	Infrensi	2,2	3,9	2,2	3,8	2,8	3,8
4	Evaluasi	2,1	3,8	2,2	3,8	2,7	3,8
5	Eksplanasi	2,2	3,1	2,2	3,5	2,4	3,6
6	Pengaturan Diri	2	3	2	3,1	2,3	3,6

Rerata	a		2,3	3,6	2,3	3,7	2,7	3,8	
No	School		Meet	1	Meet 2		Meet 3		
		N-gai	n	Criteria	N-gain	Criteria	N-gai	n Criteria	a
1	SMA N 2 Jember	0,80	)	high	0,84	high	0,87	high	
2	SMA N 1 Kalisat	0,77	,	high	0,80	high	0,84	high	
3	SMA Argopuro	0,73		high	0,75	high	0,82	high	
Rerata kes			eseluruhan				0,80		
SMA ARGOPURO-PANTI									
Intepre	etasi		2,9	4	2,9	4	3	4	
Analisis		2,1	3,9	2,3	3,9	2,9	4		
Infrensi			2	3,6	2	3,8	2,9	3,9	
Evaluasi		2	3,6	2,1	3,2	2,5	3,8		
Eksplanasi		2,1	3	2,1	3,5	2,3	3,5		
Pengaturan Diri			1,6	3	1,9	3,0	2,3	3,3	
Rerata		2,2	3,5	2,2	3,6	2,6	3,7		

Based on the data from table 1.6, it can be seen that the scores of students' critical thinking skills in the Dessiminate class have increased significantly. At SMA Negeri 2, the score of students' critical thinking skills increased from unacceptable to acceptable category. Likewise, the scores obtained by SMA 1 Kalisat and SMA Argopuro students who also experienced an increase and got an unacceptable initial score became acceptable.

1.6Data on student learning outcomes in the realm of school knowledge dissemination

Based on table 1.6, it can be seen the results of the N-gain scores of students in the Dessiminate class with an overall average of 0.80 in the high category. This shows that STEM-Cp-based viral textbooks are effective in improving students' cognitive abilities.

### **Discussion:-**

The validity of this study in the form of textbooks used is STEM-Cp-based textbooks, namely textbooks with a STEM approach accompanied by contextual problems which are expected to improve students' critical thinking skills in solving problems in the surrounding environment. The stages contained in this STEM-Cp textbook are contextual problems related to problems that occur in everyday life regarding technological innovation on problems related to the prevention and treatment of viral diseases. In the scientific aspect, textbooks discuss factual knowledge about material regarding the structure of viruses and the prevention and treatment of diseases caused by viruses, conceptual knowledge, which includes the prevention of the COVID-19 pandemic; conceptual knowledge includes the structure and classification of viruses; procedural knowledge covering the life cycle of viruses, and metacognitive knowledge about how to prevent disturbances caused by viruses. From the technological aspect, it discusses technological innovation from scientific concepts. From the technical aspect, students provide solutions to contextual problems.

Textbooks are made as one of the components that function as to support learning in order to achieve learning objectives. This is in accordance with the theory that one of the learning media is textbooks to carry out learning by teachers and students to improve the learning process in the classroom (Knight, 2015). In this study, the textbook developed was a virus textbook based on STEM-Cp which aims to improve students' critical thinking skills.

This textbook uses the STEM-Cp approach to virus material for class X SMA which aims to improve students' critical thinking skills. The application of STEM in learning is expected to be able to help students integrate aspects of Science, Technology, engineering, and Mathematics so that it has an impact on increasing students' critical thinking skills (Stohlmann et al, 2012). In addition to using the STEM approach, the developed textbooks also use Contextual Problems as reinforcement for students to understand the material being studied with problems that exist in real life. Likewise, the STEM approach that integrates science, technology, engineering and mathematics to solve given contextual problems can motivate students further because they are able to connect the concepts acquired in

class with the real world. STEM can indirectly develop critical thinking skills. Thinking patterns and reasoning that are trained continuously can trigger students' critical thinking skills (Wildan Wayan, Lisa, 2021).

Assessment of the validity of learning media, one of which is textbooks, is measured based on the results of validation as stated by Nieveen (1999). The results of the data used in the form of quantitative data obtained from the value of the questionnaire filled out by expert validators and user validators. Based on the results of the data that has been collected, the STEM-CP based textbooks on virus material get an average of 92,37% with a very valid category. This is in accordance with the criteria for the validity of textbooks (Akbar, 2013).

Interpretation	Understand, express, and meaning of various experiences, situation, data, events, conventions, beliefs, rules, procedure, or criteria
Analysis	Identify the relationship between statements, questions, concept, descriptions, or forms of interpretation intended to express beliefs, judgements, experiences, reasons information, or opinion
Inference	Identify and secure the elements needed to draw reasonable conclusions, to form guesses and hypotheses, consider relevant information from data, reports, principles, evidence, judgements, beliefs, opinions, concept, descriptions, questions, or forms interpretation
Evaluation	The credibility of statements or other interpretations regarding a persons perceptions, experiences, situations, judgements, beliefs or opinions, and has the logical power of the relationship between statements, descriptions, questions or forms of representation
Explanation	Reasoning in terms of evidence, conceptual, methodology, logical criteria, and contextual considerations at the time based on one result, and to present one reasoning in the form of convincing arguments
Self-Regulation	Self awareness to monitor one cognitive activities, the elements used in the activity, and the result after the activity, especially by applying skills in analysis and evaluation to self assessing with a view of questioning, communicating, validating, or correcting one of the reasons for result

**Tabel 1.7:-** Indicator of critical thinking skills Critical Thinking Skills Indicators Explanation.

Facione, 2013

Based on the increase in student learning outcomes followed by an increase in students' critical thinking skills, namely the N-gain result of 0.80 above 0.70 or the high category. This is in accordance with the statement that students' critical thinking skills greatly affect students' cognitive learning outcomes (Siburian j., A.D. Corebima, & M. Saptasari, 2019).

# **Conclusion:-**

There is an influence from the results of this study on increasing students' critical thinking skills using the STEM-CP textbook. This can be seen from the increase in pretest and posttest results in the strong category and can increase students' ability to solve problems in their lives.

# **References:-**

- 1. Akbar, S. 2013. Instrumen Perangkat Pembelajaran. Bandung: Remaja Rosdakarya Offset
- 2. Barko, T., & Sadler, T. (2013). Learning outcomes associated with classroom implementation of a
- 3. biotechnology-themed video game. The American Biology Teacher, 75(1), 29–33. doi:
- 4. https://doi.org/10.1525/abt.2013.75.1.7
- 5. Bybee, R. W. (2013). The case for STEM education: Challeges and Opportunity. Virginia: NSTA Press.
- 6. ISBN 978-1-936959-25-9
- 7. Birgili, B. 2015. Creative and Critical Thinking Skills in Problem-based Learning Environments. Journal of
- 8. Gifted Education and Creativity,2(2),71-80 hlm.
- 9. Boa, E. A., Wattanatorn, A., & Tagong, K. (2018). The development and validation of theblended socratic
- 10. method of teaching (BSMT): an instructional model to enhance critical thinking skills of undergraduate business students. Kasetsart Journal of Social Sciences, 39(1), 81–89. doi: https://doi.org/10.1016/j.kjss.
- 11. Çepni, S. (2018). Kuramdan uygulamaya STEM eğitimi. Ankara, Pegem Akademi Yayınları. Changwong,

K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: Analysis of a new

- 12. learning management model for Thai high schools. Journal of International Studies, 11(2), 37-48. doi:10.14254/2071-8330.2018/11-2/3
- 13. Chute, E. (2009). STEM education is branching out.Pittsburgh Post-Gazette.
- Dong, Y., Xu, C., Lagu, X., Fu, Q., Chai, CS, & Huang, Y. (2019). Menjelajahi Pengaruh Faktor Kontekstual pada Keterlibatan Guru Dalam-Layanan dalam Pengajaran STEM. PenelitiPendidikan Asia-Pasifik, 28 (1), 25-34.
- Erna Suwarni, "Pengembangan Buku Ajar Berbasis Lokal Materi Keanekaragaman Laba-Laba Di Kota Metro Sebagai Sumber Belajar Alternatif Biologi Untuk Siswa Sma Kelas X," Bioedukasi (Jurnal Pendidikan Biologi) 6, no. 2.
- Facione, P. a. (2011). Critical Thinking : What It Is and Why It Counts. Insight Assessment, (ISBN 13: 978-1-891557-07-1.), 1–28.
- 17. Facione. (2013). Critical Thinking: What It Is and Why It Counts. Measured Reasons and The California Academic Press, Millbrae, CA.
- Gojkov G, Stojanovic A and Rajic AG 2015 Critical thinking of students-indicator of education Procedia – Social and Behavioral Science 191 591- 596
- Hilya Wildana Sofiaa et al. (2020). The validity and effectivity of learning using STEAM module with biotechnology game. JPBI (Jurnal PendidikanBiologi Indonesia)p-ISSN 2442-3750, e-ISSN 2537-Vol. 6 No. 1 March 2020, pp. 91-100, 91-100.
- 20. Honey, M., Pearson, G., & Schweingrube, H. (2014). STEM Integration in K-12 Education: Status, Prospects, and an. Washington DC: National Academy of Sciences.
- 21. Hosnan, M. (2014). Pendekatan Saintifik Dan Kontekstual dalam Pembelajaran Abad 21. Bogor: Ghalia Indonesia.
- I P Sari et al, 2020, Instructional materials for optical matter based on STEM-CP (Science, Technology, Engineering, Mathematics-Contextual Problem) to increasestudent critical thinking skills in high school. Journal of Physics. ICOLSSTEM 2019 Journal of Physics: Conference Series1563 (2020) 012052IOP Publishing doi:10.1088/1742-6596/1563/1/012052.
- 23. Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. International Journal of STEM Education, 3(1), 1-11
- Sutarto, Marinda, R., & Sudarti. (2020). Application Of Stem-Cp Based Magnetic Field And Electromagnetic Induction Module To Improve Students Creative Thinking Skills At Vocational High School. Int. J. Adv. Res. 8(11), 346-350. doi:http://dx.doi.org/10.21474/IJAR01/12016.
- 25. N Hasanah, 2021 Application of STMCpE-Based chemistry books with chemoorientation in the learning of acid-base solutions toimprove of Physics: Conference Series1832 (2021) 012034 IOP Publishing doi:10.1088/1742-6596/1832/1/012034
- 26. National Research Council [NRC]. (2011). Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering and mathematics. Washington, DC: The National Academic Press.
- 27. Wang, H., Moore, TJ, Roehrig, GH, & Park, MS (2011). STEM integration: teacher perceptions and practice. Journal of Pre-College Engineering Education Research, 1(2), 1–13.
- 28. Wahono, B.; Rosalina, AM; Utomo, AP; Narulita, E. Developing STEM Based Student's Book for Grade XII Biotechnology Topics. J. Edu. Belajar. **2018**, 12, 450–456.
- 29. Wildan, Lisa (2021) Kemampuan Berpikir Kreatif dan Hasil Belajar Matematika Siswa Menggunakan Model Pembelajaran Project-Based Learning Berbasis Pendekatan STEM
- 30. Sanders, M. (2009). Integrative STEM education: Primer. The Technology Teacher, 68(4), 20-26.
- 31. Schleicher, A. (2018), World Class: How to Build a 21st-Century School System, Strong Performers and Successful Reformers in Education, OECD Publishing, Paris.
- 32. Shriner, Mary. (2006). Critical Thinking in Higher Education: An Annotated Bibliography. Insight : A Collection of Faculty Scholarship. 1(206):5966.
- Stehle, S. M., & Peters-Burton, E. E. (2019). Developing student 21 st Century skills in selected exemplary inclusive STEM high schools. International Journal of STEM Education, 6(1), 39. https://doi.org/10.1186/s40594-019-0192-1
- 34. Stohlmann, M., Moore, T., & Roehrig, G. (2012). Considerations for Teaching Integrated STEMEducation.Journal of Pre-College Engineering Education Research, 28-34.
- 35. Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Depaepe, F. (2018). Integrated STEM Education: a systematic review of instructional practices in secondary education. European Journal of STEM Education. https://doi.org/10.20897/ejsteme/85525.