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Improving student higher order thinking skills using Synectic-HOTS-oriented learning model

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ABSTRACT

The achievement of students' learning outcomes in physics lessons has a low tendency, this is due to various factors, one of which is higher-order thinking skills (HOTS) based learning that has not been fully implemented in the learning process and assessment. This study aimed to determine the differences in the Synectic-HOTS learning model in physics compared to conventional learning models. This study used a quasi-experimental study with a pre-test–post-test nonequivalent control group design. The instrument used in this study is a two-tier test question that contains 20 items of HOTS aspect. The prerequisite test showed that the data was not homogeneous, while the results of the data homogeneity test were stated to be homogeneous. Therefore, a non-parametric test was carried out using the Mann-Whitney U-test. Based on the results of the data analysis, the Asymp. Sig. (2-tailed) for the pre-test was 0.111 and the post-test was 0.001 (p=.000<05). The effect size calculation shows that the Synectic learning model is effective in the medium category. These results indicate that the application of the Synectic-HOTS model significantly improves HOTS when compared to conventional learning models. This work can open up insights to teachers about alternative, creative, and effective learning models to improve higher-order thinking skills and student learning outcomes.

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1. INTRODUCTION

One of the student's competencies skills that are needed in the industrial era 4.0 is higher order thinking. The ability to think includes critical thinking, creative thinking, problem-solving skills, and decision making are important to improve [1]–[3]. In learning physics, students should understand the concept, have creative thinking, and apply it to daily life [4]. Learning physics plays an important role in everyday life. Learning helps students think analytically and have better thinking ability. It helps them develop their life-long and problem problems solving skills [5].

Indonesian students' achievement in science is currently relatively low. At least 40% of students in Indonesia reach grade 2 in science from the Organization for Economic Cooperation and Development (OECD) average of about 78%, while highly proficient students in science are at 5 or 6 grades from OECD average of about 7%. These students are creative and independent in applying scientific knowledge to various situations. They understand concepts from their surroundings and everyday life to identify simple cases. This implies that students' cognitive abilities need to be continuously improved. One way to improve the score is with learning strategies.

One of the techniques used by the government is the introduction of higher-level thinking skills based on Regulation of the Minister of National Education (Permendiknas) no. 21 on the content standard, no. 22 on the process standard, and no. 23 on the standard of assessment [6]. Solving problems in physics learning in accordance with the correct concepts and directing personal analogies so that it generates creativity through analyzing activities [7]. Learning with problem identification, problem organization, problem investigation, and building arguments is important in providing critical thinking skills [8]. Another proof is when students were given two tier test they can answer the multiple choice correctly, but they cannot give the reason. They do not get the concept. It is in line with [4], [9] about the physics test higher order thinking skills development, stated that students creative thinking was categorized as poor. This study aimed to determine the increase in students' higher order thinking skills (HOTS) in physics learning and how the effect of using Synectic learning models on physics learning in high school.

Conventional methods used in physics classes tend to measure cognitive aspects only, even though they have used learning tools [10]–[12]. Learning activities include explaining, giving examples, asking questions and then testing students. This causes students to memorize the formulas used [13]. In accordance with observations and interviews with teachers. There are three information that can be obtained, namely the learning process is still teacher-centered, students cannot ask or answer questions, and the learning model is less varied so that an innovative learning model is needed.

Successful teaching involves versatility, innovation and responsibility to provide an education atmosphere that can meet the basic needs of the learner, it is in line with the aims of education beside to educate is improving human resources [7], [14]. It is applicable to all lessons include physics, which aim to create students' scientific behavior, reasoning ability, concept and analysis mastering also developing science and technology [15], [16]. Students may not interest in the learning if it is not fun so physics learning should be fun. There are some efforts in making fun learning through learning model, learning method, media and also material [17]. If students' interest in the learning, the learning objective can be achieved by communicating.

Learning communication should be two ways, where the students are free to communicate anything to the teacher and vice versa. Besides communication, teachers need to have creative thinking. Teachers who have creative thinking can affect students learning process. It means that teachers know how to develop students well. Learning process can be done in different model, method, and also strategy [18], [19], but it should consider students' need, learning material, and also learning tools. It is important to know that creative thinking leads to problem solving ability in different ways [20], [21], to be able to improve creative thinking skills, strategies, synergies with critical thinking and being part of higher-order thinking skills are needed [22].

Moreover, teachers should have an awareness of individual learning process. In the learning phase individuals communicate with the following aspect process the knowledge exclusively and require a specific learning environment. Therefore, it is necessary to consider helping students to overcome learning difficulties and facilitate learning through effective interaction from teacher to students during learning activities. This in line with Suratno *et al*. [23] who stated that development of cognitive ability simultaneously with students' learning processes.

According to Maryani *et al*. [24], HOTS can be developed for the students so that it trains student's higher-order thinking skills include critical thinking, synthesize through mind mapping, which both of them related to each other. Reflective study in the learning process which uses Synectic learning model, also improves students' metacognitive abilities, one of the steps of learning activities, namely exploration or reflection [25]. To support the HOTS-oriented learning process, science learning can be presented with the help of learning modules as well as a need analysis of HOTS-oriented teaching materials [26]. Likewise, Zajuli *et al.* [27] conducted an analysis of HOTS needs in an effort to generate ideas for students. Students' higher order thinking skills can actually be measured by various evaluation models. The multiple-choice test on the grounds is one of the diagnostic tests to determine of student understanding and mastery of the lessons that has been taught. This is in line with the use of a CBT-based multiple choice test [28]. Through early tests, it can be seen about the mapping of HOTS-based problem-solving abilities as studied by Istiyono *et al*. [9] either using CAT or using a physics tier-test [4].

One of the aims of education is to build quality learning, where learners are required to do something that cannot be achieved before learning, so that the learning outcomes are influenced. Many factors affect the low learning outcomes themselves, including the learning paradigm, the facilities, and students creative ability. According to Risdianto *et al*. [13], learning activities include explain, giving the example, giving question and then test the students. It causes students to memorize the formula used.

Higher order thinking skills, what is commonly called HOTS, include classification, induction, deduction, and thinking ability [2]. HOTS aspects are not only about memorize and remember but also analyze (C4), evaluate (C5), and create (C6). Students are hoped to have some abilities in analyze aspect such as collect the information then divided it into interrelated parts, know the difference between cause and effect, and also identify the problem [29]. Evaluate aspect include present ideas and determine the relations between varies method, design and test the hypothesis, also make a decision. Create aspect include taking conclusion, designing a problem solving [30], and the last make a new structure [24], [31], [32]. These aspects are similar to the Synectic learning model.

Synectic learning model which stated by Gordon in 1978 [33] was oriented on creative thinking, it is closely related to cognitive-HOTS [34] and metacognitive through reflection activity [25]. Creativity is important in learning so that how to develop students' imagination, build critical thinking skills can be done through various aspects of learning through science, art, language, and other fields of study [35], [36]. Generally, Synectic model consisted of two structures which have five and seven steps for each. This study adopted two structures of Synectic model [23], combined into five steps namely substantive input, combine direct analogies and compare analogies by explaining differences, constructing personal analogies, and generating new analogies. The structure of Synectic model is shown in Figure 1.

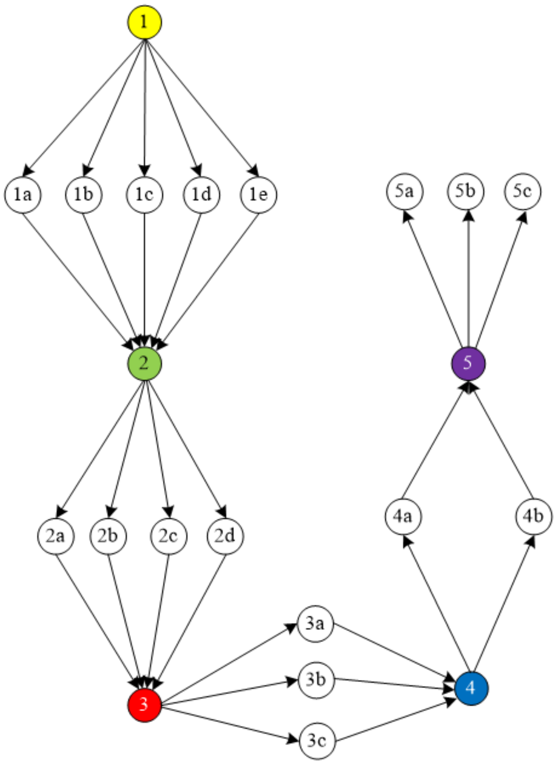

Figure 1. General phase Synectic-HOTS model

Based on Figure 1, students' way of thinking is determined in stages that include various steps towards acquiring higher order thinking skills. Each stage has two circles, the colored circle and the white circle. Each shaded circle describes the student's activity on physic lessons, while the white circle represents the performance of higher-order thinking skills in the Synectic-HOT model. The colored circle consists of the phases (white circles) of the Synectic model, namely: i) Substantive input (yellow circle): observation, understanding multiple photos/videos, identify problems as much as possible based on screen, know the definition, and understand features; ii) Combine direct analogies, compare analogies and explain the difference (blue circle) like: understanding characteristics, describe the analogy, identify the difference, explain the similarities and differences between the examples using the chosen analogy; iii) Personal analogy, such as: look for another example, consider yourself an object, discuss the results; iv) Exploration (explain the results in your own language, take note of the findings); v) Make new comparisons (To look for a new analogy, Finding similarities and differences, present ideas to the class).

This research is a an implementation of the Synectic-HOTS oriented teaching materials that have been developed previously [6]. The Synectic-HOTS model applied in this study has a novelty value in the syntax combination of the Synectic model which is oriented towards higher order thinking skills. The renewal is in the lesson plan, teaching materials, and learning evaluation.

2. RESEARCH METHOD

2.1. Research design

This research used quasi-experimental research with pre-test and post-test nonequivalent control group design. The control group used the expository learning model, while the experiment group used the Synectic-HOTS model. The details are presented in Table 1.

Table 1. Pre-test and post-test non-equivalent control group design

Group	Pre-test	Treatment	Post-test
Experiment	O_1	X_1	O_2
Control	O_1	X_0	O_2

Note: O_1=pre-test, O_2=post-test, X_1=Synectic-HOTS model, X_0=expository learning model

The research took place in public senior high school (SMAN) 2 Purworejo, Central Java, Indonesia. There were 120 students from two classes as the research subject with homogeneous variants seen from the homogeneity test results (p>0.05), then divided into two classes, namely the control class of 60 students and the experimental class of 60 students. The control class used conventional learning methods, such as presentation method, information discussion supported by teaching equipment, giving examples, and answering questions. Meanwhile, the implementation of the Synectic-HOTS learning model is assigned to the experimental class based on the lesson plan.

To ensure that the Synectic-HOTS learning model was implemented with the lesson plan, model implementation was followed. Testing tool to determine higher order thinking skills using a rational multiple-choice test consisting of 20 items containing HOTS aspects of analysis (C4), evaluation (C5) and creativity (C6). In this study, aspects of C1-C3 were not listed in the tests because the main goal of applying this model was to determine the higher order thinking ability of students in learning physics. The test questions before and after the test of the experimental class and the control class are designed differently with the same weight of questions. The pre-test and post-test questions for the experimental class and control class were made different with the same weight of questions. The blueprint for the higher order thinking skills test in physics learning for energy and work material is shown in Table 2.

Table 2. Blueprint of test

Aspect	Sub-aspect	Indicators
Analyze (C4)	Differentiate (A1)	- Differentiate minimum and maximum Work. - Differentiate the velocity of an object in a certain way using the law of conservation of energy. - Differentiate amount of kinetic energy one another.
	Organize (A2)	- Sort the smallest Work value of a moving object. - Sort the Work done by several forces that from various angles to the horizontal. - Sort the amount of kinetic energy of an object based on the law of conservation of mechanical energy.
	Attribute (A3)	- Give a characteristic that Work is a change in the potential energy. - Give a characteristic that Work is the change in the kinetic of an object.
Evaluate (C5)	Check (B1)	- Check the correctness of the Work at various constant forces. - Check the correctness of the Work at various constant forces. - Check the variation in the graph of the relationship between distance to kinetic energy, and height to potential energy. - Check the kinetic energy and velocity of objects at various positions using the conservation law of energy.
	Criticize (B2)	- Choose an easier Work to move objects vertically and horizontally. - Check the potential energy of objects at various positions/heights. - Check the path that has a greater kinetic energy value based on the figure related to the law of conservation of mechanical energy.
Create (C6)	Generating ideas (C1)	- Generating the way to determine kinetic energy of a moving object on certain path. - Generating the way to determine Work with various energy changes. - Generating the hypothesis that a change in the size of planet causes a change in its gravitational nature.
	Plan (C2)	- Plan an experiment in applying the conservation law of mechanical energy in the case of free-falling objects.
	Produce (C3)	- Produce a simple prop to determine gravitational potential energy and spring potential energy. - Produce simple works to measure the speed of objects based on the law of conservation of energy.

2.2. Data collection and analysis

The data were obtained from higher order thinking skills two tier test tests both before learning and after learning (pre and post-test). The questions were multiple choice questions totaling 20 questions on work and energy material. The questions were arranged by the researcher and content validation was carried out by three physics material experts and two physics teachers using the Aiken's V method, the average validation score was 0.825 in the good category. Meanwhile, the empirical validity test items on the higher order thinking skills test that have been tested on students as a whole are in the valid category with a value of $r_{count} > r_{table}$ of 0.444. The results of the test reliability analysis using Cronbach's alpha showed the reliability of the instrument was 0.823, including the high criteria.

Data were analyzed by using the non-parametric t-test (Mann-Whitney U test) to determine the significance value between the two experimental classes using the Synectic learning model and the two control classes using the conventional mode. The prerequisite test was carried out to determine the normality and homogeneity of data. To find out how students responded to learning, interviews were conducted with several students regarding their understanding of the learning process. To determine the effect size of the Synectic-HOTS models then calculated using Cohen's *d* by (1).

$$d = \frac{M_1 - M_2}{s} \quad (1)$$

Where, M_1-M_2 is the difference between the group means (M), s is the standard deviation of either group (0.2 small; 0.5 medium; 0.8 large; 1.3 very large).

3. RESULTS AND DISCUSSION

The physics learning process was based on the lesson plan for the work and energy material. The synectic learning model used refers to the Synectic model initiated by Gordon [33], which includes: substantive input, combining direct analogies, suggesting similarities and differences, making personal analogies, exploring and generating new ideas. Based on the higher thinking ability test scores, it showed that both pre and post-test from the conventional class are relatively lower than the class using the Synectic-HOTS learning model. The final class post-test achievement using the Synectic-HOTS learning model gets a score of 75.68, a difference of 3.15 from the conventional class. The pre and post-test score can be seen in Table 3.

Table 3. Pre-test and post-test score

Model	N	Pre-test		Post-test	
		Mean	Std. error	Mean	Std. error
Synectic learning	60	62.05	4.735	75.68	5.251
Conventional	60	63.40	6.973	72.53	4.553

In this study, Kolmogorov-Smirnov one sample test was used to determine the normality of the data. Score p=0.00<0.05 indicated that the sample did not from a normally distributed population. Meanwhile, the homogeneity test results for the pre-test showed that both of them had homogeneous variants (p>.05), with a pre-test score of .014 and a post-test score of 0.095. Based on these data, a non-parametric test was performed using the Mann-Whitney U-test as shown in Table 4. The test results show that physics learning using a conventional model with a Synectic learning model has a difference, with an Asymp. Sig. (2-tailed) of 0.111 on the pre-test, and 0.001 in the post-test (p=.000<.05). The results indicate that the implementation of the Synectic-HOTS learning model has a positive impact on improving students' higher-order thinking skills in learning physics. The effect size calculation shows that the Synectic-HOTS model is moderately effective.

Table 4. Mann-Whitney U-Test

Group	Z	Asym. Sig. (2-Tailed)	d (effect size)
Pre-test experiment-control	-1.593	.111	.641
Pos-test experiment-control	-3.284	.001	

To determine the right learning model, the teacher must determine the subject matter, student needs, teacher competence, and also the readiness of facilities and infrastructure so that they can support effective learning. The Synectic-HOTS learning model emphasizes the creative aspects of students, where one of the orientations is to improve students HOTS ability which include the ability to analyze (C4), evaluate (C5), and the ability to create (C6). This HOTS aspect can be reflected in the details of the results of the pre-test and post-test in the experimental class for Work-Energy subject matter which are presented in more detail in Figure 2.

As shown in Table 2, the HOTS aspects on the blueprint then divided into several sub aspects. In general, there is an enhancement of students' HOTS ability when viewed from the tendency of increasing scores from each aspect as shown in Figure 1 for the results on the pre-test and post-test. The student's ability in the analyzing aspect (C4) which consists of: the ability to distinguish has increased from the pre-test mean score 14.44 to 30.00 in the post-test, the sub-aspect of organizing has increased by 20.66 from the pre and post-test results. Meanwhile, the ability to attribute has pre-test score of 11.67 and a post-test score of 20.50. The aspect of evaluating (C5) is divided into checking and criticizing.

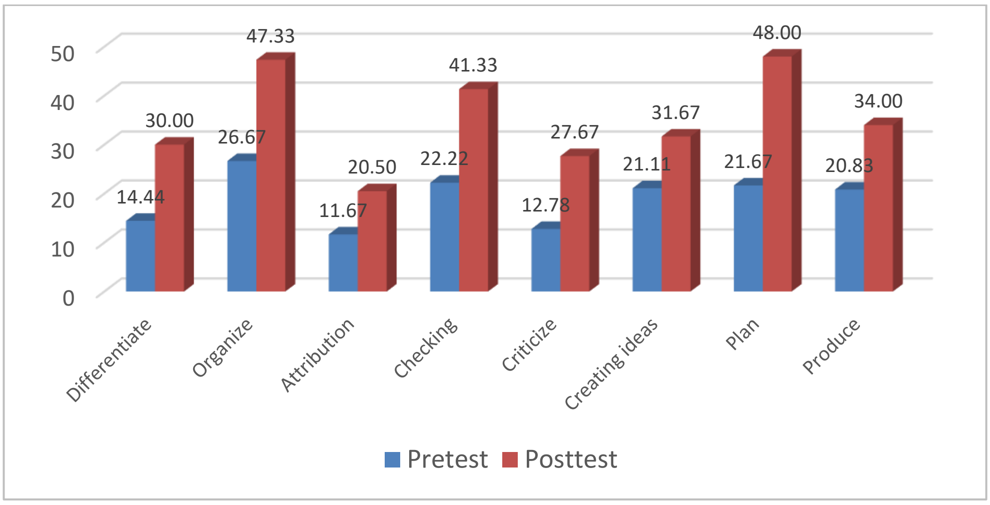

Figure 2. The percentage of students HOTS ability

The improvement occurred in the sub-aspects of checking, which was shown with the differences between pre and post-test result scores of 19.11; while the sub-aspect of criticism increased by 14.89. The creating aspect (C6) on the pre-test seems to have a tendency to score almost the same on the pre-test scores, namely 21.11, 21.67, and 20.83. However, there was a significant increase in post-test, namely 31.67, 48.00, and 34.00. From all aspects and sub-aspects in Figure 2, the analyzing aspect appears to have the highest score compared to other aspects even though in the sub-aspect the ability to attribute or give special characteristics appears to be the lowest. Students have a tendency to excellent in the ability to organize concepts and analysis of physics, so that their scores appear to be better than other aspects. Another aspect is evaluating the sub-aspects of planning ability. Students can plan a simple experiment well and solve problems related to the ability to formulate ideas or plan well. This result is supported by some researchers regarding the preparation of test instruments and test results for higher-order thinking skills [6], [9], [24], [28], [37].

Based on the results, implementing a Synectic-HOTS model can improve all aspects of HOTS, although in some aspects, especially the ability to evaluate and create, need to have more improvement. This can be shown in the increase of the mean score with a difference of 13.63. The results of students' abilities enhancement in each HOTS sub-aspect cannot be separated from the role of students in learning and teacher facilitation in guiding students at each step of implementing the Synectic model. In the physics learning process using the Synectic learning model, students are given the freedom to explore their knowledge [38]. This flexibility is manifested in Synectic-HOTS syntax which includes the ability to make metaphors as well as exploration of conceptual understanding and analysis mastery of the work and energy material. This is in line with research by Kapile and Nuraedah [39] concerning the effects of implementing a Synectic model on the development KKNI learning model in science learning. A study by Suratno *et al*. [23] on the effectiveness of the Synectic model indicates that the Synectic model can improve student creativity and learning outcomes. This statement is in accordance with the study by Suratno *et al*. [23] that Synectic learning in science learning is closely related to aspects of creativity and students' metacognitive abilities.

Meanwhile, in relation to high-order thinking skills in all aspects, especially C6, namely creating as described by several researchers [20], [40], so that the Synectic-HOTS model is deemed necessary and important to be applied in learning physics. HOTS and the Synectic model are closely related, especially in improving students' cognitive abilities in learning science, especially physics. This is in line with the results of research by Agussuryani *et al*. [41] who examined the meta-analysis of science learning by linking STEM and HOTS at the vocational school level.

The findings provide an answer to the research objectives as well as an illustration that through the HOTS-oriented Synectic-HOTS learning model it is possible to improve students higher-order thinking skills in learning physics for the subject of work and energy. Learning can take place effectively if there is good cooperation between teachers and students in a flexible manner so that student-centered learning is realized and is able to improve learning outcomes. This is an attraction for researchers, especially in educational research, how to improve learning through the development of learning models, learning strategies, and teaching materials by the Synectic-HOTS learning model.

4. CONCLUSION

It can be concluded that the implementing of the Synectic-HOTS model can significantly improve student learning outcomes. This is emerged from comparing the results of the pre-test and the post-test, either in the control class using the conventional model or in the experimental class using the Synectic-HOTS model. The Synectic-HOTS learning model is effectively used to train students' HOTS, including the ability to analyze, evaluate, and create. In this case, the ability to make analogies, explore, and come up with new ideas needs to be continuously trained for students to have a critical and creative attitude. As a suggestion, this study should be used as a reference for teachers, schools and other educators about the importance of different models that can be applied in learning, especially physics lessons. In future work, the Synectic-HOTS model can be applied on a larger scale in both learning implementation plans, document scopes, teaching materials, and field implementations. Besides, teachers can also consider adopting the lesson plan, module, and material to be used in their classroom. However, teachers should consider about students' need. The suggested techniques and methods to enhance the teaching and studying of physics are for integrative physics teaching, teacher is encouraged to incorporate creative learning models according to the student needs, and integrated into curriculum in the lesson plan. Through learning that emphasizes creativity and higher-order thinking skills, physics teachers can apply several practical ways to create a pleasant learning atmosphere, increase student motivation, and student achievement. If the implementation of learning has been running effectively, there will be a positive reciprocal relationship between teachers and students. Therefore, teachers need to design different strategies for every physics lesson in class; this is aim to helping students achieve good performance in physics.

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REFERENCES

[1] D. Henriksen, C. Richardson, and R. Mehta, "Design thinking: A creative approach to educational problems of practice," *Thinking Skills and Creativity*, vol. 26, pp. 140–153, Dec. 2017, doi: 10.1016/j.tsc.2017.10.001.

[2] U. Rosidin, A. Suyanta, and A. Abdurrahman, "A combined HOTS-based assessment/STEM learning model to improve secondary students' thinking skills: a development and evaluation study," *Journal for the Education of Gifted Young Scientists*, vol. 7, no. 3, pp. 435–448, Sep. 2019, doi: 10.17478/jegys.518464.

[3] R. Perdana, A.-N. Apriani, R. Richardo, E. Rochaendi, and C. Kusuma, "Elementary students' attitudes towards STEM and 21st-century skills," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 10, no. 3, pp. 1080–1088, Sep. 2021, doi: 10.11591/ijere.v10i3.21389.

[4] H. Putranta and S. Supahar, "Development of physics-tier tests (PysTT) to measure students' conceptual understanding and creative thinking skills: a qualitative synthesis," *Journal for the Education of Gifted Young Scientists*, vol. 7, no. 3, pp. 747–775, Sep. 2019, doi: 10.17478/jegys.587203.

[5] J. M. Cardino and R. A. O.-D. Cruz, "Understanding of learning styles and teaching strategies towards improving the teaching and learning of mathematics," *LUMAT: International Journal on Math, Science and Technology Education*, vol. 8, no. 1, May 2020, doi: 10.31129/LUMAT.8.1.1348.

[6] E. S. Kurniawan, M. Mundilarto, and E. Istiyono, "Synectic HOTS oriented: development of teaching materials for high school physics learning," *Universal Journal of Educational Research*, vol. 8, no. 11, pp. 5547–5554, Oct. 2020, doi: 10.13189/ujer.2020.081158.

[7] F. Corni, H. U. Fuchs, and E. Dumont, "Conceptual metaphor in physics education: roots of analogy, visual metaphors, and a primary physics course for student teachers," *Journal of Physics: Conference Series*, vol. 1286, no. 1, Aug. 2019, doi: 10.1088/1742-6596/1286/1/012059.

[8] R. W. Akhdinirwanto, R. Agustini, and B. Jatmiko, "Problem-based learning with argumentation as a hypothetical model to increase the critical thinking skills for junior high school students," *Jurnal Pendidikan IPA Indonesia*, vol. 9, no. 3, pp. 340–350, Sep. 2020, doi: 10.15294/jpii.v9i3.19282.

[9] E. Istiyono, W. S. B. Dwandaru, and R. Faizah, "Mapping of physics problem-solving skills of senior high school students using PhysProSS-CAT," *Research and Evaluation in Education*, vol. 4, no. 2, pp. 144–154, Dec. 2018, doi: 10.21831/reid.v4i2.22218.

[10] E. Burkholder, L. Blackmon, and C. Wieman, "Characterizing the mathematical problem-solving strategies of transitioning novice physics students," *Physical Review Physics Education Research*, vol. 16, no. 2, Nov. 2020, doi: 10.1103/PhysRevPhysEducRes.16.020134.
[11] S. Avargil, R. Lavi, and Y. J. Dori, "Students' metacognition and metacognitive strategies in science education," in *Cognition, Metacognition, and Culture in STEM Education*, Springer International Publishing, 2018, pp. 33–64.
[12] A. I. Benzer and S. Ünal, "Models and modelling in science education in turkey: a literature review," *Journal of Baltic Science Education*, vol. 20, no. 3, pp. 344–359, Jun. 2021, doi: 10.33225/jbse/21.20.344.
[13] E. Risdianto, M. J. Dinissjah, D. Nirwana, and M. Kristiawan, "The effect of ethno science-based direct instruction learning model in physics learning on students' critical thinking skill," *Universal Journal of Educational Research*, vol. 8, no. 2, pp. 611–615, Feb. 2020, doi: 10.13189/ujer.2020.080233.
[14] R. A. Madani, "Analysis of educational quality, a goal of education for all policy," *Higher Education Studies*, vol. 9, no. 1, Jan. 2019, doi: 10.5539/hes.v9n1p100.
[15] U. Usmeldi, R. Amini, and S. Trisna, "The development of research-based learning model with science, environment, technology, and society approaches to improve critical thinking of students," *Jurnal Pendidikan IPA Indonesia*, vol. 6, no. 2, Oct. 2017, doi: 10.15294/jpii.v6i2.10680.
[16] S. Xue, D. Sun, L. Zhu, H.-W. Huang, and K. Topping, "Comparing the effects of modelling and analogy on high school students' content understanding and transferability: the case of atomic structure," *Journal of Baltic Science Education*, vol. 21, no. 2, pp. 325–341, Apr. 2022, doi: 10.33225/jbse/22.21.325.
[17] J. Gore, A. Lloyd, M. Smith, J. Bowe, H. Ellis, and D. Lubans, "Effects of professional development on the quality of teaching: Results from a randomised controlled trial of quality teaching rounds," *Teaching and Teacher Education*, vol. 68, pp. 99–113, Nov. 2017, doi: 10.1016/j.tate.2017.08.007.
[18] A. Gajda, R. A. Beghetto, and M. Karwowski, "Exploring creative learning in the classroom: A multi-method approach," *Thinking Skills and Creativity*, vol. 24, pp. 250–267, Jun. 2017, doi: 10.1016/j.tsc.2017.04.002.
[19] O. Othman, Z. H., and R. Mohammad, "Creative teaching STEM module: high school students' perception," *European Journal of Educational Research*, vol. 11, no. 4, pp. 2127–2137, Oct. 2022, doi: 10.12973/eu-jer.11.4.2127.
[20] O. Siburian, A. D. Corebima, Ibrohim, and M. Saptasari, "The correlation between critical and creative thinking skills on cognitive learning results," *Eurasian Journal of Educational Research*, vol. 19, no. 81, pp. 1–16, May 2019, doi: 10.14689/ejer.2019.81.6.
[21] S. Zubaidah, N. M. Fuad, S. Mahanal, and E. Suarsini, "Improving creative thinking skills of students through differentiated science inquiry integrated with mind map," *Journal of Turkish Science Education*, vol. 14, no. 4, pp. 77–91, 2017.
[22] N. Huang, Y. Chang, and C. Chou, "Effects of creative thinking, psychomotor skills, and creative self-efficacy on engineering design creativity," *Thinking Skills and Creativity*, vol. 37, Sep. 2020, doi: 10.1016/j.tsc.2020.100695.
[23] S. Suratno, N. Komaria, Y. Yushardi, D. Dafik, and I. Wicaksono, "The effect of using synectics model on creative thinking and metacognition skills of junior high school students," *International Journal of Instruction*, vol. 12, no. 3, pp. 133–150, Jul. 2019, doi: 10.29333/iji.2019.1239a.
[24] I. Maryani, Z. K. Prasetyo, I. Wilujeng, and S. Purwanti, "Promoting higher-order thinking skills during online learning: The integration of metacognition in science for higher education," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 11, no. 4, Dec. 2022, doi: 10.11591/ijere.v11i4.23129.
[25] R. P. Antonio, "Developing students' reflective thinking skills in a metacognitive and argument-driven learning environment," *International Journal of Research in Education and Science*, vol. 6, no. 3, Jun. 2020, doi: 10.46328/ijres.v6i3.1096.
[26] M. N. Hassan, R. Mustapha, N. A. N. Yusuff, and R. Mansor, "Development of higher order thinking skills module in science primary school: Needs analysis," *International Journal of Academic Research in Business and Social Sciences*, vol. 7, no. 2, pp. 624–628, 2017.
[27] I. Zajuli, D. Vivanti, M. Miarsyah, A. Ali, W. Pramita, and T. Ageng, "HOTS-AEP: higher order thinking skills from elementary to master students in environmental learning," *European Journal of Educational Research*, vol. 8, no. 4, pp. 935–942, Oct. 2019, doi: 10.12973/eu-jer.8.4.935.
[28] E. Istiyono, W. S. B. Dwandaru, L. Erfianti, and W. Astuti, "Applying CBT in physics learning to measure students' higher order thinking skills," *Journal of Physics: Conference Series*, vol. 1440, no. 1, Jan. 2020, doi: 10.1088/1742-6596/1440/1/012061.
[29] T. A. Erdol, "Analysis of the questions in 11th Grade Philosophy Coursebook in terms of higher-order thinking skills," *Turkish Journal of Education*, vol. 9, no. 3, pp. 222–245, Jul. 2020, doi: 10.19128/turje.695928.
[30] N. Akben, "Effects of the problem-posing approach on students' problem solving skills and metacognitive awareness in science education," *Research in Science Education*, vol. 50, no. 3, pp. 1143–1165, Jun. 2020, doi: 10.1007/s11165-018-9726-7.
[31] D. R. Krathwohl, "A revision of bloom's taxonomy: an overview," *Theory into Practice*, vol. 41, no. 4, pp. 212–218, Nov. 2002, doi: 10.1207/s15430421tip4104_2.
[32] S. W. Widyaningsih, I. Yusuf, Z. K. Prasetyo, and E. Istiyono, "The development of the HOTS test of physics based on modern test theory: question modeling through e-learning of moodle LMS," *International Journal of Instruction*, vol. 14, no. 4, pp. 51–68, Oct. 2021, doi: 10.29333/iji.2021.1444a.
[33] B. R. Joyce, M. Weil, and E. Calhoun, *Models of teaching*. Prentice-Hall Englewood Cliffs, NJ, 1986.
[34] J. C. Kaufman, *Creativity 101*. New York, NY: Springer Publishing Company, 2016.
[35] K. Sawyer, *The creative classroom: Innovative teaching for 21st-century learners*. Teachers College Press, 2019.
[36] X. Tsortanidou, T. Daradoumis, and E. Barberá, "Connecting moments of creativity, computational thinking, collaboration and new media literacy skills," *Information and Learning Sciences*, vol. 120, no. 11/12, pp. 704–722, Nov. 2019, doi: 10.1108/ILS-05-2019-0042.
[37] E. Istiyono, "The analysis of senior high school students' physics HOTS in Bantul District measured using PhysReMChoTHOTS," *The 4th International Conference on Research, Implementation, and Education of Mathematics and Science (4th ICRIEMS): Research and Education for Developing Scientific Attitude in Sciences and Mathematics*, 2017, doi: 10.1063/1.4995184.
[38] A. Serikbayeva and L. Beisenbayeva, "Synectics as a modern method of solving creative problems," in *Paradigm Shifts in 21st Century Teaching and Learning*, IGI Global, 2020, pp. 145–157.
[39] C. Kapile and N. Nuraedah, "Development of KKNI oriented learning devices assisted by the synectic model," *AL-ISHLAH: Jurnal Pendidikan*, vol. 14, no. 1, pp. 1–10, Feb. 2022, doi: 10.35445/alishlah.v14i1.1197.
[40] H. Sun, Y. Xie, and J. Lavonen, "Exploring the structure of students' scientific higher order thinking in science education," *Thinking Skills and Creativity*, vol. 43, Mar. 2022, doi: 10.1016/j.tsc.2022.100999.
[41] Q. Agussuryani, S. Sudarmin, W. Sumarni, E. Cahyono, and E. Ellianawati, "STEM literacy in growing vocational school student HOTS in science learning: A meta-analysis," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 11, no. 1, pp. 51–60, Mar. 2022, doi: 10.11591/ijere.v11i1.21647.

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