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Research Article

Developing the guided inquiry-based module on the circulatory system to improve student's critical thinking skills

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ABSTRACT

The limitations of inquiry-based teaching modules impact the low critical thinking skills of students. The research objective is to develop an inquiry-based module to improve students' critical thinking skills. This development research uses the Borg and Gall model in designing and testing the module. The development was carried out in February - November 2020 at Batik Senior High School 1 of Surakarta, Central Java. The subjects of this study were students of class XI-Science Batik Senior High School 1 of Surakarta. The assessment of the feasibility and effectiveness of the module uses a validation instrument by linguists, material experts, and learning experts. Assessment of students' critical thinking skills using HOTS questions. The effectiveness of the module was tested using the Z test. The results concluded that the module was feasible to use in learning with a feasibility score of 3.83 (linguistic aspect), 3.92 (material aspect), and 3.80 (learning aspect). Furthermore, this module effectively improves students' critical thinking skills as indicated by the results of the Z test (α<0.05). This study recommends the development of inquiry-based modules in improving students' critical thinking skills.

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INTRODUCTION

The 21st-century learning reform expects students to have creative-innovative competencies (Sandika & Fitrihidajati, 2018; Sari et al., 2020), think critically in solving problems (Abosalem, 2016; Maas et al., 2018), communication and collaboration (Weinberger & Shonfeld, 2018), literacy on technological developments (Hussin, 2018), contextual learning skills (Bray & Tangney, 2016; Suryawati & Osman, 2018), and literacy on media and information (Sajidan & Afandi, 2019). Therefore, the mandate of the 2013 Curriculum also focuses on student-oriented learning, learning with a scientific approach, and competency-based (Mastur, 2017; Sufairoh, 2016; Susilana & Ihsan, 2014). The learning innovations carried out simultaneously are expected to improve students' higher-order thinking skills (Opara & Oguzor, 2011; West, 2015), which ultimately improves the quality of learning (Isaacs, 2012; Mas'ud et al., 2019).

Critical thinking skills can be trained in students through continuous, structured efforts (Changwong et al., 2018) and guidance (Setiawati & Corebima, 2017). Vong and Kaewurai (2017) state that in training students' higher-order thinking skills, it is necessary to change perspectives and put students as users of information, not just recipients of information, to foster critical thinking skills. Furthermore, these efforts need to be integrated into appropriate learning models and methods (Bevins & Price, 2016; Suryawati et al., 2018).

Several research results reveal that the learning model that is considered effective in improving critical thinking skills is a model based on problem (Criollo-C & Luján-Mora, 2019; Pluta et al., 2013), project (Anstey, 2017; Chu et al., 2016), or inquiry-based learning (Adnan & Bahri, 2018; Prayitno et al., 2017). Such a model is strongly indicated to have implications for critical thinking skills because it provides a contextual learning experience for students. Students can also dive into problems directly to learn to find realistic solutions (Ferreira & Trudel, 2012). In other words, scientific thinking skills, such as identifying, formulating problems, making hypotheses, collecting data to conclude, can be learned more contextually by students (Jasti et al., 2014; Nurhikmayati, 2019). However, the completeness of learning with this kind of inquiry model needs to be evaluated (Kim, 2015). The results of observations in schools indicate that the existing modules are relevant to the material but have not been developed based on inquiry. Therefore, it impacts improving students' critical thinking skills, which are not optimal. Some of the modules developed in recent years have limitations, such as not raising realistic problems around students contextually and not implementing the guided-inquiry model comprehensively.

On the other hand, a practical module in improving critical thinking skills can provide contextual independent learning experiences for students (Su'udiah et al., 2016; Suryawati & Osman, 2018). Contextually in question is to provide problems that are closely related to students' daily lives (Broekhuis et al., 2022). Moreover, to strengthen students' engagement with problems, modules need to be developed with the dimensions of knowledge and dimensions of higher-order thinking through questions based on high-order thinking skills (Lestari et al., 2018; Raaijmakers et al., 2018). Some researchers also stated that students' active involvement in learning needs to be raised in the module so that it can train and improve students' scientific skills (Casanoves et al., 2017).

Biology is one of the fields of study that needs to be studied with a scientific approach (Parmin & Savitri, 2020; Rofieq et al., 2021) to teach critical thinking skills (Birgili, 2015; Fisher, 2016; Nurhikmayati, 2019). The problems that exist in the perspective of biology are directly related to student life, such as the human circulatory system (Adeyemi, 2012). Most of the modules in the study of the human circulatory system are only textual and have not provided students with sufficient learning space to practice critical thinking skills (Danantyo et al., 2020; Ramadhani et al., 2021). The module developed in this study provides students with learning activities about five problems in daily life, namely sickle cell anemia, leukemia, hemophilia, atherosclerosis, and blood transfusion errors. Critical thinking skills are trained in formulating problem formulations, giving reasons, drawing conclusions, providing explanations, and evaluating. This development research aims to develop a guided-inquiry module on the circulatory system and measure the feasibility and effectiveness of the module in improving students' critical thinking skills.

METHOD

The module development in this research uses the Borg and Gall model (Gall et al., 2003). The instrument for collecting data on the feasibility of the module uses a validation questionnaire, a module practicality questionnaire, critical thinking skills questions, and an analysis of the results of critical thinking skills answers. Three experts carried out module validation, including linguists, material experts, and learning experts. Validation by linguists includes aspects of graphic feasibility and language feasibility. Material expert validation includes content feasibility, material feasibility, and guided inquiry while learning expert validation focuses on module practicality. Finally, the teacher carries out the validation of the practicality of the module. The module validation score uses a Likert scale, with a score of 1 to 4. The data obtained from the expert and teacher validation sheet questionnaires are in the form of scores calculated by equation (1).

$$\bar{x} = \frac{1}{m} \times \frac{\sum x}{n} \quad (1)$$

where: $\bar{x}$ is a average score; $\sum x$ is a total score obtained; m refers to number of items; and n refers to number of validators.

The classification of module quality includes excellent, good, sufficient, deficient, and very insufficient using equation (2). Product validity indicators on the minimum criteria are sufficient (Sari et al., 2016). The score obtained is converted into a qualitative scale according to Table 1.

$$\text{interval spacing} = \frac{\text{highest score} - \text{lowest score}}{\text{number of interval classes}} \quad (2)$$

Table 1. Guidelines for converting quantitative to qualitative data

Score	Score range	Criteria
A	$3.4 < x \leq 4$	Excellent
B	$2.8 < x \leq 3.4$	Good
C	$2.2 < x \leq 2.8$	Sufficient
D	$1.6 < x \leq 2.2$	Deficient
E	$1 < x \leq 1.6$	Very Insufficient

Table 2. The effectiveness test cycle

	Pretest	Treatment	Posttest
Control group	T_{1C}	-	T_{2C}
Experimental group	T_{1E}	X	T_{2E}

The module effectiveness test was conducted in class XI-Science Batik SHS 1 of Surakarta. A total of 160 students were involved as research subjects, consisting of 78 students in the experimental class and 82 students in the control class. The experimental class is a class that learns using a guided inquiry-based circulatory system module, while the control class uses student worksheets that are not based on inquiry. The method of implementing the module effectiveness test was carried out by pretest and post-test (Table 2). Normality and homogeneity tests were carried out with a significance level of 0.05. Test the effectiveness of the module with the Z test after the data is declared normal and homogeneous. The module is effective in improving critical thinking skills if the value of Z count < Z table with a significance of 0.05. This means that there is a difference in the average value of critical thinking skills of experimental group students compared to the control group, so it can be said that the guided inquiry-based circulatory system module is effective in improving students' critical thinking skills.

RESULTS AND DISCUSSION

The results of the problem identification show that the modules used in the circulatory system study include blood tissue, circulatory organs (heart and blood vessels), circulatory processes, and circulatory system disorders. The module has also been equipped with practice questions and material deepening. However, the level of difficulty of the questions is still classified as low-order thinking skills, so it is not optimal to train students' critical thinking skills. In addition, the results of the initial identification of critical thinking skills show that the average test results of students' critical thinking skills are 56.3. Furthermore, information deepening is carried out to design a realistic development solution. At this stage, the solution offered is to develop a module based on a scientific approach and equipped with questions based on high-order thinking skills (Bahri et al., 2020; Zubaidah et al., 2015). This module was developed based on the guided inquiry model.

Furthermore, the module was developed with problem-based learning indicators (Cargas et al., 2017), inquiry-based (Vong & Kaewurai, 2017), and contextual (Amin et al., 2017). In the module some activities provide learning experiences with process skills such as observing, experiencing, induction, deduction, and communication (Budiarti et al., 2016), which involve the active participation of students (Amin et al., 2017). The learning content in the module contains activities to analyze authentic problems in real life, collect data, verify hypotheses, analyze, evaluate, use various learning resources, build new knowledge, solve problems, and study with group work to discuss findings and share ideas (Vong & Kaewurai, 2017).

The integration of the guided-inquiry model in the developed module adopts from Maniotes and Kuhlthau (2014). The guided inquiry syntax in the module consists of opening lessons, immersing ideas, exploring problems, identifying solutions, collecting supporting data, making reports, sharing, and evaluating. An explanation of the activities of each syntax is presented in Table 3.

Table 3. Guided inquiry stages were developed in the module

Guided inquiry syntax	Teacher activities	Student activities
1. Open (motivation)	The teacher provides problems which can be in the form of pictures, videos, and questions that stimulate students to think.	Students are triggered to think about problems and formulate questions based on teacher instructions.
2.Emmerse (building background knowledge)	The teacher provokes students to suggest ideas related to the problem.	Students put forward ideas related to the problem, which were conveyed by the teacher.
3. Explore (develop problem formulation)	The teacher gives students the opportunity to develop questions related to the problem.	Students develop questions that may occur.
4. Identify (determine the appropriate problem formulation)	The teacher guides students to determine questions related to the problem.	Students determine questions related to the problem.
5. Gather (Discussion, data collection)	The teacher provides the opportunity for students to collect information from various sources.	Students collect information from various sources in accordance with predetermined questions. Learners document information in accordance with the question.
6. Create (compile reports)	a) The teacher guides students to analyze, connect the information that has been obtained. b) The teacher gives students the opportunity to compile research reports and presentation texts.	a) Students analyze, link the information that has been obtained. b) Students compile material presented by the community (in class or school)
7. Share (presentation)	The teacher provides the opportunity and guides the students to compile a presentation script.	Students submit research results to the community (at least in front of the class).
8. Evaluate (reflection)	The teacher guides students to evaluate the achievement of research objectives.	Students evaluate the achievement of research objectives.

Ennis (2011) states six elements in critical thinking focus, reason, inference, situation, clarity, and observation. Students who study with this module get a learning experience in formulating and focusing on problems, giving rational and logical reasons, giving conclusions, defending and understanding situations to clarify focus by formulating supporting questions, providing supporting explanations, and reviewing decisions made or reflections (Zubaidah et al., 2015). This module is structured with investigative activities with the theme of circulatory system disorders, namely sickle cell anemia, leukemia, hemophilia, atherosclerosis, and blood transfusion errors. Each theme presents contextual problems: sickle cell anemia, leukemia, hemophilia, atherosclerosis, and blood transfusion errors. Each investigative activity involves students actively thinking scientifically by observing the problem giving conclusions, and reflecting on the investigation results (Hossain et al., 2018; Jasti et al., 2014). Students observe and formulate the main and supporting problem formulations in the first syntax.

Then in the second syntax, students collect data or information related to the contextual case under study so that students can give reasons according to the data or information. In exploration activities, students formulate supporting problem formulations that are used further when identifying and formulating the correct problem with the teacher's guidance from a structured problem formulation. At the solution identification stage, students are trained to evaluate existing solutions. Moreover, students need to gather information following the formulation of the problem, discuss with groups to conclude, maintain data/information, and provide explanations according to the formulation of the problem (Kim, 2015). Furthermore, students are trained to collect information, give good reasons, give correct explanations, and draw conclusions (Alhassora et al., 2017; Cargas et al., 2017; Pluta et al., 2013; Shofiyah et al., 2013). Students' data is used as material in compiling research reports. This research report is in the form of a wall magazine. At this stage, students also practice developing creations. The prepared reports are shared in a sharing session. The students are trained to communicate and convey data and information to give reasons and correct explanations as a form of practice. Finally, students are trained to evaluate or review their research achievements in the final stage (Kristiani et al., 2015; Masek & Yamin, 2011). So by carrying out activities in the module, students practice formulating problem formulations, giving valid reasons, providing correct explanations, drawing conclusions, and evaluating.

The results of the validation of the experts are presented in Table 4. Linguists give a score of 3.84, the assessment of material experts is 3.96, while the results of the assessment of learning experts are 3.92.

These results indicate that the module has excellent validity. Furthermore, this module is very suitable for use in learning. The module practicality shows the same result, very good with a score of 3.80. Thus, its practicality in learning is classified as very good. However, the teacher gave input that the implementation of this module should pay attention to the availability of time and conformity with the learning implementation plan.

Table 4. Module scores of the validators

Validator	Score	Criteria
Learning expert	3.92	Excellent
Material expert	3.96	Excellent
Linguist	3.84	Excellent
Teacher	3.80	Excellent

Improvements in the development of this module were carried out following input from experts and revised the module cover design by adding more specific images. In addition, revision of the concept map design, structuring the design of the module content, adding images or illustrations to support concept understanding, tidying up existing images, adding technology material to overcome disorders that occur in the circulatory system, and adding an assessment rubric for student work guidelines.

A further stage of development is a limited trial. The revision module was piloted on ten students. They were testing students by reviewing the readability and understanding of the module language. Furthermore, students are allowed to read and complete the activities contained in the module. At the end of the trial, students gave input that the module was practical enough to use, with a score of 2.7. Finally, product revision is an activity to improve the module according to input from ten students. Revisions from student input consist of terms of language, module understanding, and image legibility, namely clarifying the image.

The pilot phase of the guided inquiry-based circulatory system module in a broader scope was carried out to see the effectiveness in improving students' critical thinking skills. After being declared valid and practical in a limited trial, this trial was carried out. The large-scale trial involved 80 students of Batik SHS 1 Surakarta class XI-Science-2 and XI-Science-3 as the experimental class. Class XI-Science-4 and XI-Science-5 as the control class, consisted of 84 students. In practice, students are divided into several working groups with heterogeneous group members, namely students with high, medium, and low abilities. These groups carry out investigative tasks starting with factual cases as observations, namely cases of leukemia, sickle cell anemia, hemophilia, atherosclerosis, and blood transfusion errors. Then the task is continued by compiling the leading problem formulation, compiling the accompanying problem formulation to explore the research theme, collecting data according to the problem formulation, drawing conclusions, and reflecting on the research achievements.

Based on the activities integrated into the module, students are trained to be skilled in critical thinking because indicators of critical thinking skills are included in learning activities (Budiarti et al., 2016; Irwan et al., 2019; Khasanah et al., 2017; Vong & Kaewurai, 2017). In addition, task completion involves students' activeness in the investigation (Amin et al., 2017). The stages of research activities in the module are scientific approaches so that they can train students' critical thinking skills (Amin et al., 2017; Vong & Kaewurai, 2017). The application of the guided inquiry syntax is reflected in the results of research and monitoring student assignments on research activities in the module. After learning, all samples were given a test with questions about critical thinking skills. The average results of the critical thinking ability test are presented in Table 5. The control class got an average score of 69, and the experimental class got a score of 82.7. The average value of the pretest results is 56.3. The pretest score is the value obtained before the test subject with the developed module. These results indicate a difference between the pretest and posttest scores in the control class and the experimental class. The average value of the experimental class is higher than the control class. Therefore, the value of critical thinking skills after using the module is higher than the pretest score. Thus, increasing the value of critical thinking skills leads to an increase in student learning outcomes.

Table 5. Value of critical thinking skills

Class	The average pretest score	The average post-test score
Control	56.3	68.2
Experiment		79.6

The results of the module effectiveness test show that Z_{count} (-9.85) < Z_{table} (1.96) (see Table 6), so it can be concluded that there is a difference in the average value of critical thinking skills of students who use the module with students who do not use the module. In other words, the guided inquiry-based circulatory system module effectively improves students' critical thinking skills.

Table 1. Z test result

	Control class	Experimental class
Mean	69.01	82.69
Median	71.42	82.14
n	83	77
n-1	82	76
CL (critical limit)	±1.38	
Z table (α = 0,05)	±1.96	
Z count	-9.85	

The results of the development and test of the guided inquiry-based circulatory system module show that it is valid and practical, so it is feasible to use. This module can effectively improve critical thinking skills. Some of the strengthening indications are the features developed in the module, including indicators of critical thinking skills included in learning activities, namely formulating problem formulations, collecting data, providing reasons, drawing conclusions, and evaluating (Maniotes & Kuhlthau, 2014). Learning activities use a scientific approach, namely a guided inquiry model, from immerse, explore, and evaluation (Fisher, 2016; Wijayaningputri et al., 2018). In this syntax, indicators of critical thinking skills are carried out, namely formulating problem formulations, collecting data, giving valid reasons, and evaluation/reflection. Modules are also developed with daily contextual problems and equipped with critical thinking questions. Furthermore, the students are actively involved in the investigation (Yücel & Usluel, 2016).

However, this module has some weaknesses, which can be used for further refinement. Some of the weaknesses referred to include the implementation of this module taking longer than the planned time. These obstacles were overcome by adjusting the topics' order to strengthen the interrelationships between the topics discussed. In this case, atherosclerosis is discussed first because, in this activity, students also learn about the histology of the heart and blood vessels, bioprocesses of blood flow, and contraction of the heart muscle.

CONCLUSION

This research and development show that the guided inquiry-based circulatory system module is very feasible and practical to use in learning. Furthermore, the use of this module is also effective in improving students' critical thinking skills. Further development of the guided-inquiry-based module is how to combine suitability, depth of material, learning experience, and time availability to increase its effectiveness.

REFERENCES

Abosalem, Y. (2016). Assessment techniques and students' higher-order thinking skills. *International Journal of Secondary Education*, *4*(1), 1–11. https://doi.org/10.11648/j.ijsedu.20160401.11

Adeyemi, S. B. (2012). Developing critical thinking skills in students: A mandate for higher education in Nigeria. *European Journal of Educational Research*, *1*(2), 155–161. https://files.eric.ed.gov/fulltext/EJ1086348.pdf

Adnan, A., & Bahri, A. (2018). Beyond effective teaching: Enhancing students' metacognitive skill through guided inquiry. *Journal of Physics: Conference Series*, *954*, 012022. https://doi.org/10.1088/1742-6596/954/1/012022

Alhassora, N. S. A., Abu, M. S., & Abdullah, A. H. (2017). Newman error analysis on evaluating skills. *Man In India*. http://home.hiroshima-u.ac.jp/cice/wp-content/uploads/publications/Journal9-1/9-1-9.pdf

Amin, A. M., Duran Corebima, A., Zubaidah, S., & Mahanal, S. (2017). The critical thinking tkills profile of preservice biology teachers in animal physiology. *Proceedings of the 3rd International Conference on Education and Training (ICET 2017)*, *November*, 179–183. https://doi.org/10.2991/icet-17.2017.30

Anstey, L. M. (2017). "Applying anatomy to something I care about": Authentic inquiry learning and student experiences of an inquiry project. *Anatomical Sciences Education*, *10*(6), 538–548. https://doi.org/10.1002/ase.1690

Bahri, A., Idris, I. S., Muis, H., Arifuddin, M., & Fikri, M. J. N. (2020). Blended learning integrated with innovative learning strategy to improve self-regulated learning. *International Journal of Instruction*, *14*(1), 779–794. https://doi.org/10.29333/IJI.2021.14147A

Bevins, S., & Price, G. (2016). Reconceptualising inquiry in science education. *International Journal of Science Education*, *38*(1), 17–29. https://doi.org/10.1080/09500693.2015.1124300

Birgili, B. (2015). Creative and critical thinking skills in problem-based learning environments. *Journal of Gifted Education and Creativity*, *2*(2), 71–80. https://doi.org/10.18200/JGEDC.2015214253

Bray, A., & Tangney, B. (2016). Enhancing student engagement through the affordances of mobile technology: a 21st century learning perspective on Realistic Mathematics Education. *Mathematics Education Research Journal*, *28*(1), 173–197. https://doi.org/10.1007/s13394-015-0158-7

Broekhuis, M., van Velsen, L., De Franco, D., Pease, A., & Hermens, H. (2022). Contextual health information behavior in the daily lives of people with type 2 diabetes: A diary study in Scotland. *Health Communication*, *37*(3), 272–284. https://doi.org/10.1080/10410236.2020.1837426

Budiarti, S., Nuswowati, M., & Cahyono, E. (2016). Guided inquiry berbantuan e-modul untuk meningkatkan keterampilan berpikir kritis. *Journal of Innovative Science Education*, *1*(1), 1–9. http://journal.unnes.ac.id/sju/index.php/jise

Cargas, S., Williams, S., & Rosenberg, M. (2017). An approach to teaching critical thinking across disciplines using performance tasks with a common rubric. *Thinking Skills and Creativity*, *26*, 24–37. https://doi.org/10.1016/j.tsc.2017.05.005

Casanoves, M., Salvadó, Z., González, Á., Valls, C., & Novo, M. T. (2017). Learning genetics through a scientific inquiry game. *Journal of Biological Education*, *51*(2), 99–106. https://doi.org/10.1080/00219266.2016.1177569

Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: Analysis of a new learning management model for Thai high schools. *Journal of International Studies*, *11*(2), 37–48. https://doi.org/10.14254/2071-8330.2018/11-2/3

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2016). 21st century skills development through inquiry-based learning: From theory to practice. *21st Century Skills Development Through Inquiry-Based Learning: From Theory to Practice*. https://doi.org/10.1007/978-981-10-2481-8

Criollo-C, S., & Luján-Mora, S. (2019). Encouraging student motivation through gamification in engineering education. In M. E. Auer & T. Tsiatsos (Eds.), *Mobile Technologies and Applications for the Internet of Things* (pp. 204–211). https://doi.org/10.1007/978-3-030-11434-3_24

Danantyo, H., ES, S. M., & Lisdiana, L. (2020). Religion-based science modul on human circulatory system. *Journal of Innovative Science …*, *9*(2), 136–143. https://doi.org/10.15294/jise.v8i3.33016

Ennis, R. H. (2011). The nature of critical thinking : an outline of critical thinking dispositions. *Sixth International Conference on Thinking at MIT*, 1–8. https://education.illinois.edu/docs/default-source/faculty-documents/robert-ennis/thenatureofcriticalthinking_51711_000.pdf

Ferreira, M. M., & Trudel, A. R. (2012). The impact of problem based learning (PBL) on student attitudes toward science, problem-solving skills, and sense of community in the classroom. *Journal of Classroom Interaction*, *47*(1), 23–30. https://www.jstor.org/stable/43858871

Fisher, M. R. (2016). Wastewater treatment provides for authentic inquiry-based experiences in the lab and beyond. *American Biology Teacher*, *78*(9), 739–745. https://doi.org/10.1525/abt.2016.78.9.739

Gall, M. D., Gall, J. P., & Borg, W. R. (2003). Educational research: An introduction, 7th edition. In *Educational Research: An introduction*. Pearson A&B Education. https://www.pearson.com/us/higher-education/product/Gall-Educational-Research-An-Introduction-7th-Edition/9780321081896.html

Hossain, Z., Bumbacher, E., Brauneis, A., Diaz, M., Saltarelli, A., Blikstein, P., & Riedel-Kruse, I. H. (2018). Design guidelines and empirical case study for scaling authentic inquiry-based science learning via open online courses and interactive biology cloud labs. *International Journal of Artificial Intelligence in Education*, *28*(4), 478–507. https://doi.org/10.1007/s40593-017-0150-3

Hussin, A. A. (2018). Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies*, *6*(3), 92–98. https://doi.org/10.7575/aiac.ijels.v.6n.3p.92

Irwan, I., Maridi, M., & Dwiastuti, S. (2019). Developing guided inquiry-based ecosystem module to improve students' critical thinking skills. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *5*(1), 51–60. https://doi.org/10.22219/jpbi.v5i1.7287

Isaacs, S. (2012). Turning on mobile learning in Africa and the Middle East. In *UNESCO Working Paper Series on Mobile Learning*. https://doi.org/10.216358

Jasti, C., Hug, B., Waters, J. L., & Whitaker, R. J. (2014). How do small things make a big difference? Activities to teach about human–microbe interactions. *The American Biology Teacher*, *76*(9), 601–608. https://doi.org/10.1525/abt.2014.76.9.6

Khasanah, A. N., Sajidan, S., & Widoretno, S. (2017). Effectiveness of critical thinking indicator-based module in empowering student's learning outcome in respiratory system study material. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 187–195. https://doi.org/10.15294/jpii.v6i1.8490

Kim, S. (2015). *An analysis of teacher question types in inquiry-based classroom and traditional classroom settings* [University of Lowa]. https://eric.ed.gov/?id=ED567634

Kristiani, N., Susilo, H., Rohman, F., & Aloysius, D. C. (2015). The contribution of students' metacognitive skills and scientific attitude towards their academic achievements in biology learning implementing Thinking Empowerment by Questioning (TEQ) learning integrated with inquiry learning (TEQI). *International Journal of Educational Policy Research and Review*, *2*(9), 113–120. https://journalissues.org/wp-content/uploads/2015/11/Kristiani-et-al.pdf

Lestari, D. A. B., Astuti, B., & Darsono, T. (2018). Implementasi LKS dengan pendekatan STEM (science, technology, engineering, and mathematics) untuk meningkatkan kemampuan berpikir kritis siswa. *Jurnal Pendidikan Fisika Dan Teknologi*, *4*(2), 202. https://doi.org/10.29303/jpft.v4i2.809

Maas, T., Jochim, A., & Gross, B. (2018). Mind the gap: Will all students benefit from 21st Century learning? *Center on Reinventing Public Education*, *October*, 1–17. https://lib-ezproxy.concordia.ca/login?qurl=https%3A%2F%2Fwww.proquest.com%2Freports%2Fmind-gap-will-all-students-benefit-21st-century%2Fdocview%2F2461139420%2Fse-2%3Faccountid%3D10246%0Ahttps://concordiauniversity.on.worldcat.org/atoztitles/link??sid=Pro

Maniotes, L. K., & Kuhlthau, C. C. (2014). Making the shift: From traditional research to guiding inquiry learning. *Knowledge Quest*, *43*(2), 8–17. http://files.eric.ed.gov/fulltext/EJ1045936.pdf

Mas'ud, A., Haerullah, A., Husen, I., Pagala, J., Papuangan, N., & Sundari. (2019). The development of lesson design to improve collaboration activities and scientific work of student at SMAN 6 Ternate based on lesson study for learning community. *AIP Conference Proceedings*, *2194*. https://doi.org/10.1063/1.5139793

Masek, A., & Yamin, S. (2011). The effect of problem based learning on critical thinking ability: A theoretical and empirical review. *International Review of Social Sciences and Humanities*, *2*(1), 215–221.

Mastur, M. (2017). Implementasi Kurikulum 2013 dalam pelaksanaan pembelajaran di SMP. *Jurnal Inovasi Teknologi Pendidikan*, *4*(1), 50. https://doi.org/10.21831/jitp.v4i1.10131

Nurhikmayati, I. (2019). Efektivitas bahan ajar berbasis saintifik untuk meningkatkan kemampuan berpikir kritis siswa. *Jurnal THEOREMS (The Original Research of Mathematics)*, *3*(2), 124–133. https://doi.org/10.31949/th.v3i2.1171

Opara, J. A., & Oguzor, N. S. (2011). Inquiry instructional method and the school science currículum. *Current Research Journal of Social Sciences*, *3*(3), 188–198. https://maxwellsci.com/print/crjss/v3-188-198.pdf

Parmin, P., & Savitri, E. N. (2020). The influence of science, environment, technology, and society in creative industries on scientific based business designing skills of pre-service science teachers. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *8*(1), 27–38. https://doi.org/10.24815/jpsi.v8i1.15362

Pluta, W. J., Richards, B. F., & Mutnick, A. (2013). PBL and Beyond: Trends in collaborative learning. *Teaching and Learning in Medicine*, *25*(SUPPL.1). https://doi.org/10.1080/10401334.2013.842917

Prayitno, B. A., Aloysius, D. C., Susilo, H., Zubaidah, S., & Ramli, M. (2017). Closing the science process skills gap between students with high and low level academic achievement. *Journal of Baltic Science Education*, *16*(2), 266–277. https://doi.org/10.33225/jbse/17.16.266.

Raaijmakers, S. F., Baars, M., Schaap, L., Paas, F., van Merriënboer, J., & van Gog, T. (2018). Training self-regulated learning skills with video modeling examples: do task-selection skills transfer? *Instructional Science*, *46*(2), 273–290. https://doi.org/10.1007/s11251-017-9434-0

Ramadhani, Y., Helendra, H., Farma, S. A., & Syamsurizal, S. (2021). Validity of the human circulatory system booklets as an independent teaching material for natural science in class VIII junior high school. *Bioeducation Journal*, *5*(1). https://doi.org/10.24036/bioedu.v5i1.288

Rofieq, A., Hindun, I., Shultonnah, L., & Miharja, F. J. (2021). Developing textbook based on scientific approach, critical thinking, and science process skills. *Journal of Physics: Conference Series*, *1839*(1).

https://doi.org/10.1088/1742-6596/1839/1/012030

Sajidan, S., & Afandi, A. (2019). High level thinking skills empower students primary education through innovative learning. *Social, Humanities, and Educational Studies (SHEs): Conference Series*, *1*(2), 9. https://doi.org/10.20961/shes.v1i2.26724

Sandika, B., & Fitrihidajati, H. (2018). Improving creative thinking skills and scientific attitude through inquiry-based learning in basic biology lecture toward students of biology education. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *4*(1), 23–28. https://doi.org/10.22219/jpbi.v4i1.5326

Sari, D. E., Hindun, I., Mahmudati, N., Miharja, F. J., & Fauzi, A. (2020). Are male and female students different in high-order thinking skills? *JPI (Jurnal Pendidikan Indonesia)*, *9*(1), 42. https://doi.org/10.23887/jpi-undiksha.v9i1.17575

Sari, F. K., Farida, F., & Syazali, M. (2016). Pengembangan media pembelajaran (modul) berbantuan geogebra pokok bahasan turunan. *Al-Jabar : Jurnal Pendidikan Matematika*, *7*(2), 135–152. https://doi.org/10.24042/ajpm.v7i2.24

Setiawati, H., & Corebima, A. D. (2017). Empowering critical thinking skills of the students having different academic ability in biology learning of senior high school through PQ4R - TPS strategy. *The International Journal of Social Sciences and Humanities Invention*, *4*(5), 3521–3526. https://doi.org/10.18535/ijsshi/v4i5.09

Shofiyah, N., Supardi, Z. A. I., & Jatmiko, B. (2013). Mengembangkan penalaran ilmiah (scientific reasoning) siswa melalui model pembelajaran 5E pada siswa kelas X SMAN 15 Surabaya. *Jurnal Pendidikan IPA Indonesia*, *2*(1), 83–87. https://doi.org/10.15294/jpii.v2i1.2514

Su'udiah, F., Degeng, I. N. S., & Kuswandi, D. (2016). Pengembangan buku teks tematik berbasis kontekstual. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(9), 1744–1748. https://doi.org/10.17977/jp.v1i9.6743

Sufairoh, S. (2016). Pendekatan saintifik dan model pembelajaran K-13. *Jurnal Pendidikan Profesional*, *5*(3). http://www.jurnalpendidikanprofesional.com/index.php/JPP/article/view/186

Suryawati, E., & Osman, K. (2018). Contextual learning: Innovative approach towards the development of students' scientific attitude and natural science performance. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(1), 61–76. https://doi.org/10.12973/ejmste/79329

Suryawati, E., Suzanti, F., Suwondo, S., & Yustina, Y. (2018). The implementation of school-literacy-movement: Integrating scientific literacy, characters, and HOTS in science learning. *Jurnal Pendidikan Biologi Indonesia*, *4*(3), 215–224. https://doi.org/10.22219/jpbi.v4i3.6876

Susilana, R., & Ihsan, H. (2014). Pendekatan saintifik dalam implementasi kurikulum 2013 berdasarkan kajian teori psikologi belajar. *Edutech*, *1*(2), 183–195. https://doi.org/10.17509/edutech.v13i2.3095

Vong, S. A., & Kaewurai, W. (2017). Instructional model development to enhance critical thinking and critical thinking teaching ability of trainee students at regional teaching training center in Takeo province, Cambodia. *Kasetsart Journal of Social Sciences*, *38*(1), 88–95. https://doi.org/10.1016/j.kjss.2016.05.002

Weinberger, Y., & Shonfeld, M. (2018). Students' willingness to practice collaborative learning. *Teaching Education*, *00*(00), 1–17. https://doi.org/10.1080/10476210.2018.1508280

West, D. M. (2015). Connected learning: How mobile technology can imporve education. *Center for Technology Innovation at Brookings*, *December*, 1–8. https://www.brookings.edu/wp-content/uploads/2016/07/west_connected-learning_v11.pdf

Wijayaningputri, A. R., Widodo, W., & Munasir, M. (2018). The effect of guided-inquiry model on science process skills indicators. *JPPS (Jurnal Penelitian Pendidikan Sains)*, *8*(1), 1542–1546. https://journal.unesa.ac.id/index.php/jpps/article/view/3856/2187

Yücel, Ü. A. I., & Usluel, Y. K. (2016). Knowledge building and the quantity, content and quality of the interaction and participation of students in an online collaborative learning environment. *Computers and Education*, *97*, 31–48. https://doi.org/10.1016/j.compedu.2016.02.015

Zubaidah, S., Corebima, A. D., & Mistianah, M. (2015). Asesmen berpikir kritis terintegrasi tes essay. *Symbion: Symposium on Biology Education*, 200–213. https://www.researchgate.net/publication/322315188_ Asesmen_Berpikir_Kritis_Terintegrasi_Tes_Essay