BUKTI KORESPONDENSI
ARTIKEL JURNAL INTERNATIONAL BEREPUTASI

Judul artikel	:	Integrating metacognitive strategies impact in virtual science experiments for undergraduate students' HOTS
Jurnal	:	Cakrawala Pendidikan (June 2023), Vol 42, No 2
Penulis	:	Trikinasih Handayani, Butch O. Saulon, Ika Maryani

No	Perihal	Tanggal
1	Bukti konfirmasi submit artikel dan artikel yang disubmit	08 Juli 2022
2	Bukti Konfirmasi review dan hasil review	08 September2022
3	Bukti Konfirmasi submit review dan artikel yang diresubmit	29 september 2022
4	: Buti Konfirmasi artikel accepted	18 November 2022
5	Bukti konfirmasi artikel Published online	14 Mei 2023

1. Bukti konfirmasi submit artikel dan artikel yang disubmit (08 Juli 2022)

[CP] Submission Acknowledgement

Prof. Dr. Sulis Triyono <cakrawala@uny.ac.id> Jul 8, 2022, 11:13 AM

Dear Trikinasih Handayani,

Thank you for submitting the manuscript, "INTEGRATING METACOGNITIVE STRATEGIES IMPACT IN VIRTUAL SCIENCE EXPERIMENTS FOR UNDERGRADUATE
STUDENTS' HOTS" to Jurnal Cakrawala Pendidikan. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL:
https://journal.uny.ac.id/index.php/cp/author/submission/51752
Username: trikinasih

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Sincerely,

Prof. Dr. Sulis Triyono
Jurnal Cakrawala Pendidikan

____

Cakrawala Pendidikan
http://journal.uny.ac.id/index.php/cp

--

INTEGRATING METACOGNITIVE STRATEGIES IMPACT IN VIRTUAL SCIENCE EXPERIMENTS FOR UNDERGRADUATE STUDENTS' HOTS

Journal	Cakrawala Pendidikan
Manuscript ID	#51752
Manuscript type	Article
Keyword	***higher-order thinking skills, metacognition, undergraduate science students, virtual science experiment***
Abstract	Higher Order Thinking Skills (HOTS) are essential variables that support the achievement of science learning objectives. However, distance learning during the Covid-19 Pandemic was the cause of the lack of maximum HOTS for undergraduate science students due to their lack of involvement in experiments. Therefore, this study aims to apply a metacognition-integrated science virtual experiment model and examine its impact on students' HOTS science. A quasi-experiment was involved with a randomized pretest-posttest comparison group design to see the impact of the implementation of this model. Participants in the two treatment groups were randomly selected from two private universities in Indonesia. The HOTS of participants were assessed using multiple-choice questions. Observation sheets were used to measure the implementation of the learning model being developed. A general linear model with MANOVA was used to test the effect of the model, while Partial Eta Squared was used to measure the effect size of the model on HOTS. The results showed that the virtual science experimental model integrated with metacognition strategies significantly affected students' HOTS. The effect size measurement shows a high effect in the experimental group. Researchers recommend that universities apply a similar model to encourage students' achievement of HOTS.

INTEGRATING METACOGNITIVE STRATEGIES IMPACT IN VIRTUAL SCIENCE EXPERIMENTS FOR UNDERGRADUATE STUDENTS' HOTS

Trikinasih Handayani[1*], Butch O. Saulon[2], Ika Maryani[3]
[1] Department of Biology Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[2] School of Graduate Studies, University of Nueva Caceres, Bicol Region, Philippines
[3] Department of Elementary School Teacher Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
*e-mail: trikinasih@pbio.uad.ac.id

Abstract: Higher Order Thinking Skills (HOTS) are essential variables that support the achievement of science learning objectives. However, distance learning during the Covid-19 Pandemic was the cause of the lack of maximum HOTS for undergraduate science students due to their lack of involvement in experiments. Therefore, this study aims to apply a metacognition-integrated science virtual experiment model and examine its impact on students' HOTS science. A quasi-experiment was involved with a randomized pretest-posttest comparison group design to see the impact of the implementation of this model. Participants in the two treatment groups were randomly selected from two private universities in Indonesia. The HOTS of participants were assessed using multiple-choice questions. Observation sheets were used to measure the implementation of the learning model being developed. A general linear model with MANOVA was used to test the effect of the model, while Partial Eta Squared was used to measure the effect size of the model on HOTS. The results showed that the virtual science experimental model integrated with metacognition strategies significantly affected students' HOTS. The effect size measurement shows a high effect in the experimental group. Researchers recommend that universities apply a similar model to encourage students' achievement of HOTS.

Keywords: higher-order thinking skills, metacognition, undergraduate science students, virtual science experiment

INTRODUCTION

Higher Order Thinking Skills (HOTS) for pre-service teacher is very important in supporting the achievement of Technological Pedagogical and Content Knowledge (TPACK) (Ilmi et al., 2020). There have been many lessons that empower HOTS, including ILMIZI (Ichsan, 2019), Science, Technology, Engineering, and Mathematics (STEM) (Rosidin et al., 2019), discovery learning (Indah, 2020), Project-based Learning (PjBL) (Suherman et al., 2020), or the combination of STEM-PjBL (Maryani, Astrianti, et al., 2021). These models have proven effective in training HOTS, but the Covid-19 Pandemic hampers their implementation.

The Covid-19 pandemic provides the impetus for institutions to change the learning process (Giatman et al., 2020; Stevanović et al., 2021). This necessitates lecturers' and students' readiness to use technology and solve problems effectively (Gestiardi et al., 2021). The situation in the field is the lack of preparedness of lecturers and students to adapt to the rapid changes, so the follow-up to learning is also not optimal (Firmansyah et al., 2021). As a result, there are many learning losses (Storey & Zhang, n.d.), learning objectives are not achieved (Yusuf, 2021), and student interest and involvement in distance learning are very low (Nambiar, 2020). These problems have a direct impact on student HOTS.

Higher-order Thinking Skills (HOTS) play a significant role in developing and applying scientific concepts in adult learners. These skills assess an individual's memory and his or her capacity to analyze, synthesize, and evaluate (Thomas & Thorne, 2009). The higher-order thinking process is pursued through remembering, understanding, applying, analyzing, making judgments, and making decisions (Brookhart, 2010; Heong et al., 2011).

The strong demand for the development of HOTS in the Institutes of Education and Education Personnel (IEEPs) runs counter to the HOTS of pre-service teachers at these institutions. It means that many prospective teachers in IEEPs have low levels of thinking (lower-order thinking skills) *(Gradini et al., 2018; Wiyoko & Aprizan, 2020).* According to studies, the learning models in IEEPs have not been able to promote HOTS in their students. Previous research has been conducted to assess the effectiveness of the following learning models in improving college students' HOTS: PBL (Fakhriyah, 2014), RMS (Reading, Mapping, and Sharing) (Diani et al., 2018), CUPs (Conceptual Understanding Procedures) (Saregar et al., 2016), Constructive Controversy (CC) and Modified Free Inquiry (MFI) (Pratiwi, 2014), film (Anthony et al., 2014), and Guided Inquiry Laboratory-Based Module (Prihmardoyo et al., 2017). Unfortunately, research in Indonesia still revolves around HOTS measurement and analysis instruments. Only a few academics have developed a distance learning method built on HOTS empowerment, and many overlook the incorporation of the aforementioned learning models into distance learning during the Covid-19 epidemic.

The key to success in distance learning is independence (Kauffman, 2015). The virtual science experiment model must be developed in such a way that student independence is maximized. One approach would be to incorporate metacognitive strategies into the learning model (Panahandeh & Asl, 2014). Metacognition is the knowledge of cognition as well as the regulation of cognition (Winne, 2017). The former involves metacognitive knowledge and experience, whereas the latter incorporates metacognitive strategies. This theory is relevant in this case because the metacognitive dimension is the most important dimension of knowledge after the factual, conceptual, and procedural dimensions.

Previous related studies show that metacognitive strategies have several advantages, including assisting students in monitoring their progress and controlling their learning process (via reading, writing, and problem-solving), contributing to the learner's desire to learn beyond his or her intellectual abilities; and improving student academic achievement across age, cognitive abilities, and learning domains, including reading, writing, math, reasoning, and problem-solving (Veenman et al., 2004; Wang et al., 1990). Undergraduate students' metacognition should be optimized for them to sharpen their thinking skills in overcoming real-world problems (Kleitman & Narciss, 2019).

Students can engage in metacognition activities in the classroom by reflecting on the thinking processes involved in the learning process; looking for other concrete examples from previous learning experiences and thought patterns; analyzing the benefits of using the mindset and the disadvantages of not using it, leading to an understanding of where the strategy should be used; and generalizing and formulating rules regarding these thought patterns (Zohar, 1999, 2004; Zohar & Dori, 2012). Previous research has also succeeded in developing a metacognition-based learning model called MiSHE (Metacognition in science for higher education) (Maryani, Prasetyo, et al., 2021). This model has the advantage of involving students from lesson planning to reflection. The MiSHE model is also claimed to be successful in training students' self-regulation for distance learning and managing the tasks assigned to them. Furthermore, one part of the MiSHE Model is virtual experiment-based learning. Thus, researchers are interested in implementing this learning model, which is integrated with metacognition strategies, to determine its effect on students' HOTS Science.

METHODS

This study used an experimental study with a randomized pretest-posttest comparison group design (Creswell, 2012), to know the impact of this model compared with the other model. The experimental class consisted of 39 students, while the control class consisted of 40 students. The research design used a randomized Pretest-Posttest Comparison Group Design referring to Creswell (2012).

HOTS data is collected through a test that uses seven valid questions for each material (there are seven materials in this lesson). The validity and reliability of the questions are sought with response theory items for multiple-choice questions. Data analysis was performed using the General Linear Model with Multivariate of Variance (MANOVA). After establishing the significant effect of the model on students' HOTS, the effect size was calculated. Effect size shows the degree of the experiment model's significant effect on students' HOTS. It is defined as the standard deviation between the control and experimental groups' scores. Cohen's d is the appropriate effect size in this circumstance. A large Cohen's d value indicates that the difference between the control and experimental groups is significant. The effect size was also computed in MANOVA using Eta squared. An Eta squared value of 0.01 suggests a small effect, 0.03 indicates a moderate effect, and 0.5 indicates a big effect (Bakker et al., 2019; Cohen, 1988; Mordkoff, 2019).

FINDINGS AND DISCUSSION

Findings

The syntax of the metacognition integrated virtual science learning model results from integrating metacognition theory into virtual experiments. Metacognition consists of aspects of knowledge and regulation. Metacognitive knowledge consists of three components, namely awareness of knowledge/person variables, awareness of thinking/task variables, and awareness of thinking/strategy variables (Thamraksa, 2005). Metacognition regulation is a person's internal subjective response to metacognitive knowledge. Metacognition regulation is monitoring cognitive activity and ensuring that cognitive goals have been achieved (Berry, 1983).

Metacognition activities in this model are carried out through five activities. The first activity is to reflect on students' thinking processes in virtual experiments. The second activity is to look for other concrete examples from previous learning experiences. The third activity analyzes the learning experience's advantages and disadvantages. The fourth activity is generalizing and formulating rules regarding the learning experience. The last activity is to name the learning experience as a learning strategy (Zohar, 1999, 2004; Zohar & Dori, 2012). The metacognition learning model has components of planning, monitoring, and evaluating (Dimaggi et al., 2014). Based on the description of the integration of metacognitive knowledge and the regulation of metacognition, the syntax of the virtual science experiment model is metacognitively integrated, which consists of six steps, namely, awareness, posing essential questions, planning, monitoring, evaluating, and reflecting.

After the model was implemented, students' HOTS data were obtained for each material. The pre-test was conducted once, while the post-test was performed seven times. The data is then analyzed for prerequisites (normality and homogeneity) to determine whether the influence of the model on HOTS can be analyzed using parametric statistics. The results of the normality test conducted as the requirement for multivariate analysis are presented in Table 1.

Table 1. Tests of Normality

Data	Model	Kolmogorov-Smirnov[a]	
		Statistic	Sig.
Pretest	experiment	.101	.200*
	control	.105	.200*
Post-test 1	experiment	.157	.015
	control	.131	.092
Post-test 2	experiment	.071	.200*
	control	.086	.200*
Post-test 3	experiment	.097	.200*
	control	.096	.200*
Post-test 4	experiment	120	.151
	control	.126	.118
Post-test 5	experiment	.147	.029
	control	.082	.200*
Post-test 6	experiment	.106	.200*
	control	.125	.131
Post-test 7	experiment	.139	.051
	control	.090	.200*

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 1 shows that all data are normally distributed, confirmed by the value of sig > 0.05 (α) in the Shapiro-Wilk column. The normality of the data in all treatment groups has met the assumption to continue testing the hypothesis using the General Linear Model (Multivariate of Variance). The second assumption test is the homogeneity test (Table 2).

Table 2. Tests of Homogeneity through Box's Test of Equality of Covariance Matrices

Box's Test of Equality of Covariance Matrices	
Box's M F	223,844 2,800
df1	72
df2	36809,703
Sig.	,000
Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.	
a. Design: Intercept + Model Within Subjects Design: time	

Box's M value shows the homogeneity of the HOTS scores achieved by the experimental and control groups. A sig value of 0.000 or below 0.05 indicates that the data are not homogeneous or that the HOTS scores in each treatment group vary greatly. In an experimental study, this inhomogeneity is not a problem, because it is difficult to get the same variation in scores in two groups that are subjected to different treatments. In a quasi-experimental design, the error factor (subject, sample, treatment, etc.) has a significant effect on the change in pretest to posttest scores, resulting in broad variation in the scores achieved by research subjects. Additionally, it is difficult for all subjects in the experimental group to see identical improvement in scores. Due to the impossibility of obtaining the same variance in scores between two groups given to different treatments (Widhiarso, 2011), this inhomogeneity can be overlooked (Blanca et al., 2017). MANOVA is a robust test for data homogeneity disturbances when the sample size difference between the two treatment groups is between 7 and 15 participants (Ramsey, 2007).

The GLM test with Multivariate Analysis of Variance (MANOVA) revealed an interaction between time (pre-post-test) and group (experiment-control). The interaction demonstrated that the difference in scores between the two groups (experiment-control) was substantially different from pre- to post-test. The MD value for the experimental group was -17.505 with a significance value of 0.000 (0.05), indicating that the experimental group saw a significant rise in HOTS. The MD value in the control group was -11.069* with a significance value of 0.001, showing a statistically significant increase. The greatest rise occurred in the experimental group, with a mean difference of 17.505 between pretest and posttest. Additionally, the findings of the multivariate test in Table 3 were evaluated to ascertain the virtual practicum's impact on students' HOTS.

Table 3. Multivariate Tests

Learning model		Sig.	Partial Eta Squared
Experiment	Pillai's trace	.000	.745
	Wilks' lambda	.000	.745
	Hotelling's trace	.000	.745
	Roy's largest root	.000	.745
Control	Pillai's trace	.000	.354
	Wilks' lambda	.000	.354
	Hotelling's trace	.000	.354
	Roy's largest root	.000	.354

within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means

The significance values in Table 3 indicate that virtual practicums influence increasing students' HOTS. As mentioned by (Leech et al., 2013), the treatment's efficacy can be seen in Wilks' Lambda column. In the experimental group, Partial Eta Squared of 0.745 indicates that the given treatment successfully increased students' HOTS by 74.5%, while the observed increase in HOTS in the control group was only 35.4%. The partial eta square value indicates the magnitude of an effect of a treatment (with a small effect being 0.01; a medium effect being 0.3, and a large effect being 0.5) (Bakker et al., 2019; Cohen, 1988; Mordkoff, 2019). The effect size discovered in this study is regarded as quite high, as it exceeds 50%. Thus, with big effect size and a 74.5%

rise in HOTS, it can be concluded that virtual practicums have a considerable influence on students' HOTS. This rise is bigger than the increase in HOTS observed in students studying using other models.

Discussion

The virtual experiment syntax established in this study is the outcome of incorporating metacognitive theory into the stages of virtual science experiment. Students who participate actively in experiment, the will demonstrate an enhancement in both their individual and collaborative cognitive and metacognitive functions (Zarouk et al., 2020). Metacognition is comprised of knowledge and regulation components. Metacognitive knowledge consists of three components, namely awareness of knowledge/person variables, awareness of thinking/task variables, and awareness of thinking/strategy variables. Declarative, procedural, and conditional knowledge are all examples of metacognitive knowledge (Thamraksa, 2005). Metacognition regulation is the subjective internal response of an individual to metacognitive knowledge. This response is likewise directed at problem-solving strategic tasks. Metacognition regulation is the process of observing cognitive activity and ascertaining if cognitive objectives are met (Berry, 1983). Planning, monitoring, and assessing are the components of the metacognition learning model (Dimaggi et al., 2014). These three elements then become part of the virtual experiment phases in the planning, monitoring, and reflection portions, which correspond to the PjBL model.

The virtual experiment model used in this study places a premium on students' autonomy and flexibility of thought when it comes to problem-solving through work-based projects. Students are compelled to explore contextual learning problems. The problem-solving activities conducted in the classroom include mind mapping, contextual project work in the surrounding environment, virtual project work using Tracker, PhET, and sound meter software, as well as making video presentations. Each lesson began with an activity that helps students identify their strengths and weaknesses (awareness) in terms of science topics, and then move on to developing problem-solving methods (planning, monitoring, evaluating).

The implementation phase of the model also showed that the students' HOTS increased due to the use of this model. The increase in students' HOTS in the areas of logic, reasoning, and analysis was seen in their activity of assessing science problems that arise in their environment (Ichsan et al., 2019). The students were tasked with the responsibility of resolving these issues through the development of works. Each session contained a variety of works, including mind mapping, science experiments (contextual and virtual), and video presentations. The students had to study and understand the information using logic and reasoning to complete the project in the form of mind mapping. They were required to examine difficulties to complete science projects such as building simple automobiles, electrical circuits, simple compasses, simple pendulums, and solar system simulations. Besides that, the students were also accustomed to discussing issues with other students to develop their problem-solving skills.

The increase in students' HOTS in the evaluation aspect occurred because they were required to evaluate the achievement of their learning objectives, the suitability of the work produced with the problem, as well as the suitability of time and strategy with the expected results. The increase in the students' creation scores happened because of students becoming accustomed to making items that correspond to the learning objectives. The students were allowed to collaborate to convey their thoughts. At this step, opinions were gathered, clarified, logically reasoned, and expressed to others (Mumford & McIntosh, 2017; Sodikova, 2020). Each student's product was unique in terms of shape, substance, and outcome since they used the materials available in their immediate area while leveraging their prior knowledge.

At each step of learning, students' higher-order thinking skills (HOTS), specifically their ability to solve problems and make judgments, were also developed. For instance, when students used Tracker software to analyze the motion of an object (a wind-powered car), they ran into numerous complications. Despite the availability of the tutorials, some students were unable to complete the project by the deadline. This occurred because some pupils were technically incapable of using the software used in the analytical procedure. Students who had completed the project were then asked to mentor other students during virtual face-to-face encounters. This accomplishment arose as a result of students' willingness to experiment with various methods for solving issues, such as using MS Excel for mathematical operations and graph creation. Another example is the experiment with electricity using PhET Simulation, where numerous electrical circuits burnt throughout the project due to faulty wiring and resistance. Students who ventured to experiment with alternate steps were successful in determining the correct order. Problem-solving is a fundamental cognitive function in humans that interacts with other skills such as abstraction, decision making, analysis, and synthesis (Drigas & Mitsea, 2020). Students who develop strong problem-solving and judgment abilities will develop into self-assured, creative, and autonomous thinkers. The society produced by these individuals is easily capable of resolving everyday difficulties (Özreçberoğlu & Çağanağa, 2018).

The advantages of this virtual experiment model are that it is designed using quantifiable scientific procedures and involving experts, adaptable to normal or pandemic conditions by adjusting the learning activities, consists of learning activities that teach students to make decisions, take responsibility for their actions, and complete complex tasks or assist other friends with their assignments, is grounded in real-world problems and emphasizes project-based learning, which is critical for the development of outcome-based education curriculum, and is comprised of projects that foster the emergence of open-ended solutions, thereby preparing students to be problem solvers. However, the efficiency of this virtual experiment is also influenced by other aspects, such as self-regulation (Sulisworo et al., 2020) and student technology readiness (Indriyanti et al., 2020).

CONCLUSION

This study was successful in generating a virtual science experiment design that incorporates metacognitive strategies using syntax, including increasing awareness, posing essential questions, planning, monitoring, evaluating, and reflecting. This model has a significant effect on students' HOTS, particularly in the areas of logic, reasoning, analysis, assessment, invention, problem-solving, and making judgments. These criteria are met when a support system in the form of instructional materials and student worksheets is in place. Collaboration between students and communication between students and the instructor as a social system, as well as the principle of reactions that occur when the lecturer provides reinforcement, all contribute to the experiment model's feasibility. According to the findings, lecturers should monitor students' knowledge and reflection of learning objectives to ensure that learning activities truly engage the domain of metacognition. Although it will take some time, this strategy appears to be worth considering by university science departments as a science experiment solution during the pandemic age.

ACKNOWLEDGMENT

We want to express our gratitude to Alpendi, Moh. Irma Sukarelawan, and Rully Charitas Indra Prahmana for their contributions to this final analysis, revision, and discussion manuscript. Furthermore, we are grateful to Universitas Ahmad Dahlan and University of Nueva Caceres for giving us a research collaboration opportunity. Finally, we would like to express our gratitude to Universitas Ahmad Dahlan for providing financial support through a supported professorship candidate research grant.

REFERENCES

Anthony, R., Aryani, F., & Wrastari, T. (2014). Pengaruh penggunaan film sebagai media belajar terhadap pencapaian higher order thinking skill pada mahasiswa Fakultas Psikologi UNAIR. *Jurnal Psikologi Klinis Dan Kesehatan Mental*, *03*(1), 40–47. http://journal.unair.ac.id/download-fullpapers-jpkkb65e5e6f32full.pdf

Bakker, A., Cai, J., English, L., Kaiser, G., Mesa, V., & Van Dooren, W. (2019). Beyond small, medium, or large: points of consideration when interpreting effect sizes. *Educational Studies in Mathematics 2019 102:1*, *102*(1), 1–8. https://doi.org/10.1007/S10649-019-09908-4

Berry, D. C. (1983). Metacognitive Experience and Transfer of Logical Reasoning. *The Quarterly Journal of Experimental Psychology Section A*, *35*(1), 39–49. https://doi.org/10.1080/14640748308402115

Blanca, M. J., Alarcón, R., Arnau, J., Bono, R., & Bendayan, R. (2017). Datos no normales: ¿es el ANOVA una opción válida? *Psicothema*, *29*(4), 552–557. https://doi.org/10.7334/PSICOTHEMA2016.383

Brookhart, S. M. (2010). *How to Assess Higher-order Thinking Skills in Your Classroom - Susan M. Brookhart - Google Buku*. ASCD. https://books.google.co.id/books?id=AFIxeGsV6SMC&printsec=frontcover&hl=id#v=onepage&q&f=false

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates, Publishers.

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative* (4th ed.). Pearson Education Inc.

Diani, R., Asyhari, A., & Julia, O. N. (2018). Pengaruh Model Rms (Reading, Mind Mapping and Sharing) Terhadap Kemampuan Berpikir Tingkat Tinggi Siswa Pada Pokok Bahasan Impuls Dan Momentum. *Jurnal Pendidikan Edutama*, *5*(1), 31. https://doi.org/10.30734/jpe.v5i1.128

Dimaggi, G., MacBethab, A., Gumleyc, A., Schwannauerd, M., Carcionee, A., Fisherd, R., & Hamish McLeod, J. (2014). Metacognition, symptoms and premorbid functioning in a first episode psychosis sample. *Comprehensive Psychiatry*, *55*(2), 268–273. https://doi.org/10.1016/J.COMPPSYCH.2013.08.027

Drigas, A., & Mitsea, E. (2020). The 8 Pillars of Metacognition. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(21), 162–178. https://www.online-journals.org/index.php/i-jet/article/view/14907

Fakhriyah, F. (2014). Penerapan problem based learning dalam upaya mengembangkan kemampuan berpikir kritis mahasiswa. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 95–101. https://doi.org/10.15294/jpii.v3i1.2906

Firmansyah, R., Firmansyah, R., Putri, D., Wicaksono, M., Putri, S., Widianto, A., & Palil, M. (2021). Educational Transformation: An Evaluation of Online Learning Due To COVID-19. *International Journal of Emerging Technologies in Learning (IJET)*, *16*(7), 61–76.

Gestiardi, R., Sarwanto, S., Chumdari, C., & Maryani, I. (2021). Using an Technology Readiness Model to Understand Perceived Usefulness of Learning in the Covid-19 Era. *International Journal of Elementary Education*, *5*(4), 631. https://doi.org/10.23887/ijee.v5i4.39188

Giatman, M., Siswati, S., & Basri, I. Y. (2020). Online Learning Quality Control in the Pandemic Covid-19 Era in Indonesia. *Journal of Nonformal Education*, *6*(2), 168–175. https://doi.org/10.15294/JNE.V6I2.25594

Gradini, E., Firmansyah, F., & Noviani, J. (2018). Menakar kemampuan berpikir tingkat tinggi calon guru matematika melalui level HOTS Marzano. *Eduma : Mathematics Education Learning and Teaching*, *7*(2), 41–48. https://doi.org/10.24235/eduma.v7i2.3357

Heong, Y. M., Othman, W. B., Yunos, J. B. M., Kiong, T. T., Hassan, R. Bin, & Mohamad, M. M. B. (2011). The Level of Marzano Higher Order Thinking Skillsamong Technical Education Students. *International Journal of Social Science and Humanity*, *1*(2), 121–125. https://doi.org/10.7763/ijssh.2011.v1.20

Ichsan, I. Z. (2019). ILMIZI: Innovation Learning Model for Natural Science and Environmental Learning based on HOTS. *International Journal for Educational and Vocational Studies*, *1*(6), 578–584. https://doi.org/10.29103/IJEVS.V1I6.1640

Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Ali, A., Arif, W. P., & Prayitno, T. A. (2019). HOTS-AEP: Higher Order Thinking Skills from Elementary to Master Students in Environmental Learning. *European Journal of Educational Research*, *8*(4), 935–942. http://www.eu-jer.com/

Ilmi, A. M., Sukarmin, & Sunarno, W. (2020). Development of TPACK based-physics learning media to improve HOTS and scientific attitude. *Journal of Physics: Conference Series*, *1440*(1), 012049. https://doi.org/10.1088/1742-6596/1440/1/012049

Indah, P. (2020). Development of HOTS (High Order Thinking Skill) Oriented Learning Through Discovery Learning Model to Increase The Critical Thinking Skill of High School Students. *International Journal of Chemistry Education Research*, *3*(3), 26–32. https://doi.org/10.20885/IJCER.VOL4.ISS1.ART4

Indriyanti, N. Y., Yamtinah, S., & Muawiyah, D. (2020). An Inquiry into Students' Metacognition and Learning Achievement in a Blended Learning Design. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(21), 77–88. https://www.online-journals.org/index.php/i-jet/article/view/12907

Kauffman, H. (2015). A review of predictive factors of student success in and satisfaction with online learning. *Research in Learning Technology*, *23*. https://doi.org/10.3402/RLT.V23.26507

Kleitman, S., & Narciss, S. (2019). Introduction to the special Issue "applied metacognition: real-world applications beyond learning." *Metacognition and Learning 2019 14:3*, *14*(3), 335–342. https://doi.org/10.1007/S11409-019-09214-7

Leech, N., Barrett, K., & Morgan, G. A. (2013). SPSS for intermediate statistics: use and interpretation, third edition. *SPSS for Intermediate Statistics*. https://doi.org/10.4324/9781410616739

Maryani, I., Astrianti, C., Yuli, V., Prodi, E., Guru, P., Dasar, S., Dahlan, A., Ki, J., Pemanahan, A., & Yogyakarta, S. (2021). The Effect of The STEM-PjBL Model on The Higher-Order Thinking Skills of Elementary School Students. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, *30*(2), 110–122. https://doi.org/10.17977/UM009V30I22021P110

Maryani, I., Prasetyo, Z. K., & Wilujeng, I. (2021). *Model Pembelajaran MiSHE (Metacognition in Science for Higher Education)* (1st ed.). K-media. https://books.google.co.id/books?hl=en&lr=&id=2AtBEAAAQBAJ&oi=fnd&pg=PA2&ots=PJKWfg6Sd6&sig=31fdSDA_QfyTj5r_5O1HpwZCw9w&redir_esc=y#v=onepage&q&f=false

Mordkoff, J. T. (2019). A Simple Method for Removing Bias From a Popular Measure of Standardized Effect Size: Adjusted Partial Eta Squared: *Https://Doi.Org/10.1177/2515245919855053*, *2*(3), 228–232.

https://doi.org/10.1177/2515245919855053

Mumford, M. D., & McIntosh, T. (2017). Creative thinking processes: the past and the future. *The Journal of Creative Behavior*, *51*(4), 317–322. https://doi.org/10.1002/JOCB.197

Nambiar, D. (2020). The Impact of Online Learning during Covid-19 Pandemic: Students' and Teachers' Perspective. *The International Journal of Indian Psychology*, *8*(2), 686–690. https://doi.org/10.25215/0802.094

Özreçberoğlu, N., & Çağanağa, Ç. K. (2018). Making It Count: Strategies for Improving Problem-Solving Skills in Mathematics for Students and Teachers' Classroom Management. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(4), 1253–1261. https://doi.org/10.29333/EJMSTE/82536

Panahandeh, E., & Asl, S. E. (2014). The Effect of Planning and Monitoring as Metacognitive Strategies on Iranian EFL Learners' Argumentative Writing Accuracy. *Procedia - Social and Behavioral Sciences*, *98*, 1409–1416. https://doi.org/10.1016/J.SBSPRO.2014.03.559

Pratiwi, R. D. (2014). Penerapan Constructive Controversy Dan Modified Free Inquiry Terhadap Hots Mahasiswa. *Formatif : Jurnal Ilmiah Pendidikan MIPA*, *4*(2), 100–111.

Prihmardoyo, W., Sajidan, & Maridi. (2017). Effectiveness of Guided Inquiry Laboratory-Based Module and Indicator of Analytical Thinking Skills in the Matter of Respiratory System in Senior High School Wahyu. *Advances in Social Science, Education and Humanities Research (ASSEHR)*, *158*(Ictte), 803–813.

Ramsey, P. . (2007). Factorial design. In *Encyclopedia of measurement and statistics* (In Salkind). Sage Publication.

Rosidin, U., Suyatna, A., & Abdurrahman, A. (2019). 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*, *7*(3), 435–448. https://doi.org/10.17478/JEGYS.518464

Saregar, A., Latifah, S., & Sari, M. (2016). Efektivitas Model Pembelajaran CUPs: Dampak Terhadap Kemampuan Berpikir Tingkat Tinggi Peserta Didik Madrasah Aliyah Mathla'ul Anwar Gisting Lampung. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *5*(2), 233. https://doi.org/10.24042/jpifalbiruni.v5i2.123

Sodikova, D. (2020). Formation of creative relationship through students using the creativity of eastern thinkers. *Mental Enlightenment Scientific-Methodological*

Journal Volume, *2020*(1). https://uzjournals.edu.uz/tziuj/vol2020/iss1/44

Stevanović, A., Božić, R., & Radović, S. (2021). Higher education students' experiences and opinion about distance learning during the Covid-19 pandemic. *Journal of Computer Assisted Learning*, *37*(6), 1682–1693. https://doi.org/10.1111/JCAL.12613

Storey, N., & Zhang, Q. (n.d.). *A Meta-analysis of COVID Learning Loss*. https://doi.org/10.35542/OSF.IO/QEKW2

Suherman, Prananda, M. R., Proboningrum, D. I., Pratama, E. R., Laksono, P., & Amiruddin. (2020). Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model Assisted by Geogebra. *Journal of Physics: Conference Series*, *1467*(1), 012027. https://doi.org/10.1088/1742-6596/1467/1/012027

Sulisworo, D., Fitrianawati, M., & Maryani, I. (2020). Students' self-regulated learning (SRL) profile dataset measured during Covid-19 mitigation in Yogyakarta, Indonesia. *Data in Brief*, *33*, 106422. https://doi.org/10.1016/j.dib.2020.106422

Thamraksa, C. (2005). *Metacognition: A Key to Success for EFL Learners*. http://www.bu.ac.th/knowledgecenter/epaper/jan_june2005/chutima.pdf

Thomas, A., & Thorne, G. (2009). *How To Increase Higher Level Thinking | Center for Development and Learning*. The Center for Development And Learning. http://www.cdl.org/articles/how-to-increase-high-order-thinking/

Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction*, *14*, 89–109. https://doi.org/10.1016/j.learninstruc.2003.10.004

Wang, M. C., Haertel, G. D., & Walberg, H. J. (1990). What influences learning? a content analysis of review literature. *The Journal of Educational Research*, *84*(1), 30–43. https://doi.org/10.1080/00220671.1990.10885988

Widhiarso, W. (2011). *Aplikasi anava campuran untuk eksperimen pretest dan postest desain eksperimen*. http://widhiarso.staff.ugm.ac.id/files/Aplikasi Anava Mixed Design untuk Eksperimen-revised 2011.pdf

Winne, P. H. (2017). Cognition and Metacognition within Self-Regulated Learning. *Handbook of Self-Regulation of Learning and Performance*, 36–48. https://doi.org/10.4324/9781315697048-3

Wiyoko, T., & Aprizan, A. (2020). Analisis profil kemampuan kognitif mahasiswa PGSD pada mata kuliah ilmu alamiah dasar. *IJIS Edu : Indonesian Journal of Integrated Science Education*, *2*(1), 2020. https://doi.org/10.29300/ijisedu.v2i1.2384

Yusuf, N. (2021). *The Effect of Online Tutoring Applications on Student Learning*

Outcomes during the COVID-19 Pandemic. *11*(2), 81–88.

Zarouk, M. Y., Olivera, E., Peres, P., & Khaldi, M. (2020). The Impact of Flipped Project-Based Learning on Self-Regulation in Higher Education. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(17), 127–147. https://www.online-journals.org/index.php/i-jet/article/view/14135

Zohar, A. (1999). Teachers' metacognitive knowledge and the instruction of higher order thinking. *Teaching and Teacher Education*, *15*, 413–429. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1.2295%7B&%7Drep=rep1%7B&%7Dtype=pdf

Zohar, A. (2004). Teachers' metacognitive declarative knowledge and the teaching of higher order thinking. In *Higher Order Thinking in Science Classrooms: Students' Learning and Teachers' Professional Development* (pp. 177–196). Springer Netherlands. https://doi.org/10.1007/978-1-4020-1854-1_11

Zohar, A., & Dori, Y. (Yehudit). (2012). *Metacognition in science education : trends in current research*. Springer.

2. Bukti Konfirmasi review dan hasil review (08 September 2022)

[CP] Editor Decision

Journal Manager <binar@uny.ac.id>

Trikinasih Handayani:

We have reached a decision regarding your submission to Jurnal Cakrawala Pendidikan, "INTEGRATING METACOGNITIVE STRATEGIES IMPACT IN VIRTUAL SCIENCE
EXPERIMENTS FOR UNDERGRADUATE STUDENTS' HOTS".

Our decision is: Revisions Required

Please revise your paper according to the reviewers comments below and also the comments in the soft-copy of your article (file attached), then
highlight in yellow the revised part. Return the revised manuscript within 2 weeks (14 days) to be considered for the ... publication.

If you have any questions, please let us know

Thank you very much

Best regards

Journal Manager
binar@uny.ac.id

Cakrawala Pendidikan
http://journal.uny.ac.id/index.php/cp

--

INTEGRATING METACOGNITIVE STRATEGIES IMPACT IN VIRTUAL SCIENCE EXPERIMENTS FOR UNDERGRADUATE STUDENTS' HOTS

Commented [R1]: Need revision in many parts

Trikinasih Handayani[1*], Butch O. Saulon[2], Ika Maryani[3]
[1] Department of Biology Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[2] School of Graduate Studies, University of Nueva Caceres, Bicol Region, Philippines
[3] Department of Elementary School Teacher Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
*e-mail: trikinasih@pbio.uad.ac.id

Abstract: Higher Order Thinking Skills (HOTS) are essential variables that support the achievement of science learning objectives. However, distance learning during the Covid-19 Pandemic was the cause of the lack of maximum HOTS for undergraduate science students due to their lack of involvement in experiments. Therefore, this study aims to apply a metacognition-integrated science virtual experiment model and examine its impact on students' HOTS science. A quasi-experiment was involved with a randomized pretest-posttest comparison group design to see the impact of the implementation of this model. Participants in the two treatment groups were randomly selected from two private universities in Indonesia. The HOTS of participants were assessed using multiple-choice questions. Observation sheets were used to measure the implementation of the learning model being developed. A general linear model with MANOVA was used to test the effect of the model, while Partial Eta Squared was used to measure the effect size of the model on HOTS. The results showed that the virtual science experimental model integrated with metacognition strategies significantly affected students' HOTS. The effect size measurement shows a high effect in the experimental group. Researchers recommend that universities apply a similar model to encourage students' achievement of HOTS.

Keywords: higher-order thinking skills, metacognition, undergraduate science students, virtual science experiment

INTEGRASI DAMPAK STRATEGI METAKOGNITIF DALAM EKSPERIMEN SAINS VIRTUAL UNTUK HOTS MAHASISWA

Abstrak: Higher Order Thinking Skills (HOTS) merupakan variabel penting yang mendukung tercapainya tujuan pembelajaran IPA. Namun, pembelajaran jarak jauh di masa Pandemi Covid-19 menjadi penyebab kurangnya HOTS secara maksimal bagi mahasiswa S1 IPA karena kurangnya keterlibatan mereka dalam kegiatan eksperimen. Oleh karena itu, penelitian ini bertujuan untuk menerapkan model eksperimen virtual sains terintegrasi metakognisi dan menguji pengaruhnya terhadap HOTS sains mahasiswa. Sebuah kuasi-eksperimen dilakukan dengan desain kelompok pembanding pretest-posttest acak untuk melihat dampak dari penerapan model ini. Subjek dalam dua kelompok perlakuan dipilih secara acak dari dua perguruan tinggi swasta di Indonesia. HOTS mahasiswa dinilai menggunakan pertanyaan pilihan ganda. Lembar observasi digunakan untuk mengukur keterlaksanaan model pembelajaran yang dikembangkan. Model linier umum dengan MANOVA digunakan untuk menguji pengaruh model, sedangkan Partial Eta Squared digunakan untuk mengukur ukuran efek model pada HOTS. Hasil penelitian menunjukkan bahwa model eksperimen IPA virtual terintegrasi dengan strategi metakognisi berpengaruh signifikan terhadap HOTS mahasiswa. Pengukuran effect size menunjukkan pengaruh yang tinggi pada kelompok eksperimen.

Peneliti merekomendasikan agar perguruan tinggi menerapkan model serupa untuk mendorong prestasi HOTS mahasiswa.

Kata Kunci: keterampilan berpikir tingkat tinggi, metakognisi, mahasiswa S1 IPA, eksperimen sains virtual

INTRODUCTION

Higher Order Thinking Skills (HOTS) for pre-service teacher is very important in supporting the achievement of Technological Pedagogical and Content Knowledge (TPACK) (Ilmi et al., 2020). There have been many lessons that empower HOTS, including ILMIZI (Ichsan, 2019), Science, Technology, Engineering, and Mathematics (STEM) (Rosidin et al., 2019), discovery learning (Indah, 2020), Project-based Learning (PjBL) (Suherman et al., 2020), or the combination of STEM-PjBL (Maryani, Astrianti, et al., 2021). These models have proven effective in training HOTS, but the Covid-19 Pandemic hampers their implementation.

The Covid-19 pandemic provides the impetus for institutions to change the learning process (Giatman et al., 2020; Stevanović et al., 2021). This necessitates lecturers' and students' readiness to use technology and solve problems effectively (Gestiardi et al., 2021). The situation in the field is the lack of preparedness of lecturers and students to adapt to the rapid changes, so the follow-up to learning is also not optimal (Firmansyah et al., 2021). As a result, there are many learning losses (Storey & Zhang, n.d.), learning objectives are not achieved (Yusuf, 2021), and student interest and involvement in distance learning are very low (Nambiar, 2020). These problems have a direct impact on student HOTS.

Higher-order Thinking Skills (HOTS) play a significant role in developing and applying scientific concepts in adult learners. These skills assess an individual's memory and his or her capacity to analyze, synthesize, and evaluate (Thomas & Thorne, 2009). The higher-order thinking process is pursued through remembering, understanding, applying, analyzing, making judgments, and making decisions (Brookhart, 2010; Heong et al., 2011).

The strong demand for the development of HOTS in the Institutes of Education and Education Personnel (IEEPs) runs counter to the HOTS of pre-service teachers at these institutions. It means that many prospective teachers in IEEPs have low levels of thinking (lower-order thinking skills) (Gradini et al., 2018; Wiyoko & Aprizan, 2020). According to studies, the learning models in IEEPs have not been able to promote HOTS in their students. Previous research has been conducted to assess the effectiveness of the following learning models in improving college students' HOTS: PBL (Fakhriyah, 2014), RMS (Reading, Mapping, and Sharing) (Diani et al., 2018), CUPs (Conceptual Understanding Procedures) (Saregar et al., 2016), Constructive Controversy (CC) and Modified Free Inquiry (MFI) (Pratiwi, 2014), film (Anthony et al., 2014), and Guided Inquiry Laboratory-Based Module (Prihmardoyo et al., 2017). Unfortunately, research in Indonesia still revolves around HOTS measurement and analysis instruments. Only a few academics have developed a distance learning method built on HOTS empowerment, and many overlook the incorporation of the aforementioned learning models into distance learning during the Covid-19 epidemic.

The key to success in distance learning is independence (Kauffman, 2015). The virtual science experiment model must be developed in such a way that student independence is maximized. One approach would be to incorporate metacognitive strategies into the learning model (Panahandeh & Asl, 2014). Metacognition is the knowledge of cognition as well as the regulation of cognition (Winne, 2017). The former involves metacognitive knowledge and experience, whereas the latter incorporates metacognitive strategies. This theory is relevant in this case because the metacognitive dimension is the most important dimension of knowledge after the factual, conceptual, and procedural dimensions.

Previous related studies show that metacognitive strategies have several advantages, including assisting students in monitoring their progress and controlling their learning process (via reading, writing, and problem-solving), contributing to the learner's desire to learn beyond his or her intellectual abilities; and improving student academic achievement across age, cognitive abilities, and learning domains, including reading, writing, math, reasoning, and problem-solving (Veenman et al., 2004; Wang et al., 1990). Undergraduate students' metacognition should be optimized for them to sharpen their thinking skills in overcoming real-world problems (Kleitman & Narciss, 2019).

Students can engage in metacognition activities in the classroom by reflecting on the thinking processes involved in the learning process; looking for other concrete examples from previous learning experiences and thought patterns; analyzing the benefits of using the mindset and the disadvantages of not using it, leading to an understanding of where the strategy should be used; and generalizing and formulating rules regarding these thought patterns (Zohar, 1999, 2004; Zohar & Dori, 2012). Previous research has also succeeded in developing a metacognition-based learning model called MiSHE (Metacognition in science for higher education) (Maryani, Prasetyo, et al., 2021). This model has the advantage of involving students from lesson planning to reflection. The MiSHE model is also claimed to be successful in training students' self-regulation for distance learning and managing the tasks assigned to them. Furthermore, one part of the MiSHE Model is virtual experiment-based learning. Thus, researchers are interested in implementing this learning model, which is integrated with metacognition strategies, to determine its effect on students' HOTS Science.

METHODS

This study used an experimental study with a randomized pretest-posttest comparison group design (Creswell, 2012), to know the impact of this model compared with the other model. The experimental class consisted of 39 students, while the control class consisted of 40 students. The research design used a randomized Pretest-Posttest Comparison Group Design referring to Creswell (2012).

HOTS data is collected through a test that uses seven valid questions for each material (there are seven materials in this lesson). The validity and reliability of the questions are sought with response theory items for multiple-choice questions. Data analysis was performed using the General Linear Model with Multivariate of Variance (MANOVA). After establishing the significant effect of the model on students' HOTS, the effect size was calculated. Effect size shows the degree of the experiment model's significant effect on students' HOTS. It is defined as the standard deviation between the control and experimental groups' scores. Cohen's d is the appropriate effect size in this circumstance. A large Cohen's d value indicates that the difference between the control and experimental groups is significant. The effect size was also computed in MANOVA using Eta squared. An Eta squared value of 0.01 suggests a small effect, 0.03 indicates a moderate effect, and 0.5 indicates a big effect (Bakker et al., 2019; Cohen, 1988; Mordkoff, 2019).

Commented [R2]: How are the results?

Please inform to readers

Commented [R3R2]: What are indicators of HOTS?

Commented [R4]: Please write the hypothesis

Assumptions to conduct ANOVA

FINDINGS AND DISCUSSION

Findings

The syntax of the metacognition integrated virtual science learning model results from integrating metacognition theory into virtual experiments. Metacognition consists of aspects of knowledge and regulation. Metacognitive knowledge consists of three components, namely awareness of knowledge/person variables, awareness of thinking/task variables, and awareness of thinking/strategy variables (Thamraksa, 2005). Metacognition regulation is a person's internal subjective response to metacognitive knowledge. Metacognition regulation is

Commented [R5]: Syntax should be described in methods

Here, please describe th implementation in the classroom monitoring cognitive activity and ensuring that cognitive goals have been achieved (Berry, 1983).

Metacognition activities in this model are carried out through five activities. The first activity is to reflect on students' thinking processes in virtual experiments. The second activity is to look for other concrete examples from previous learning experiences. The third activity analyzes the learning experience's advantages and disadvantages. The fourth activity is generalizing and formulating rules regarding the learning experience. The last activity is to name the learning experience as a learning strategy (Zohar, 1999, 2004; Zohar & Dori, 2012). The metacognition learning model has components of planning, monitoring, and evaluating (Dimaggi et al., 2014). Based on the description of the integration of metacognitive knowledge and the regulation of metacognition, the syntax of the virtual science experiment model is metacognitively integrated, which consists of six steps, namely, awareness, posing essential questions, planning, monitoring, evaluating, and reflecting.

After the model was implemented, students' HOTS data were obtained for each material. The pre-test was conducted once, while the post-test was performed seven times. The data is then analyzed for prerequisites (normality and homogeneity) to determine whether the influence of the model on HOTS can be analyzed using parametric statistics. The results of the normality test conducted as the requirement for multivariate analysis are presented in Table 1.

***

Commented [R6]: Please describe first using statistics descriptive

Commented [R7R6]: How is the implementation in the class?

Table 1. Tests of Normality

Data	Model	Kolmogorov-Smirnov[a]	
		Statistic	Sig.
Pretest	experiment	.101	.200*
	control	.105	.200*
Post-test 1	experiment	.157	.015
	control	.131	.092
Post-test 2	experiment	.071	.200*
	control	.086	.200*
Post-test 3	experiment	.097	.200*
	control	.096	.200*
Post-test 4	experiment	120	.151
	control	.126	.118
Post-test 5	experiment	.147	.029

Data	Model	Kolmogorov-Smirnov[a]	
		Statistic	Sig.
	control	.082	.200*
Post-test 6	experiment	.106	.200*
	control	.125	.131
Post-test 7	experiment	.139	.051
	control	.090	.200*

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 1 shows that all data are normally distributed, confirmed by the value of sig > 0.05 (α) in the Shapiro-Wilk column. The normality of the data in all treatment groups has met the assumption to continue testing the hypothesis using the General Linear Model (Multivariate of Variance). The second assumption test is the homogeneity test (Table 2).

Table 2. Tests of Homogeneity through Box's Test of Equality of Covariance Matrices

Box's Test of Equality of Covariance Matrices	
Box's M	223,844
F	2,800
df1	72
df2	36809,703
Sig.	,000
Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.	
a. Design: Intercept + Model Within Subjects Design: time	

Box's M value shows the homogeneity of the HOTS scores achieved by the experimental and control groups. A sig value of 0.000 or below 0.05 indicates that the data are not homogeneous or that the HOTS scores in each treatment group vary greatly. In an experimental study, this inhomogeneity is not a problem, because it is difficult to get the same variation in scores in two groups that are subjected to different treatments. In a quasi-

Commented [R8]: Describe deeper about interpretation of tables.

experimental design, the error factor (subject, sample, treatment, etc.) has a significant effect on the change in pretest to posttest scores, resulting in broad variation in the scores achieved by research subjects. Additionally, it is difficult for all subjects in the experimental group to see identical improvement in scores. Due to the impossibility of obtaining the same variance in scores between two groups given to different treatments (Widhiarso, 2011), this inhomogeneity can be overlooked (Blanca et al., 2017). MANOVA is a robust test for data homogeneity disturbances when the sample size difference between the two treatment groups is between 7 and 15 participants (Ramsey, 2007).

The GLM test with Multivariate Analysis of Variance (MANOVA) revealed an interaction between time (pre-post-test) and group (experiment-control). The interaction demonstrated that the difference in scores between the two groups (experiment-control) was substantially different from pre- to post-test. The MD value for the experimental group was -17.505 with a significance value of 0.000 (0.05), indicating that the experimental group saw a significant rise in HOTS. The MD value in the control group was -11.069* with a significance value of 0.001, showing a statistically significant increase. The greatest rise occurred in the experimental group, with a mean difference of 17.505 between pretest and posttest. Additionally, the findings of the multivariate test in Table 3 were evaluated to ascertain the virtual practicum's impact on students' HOTS.

Table 3. Multivariate Tests

Learning model		Sig.	Partial Eta Squared
Experiment	Pillai's trace	.000	.745
	Wilks' lambda	.000	.745
	Hotelling's trace	.000	.745
	Roy's largest root	.000	.745
Control	Pillai's trace	.000	.354
	Wilks' lambda	.000	.354
	Hotelling's trace	.000	.354
	Roy's largest root	.000	.354

within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means

The significance values in Table 3 indicate that virtual practicums influence increasing students' HOTS. As mentioned by (Leech et al., 2013), the treatment's efficacy can be seen in Wilks' Lambda column. In the experimental group, Partial Eta Squared of 0.745 indicates that the given treatment successfully increased students' HOTS by 74.5%, while the observed increase in HOTS in the control group was only 35.4%. The partial eta square value indicates the magnitude of an effect of a treatment (with a small effect being 0.01; a medium effect being 0.3, and a large effect being 0.5) (Bakker et al., 2019; Cohen, 1988; Mordkoff, 2019). The effect size discovered in this study is regarded as quite high, as it exceeds 50%. Thus, with big effect size and a 74.5% rise in HOTS, it can be concluded that virtual practicums have a considerable influence on students' HOTS. This rise is bigger than the increase in HOTS observed in students studying using other models.

Discussion

The virtual experiment syntax established in this study is the outcome of incorporating metacognitive theory into the stages of virtual science experiment. Students who participate actively in experiment, the will demonstrate an enhancement in both their individual and collaborative cognitive and metacognitive functions (Zarouk et al., 2020). Metacognition is comprised of knowledge and regulation components. Metacognitive knowledge consists of three components, namely awareness of knowledge/person variables, awareness of thinking/task variables, and awareness of thinking/strategy variables. Declarative, procedural, and conditional knowledge are all examples of metacognitive knowledge (Thamraksa, 2005). Metacognition regulation is the subjective internal response of an individual to metacognitive knowledge. This response is likewise directed at problem-solving strategic tasks. Metacognition regulation is the process of observing cognitive activity and ascertaining if cognitive objectives are met (Berry, 1983). Planning, monitoring, and assessing are the components of the metacognition learning model (Dimaggi et al., 2014). These three elements then become part of the virtual experiment phases in the planning, monitoring, and reflection portions, which correspond to the PjBL model.

The virtual experiment model used in this study places a premium on students' autonomy and flexibility of thought when it comes to problem-solving through work-based projects. Students are compelled to explore contextual learning problems. The problem-solving activities conducted in the classroom include mind mapping, contextual project work in the surrounding environment, virtual project work using Tracker, PhET, and sound meter software, as well as making video presentations. Each lesson began with an activity that helps students identify their strengths and weaknesses (awareness) in terms of science topics, and then move on to developing problem-solving methods (planning, monitoring, evaluating).

The implementation phase of the model also showed that the students' HOTS increased due to the use of this model. The increase in students' HOTS in the areas of logic, reasoning, and analysis was seen in their activity of assessing science problems that arise in their environment (Ichsan et al., 2019). The students were tasked with the responsibility of resolving these issues through the development of works. Each session contained a variety of works, including mind mapping, science experiments (contextual and virtual), and video presentations. The students had to study and understand the information using logic and reasoning to complete the project in the form of mind mapping. They were required to examine difficulties to complete science projects such as building simple automobiles, electrical circuits, simple compasses, simple pendulums, and solar system simulations. Besides that, the students were also accustomed to discussing issues with other students to develop their problem-solving skills.

The increase in students' HOTS in the evaluation aspect occurred because they were required to evaluate the achievement of their learning objectives, the suitability of the work produced with the problem, as well as the suitability of time and strategy with the expected results. The increase in the students' creation scores happened because of students becoming accustomed to making items that correspond to the learning objectives. The students were allowed to collaborate to convey their thoughts. At this step, opinions were gathered, clarified, logically reasoned, and expressed to others (Mumford & McIntosh, 2017; Sodikova, 2020). Each student's product was unique in terms of shape, substance, and outcome since they used the materials available in their immediate area while leveraging their prior knowledge.

At each step of learning, students' higher-order thinking skills (HOTS), specifically their ability to solve problems and make judgments, were also developed. For instance, when students used Tracker software to analyze the motion of an object (a wind-powered car), they ran into numerous complications. Despite the availability of the tutorials, some students were unable to complete the project by the deadline. This occurred because some pupils were technically incapable of using the software used in the analytical procedure. Students who had completed the project were then asked to mentor other students during virtual face-to-face encounters. This accomplishment arose as a result of students' willingness to experiment with various methods for solving issues, such as using MS Excel for mathematical operations and graph creation. Another example is the experiment with electricity using PhET Simulation, where numerous electrical circuits burnt throughout the project due to faulty wiring and resistance. Students who ventured to experiment with alternate steps were successful in determining the correct order. Problem-solving is a fundamental cognitive function in humans that interacts with other skills such as abstraction, decision making, analysis, and synthesis (Drigas & Mitsea, 2020). Students who develop strong problem-solving and judgment abilities will develop into self-assured, creative, and autonomous thinkers. The society produced by these individuals is easily capable of resolving everyday difficulties (Özreçberoğlu & Çağanağa, 2018).

The advantages of this virtual experiment model are that it is designed using quantifiable scientific procedures and involving experts, adaptable to normal or pandemic conditions by adjusting the learning activities, consists of learning activities that teach students to make decisions, take responsibility for their actions, and complete complex tasks or assist other friends with their assignments, is grounded in real-world problems and emphasizes project-based learning, which is critical for the development of outcome-based education curriculum, and is comprised of projects that foster the emergence of open-ended solutions, thereby preparing students to be problem solvers. However, the efficiency of this virtual experiment is also influenced by other aspects, such as self-regulation (Suliswor o et al., 2020) and student technology readiness (Indriyanti et al., 2020).

***

Commented [R9]: Add research topic can be conduct in the future based on this result

CONCLUSION

This study was successful in generating a virtual science experiment design that incorporates metacognitive strategies using syntax, including increasing awareness, posing essential questions, planning, monitoring, evaluating, and reflecting. This model has a significant effect on students' HOTS, particularly in the areas of logic, reasoning, analysis, assessment, invention, problem-solving, and making judgments. These criteria are met when a support system in the form of instructional materials and student worksheets is in place. Collaboration between students and communication between students and the instructor as a social system, as well as the principle of reactions that occur when the lecturer provides reinforcement, all contribute to the experiment model's feasibility. According to the findings, lecturers should monitor students' knowledge and reflection of learning objectives to ensure that learning activities truly engage the domain of metacognition. Although it will take some time, this strategy appears to be worth considering by university science departments as a science experiment solution during the pandemic age.

ACKNOWLEDGMENT

We want to express our gratitude to Alpendi, Moh. Irma Sukarelawan, and Rully Charitas Indra Prahmana for their contributions to this final analysis, revision, and discussion manuscript. Furthermore, we are grateful to Universitas Ahmad Dahlan and University of Nueva Caceres for giving us a research collaboration opportunity. Finally, we would like to express our gratitude to Universitas Ahmad Dahlan for providing financial support through a supported professorship candidate research grant.

REFERENCES

Anthony, R., Aryani, F., & Wrastari, T. (2014). Pengaruh penggunaan film sebagai media belajar terhadap pencapaian higher order thinking skill pada mahasiswa Fakultas Psikologi UNAIR. *Jurnal Psikologi Klinis Dan Kesehatan Mental*, *03*(1), 40–47. http://journal.unair.ac.id/download-fullpapers-jpkkb65e5e6f32full.pdf

Bakker, A., Cai, J., English, L., Kaiser, G., Mesa, V., & Van Dooren, W. (2019). Beyond small, medium, or large: points of consideration when interpreting effect sizes. *Educational Studies in Mathematics 2019 102:1*, *102*(1), 1–8. https://doi.org/10.1007/S10649-019-09908-4

Berry, D. C. (1983). Metacognitive Experience and Transfer of Logical Reasoning. *The Quarterly Journal of Experimental Psychology Section A*, *35*(1), 39–49. https://doi.org/10.1080/14640748308402115

Blanca, M. J., Alarcón, R., Arnau, J., Bono, R., & Bendayan, R. (2017). Datos no normales: ¿es el ANOVA una opción válida? *Psicothema*, *29*(4), 552–557. https://doi.org/10.7334/PSICOTHEMA2016.383

Brookhart, S. M. (2010). *How to Assess Higher-order Thinking Skills in Your Classroom - Susan M. Brookhart - Google Buku*. ASCD. https://books.google.co.id/books?id=AFIxeGsV6SMC&printsec=frontcover&hl=id#v=onepage&q&f=false

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates, Publishers.

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative* (4th ed.). Pearson Education Inc.

Diani, R., Asyhari, A., & Julia, O. N. (2018). Pengaruh Model Rms (Reading, Mind Mapping and Sharing) Terhadap Kemampuan Berpikir Tingkat Tinggi Siswa Pada Pokok Bahasan

Impuls Dan Momentum. *Jurnal Pendidikan Edutama*, *5*(1), 31. https://doi.org/10.30734/jpe.v5i1.128

Dimaggi, G., MacBethab, A., Gumleyc, A., Schwannauerd, M., Carcionee, A., Fisherd, R., & Hamish McLeod, J. (2014). Metacognition, symptoms and premorbid functioning in a first episode psychosis sample. *Comprehensive Psychiatry*, *55*(2), 268–273. https://doi.org/10.1016/J.COMPPSYCH.2013.08.027

Drigas, A., & Mitsea, E. (2020). The 8 Pillars of Metacognition. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(21), 162–178. https://www.online-journals.org/index.php/i-jet/article/view/14907

Fakhriyah, F. (2014). Penerapan problem based learning dalam upaya mengembangkan kemampuan berpikir kritis mahasiswa. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 95–101. https://doi.org/10.15294/jpii.v3i1.2906

Firmansyah, R., Firmansyah, R., Putri, D., Wicaksono, M., Putri, S., Widianto, A., & Palil, M. (2021). Educational Transformation: An Evaluation of Online Learning Due To COVID-19. *International Journal of Emerging Technologies in Learning (IJET)*, *16*(7), 61–76.

Gestiardi, R., Sarwanto, S., Chumdari, C., & Maryani, I. (2021). Using an Technology Readiness Model to Understand Perceived Usefulness of Learning in the Covid-19 Era. *International Journal of Elementary Education*, *5*(4), 631. https://doi.org/10.23887/ijee.v5i4.39188

Giatman, M., Siswati, S., & Basri, I. Y. (2020). Online Learning Quality Control in the Pandemic Covid-19 Era in Indonesia. *Journal of Nonformal Education*, *6*(2), 168–175. https://doi.org/10.15294/JNE.V6I2.25594

Gradini, E., Firmansyah, F., & Noviani, J. (2018). Menakar kemampuan berpikir tingkat tinggi calon guru matematika melalui level HOTS Marzano. *Eduma : Mathematics Education Learning and Teaching*, *7*(2), 41–48. https://doi.org/10.24235/eduma.v7i2.3357

Heong, Y. M., Othman, W. B., Yunos, J. B. M., Kiong, T. T., Hassan, R. Bin, & Mohamad, M. M. B. (2011). The Level of Marzano Higher Order Thinking Skillsamong Technical Education Students. *International Journal of Social Science and Humanity*, *1*(2), 121–125. https://doi.org/10.7763/ijssh.2011.v1.20

Ichsan, I. Z. (2019). ILMIZI: Innovation Learning Model for Natural Science and Environmental Learning based on HOTS. *International Journal for Educational and Vocational Studies*, *1*(6), 578–584. https://doi.org/10.29103/IJEVS.V1I6.1640

Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Ali, A., Arif, W. P., & Prayitno, T. A. (2019). HOTS-AEP: Higher Order Thinking Skills from Elementary to Master Students in Environmental

Learning. *European Journal of Educational Research*, *8*(4), 935–942. http://www.eu-jer.com/

Ilmi, A. M., Sukarmin, & Sunarno, W. (2020). Development of TPACK based-physics learning media to improve HOTS and scientific attitude. *Journal of Physics: Conference Series*, *1440*(1), 012049. https://doi.org/10.1088/1742-6596/1440/1/012049

Indah, P. (2020). Development of HOTS (High Order Thinking Skill) Oriented Learning Through Discovery Learning Model to Increase The Critical Thinking Skill of High School Students. *International Journal of Chemistry Education Research*, *3*(3), 26–32. https://doi.org/10.20885/IJCER.VOL4.ISS1.ART4

Indriyanti, N. Y., Yamtinah, S., & Muawiyah, D. (2020). An Inquiry into Students' Metacognition and Learning Achievement in a Blended Learning Design. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(21), 77–88. https://www.online-journals.org/index.php/i-jet/article/view/12907

Kauffman, H. (2015). A review of predictive factors of student success in and satisfaction with online learning. *Research in Learning Technology*, *23*. https://doi.org/10.3402/RLT.V23.26507

Kleitman, S., & Narciss, S. (2019). Introduction to the special Issue "applied metacognition: real-world applications beyond learning." *Metacognition and Learning 2019 14:3*, *14*(3), 335–342. https://doi.org/10.1007/S11409-019-09214-7

Leech, N., Barrett, K., & Morgan, G. A. (2013). SPSS for intermediate statistics: use and interpretation, third edition. *SPSS for Intermediate Statistics*. https://doi.org/10.4324/9781410616739

Maryani, I., Astrianti, C., Yuli, V., Prodi, E., Guru, P., Dasar, S., Dahlan, A., Ki, J., Pemanahan, A., & Yogyakarta, S. (2021). The Effect of The STEM-PjBL Model on The Higher-Order Thinking Skills of Elementary School Students. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, *30*(2), 110–122. https://doi.org/10.17977/UM009V30I22021P110

Maryani, I., Prasetyo, Z. K., & Wilujeng, I. (2021). *Model Pembelajaran MiSHE (Metacognition in Science for Higher Education)* (1st ed.). K-media. https://books.google.co.id/books?hl=en&lr=&id=2AtBEAAAQBAJ&oi=fnd&pg=PA2&ots=PJKWfg6Sd6&sig=31fdSDA_QfyTj5r_5O1HpwZCw9w&redir_esc=y#v=onepage&q&f=false

Mordkoff, J. T. (2019). A Simple Method for Removing Bias From a Popular Measure of Standardized Effect Size: Adjusted Partial Eta Squared: *Https://Doi.Org/10.1177/2515245919855053*, *2*(3), 228–232.

https://doi.org/10.1177/2515245919855053
Mumford, M. D., & McIntosh, T. (2017). Creative thinking processes: the past and the future. *The Journal of Creative Behavior*, *51*(4), 317–322. https://doi.org/10.1002/JOCB.197
Nambiar, D. (2020). The Impact of Online Learning during Covid-19 Pandemic: Students' and Teachers' Perspective. *The International Journal of Indian Psychology*, *8*(2), 686–690. https://doi.org/10.25215/0802.094
Özreçberoğlu, N., & Çağanağa, Ç. K. (2018). Making It Count: Strategies for Improving Problem-Solving Skills in Mathematics for Students and Teachers' Classroom Management. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(4), 1253–1261. https://doi.org/10.29333/EJMSTE/82536
Panahandeh, E., & Asl, S. E. (2014). The Effect of Planning and Monitoring as Metacognitive Strategies on Iranian EFL Learners' Argumentative Writing Accuracy. *Procedia - Social and Behavioral Sciences*, *98*, 1409–1416. https://doi.org/10.1016/J.SBSPRO.2014.03.559
Pratiwi, R. D. (2014). Penerapan Constructive Controversy Dan Modified Free Inquiry Terhadap Hots Mahasiswa. *Formatif : Jurnal Ilmiah Pendidikan MIPA*, *4*(2), 100–111.
Prihmardoyo, W., Sajidan, & Maridi. (2017). Effectiveness of Guided Inquiry Laboratory-Based Module and Indicator of Analytical Thinking Skills in the Matter of Respiratory System in Senior High School Wahyu. *Advances in Social Science, Education and Humanities Research (ASSEHR)*, *158*(Ictte), 803–813.
Ramsey, P. . (2007). Factorial design. In *Encyclopedia of measurement and statistics* (In Salkind). Sage Publication.
Rosidin, U., Suyatna, A., & Abdurrahman, A. (2019). 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*, *7*(3), 435–448. https://doi.org/10.17478/JEGYS.518464
Saregar, A., Latifah, S., & Sari, M. (2016). Efektivitas Model Pembelajaran CUPs: Dampak Terhadap Kemampuan Berpikir Tingkat Tinggi Peserta Didik Madrasah Aliyah Mathla'ul Anwar Gisting Lampung. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *5*(2), 233. https://doi.org/10.24042/jpifalbiruni.v5i2.123
Sodikova, D. (2020). Formation of creative relationship through students using the creativity of eastern thinkers. *Mental Enlightenment Scientific-Methodological Journal Volume*, *2020*(1). https://uzjournals.edu.uz/tziuj/vol2020/iss1/44
Stevanović, A., Božić, R., & Radović, S. (2021). Higher education students' experiences and

opinion about distance learning during the Covid-19 pandemic. *Journal of Computer Assisted Learning*, *37*(6), 1682–1693. https://doi.org/10.1111/JCAL.12613

Storey, N., & Zhang, Q. (n.d.). *A Meta-analysis of COVID Learning Loss*. https://doi.org/10.35542/OSF.IO/QEKW2

Suherman, Prananda, M. R., Proboningrum, D. I., Pratama, E. R., Laksono, P., & Amiruddin. (2020). Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model Assisted by Geogebra. *Journal of Physics: Conference Series*, *1467*(1), 012027. https://doi.org/10.1088/1742-6596/1467/1/012027

Sulisworo, D., Fitrianawati, M., & Maryani, I. (2020). Students' self-regulated learning (SRL) profile dataset measured during Covid-19 mitigation in Yogyakarta, Indonesia. *Data in Brief*, *33*, 106422. https://doi.org/10.1016/j.dib.2020.106422

Thamraksa, C. (2005). *Metacognition: A Key to Success for EFL Learners*. http://www.bu.ac.th/knowledgecenter/epaper/jan_june2005/chutima.pdf

Thomas, A., & Thorne, G. (2009). *How To Increase Higher Level Thinking | Center for Development and Learning*. The Center for Development And Learning. http://www.cdl.org/articles/how-to-increase-high-order-thinking/

Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction*, *14*, 89–109. https://doi.org/10.1016/j.learninstruc.2003.10.004

Wang, M. C., Haertel, G. D., & Walberg, H. J. (1990). What influences learning? a content analysis of review literature. *The Journal of Educational Research*, *84*(1), 30–43. https://doi.org/10.1080/00220671.1990.10885988

Widhiarso, W. (2011). *Aplikasi anava campuran untuk eksperimen pretest dan postest desain eksperimen*. http://widhiarso.staff.ugm.ac.id/files/Aplikasi Anava Mixed Design untuk Eksperimen-revised 2011.pdf

Winne, P. H. (2017). Cognition and Metacognition within Self-Regulated Learning. *Handbook of Self-Regulation of Learning and Performance*, 36–48. https://doi.org/10.4324/9781315697048-3

Wiyoko, T., & Aprizan, A. (2020). Analisis profil kemampuan kognitif mahasiswa PGSD pada mata kuliah ilmu alamiah dasar. *IJIS Edu : Indonesian Journal of Integrated Science Education*, *2*(1), 2020. https://doi.org/10.29300/ijisedu.v2i1.2384

Yusuf, N. (2021). *The Effect of Online Tutoring Applications on Student Learning Outcomes during the COVID-19 Pandemic*. *11*(2), 81–88.

Zarouk, M. Y., Olivera, E., Peres, P., & Khaldi, M. (2020). The Impact of Flipped Project-

Based Learning on Self-Regulation in Higher Education. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(17), 127–147. https://www.online-journals.org/index.php/i-jet/article/view/14135

Zohar, A. (1999). Teachers' metacognitive knowledge and the instruction of higher order thinking. *Teaching and Teacher Education*, *15*, 413–429. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1.2295%7B&%7Drep=rep1%7B&%7Dtype=pdf

Zohar, A. (2004). Teachers' metacognitive declarative knowledge and the teaching of higher order thinking. In *Higher Order Thinking in Science Classrooms: Students' Learning and Teachers' Professional Development* (pp. 177–196). Springer Netherlands. https://doi.org/10.1007/978-1-4020-1854-1_11

Zohar, A., & Dori, Y. (Yehudit). (2012). *Metacognition in science education : trends in current research*. Springer.

3. Bukti Konfirmasi submit review dan artikel yang diresubmit
(29 september 2022)

INTEGRATING METACOGNITIVE STRATEGIES IMPACT IN VIRTUAL SCIENCE EXPERIMENTS FOR UNDERGRADUATE STUDENTS' HOTS

Commented [R1]: Need revision in many parts

Trikinasih Handayani[1*], Butch O. Saulon[2], Ika Maryani[3]
[1] Department of Biology Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[2] School of Graduate Studies, University of Nueva Caceres, Bicol Region, Philippines
[3] Department of Elementary School Teacher Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
*e-mail: trikinasih@pbio.uad.ac.id

Abstract: Higher Order Thinking Skills (HOTS) are essential variables that support the achievement of science learning objectives. However, distance learning during the Covid-19 Pandemic was the cause of the lack of maximum HOTS for undergraduate science students due to their lack of involvement in experiments. Therefore, this study aims to apply a metacognition-integrated science virtual experiment model and examine its impact on students' HOTS science. A quasi-experiment was involved with a randomized pretest-posttest comparison group design to see the impact of the implementation of this model. Participants in the two treatment groups were randomly selected from two private universities in Indonesia. The HOTS of participants were assessed using multiple-choice questions. Observation sheets were used to measure the implementation of the learning model being developed. A general linear model with MANOVA was used to test the effect of the model, while Partial Eta Squared was used to measure the effect size of the model on HOTS. The results showed that the virtual science experimental model integrated with metacognition strategies significantly affected students' HOTS. The effect size measurement shows a high effect in the experimental group. Researchers recommend that universities apply a similar model to encourage students' achievement of HOTS.

Keywords: higher-order thinking skills, metacognition, undergraduate science students, virtual science experiment

INTEGRASI DAMPAK STRATEGI METAKOGNITIF DALAM EKSPERIMEN SAINS VIRTUAL UNTUK HOTS MAHASISWA

Abstrak: Higher Order Thinking Skills (HOTS) merupakan variabel penting yang mendukung tercapainya tujuan pembelajaran IPA. Namun, pembelajaran jarak jauh di masa Pandemi Covid-19 menjadi penyebab kurangnya HOTS secara maksimal bagi mahasiswa S1 IPA karena kurangnya keterlibatan mereka dalam kegiatan eksperimen. Oleh karena itu, penelitian ini bertujuan untuk menerapkan model eksperimen virtual sains terintegrasi metakognisi dan menguji pengaruhnya terhadap HOTS sains mahasiswa. Sebuah kuasi-eksperimen dilakukan dengan desain kelompok pembanding pretest-posttest acak untuk melihat dampak dari penerapan model ini. Subjek dalam dua kelompok perlakuan dipilih secara acak dari dua perguruan tinggi swasta di Indonesia. HOTS mahasiswa dinilai menggunakan pertanyaan pilihan ganda. Lembar observasi digunakan untuk mengukur keterlaksanaan model pembelajaran yang dikembangkan. Model linier umum dengan MANOVA digunakan untuk menguji pengaruh model, sedangkan Partial Eta Squared digunakan untuk mengukur ukuran efek model pada HOTS. Hasil penelitian menunjukkan bahwa model eksperimen IPA virtual terintegrasi dengan strategi metakognisi berpengaruh signifikan terhadap HOTS mahasiswa. Pengukuran effect size menunjukkan pengaruh yang tinggi pada kelompok eksperimen. Peneliti merekomendasikan agar perguruan tinggi menerapkan model serupa untuk mendorong prestasi HOTS mahasiswa.

Kata Kunci: keterampilan berpikir tingkat tinggi, metakognisi, mahasiswa S1 IPA, eksperimen sains virtual

INTRODUCTION

Higher Order Thinking Skills (HOTS) for pre-service teacher is very important in supporting the achievement of Technological Pedagogical and Content Knowledge (TPACK) (Ilmi et al., 2020). There have been many lessons that empower HOTS, including ILMIZI (Ichsan, 2019), Science, Technology, Engineering, and Mathematics (STEM) (Rosidin et al., 2019), discovery learning (Indah, 2020), Project-based Learning (PjBL) (Suherman et al., 2020), or the combination of STEM-PjBL (Maryani, Astrianti, et al., 2021). These models have proven effective in training HOTS, but the Covid-19 Pandemic hampers their implementation.

The Covid-19 pandemic provides the impetus for institutions to change the learning process (Giatman et al., 2020; Stevanović et al., 2021). This necessitates lecturers' and students' readiness to use technology and solve problems effectively (Gestiardi et al., 2021). The situation in the field is the lack of preparedness of lecturers and students to adapt to the rapid changes, so the follow-up to learning is also not optimal (Firmansyah et al., 2021). As a result, there are many learning losses (Storey & Zhang, n.d.), learning objectives are not achieved (Yusuf, 2021), and student interest and involvement in distance learning are very low (Nambiar, 2020). These problems have a direct impact on student HOTS.

Higher-order Thinking Skills (HOTS) play a significant role in developing and applying scientific concepts in adult learners. These skills assess an individual's memory and his or her capacity to analyze, synthesize, and evaluate (Thomas & Thorne, 2009). The higher-order thinking process is pursued through remembering, understanding, applying, analyzing, making judgments, and making decisions (Brookhart, 2010; Heong et al., 2011).

The strong demand for the development of HOTS in the Institutes of Education and Education Personnel (IEEPs) runs counter to the HOTS of pre-service teachers at these institutions. It means that many prospective teachers in IEEPs have low levels of thinking (lower-order thinking skills) (Gradini et al., 2018; Wiyoko & Aprizan, 2020). According to studies, the learning models in IEEPs have not been able to promote HOTS in their students. Previous research has been conducted to assess the effectiveness of the following learning models in improving college students' HOTS: PBL (Fakhriyah, 2014), RMS (Reading, Mapping, and Sharing) (Diani et al., 2018), CUPs (Conceptual Understanding Procedures) (Saregar et al., 2016), Constructive Controversy (CC) and Modified Free Inquiry (MFI) (Pratiwi, 2014), film (Anthony et al., 2014), and Guided Inquiry Laboratory-Based Module (Prihmardoyo et al., 2017). Unfortunately, research in Indonesia still revolves around HOTS measurement and analysis instruments. Only a few academics have developed a distance learning method built on HOTS empowerment, and many overlook the incorporation of the aforementioned learning models into distance learning during the Covid-19 epidemic.

The key to success in distance learning is independence (Kauffman, 2015). The virtual science experiment model must be developed in such a way that student independence is maximized. One approach would be to incorporate metacognitive strategies into the learning model (Panahandeh & Asl, 2014). Metacognition is the knowledge of cognition as well as the regulation of cognition (Winne, 2017). The former involves metacognitive knowledge and experience, whereas the latter incorporates metacognitive strategies. This theory is relevant in this case because the metacognitive dimension is the most important dimension of knowledge after the factual, conceptual, and procedural dimensions.

Previous related studies show that metacognitive strategies have several advantages, including assisting students in monitoring their progress and controlling their learning process (via reading, writing, and problem-solving), contributing to the learner's desire to learn beyond his or her intellectual abilities; and improving student academic achievement across age, cognitive abilities, and learning domains, including reading, writing, math, reasoning, and problem-solving (Veenman et al., 2004; Wang et al., 1990). Undergraduate students' metacognition should be optimized for them to sharpen their thinking skills in overcoming real-world problems (Kleitman & Narciss, 2019).

Students can engage in metacognition activities in the classroom by reflecting on the thinking processes involved in the learning process; looking for other concrete examples from previous learning experiences and thought patterns; analyzing the benefits of using the mindset and the disadvantages of not using it, leading to an understanding of where the strategy should be used; and generalizing and formulating rules regarding these thought patterns (Zohar, 1999, 2004; Zohar & Dori, 2012). Previous research has also succeeded in developing a metacognition-based learning model called MiSHE (Metacognition in science for higher education) (Maryani, Prasetyo, & Wilujeng, 2021). This model has the advantage of involving students from lesson planning to reflection. The MiSHE model is also claimed to be successful in training students' self-regulation for distance learning and managing the tasks assigned to them. Furthermore, one part of the MiSHE Model is virtual experiment-based learning. Thus, researchers are interested in implementing this learning model, which is integrated with metacognition strategies, to determine its effect on students' HOTS Science.

METHODS

This study used an experimental study with a randomized pretest-posttest comparison group design (Creswell, 2012), to know the impact of this model compared with the other model. The experimental class consisted of 39 students, while the control class consisted of 40 students. The research design used a randomized Pretest-Posttest Comparison Group Design referring to Creswell (2012).

HOTS data is collected through a test that uses seven valid questions for each material (there are seven materials in this lesson). The indicators of HOTS questions are logic, reasoning, analysis, evaluation, creation, problem-solving, and decision making (Heong et al., 2011; R. Marzano, 2013; R. J. Marzano, 1993; R. J. Marzano & Kendall, 2006; Zohar & Dori, 2003). The validity and reliability of the questions are sought with response theory items for multiple-choice questions. The construct validity of the items was analyzed using item response theory with EFA (Explanatory Factor Analysis). The results can be seen in the attachment and previously published by Maryani, Prasetyo, Wilujeng, et al (2021) Data analysis was performed using the General Linear Model with Multivariate of Variance (MANOVA). After establishing the significant effect of the model on students' HOTS, the effect size was calculated. Effect size shows the degree of the experiment model's significant effect on students' HOTS. It is defined as the standard deviation between the control and experimental groups' scores. Cohen's d is the appropriate effect size in this circumstance. A large Cohen's d value indicates that the difference between the control and experimental groups is significant. The effect size was also computed in MANOVA using Eta squared. An Eta squared value of 0.01 suggests a small effect, 0.03 indicates a moderate effect, and 0.5 indicates a big effect (Bakker et al., 2019; Cohen, 1988; Mordkoff, 2019).

Hypothesis

H0: The integrated metacognition virtual practicums have significant effects on students' HOTS.

H1: The integrated metacognition virtual practicums have no significant effects on students' HOTS.

Commented [R2]: How are the results?

Please inform to readers

Commented [R3R2]: What are indicators of HOTS?

Commented [L4R2]: logic, reasoning, analysis, evaluation, creation, problem-solving, and decision making.

Commented [R5]: Please write the hypothesis

Assumptions to conduct ANOVA

Commented [L6R5]: The construct validity of the experiment model shows the effectiveness of the model on increasing students' HOTS. The following hypotheses were examined in the test.
H0: The integrated metacognition virtual practicums have significant effects on students' HOTS.
H1: The integrated metacognition virtual practicums have no significant effects on students' HOTS.

FINDINGS AND DISCUSSION

Findings

The syntax of the metacognition integrated virtual science learning model results from integrating metacognition theory into virtual experiments. The syntax for this model uses the MiSHE model, which was previously developed by Maryani, Prasetyo, et al (2021) and Maryani et al (2022) by integrating metacognition into project-based learning. The syntax is: awareness, essential questions, planning, monitoring, evaluation, and reflection.

The learning process took place over seven sessions in two groups at different universities. Researchers involved three practicing lecturers as observers who also provided input on the implementation of the model. Observations are carried out through monitoring in Google Classroom so that the syntax of this model can be monitored optimally. Learning is carried out online using Google Classroom, Google Meet, Google Forms, YouTube, and the PhET simulation to carry out each stage of the model. The practicum carried out by students can be seen in Table 1.

Table 1. Virtual Experiment Activities

Subject Matter	Experiment
Motion and Force	Make a wind-powered toy car
Effort and energy	Analyze the motion of a toy car using Tracker Software
Electricity	Create electrical circuits with PhET simulation
Magnets	Create a magnet and a simple compass
Vibration, wave, and sound	Analyze vibration and sound intensity
Light	Analyze the phenomenon of the properties of light in the environment
Earth and solar system	Create solar system replicas and simulations

Metacognition consists of aspects of knowledge and regulation. Metacognitive knowledge consists of three components, namely awareness of knowledge/person variables, awareness of thinking/task variables, and awareness of thinking/strategy variables (Thamraksa, 2005). Metacognition regulation is a person's internal subjective response to metacognitive knowledge. Metacognition

Commented [R7]: Syntax should be described in methods

Here, please describe th implementation in the classroom

Commented [L8R7]: Awareness
Essential questions
Planning
Monitoring
Evaluation
Reflection

regulation is monitoring cognitive activity and ensuring that cognitive goals have been achieved (Berry, 1983).

Metacognition activities in this model are carried out through five activities. The first activity is to reflect on students' thinking processes in virtual experiments. The second activity is to look for other concrete examples from previous learning experiences. The third activity analyzes the learning experience's advantages and disadvantages. The fourth activity is generalizing and formulating rules regarding the learning experience. The last activity is to name the learning experience as a learning strategy (Zohar, 1999, 2004; Zohar & Dori, 2012). The metacognition learning model has components of planning, monitoring, and evaluating (Dimaggi et al., 2014). Based on the description of the integration of metacognitive knowledge and the regulation of metacognition, the syntax of the virtual science experiment model is metacognitively integrated, which consists of six steps, namely, awareness, posing essential questions, planning, monitoring, evaluating, and reflecting.

After the model was implemented, students' HOTS data were obtained for each material. The pre-test was conducted once, while the post-test was performed seven times. The descriptive analysis of HOTS data can be seen in Table 2.

Table 2. Result of student HOTS

Treatment	Parameter	Pre test	Postest 1	Postest 2	Postest 3	Postest 4	Postest 5	Postest 6	Postest 7
Metacognition-virtual practicum	Mean	48,84	66,34	73,52	73,61	78,13	73,31	80,01	81,33
	Std.dev	11,15	15,93	15,53	10,44	13,02	14,26	10,93	8,63
	Min	32,60	32,10	33,30	51,40	53,60	46,40	59,50	60,00
	Max	73,10	96,40	100,00	94,30	100,00	96,40	100,00	100,00
Virtual practicum	Mean	41,02	55,94	60,32	55,52	61,81	65,11	67,36	72,31
	Std.dev	10,19	18,69	15,69	14,99	18,39	23,47	20,24	8,10
	Min	14,80	17,90	28,60	24,29	21,40	3,60	26,30	56,67
	Max	63,80	96,40	88,10	90,00	96,40	100,00	100,00	86,67

The data is then analyzed for prerequisites (normality and homogeneity) to determine whether the influence of the model on HOTS can be analyzed using parametric statistics. The results of the normality test conducted as the requirement for multivariate analysis are presented in Table 3.

***

Commented [R9]: Please describe first using statistics descriptive

Commented [R10R9]: How is the implementation in the class?

Commented [L11R9]: Cek narasi di tabel 1 dan paragraf sebelumnya

Table 3. Tests of Normality

Data	Model	Kolmogorov-Smirnov[a]	
		Statistic	Sig.
Pretest	experiment	.101	.200*
	control	.105	.200*
Post-test 1	experiment	.157	.015
	control	.131	.092
Post-test 2	experiment	.071	.200*
	control	.086	.200*
Post-test 3	experiment	.097	.200*
	control	.096	.200*
Post-test 4	experiment	120	.151
	control	.126	.118
Post-test 5	experiment	.147	.029
	control	.082	.200*
Post-test 6	experiment	.106	.200*
	control	.125	.131
Post-test 7	experiment	.139	.051
	control	.090	.200*

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 1 shows that all data are normally distributed, confirmed by the value of sig > 0.05 (α) in the Shapiro-Wilk column. The normality of the data in all treatment groups has met the assumption to continue testing the hypothesis using the General Linear Model (Multivariate of Variance). The second assumption test is the homogeneity test (Table 4).

Table 4. Tests of Homogeneity through Box's Test of Equality of Covariance Matrices

Box's Test of Equality of Covariance Matrices	
Box's M	223,844
F	2,800
df1	72
df2	36809,703
Sig.	,000
Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.	

a. Design: Intercept + Model Within Subjects Design: time

Box's M value shows the homogenity of the HOTS scores achieved by the experimental and control groups. Rencher and Cristensen made the following observation that M-test is available in many software packages including SPSS and the rejection of null hypothesis of equal covariance matrices is not a serious problem when the number of observations is the same in each group (Sarma & Vardhan, 2018). A sig value of 0.000 or below 0.05 indicates that the data are not homogeneous or that the HOTS scores in each treatment group vary greatly. In an experimental study, this inhomogeneity is not a problem, because it is difficult to get the same variation in scores in two groups that are subjected to different treatments. In a quasi-experimental design, the error factor (subject, sample, treatment, etc.) has a significant effect on the change in pretest to posttest scores, resulting in broad variation in the scores achieved by research subjects. Additionally, it is difficult for all subjects in the experimental group to see identical improvement in scores. Due to the impossibility of obtaining the same variance in scores between two groups given to different treatments (Widhiarso, 2011), this inhomogeneity can be overlooked (Blanca et al., 2017). MANOVA is a robust test for data homogeneity disturbances when the sample size difference between the two treatment groups is between 7 and 15 participants (Ramsey, 2007).

The GLM test with Multivariate Analysis of Variance (MANOVA) revealed an interaction between time (pre-post-test) and group (experiment-control). The interaction demonstrated that the difference in scores between the two groups (experiment-control) was substantially different from pre- to post-test. The MD value for the experimental group was -17.505 with a significance value of 0.000 (0.05), indicating that the experimental group saw a significant rise in HOTS. The MD value in the control group was -11.069* with a significance value of 0.001, showing a statistically significant increase. The greatest rise occurred in the experimental group, with a mean difference of 17.505 between pretest and posttest. Additionally, the findings of the multivariate test in Table 5 were evaluated to ascertain the virtual practicum's impact on students' HOTS.

Table 5. Multivariate Tests

Learning model		Sig.	Partial Eta Squared
Experiment	Pillai's trace	.000	.745
	Wilks' lambda	.000	.745

Commented [R12]: Describe deeper about interpretation of tables.

Commented [L13R12]:

Learning model		Sig.	Partial Eta Squared
	Hotelling's trace	.000	.745
	Roy's largest root	.000	.745
Control	Pillai's trace	.000	.354
	Wilks' lambda	.000	.354
	Hotelling's trace	.000	.354
	Roy's largest root	.000	.354

within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means

The significance values in Table 3 indicate that virtual practicums influence increasing students' HOTS. As mentioned by (Leech et al., 2013), the treatment's efficacy can be seen in Wilks' Lambda column. In the experimental group, Partial Eta Squared of 0.745 indicates that the given treatment successfully increased students' HOTS by 74.5%, while the observed increase in HOTS in the control group was only 35.4%. The partial eta square value indicates the magnitude of an effect of a treatment (with a small effect being 0.01; a medium effect being 0.3, and a large effect being 0.5) (Bakker et al., 2019; Cohen, 1988; Mordkoff, 2019). The effect size discovered in this study is regarded as quite high, as it exceeds 50%. Thus, with big effect size and a 74.5% rise in HOTS, it can be concluded that virtual practicums have a considerable influence on students' HOTS. This rise is bigger than the increase in HOTS observed in students studying using other models.

Discussion

The virtual experiment syntax established in this study is the outcome of incorporating metacognitive theory into the stages of virtual science experiment. Students who participate actively in experiment, the will demonstrate an enhancement in both their individual and collaborative cognitive and metacognitive functions (Zarouk et al., 2020). Metacognition is comprised of knowledge and regulation components. Metacognitive knowledge consists of three components, namely awareness of knowledge/person variables, awareness of thinking/task variables, and awareness of thinking/strategy variables. Declarative, procedural, and conditional knowledge are all examples of metacognitive knowledge (Thamraksa, 2005). Metacognition regulation is the subjective internal response of an individual to metacognitive knowledge. This response is likewise directed at problem-solving strategic tasks. Metacognition regulation is the process of observing cognitive activity and ascertaining if cognitive objectives are met (Berry, 1983). Planning, monitoring, and assessing are the components of the metacognition learning model (Dimaggi et al., 2014). These three elements then become part of the virtual experiment phases in the planning, monitoring, and reflection portions, which correspond to the PjBL model.

The virtual experiment model used in this study places a premium on students' autonomy and flexibility of thought when it comes to problem-solving through work-based projects. Students are compelled to explore contextual learning problems. The problem-solving activities conducted in the classroom include mind mapping, contextual project work in the surrounding environment, virtual project work using Tracker, PhET, and sound meter software, as well as making video presentations. Each lesson began with an activity that helps students identify their strengths and weaknesses (awareness) in terms of science topics, and then move on to developing problem-solving methods (planning, monitoring, evaluating).

The implementation phase of the model also showed that the students' HOTS increased due to the use of this model. The increase in students' HOTS in the areas of logic, reasoning, and analysis was seen in their activity of assessing science problems that arise in their environment (Ichsan et al., 2019). The students were tasked with the responsibility of resolving these issues through the development of works. Each session contained a variety of works, including mind mapping, science experiments (contextual and virtual), and video presentations. The students had to study and understand the information using logic and reasoning to complete the project in the form of mind mapping. They were required to examine difficulties to complete science projects such as building simple automobiles, electrical circuits, simple compasses, simple pendulums, and solar system simulations. Besides that, the students were also accustomed to discussing issues with other students to develop their problem-solving skills.

The increase in students' HOTS in the evaluation aspect occurred because they were required to evaluate the achievement of their learning objectives, the suitability of the work produced with the problem, as well as the suitability of time and strategy with the expected results. The increase in the students' creation scores happened because of students becoming accustomed to making items that correspond to the learning objectives. The students were allowed to collaborate to convey their thoughts. At this step, opinions were gathered, clarified, logically reasoned, and expressed to others (Mumford & McIntosh, 2017; Sodikova, 2020). Each student's product was unique in terms of shape, substance, and outcome since they used the materials available in their immediate area while leveraging their prior knowledge.

At each step of learning, students' higher-order thinking skills (HOTS), specifically their ability to solve problems and make judgments, were also developed. For instance, when students used Tracker software to analyze the motion of an object (a wind-powered car), they ran into numerous complications. Despite the availability of the tutorials, some students were unable to complete the project by the deadline. This occurred because some pupils were technically incapable of using the software used in the analytical procedure. Students who had completed the project were then asked to mentor other students during virtual face-to-face encounters. This accomplishment arose as a result of students' willingness to experiment with various methods for solving issues, such as using MS Excel for mathematical operations and graph creation. Another example is the experiment with electricity using PhET Simulation, where numerous electrical circuits burnt throughout the project due to faulty wiring and resistance. Students who ventured to experiment with alternate steps were successful in determining the correct order. Problem-solving is a fundamental cognitive function in humans that interacts with other skills such as abstraction, decision making, analysis, and synthesis (Drigas & Mitsea, 2020). Students who develop strong problem-solving and judgment abilities will develop into self-assured, creative, and autonomous thinkers. The society produced by these individuals is easily capable of resolving everyday difficulties (Özreçberoğlu & Çağanağa, 2018).

The advantages of this virtual experiment model are that it is designed using quantifiable scientific procedures and involving experts, adaptable to normal or pandemic conditions by adjusting the learning activities, consists of learning activities that teach students to make decisions, take responsibility for their actions, and complete complex tasks or assist other friends with their assignments, is grounded in real-world problems and emphasizes project-based learning, which is critical for the development of outcome-based education curriculum, and is comprised of projects that foster the emergence of open-ended solutions, thereby preparing students to be problem solvers. However, the efficiency of this virtual experiment is also influenced by other aspects, such as self-regulation (Sulisworo et al., 2020) and student technology readiness (Indriyanti et al., 2020). Future research can adopt or modify this model to measure its impact on these two variables. The linkage of metacognition to self-regulation makes it seem like an association (Kristiani et al., 2015; Review, 2018; Rhodes, 2019; Shen & Liu, 2011). Meanwhile, the virtual lab used during practicum requires technological readiness (Firdaus et al., 2020; Halamka & Cerrato, 2021). Continuous application of the model allows students to be trained in HOTS continuously. When in real life or in industry, it can support their ability to solve contextual problems for better work performance.

***

Commented [R14]: Add research topic can be conduct in the future based on this result

CONCLUSION

This study was successful in generating a virtual science experiment design that incorporates metacognitive strategies using syntax, including increasing awareness, posing essential questions, planning, monitoring, evaluating, and reflecting. This model has a significant effect on students' HOTS, particularly in the areas of logic, reasoning, analysis, assessment, invention, problem-solving, and making judgments. These criteria are met when a support system in the form of instructional materials and student worksheets is in place. Collaboration between students and communication between students and the instructor as a social system, as well as the principle of reactions that occur when the lecturer provides reinforcement, all contribute to the experiment model's feasibility. According to the findings, lecturers should monitor students' knowledge and reflection of learning objectives to ensure that learning activities truly engage the domain of metacognition. Although it will take some time, this strategy appears to be worth considering by university science departments as a science experiment solution during the pandemic age.

ACKNOWLEDGMENT

We want to express our gratitude to Alpendi, Moh. Irma Sukarelawan, and Rully Charitas Indra Prahmana for their contributions to this final analysis, revision, and discussion manuscript. Furthermore, we are grateful to Universitas Ahmad Dahlan and University of Nueva Caceres for giving us a research collaboration opportunity. Finally, we would like to express our gratitude to Universitas Ahmad Dahlan for providing financial support through a supported professorship candidate research grant.

REFERENCES

Anthony, R., Aryani, F., & Wrastari, T. (2014). Pengaruh penggunaan film sebagai media belajar terhadap pencapaian higher order thinking skill pada mahasiswa Fakultas Psikologi UNAIR. *Jurnal Psikologi Klinis Dan Kesehatan Mental*, *03*(1), 40–47. http://journal.unair.ac.id/download-fullpapers-jpkkb65e5e6f32full.pdf

Bakker, A., Cai, J., English, L., Kaiser, G., Mesa, V., & Van Dooren, W. (2019). Beyond small, medium, or large: points of consideration when interpreting effect sizes. *Educational Studies in Mathematics 2019 102:1*, *102*(1), 1–8. https://doi.org/10.1007/S10649-019-

09908-4

Berry, D. C. (1983). Metacognitive Experience and Transfer of Logical Reasoning. *The Quarterly Journal of Experimental Psychology Section A*, *35*(1), 39–49. https://doi.org/10.1080/14640748308402115

Blanca, M. J., Alarcón, R., Arnau, J., Bono, R., & Bendayan, R. (2017). Datos no normales: ¿es el ANOVA una opción válida? *Psicothema*, *29*(4), 552–557. https://doi.org/10.7334/PSICOTHEMA2016.383

Brookhart, S. M. (2010). *How to Assess Higher-order Thinking Skills in Your Classroom - Susan M. Brookhart - Google Buku*. ASCD. https://books.google.co.id/books?id=AFIxeGsV6SMC&printsec=frontcover&hl=id#v=onepage&q&f=false

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates, Publishers.

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative* (4th ed.). Pearson Education Inc.

Diani, R., Asyhari, A., & Julia, O. N. (2018). Pengaruh Model Rms (Reading, Mind Mapping and Sharing) Terhadap Kemampuan Berpikir Tingkat Tinggi Siswa Pada Pokok Bahasan Impuls Dan Momentum. *Jurnal Pendidikan Edutama*, *5*(1), 31. https://doi.org/10.30734/jpe.v5i1.128

Dimaggi, G., MacBethab, A., Gumleyc, A., Schwannauerd, M., Carcionee, A., Fisherd, R., & Hamish McLeod, J. (2014). Metacognition, symptoms and premorbid functioning in a first episode psychosis sample. *Comprehensive Psychiatry*, *55*(2), 268–273. https://doi.org/10.1016/J.COMPPSYCH.2013.08.027

Drigas, A., & Mitsea, E. (2020). The 8 Pillars of Metacognition. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(21), 162–178. https://www.online-journals.org/index.php/i-jet/article/view/14907

Fakhriyah, F. (2014). Penerapan problem based learning dalam upaya mengembangkan kemampuan berpikir kritis mahasiswa. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 95–101. https://doi.org/10.15294/jpii.v3i1.2906

Firdaus, Fatiatun, Jumini, S., Trisnowati, E., & Dahnuss, D. (2020). Proteus as a virtual simulation to improve readiness and process skills in laboratory experiment. *Journal of Physics: Conference Series*, *1517*(1). https://doi.org/10.1088/1742-6596/1517/1/012074

Firmansyah, R., Firmansyah, R., Putri, D., Wicaksono, M., Putri, S., Widianto, A., & Palil, M. (2021). Educational Transformation: An Evaluation of Online Learning Due To COVID-

19. *International Journal of Emerging Technologies in Learning (IJET)*, *16*(7), 61–76.

Gestiardi, R., Sarwanto, S., Chumdari, C., & Maryani, I. (2021). Using an Technology Readiness Model to Understand Perceived Usefulness of Learning in the Covid-19 Era. *International Journal of Elementary Education*, *5*(4), 631. https://doi.org/10.23887/ijee.v5i4.39188

Giatman, M., Siswati, S., & Basri, I. Y. (2020). Online Learning Quality Control in the Pandemic Covid-19 Era in Indonesia. *Journal of Nonformal Education*, *6*(2), 168–175. https://doi.org/10.15294/JNE.V6I2.25594

Gradini, E., Firmansyah, F., & Noviani, J. (2018). Menakar kemampuan berpikir tingkat tinggi calon guru matematika melalui level HOTS Marzano. *Eduma : Mathematics Education Learning and Teaching*, *7*(2), 41–48. https://doi.org/10.24235/eduma.v7i2.3357

Halamka, J., & Cerrato, P. (2021). Understanding the role of digital platforms in technology readiness. *Regenerative Medicine*, *16*(3), 207–213. https://doi.org/10.2217/rme-2020-0135

Heong, Y. M., Othman, W. B., Yunos, J. B. M., Kiong, T. T., Hassan, R. Bin, & Mohamad, M. M. B. (2011). The Level of Marzano Higher Order Thinking Skillsamong Technical Education Students. *International Journal of Social Science and Humanity*, *1*(2), 121–125. https://doi.org/10.7763/ijssh.2011.v1.20

Ichsan, I. Z. (2019). ILMIZI: Innovation Learning Model for Natural Science and Environmental Learning based on HOTS. *International Journal for Educational and Vocational Studies*, *1*(6), 578–584. https://doi.org/10.29103/IJEVS.V1I6.1640

Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Ali, A., Arif, W. P., & Prayitno, T. A. (2019). HOTS-AEP: Higher Order Thinking Skills from Elementary to Master Students in Environmental Learning. *European Journal of Educational Research*, *8*(4), 935–942. http://www.eu-jer.com/

Ilmi, A. M., Sukarmin, & Sunarno, W. (2020). Development of TPACK based-physics learning media to improve HOTS and scientific attitude. *Journal of Physics: Conference Series*, *1440*(1), 012049. https://doi.org/10.1088/1742-6596/1440/1/012049

Indah, P. (2020). Development of HOTS (High Order Thinking Skill) Oriented Learning Through Discovery Learning Model to Increase The Critical Thinking Skill of High School Students. *International Journal of Chemistry Education Research*, *3*(3), 26–32. https://doi.org/10.20885/IJCER.VOL4.ISS1.ART4

Indriyanti, N. Y., Yamtinah, S., & Muawiyah, D. (2020). An Inquiry into Students' Metacognition and Learning Achievement in a Blended Learning Design. *International*

Journal of Emerging Technologies in Learning (IJET), *15*(21), 77–88. https://www.online-journals.org/index.php/i-jet/article/view/12907

Kauffman, H. (2015). A review of predictive factors of student success in and satisfaction with online learning. *Research in Learning Technology*, *23*. https://doi.org/10.3402/RLT.V23.26507

Kleitman, S., & Narciss, S. (2019). Introduction to the special Issue "applied metacognition: real-world applications beyond learning." *Metacognition and Learning 2019 14:3*, *14*(3), 335–342. https://doi.org/10.1007/S11409-019-09214-7

Kristiani, N., Susilo, H., Rohman, F., & Corebima, A. D. (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://doi.org/10.15739/IJEPRR.020

Leech, N., Barrett, K., & Morgan, G. A. (2013). SPSS for intermediate statistics: use and interpretation, third edition. *SPSS for Intermediate Statistics*. https://doi.org/10.4324/9781410616739

Maryani, I., Astrianti, C., Yuli, V., Prodi, E., Guru, P., Dasar, S., Dahlan, A., Ki, J., Pemanahan, A., & Yogyakarta, S. (2021). The Effect of The STEM-PjBL Model on The Higher-Order Thinking Skills of Elementary School Students. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, *30*(2), 110–122. https://doi.org/10.17977/UM009V30I22021P110

Maryani, I., Prasetyo, Z. K., & Wilujeng, I. (2021). *Model Pembelajaran MiSHE (Metacognition in Science for Higher Education)*. K-Media. https://books.google.co.id/books?id=2AtBEAAAQBAJ&lr=&source=gbs_navlinks_s

Maryani, I., Prasetyo, Z. K., Wilujeng, I., & Purwanti, S. (2022). 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*, *11*(4), 1980–1988. https://doi.org/10.11591/ijere.v11i4.23129

Maryani, I., Prasetyo, Z. K., Wilujeng, I., Purwanti, S., & Fitrianawati, M. (2021). HOTs Multiple Choice and Essay Questions: A Validated Instrument to Measure Higher Order Thinking Skills of Prospective Teachers. *The Journal of Turkish Science Education*, *18*(3), 1–20.

Marzano, R. (2013). Objectives that Students Understand. *School, Families, Communities*, *68*(8).

Marzano, R. J. (1993). How classroom teachers approach the teaching of thinking. *Theory Into*

Practice, *32*(3), 154–160. https://doi.org/10.1080/00405849309543591

Marzano, R. J., & Kendall, J. S. (2006). *The new taxonomy of educational objectives* (2nd ed.). Corwin Press.

Mordkoff, J. T. (2019). A Simple Method for Removing Bias From a Popular Measure of Standardized Effect Size: Adjusted Partial Eta Squared: *Https://Doi.Org/10.1177/2515245919855053*, *2*(3), 228–232. https://doi.org/10.1177/2515245919855053

Mumford, M. D., & McIntosh, T. (2017). Creative thinking processes: the past and the future. *The Journal of Creative Behavior*, *51*(4), 317–322. https://doi.org/10.1002/JOCB.197

Nambiar, D. (2020). The Impact of Online Learning during Covid-19 Pandemic: Students' and Teachers' Perspective. *The International Journal of Indian Psychology*, *8*(2), 686–690. https://doi.org/10.25215/0802.094

Özreçberoğlu, N., & Çağanağa, Ç. K. (2018). Making It Count: Strategies for Improving Problem-Solving Skills in Mathematics for Students and Teachers' Classroom Management. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(4), 1253–1261. https://doi.org/10.29333/EJMSTE/82536

Panahandeh, E., & Asl, S. E. (2014). The Effect of Planning and Monitoring as Metacognitive Strategies on Iranian EFL Learners' Argumentative Writing Accuracy. *Procedia - Social and Behavioral Sciences*, *98*, 1409–1416. https://doi.org/10.1016/J.SBSPRO.2014.03.559

Pratiwi, R. D. (2014). Penerapan Constructive Controversy Dan Modified Free Inquiry Terhadap Hots Mahasiswa. *Formatif : Jurnal Ilmiah Pendidikan MIPA*, *4*(2), 100–111.

Prihmardoyo, W., Sajidan, & Maridi. (2017). Effectiveness of Guided Inquiry Laboratory-Based Module and Indicator of Analytical Thinking Skills in the Matter of Respiratory System in Senior High School Wahyu. *Advances in Social Science, Education and Humanities Research (ASSEHR)*, *158*(Ictte), 803–813.

Ramsey, P. . (2007). Factorial design. In *Encyclopedia of measurement and statistics* (In Salkind). Sage Publication.

Review, E. P. (2018). *The Role of Self-Regulatory and Metacognitive Competence in the Motor Performance Difficulties of Children with Developmental Coordination Disorder : A Theoretical and Empirical Review Author (s): Claire Sangster Jokić and David Whitebread Published by .* *23*(1), 75–98. https://doi.org/10.1007/s

Rhodes, M. G. (2019). Metacognition: *Https://Doi.Org/10.1177/0098628319834381*, *46*(2), 168–175. https://doi.org/10.1177/0098628319834381

Rosidin, U., Suyatna, A., & Abdurrahman, A. (2019). 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*, *7*(3), 435–448. https://doi.org/10.17478/JEGYS.518464

Saregar, A., Latifah, S., & Sari, M. (2016). Efektivitas Model Pembelajaran CUPs: Dampak Terhadap Kemampuan Berpikir Tingkat Tinggi Peserta Didik Madrasah Aliyah Mathla'ul Anwar Gisting Lampung. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *5*(2), 233. https://doi.org/10.24042/jpifalbiruni.v5i2.123

Sarma, K., & Vardhan, R. V. (2018). *Multivariate Statistic Made Simple (A Practical Approach)*. Taylor & Francis Group. https://books.google.co.id/books?id=RouADwAAQBAJ&printsec=frontcover#v=onepage&q&f=false

Shen, C.-Y., & Liu, H.-C. (2011). Metacognitive Skills Development: A Web-Based Approach in Higher Education. *Turkish Online Journal of Educational Technology - TOJET*, *10*(2), 140–150.

Sodikova, D. (2020). Formation of creative relationship through students using the creativity of eastern thinkers. *Mental Enlightenment Scientific-Methodological Journal Volume*, *2020*(1). https://uzjournals.edu.uz/tziuj/vol2020/iss1/44

Stevanović, A., Božić, R., & Radović, S. (2021). Higher education students' experiences and opinion about distance learning during the Covid-19 pandemic. *Journal of Computer Assisted Learning*, *37*(6), 1682–1693. https://doi.org/10.1111/JCAL.12613

Storey, N., & Zhang, Q. (n.d.). *A Meta-analysis of COVID Learning Loss*. https://doi.org/10.35542/OSF.IO/QEKW2

Suherman, Prananda, M. R., Proboningrum, D. I., Pratama, E. R., Laksono, P., & Amiruddin. (2020). Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model Assisted by Geogebra. *Journal of Physics: Conference Series*, *1467*(1), 012027. https://doi.org/10.1088/1742-6596/1467/1/012027

Sulisworo, D., Fitrianawati, M., & Maryani, I. (2020). Students' self-regulated learning (SRL) profile dataset measured during Covid-19 mitigation in Yogyakarta, Indonesia. *Data in Brief*, *33*, 106422. https://doi.org/10.1016/j.dib.2020.106422

Thamraksa, C. (2005). *Metacognition: A Key to Success for EFL Learners*. http://www.bu.ac.th/knowledgecenter/epaper/jan_june2005/chutima.pdf

Thomas, A., & Thorne, G. (2009). *How To Increase Higher Level Thinking | Center for Development and Learning*. The Center for Development And Learning.

http://www.cdl.org/articles/how-to-increase-high-order-thinking/
Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction*, *14*, 89–109. https://doi.org/10.1016/j.learninstruc.2003.10.004
Wang, M. C., Haertel, G. D., & Walberg, H. J. (1990). What influences learning? a content analysis of review literature. *The Journal of Educational Research*, *84*(1), 30–43. https://doi.org/10.1080/00220671.1990.10885988
Widhiarso, W. (2011). *Aplikasi anava campuran untuk eksperimen pretest dan postest desain eksperimen*. http://widhiarso.staff.ugm.ac.id/files/Aplikasi Anava Mixed Design untuk Eksperimen-revised 2011.pdf
Winne, P. H. (2017). Cognition and Metacognition within Self-Regulated Learning. *Handbook of Self-Regulation of Learning and Performance*, 36–48. https://doi.org/10.4324/9781315697048-3
Wiyoko, T., & Aprizan, A. (2020). Analisis profil kemampuan kognitif mahasiswa PGSD pada mata kuliah ilmu alamiah dasar. *IJIS Edu : Indonesian Journal of Integrated Science Education*, *2*(1), 2020. https://doi.org/10.29300/ijisedu.v2i1.2384
Yusuf, N. (2021). *The Effect of Online Tutoring Applications on Student Learning Outcomes during the COVID-19 Pandemic*. *11*(2), 81–88.
Zarouk, M. Y., Olivera, E., Peres, P., & Khaldi, M. (2020). The Impact of Flipped Project-Based Learning on Self-Regulation in Higher Education. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(17), 127–147. https://www.online-journals.org/index.php/i-jet/article/view/14135
Zohar, A. (1999). Teachers' metacognitive knowledge and the instruction of higher order thinking. *Teaching and Teacher Education*, *15*, 413–429. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1.2295%7B&%7Drep=rep1%7B&%7Dtype=pdf
Zohar, A. (2004). Teachers' metacognitive declarative knowledge and the teaching of higher order thinking. In *Higher Order Thinking in Science Classrooms: Students' Learning and Teachers' Professional Development* (pp. 177–196). Springer Netherlands. https://doi.org/10.1007/978-1-4020-1854-1_11
Zohar, A., & Dori, Y. (Yehudit). (2012). *Metacognition in science education : trends in current research*. Springer.
Zohar, A., & Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: are they mutually exclusive? *Journal of the Learning Sciences*, *12*(2), 145–181.

https://doi.org/10.1207/S15327809JLS1202_1

Appendix 1. The result of content validity of HOTS questions

No		1	2	3	4	5	6		8	9	10	Average of Aiken V index
Penilai	1	4	4	4	3	3	4	4	3	3	5	
	2	5	5	5	5	5	5	4	5	4	5	
	3	4	4	4	5	5	5	5	5	5	5	
	4	4	4	5	5	5	5	5	4	4	4	
	5	5	5	5	4	4	5	5	5	5	5	
	6	4	4	4	4	5	4	4	4	4	4	
	7	5	5	5	5	5	5	5	5	5	5	
S_1		3	3	3	2	2	3	3	2	2	4	
S_2		4	4	4	4	4	4	3	4	3	4	
S_3		3	3	3	4	4	4	4	4	4	4	
S_4		3	3	4	4	4	4	4	3	3	3	
S_5		4	4	4	3	3	4	4	4	4	4	
S_6		3	3	3	3	4	3	3	3	3	3	
S_7		4	4	4	4	4	4	4	4	4	4	
Σs		24	24	25	24	25	26	25	24	23	26	
N (c-1)		28	28	28	28	28	28	28	28	28	28	
V		0,857	0,857	0,893	0,857	0,893	0,929	0,893	0,857	0,821	0,929	**0,879**
Validity		Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	**Valid**
Category		High	High	High	High	High	High	High	High	High	High	**Tinggi**

Appendix 2. The result of construct validity of HOTS Questions

a) Unidimensional Assumtion Test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.830
Bartlett's Test of Sphericity	Approx. Chi-Square	6260.265
	df	2926
	Sig.	.000

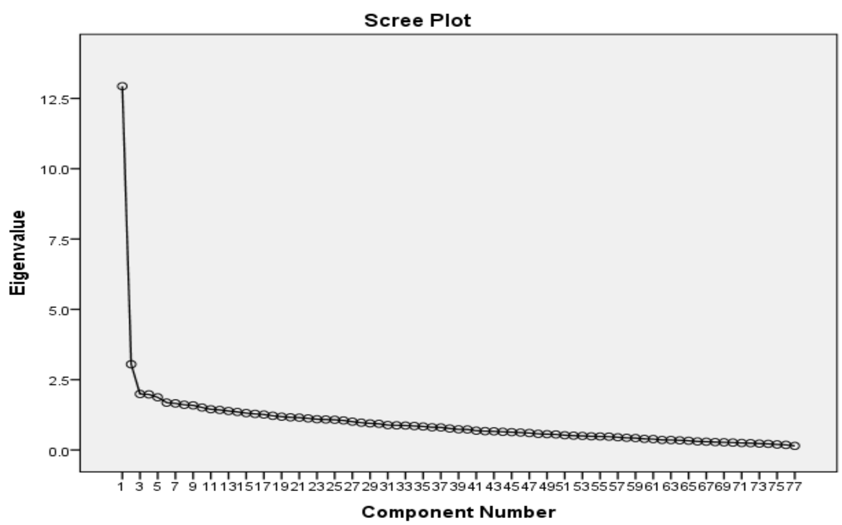
The Result of Factor Analysis

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	12.931	16.794	16.794	12.931	16.794	16.794
2	3.049	3.960	20.754	3.049	3.960	20.754
3	1.991	2.585	23.339	1.991	2.585	23.339
4	1.976	2.566	25.905	1.976	2.566	25.905
5	1.872	2.432	28.337	1.872	2.432	28.337
6	1.684	2.187	30.524	1.684	2.187	30.524
7	1.656	2.151	32.674	1.656	2.151	32.674
8	1.608	2.088	34.762	1.608	2.088	34.762
9	1.587	2.061	36.823	1.587	2.061	36.823
10	1.510	1.962	38.785	1.510	1.962	38.785
11	1.447	1.880	40.665	1.447	1.880	40.665
12	1.425	1.850	42.515	1.425	1.850	42.515
13	1.387	1.801	44.315	1.387	1.801	44.315
14	1.352	1.755	46.071	1.352	1.755	46.071
15	1.311	1.702	47.773	1.311	1.702	47.773
16	1.283	1.666	49.439	1.283	1.666	49.439
17	1.260	1.637	51.076	1.260	1.637	51.076
18	1.215	1.578	52.654	1.215	1.578	52.654
19	1.185	1.539	54.193	1.185	1.539	54.193
20	1.161	1.508	55.702	1.161	1.508	55.702
21	1.150	1.493	57.195	1.150	1.493	57.195
22	1.124	1.459	58.654	1.124	1.459	58.654
23	1.093	1.419	60.073	1.093	1.419	60.073
24	1.084	1.408	61.481	1.084	1.408	61.481
25	1.073	1.394	62.876	1.073	1.394	62.876
26	1.050	1.363	64.239	1.050	1.363	64.239
27	1.006	1.307	65.546	1.006	1.307	65.546
28	.971	1.261	66.807			
29	.944	1.227	68.034			
30	.932	1.210	69.244			
31	.885	1.149	70.393			

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
32	.876	1.138	71.531			
33	.869	1.129	72.660			
34	.852	1.107	73.767			
35	.835	1.084	74.851			
36	.806	1.046	75.897			
37	.802	1.042	76.939			
38	.763	.991	77.930			
39	.733	.952	78.882			
40	.730	.947	79.829			
41	.686	.890	80.720			
42	.670	.871	81.590			
43	.664	.862	82.452			
44	.646	.840	83.292			
45	.633	.822	84.114			
46	.620	.805	84.919			
47	.603	.784	85.703			
48	.573	.745	86.448			
49	.562	.730	87.178			
50	.554	.720	87.898			
51	.524	.681	88.578			
52	.509	.661	89.239			
53	.501	.651	89.890			
54	.484	.629	90.519			
55	.482	.626	91.144			
56	.474	.616	91.760			
57	.452	.587	92.348			
58	.431	.560	92.908			
59	.422	.549	93.456			
60	.395	.514	93.970			
61	.387	.503	94.473			
62	.357	.464	94.937			
63	.354	.460	95.396			
64	.343	.445	95.841			
65	.329	.427	96.268			
66	.303	.393	96.662			
67	.294	.382	97.044			
68	.280	.363	97.407			
69	.273	.355	97.762			
70	.264	.343	98.105			
71	.248	.322	98.427			
72	.240	.312	98.739			
73	.228	.296	99.035			

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
74	.218	.284	99.319			
75	.197	.255	99.574			
76	.182	.236	99.810			
77	.146	.190	100.000			
Extraction Method: Principal Component Analysis.						

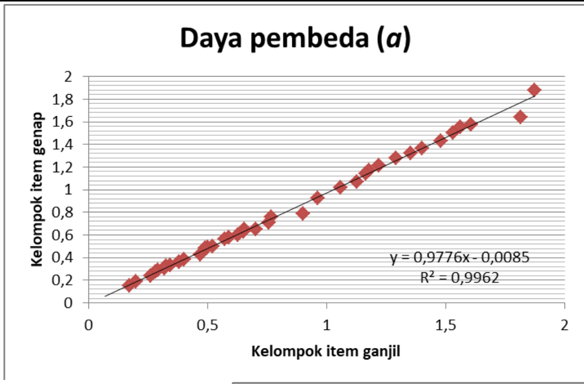
Appendix 3. The Result of Explanatory Factor Analysis (EFA)

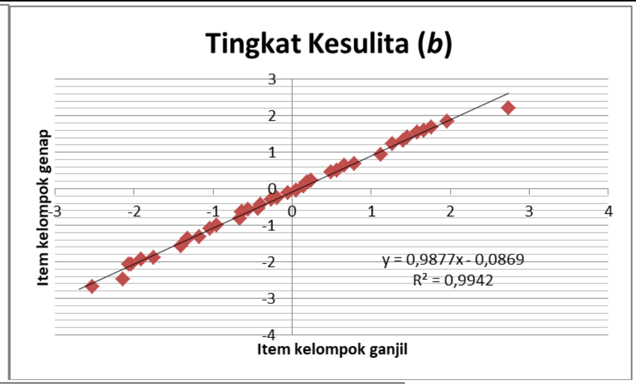


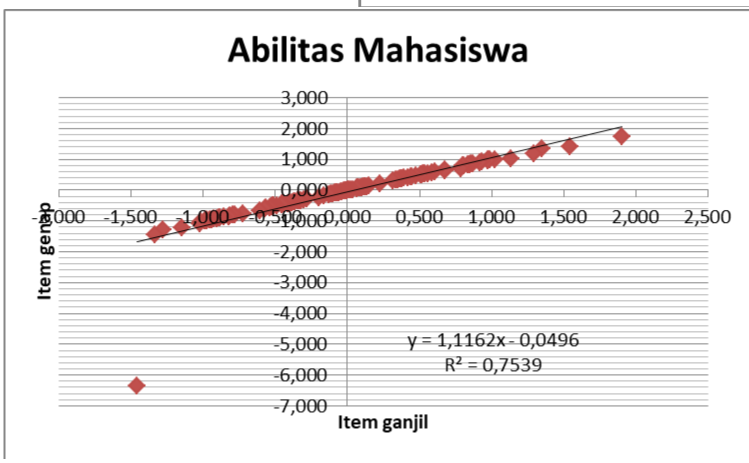
Appendix 4. Matrix of covarian of students' HOTS

	K1	*K2*	*K3*	*K4*	*K5*	*K6*	*K7*	*K8*	*K9*	*K10*
K1	0,0726									
K2	0,0227	0,0132								
K3	0,0130	0,0066	0,0036							
K4	0,0250	0,0090	0,0052	0,0098						
K5	0,0077	0,0036	0,0020	0,0031	0,0012					
K6	0,0062	0,0024	0,0014	0,0023	0,0008	0,0006				
K7	0,0233	0,0089	0,0050	0,0089	0,0029	0,0022	0,0083			
K8	0,0092	0,0044	0,0023	0,0034	0,0013	0,0009	0,0033	0,0016		

K9	0,0312	0,0124	0,0070	0,0122	0,0040	0,0030	0,0113	0,0046	0,0156	
K10	0,0813	0,0555	0,0251	0,0300	0,0129	0,0095	0,0327	0,0163	0,0442	0,7280







Appendix 5. Fit Model of Multiple choices questions

Item	Model			result		
	1 PL	2 PL	3 PL	1 PL	2 PL	3 PL
A4	0,5732	0,9958	0,5875	fit	fit	fit
A31	0,3301	0,8112	0,8483	fit	fit	fit
B10	0,0089	0,2528	0,0593	Unfit	fit	fit
B34	0,2364	0,8689	0,4245	fit	fit	fit
A29	0,9182	0,9991	0,8764	fit	fit	fit
A30	0,0609	0,9621	0,5738	fit	fit	fit
B24	0,0000	0,7868	0,9740	Unfit	fit	fit
A11	0,0635	0,5444	0,8396	fit	fit	fit
B14	0,7890	0,8668	0,3083	fit	fit	fit
A21	0,0249	0,5732	0,5108	Unfit	fit	fit
B28	0,0000	0,1786	0,8239	Unfit	fit	fit
A14	0,5032	0,3952	0,6102	fit	fit	fit
B5	0,0417	0,2135	0,4153	Unfit	fit	fit
B15	0,0004	0,1746	0,5570	Unfit	fit	fit

Item	Model			result		
	1 PL	2 PL	3 PL	1 PL	2 PL	3 PL
B35	0,0065	0,5289	0,6731	Unfit	fit	fit
B29	0,0000	0,9854	0,0153	Unfit	fit	Unfit
B37	0,0000	0,6063	0,0311	Unfit	fit	Unfit
A5	0,0457	0,6021	0,4927	Unfit	fit	fit
A12	0,0075	0,8058	0,8069	Unfit	fit	fit
A24	0,0007	0,9616	0,0380	Unfit	fit	Unfit
A34	0,0000	0,3036	0,0245	Unfit	fit	Unfit
B6	0,0005	0,9468	0,0148	Unfit	fit	Unfit
B17	0,4825	0,9300	0,1163	fit	fit	fit
A10	0,8660	0,7164	0,3860	fit	fit	fit
A16	0,0001	0,5023	0,0922	ocok	fit	fit
A27	0,2404	0,8943	0,9934	fit	fit	fit
A37	0,0746	0,9533	0,7636	Unfit	fit	fit
B7	0,5434	0,8487	0,2120	fit	fit	fit
B20	0,8309	0,8638	0,5522	fit	fit	fit
B27	0,0002	0,7554	0,2211	Unfit	fit	fit
B40	0,0011	0,8517	0,0097	Unfit	fit	fit
B31	0,0369	0,6640	0,4071	Unfit	fit	fit
B32	0,0000	0,6169	0,7279	Unfit	fit	fit
B33	0,6416	0,4072	0,8388	fit	fit	fit
A6	0,0016	0,6528	0,1847	Unfit	fit	fit
A23	0,7706	0,4017	0,0261	fit	fit	Unfit
A33	0,1290	0,5673	0,6403	fit	fit	fit
B8	0,0040	0,3494	0,7479	Unfit	fit	fit
B18	0,0772	0,9217	0,5823	fit	fit	fit
B30	0,0572	0,6113	0,0804	fit	fit	fit
B38	0,0012	0,9299	0,6805	Unfit	fit	fit
A1	0,0428	0,9666	0,0541	Unfit	fit	fit
A13	0,9609	0,9011	0,4321	fit	fit	fit
A22	0,4930	0,8962	0,1814	fit	fit	fit
A32	0,0001	0,7863	0,0312	Unfit	fit	Unfit
B4	0,9927	0,7294	0,4784	fit	fit	fit
B16	0,0000	0,0971	-	Unfit	fit	Unfit
B25	0,5775	0,9526	0,8770	fit	fit	fit
B36	0,1344	0,4397	0,8969	fit	fit	fit
A9	0,4815	0,8094	0,1710	fit	fit	fit
A2	0,6378	0,8078	0,0985	fit	fit	fit
A3	0,4694	0,6777	0,5001	fit	fit	fit
A18	0,3979	0,9869	0,2563	fit	fit	fit
A19	0,7895	0,8893	0,9913	fit	fit	fit
A20	0,3975	0,9510	0,5755	fit	fit	fit
A28	0,6230	0,5950	0,2663	fit	fit	fit
B1	0,9216	0,4871	0,2442	fit	fit	fit

Item	Model			result		
	1 PL	2 PL	3 PL	1 PL	2 PL	3 PL
B2	0,0000	0,1281	0,0621	Unfit	fit	fit
B3	0,0070	0,0446	0,0521	Unfit	Unfit	fit
B11	0,0009	0,5223	0,5252	Unfit	fit	fit
B12	0,0017	0,8852	0,6648	Unfit	fit	fit
B13	0,8521	0,9823	0,9689	fit	fit	fit
B21	0,0012	0,9317	0,1128	Unfit	fit	fit
B22	0,0081	0,1443	0,7384	Unfit	fit	fit
B23	0,0544	0,2435	0,0900	fit	fit	fit
A17	0,4158	0,5300	0,4189	fit	fit	fit
B9	0,0000	0,6449	0,1600	Unfit	fit	fit
B26	0,0093	0,9988	0,2167	Unfit	fit	fit
B39	0,0036	0,8949	0,1111	Unfit	fit	fit
A7	0,4430	0,9948	0,6033	fit	fit	fit
A25	0,7249	0,6235	0,7667	fit	fit	fit
A35	0,0115	0,2105	0,0009	Unfit	fit	fit
B19	0,5737	0,4752	0,5759	fit	fit	fit
NUMBER OF FIT ITEM				38	72	64

Fit Model of essay questions

Item	X^2				result
	Statistic	df	RMSEA	P-Value	
A26	0,581	4	0,000	0,965	fit
A8	3,771	5	0,000	0,583	fit
A36	7,614	3	0,076	0,055	fit
A15	4,749	4	0,026	0,314	fit

Result of multiple choices questions item parameter test

Item	Discriminant index		Difficulties index		conclusion
	a_i	result	b_i	result	
A4	0.499	good	0.943	good	accepted
A31	0.588	good	-1.172	good	accepted
B10	0.344	good	1.222	good	accepted
B34	0.382	good	0.142	good	accepted
A29	0.483	good	-2.136	poor	revised
A30	1.291	good	-2.063	poor	revised
B24	0.200	good	-0.049	good	accepted
A11	0.333	good	-1.560	good	accepted
B14	0.562	good	-2.031	poor	revised
A21	0.287	good	0.449	good	accepted
B28	0.187	good	0.237	good	accepted
A14	0.709	good	0.075	good	accepted
B5	0.320	good	1.269	good	accepted
B15	0.261	good	-0.429	good	accepted

Item	Discriminant index		Difficulties index		**conclusion**
	a_i	**result**	***b_i***	**result**	
B35	0.382	good	-0.647	good	accepted
B29	1.875	good	0.237	good	accepted
B37	1.814	good	-0.255	good	accepted
A5	0.927	good	-1.034	good	accepted
A12	0.327	good	-1.354	good	accepted
A24	1.180	good	1.692	good	accepted
A34	1.605	good	1.589	good	accepted
B6	1.643	good	0.568	good	accepted
B17	0.761	good	-0.635	good	accepted
A10	0.521	good	1.543	good	accepted
A16	1.365	good	-0.189	good	accepted
A27	0.963	good	-2.697	poor	accepted
A37	0.365	good	-1.889	good	accepted
B7	0.653	good	1.313	good	accepted
B20	0.492	good	-0.577	good	accepted
B27	1.433	good	0.054	good	accepted
B40	1.324	good	1.844	good	accepted
B31	0.303	good	0.489	good	accepted
B32	0.240	good	0.185	good	accepted
B33	0.627	good	-1.318	good	accepted
A6	1.481	good	0.179	good	accepted
A23	0.468	good	-0.666	good	accepted
A33	0.291	good	-2.062	poor	revised
B8	0.272	good	-0.552	good	accepted
B18	1.562	good	-1.749	good	accepted
B30	1.060	good	1.597	good	accepted
B38	1.126	good	-0.827	good	accepted
A1	1.072	good	1.671	good	accepted
A13	0.499	good	1.406	good	accepted
A22	0.790	good	1.767	good	accepted
A32	1.554	good	-1.092	good	accepted
B4	0.600	good	-0.107	good	accepted
B16	0.149	good	0.658	good	accepted
B25	1.021	good	-2.686	poor	revised
B36	0.325	good	-0.951	Baik	accepted
A9	0.653	good	1.959	Baik	accepted
A2	0.902	good	-1.311	Baik	accepted
A3	0.758	good	0.162	Baik	accepted
A18	0.628	good	-0.054	Baik	accepted
A19	0.651	good	-0.996	Baik	accepted
A20	0.577	good	1.456	Baik	accepted
A28	0.426	good	2.742	poor	revised
B1	0.704	good	2.207	good	accepted

Item	Discriminant index		Difficulties index		**conclusion**
	a_i	**result**	***b_i***	**result**	
B2	1.352	good	-0.295	good	accepted
B3	1.278	good	0.788	good	accepted
B11	1.215	good	-0.404	good	accepted
B12	1.532	good	-1.408	good	accepted
B13	0.767	good	-1.929	good	accepted
B21	1.143	good	0.628	good	accepted
B22	0.282	good	-0.635	good	accepted
B23	0.402	good	1.123	good	accepted
A17	0.574	good	-2.469	poor	revised
B9	1.503	good	0.683	good	accepted
B26	1.166	good	-0.422	good	accepted
B39	1.173	good	1.407	good	accepted
A7	0.491	good	0.194	good	accepted
A25	1.220	good	-2.526	poor	revised
A35	1.578	good	-1.915	good	accepted
B19	0.651	good	-2.078	poor	revised

Result of essay questions item parameter test

Item	Discriminant index		Difficulties index				conclusion
	a	Ket	*b*	b2	b (mean)	Ket	
A26	7,717	poor	-0,981	-0,130	-0,555	good	revised
A8	0,07	good	-0,851	-0,434	-0,642	good	accepted
A46	1,402	good	-0,865	1,871	0,503	good	accepted
A15	0,173	good	-0,260	-	-0,260	good	accepted

4. Bukti Konfirmasi artikel accepted (18 Novemeber 2022)

[CP] Editor Decision: Accept

Editor of Cakrawala Pendidikan <cakrawala@uny.ac.id> 5:00 PM

Dear Trikinasih Handayani:

Congratulation,

After a thorough review process, The Editorial Team of Jurnal Cakrawala Pendidikan has reached a decision regarding your submission.

The Editorial Team is pleased to inform you that your manuscript has been ACCEPTED.

We kindly ask you to pay the Article Processing Charge. The Article Processing Charge is Rp4.000.000,00. / $350.

For payment procedure, please visit this page : https://uny.id/cppayment

Please send the receipt/payslip (either a scan, a photo, a .pdf file, or a .jpg file) to cakrawala@uny.ac.id, CC: sulis@uny.ac.id, email subject: CAKRAWALA PENDIDIKAN PUBLICATION FEE. Please write the author's name and the
article title in your email.

Thank you very much for submitting your article to Jurnal Cakrawala Pendidikan. We welcome your contributions in the future.

Best regards.

Editor of Cakrawala Pendidikan
Universitas Negeri Yogyakarta
Phone 0274586168
cakrawala@uny.ac.id

Cakrawala Pendidikan
http://journal.uny.ac.id/index.php/cp

5.Bukti Konfirmasi artikel published Online (14 Mei 2023)

Archive | Editorial Team | Kotak Masuk (322) - trikinasih | Search results - trikinasih@pbio

https://journal.uny.ac.id/index.php/cp/author/index/completed

Most Visited | Google Meet | Kelas | Rencana Ploting PP... | Modul PPG Prajaba... | Markah Lain

Printed ISSN: 0216-1370 | Online ISSN: 2442-8620

Cakrawala Pendidikan
Jurnal Ilmiah Pendidikan

OPEN ACCESS

HOME | ABOUT | USER HOME | SEARCH | CURRENT | ARCHIVES | ANNOUNCEMENTS | CALL FOR PAPERS

USER

You are logged in as...
trikinasih
» My Journals
» My Profile
» Log Out

2017 | 2018

JOURNAL CONTENT

Search

Home > User > Author > **Archive**

Archive

ACTIVE | ARCHIVE

ID	MM-DD SUBMIT	SEC	AUTHORS	TITLE	VIEWS	STATUS
51752	07-08	ART	Handayani, Saulon, Maryani	INTEGRATING METACOGNITIVE STRATEGIES IMPACT IN VIRTUAL...	0	Vol 42, No 2 (2023): Cakrawala Pendidikan (June 2023)

1 - 1 of 1 Items

Start a New Submission

CLICK HERE to go to step one of the five-step submission process.

Refbacks

ALL | NEW | PUBLISHED | IGNORED

	DATE ADDED	HITS	URL	ARTICLE	TITLE	STATUS	ACTION
☐	2023-05-30	2	http://journal.uny.ac.id/index.php/cp/issue/view...	Integrating metacognitive strategies impact in virtual science	—	New	EDIT | DELETE

Editorial Team
Publication Ethics
Focus & Scope
Author Guidelines
Peer-Review Process
Publishing System
Indexing
Author(s) Fees
Contact

Cakrawala Pendidikan
Q3 Education
best quartile
SJR 2022
0.36