International Journal of Learning, Teaching and Educational Research
Vol. 19, No. 5, pp. 141-152, May 2020
https://doi.org/10.26803/ijlter.19.5.8

Development of the Innovative Smart Orbital (ISO) Medium to Improve the Cognitive Skills on the Heat Transfer Concept

Firmanul Catur Wibowo*, Esmar Budi and Lari Andres Sanjaya
Department of Physics Education
Universitas Negeri Jakarta, Indonesia
https://orcid.org/0000-0001-9632-6061
https://orcid.org/0000-0002-7960-0839
https://orcid.org/0000-0002-2642-1909

Dina Rahmi Darman
Department of Physics Education
Universitas Sultan Ageng Tirtayasa, Indonesia
https://orcid.org/0000-0002-4602-2657

Mohamad Syarif Sumantri and Dinas Kurnia Robby
Faculty of Education
Universitas Negeri Jakarta, Indonesia
https://orcid.org/0000-0002-2862-9826
https://orcid.org/0000-0002-2041-0571

Abstract. Learning media can enhance the learning process and can enhance cognitive skills. This research aims to use the Innovative Smart Orbital (ISO) approach to improve the cognitive skills on the concept of heat transfer. ISO is a new development medium which is a modification of the snakes and ladders games. An experimental class and a control class were used in this study. The experimental class learning is done using inquiry with ISO. In the control class, learning is done using inquiry only. Three hundred and four (304) students from 10 classes took part in this study. A purposive sampling technique was used to select them. The posttest score of cognitive skills of students before learning was 18.2 with an ideal score of 60. The posttest score of cognitive skills of students after learning was 49.5. The man normalized gain score <g> of the experimental class was 0.44. Using the ISO medium led to a moderate increase in cognitive skills on the heat transfer concept.

Keywords: Innovative Smart Orbital (ISO); medium; cognitive skills; heat transfer concept

* Corresponding author: Firmanul Catur Wibowo, email: fcwibowo@unj.ac.id

1. Introduction

Science is dynamic and moves along with its times and technology (Shinn & Joerges, 2002). Science develops as an effort to adjust to the demands and needs of the increasingly complex educational field. Education continues to be developed and continues to be fostered in the face of rapid world competition that prioritizes technology as the basis for the development of increasingly quality education (Wibowo, et a., 2019 & Hirsh-Pasek et al., 2015). The application of the Education Unit Level Curriculum requires an increase in the role of students in each learning activity (Morales-Martinez et al., 2018). The position of the student who was previously the object of learning has now turned to the subject of learning (Herro & Quigley, 2016). The curriculum requires junior and middle high school Physics teachers to be creative. For example, in preparing a syllabus, which is in accordance with the conditions of the student situation or location (regional).

Learning is a process that is based on a change in a person (Gan, Menkhoff & Smith, 2015; Al Said, Du, Al Khatib, Romanowski & Barham, 2019). Changes in learning outcomes can be shown in various forms such as changes in knowledge, understanding, attitudes and behavior, skills and habits that exist in individuals who learn (Wehn & Montalvo, 2018; Darman et al., 2019). Learning outcomes are the results of student learning activities that illustrate the skills or mastery of teaching materials (Shadiev, Hwang, Huang & Liu, 2017). The learning outcomes are usually expressed by test scores or numbers given by the teacher.

Interesting learning media can increase student interest in learning a subject matter. Learning media can provide real experiences that stimulate one's own activities for learning (Chotimah, Bernard & Wulandari, 2018; Wibowo et al., 2016). Games can be a learning tool that is played to motivate and change attitudes (Mustamin, Ahmad, Jasruddin, Syam & Fitriani, 2019). Games related to education support the understanding of concepts (Alsawaier, 2018; Arango-Lopez, Ceron Valdivieso, Collazos, Gutierrez & Moreira, 2018). Learning media are tools, methods, techniques, which are used in order to make communication more effective and to increase interactions between teachers and students in the learning process at school (Kariippanon, Cliff, Lancaster, Okely & Parrish, 2017; Sun & Wu, 2016).

Learning media can enhance the learning process and can also enhance learning outcomes (tom Dieck, Jung 7, tom Dieck, 2018; Hong et al., 2016). The function of learning media can arouse motivation and stimulate learning activities and even bring psychological influence on students (Wijekumar et al., 2019; Graham et al., 2017). Factors that must be considered in the selection of instructional media include: rational (it must make sense and be easy to understand), scientific (it must be used in accordance with reason and scientific principles), economical (affordable to schools, students and teachers), practical & efficient (it is easily available and is appropriate for its use) and functional (it is useful for learning).

A game is a contest between players who interact with each other by following certain rules to achieve certain goals. As a learning aid, games have many advantages, including: it is a fun and entertaining activity to do, it allows for

active participation from students to learn, so learning is not only one way, it is flexible, meaning that it can adjust to the situation and they generally require little effort to do. However, there are also some disadvantages to use games are learning aids. Sometimes, they may be quite complex to understand and may require a lot of time to explain. Moreover, there are often educational materials that would be very challenging to explain via games. Students who do not understand the rules of the games can create difficulties for the teacher and other students.

Physics is one subject that is of particular concern to both teachers and students. This subject is considered difficult because it deals with complex formulas and complex materials. This makes the students' interest to study Physics decrease. Heat transfer is one subject in Physics which is considered to be very difficult. This topic requires more effort to understand compared to other topics. However, to improve students' understanding in learning heat material and heat transfer concepts, a smart and fun Physics learning media must be introduced. Innovative Smart Orbital (ISO) consists of three words. This media is considered innovative because it is a novel way of using the snakes and ladders game in the teaching of Physics concepts. The media is smart which means that it is expected to facilitate learning so that students can learn in smarter ways which are more interesting and engaging. And orbital means that this learning media has an expanded trajectory similar to the orbital paths of starts and planets. The cognitive skills of students in this study is an increase in learning outcomes from the mean normalized gain score <g> before and after learning. Thus, the purpose of this research is the development of ISO, which is an Innovative Smart Orbital (ISO) medium to improve the cognitive skills of students on the concept of heat transfer.

2. Research Methodology

An experimental class and a control class have been used in this study. The population of this research is VII grade students at the Middle School in Semarang City, Indonesia. The sample for this research was 304 students from 10 classes, who were selected using a purposive sampling technique. The sample in this study was selected by using the random sampling cluster technique, which consist of taking two classes randomly from the population with the condition that the population is homogeneous. One class acts as an experimental class and the other class becomes the control class. After the homogeneity test was carried out. It turned out that the population was homogeneous, so the next step was to draw the sample.

An initial analysis was conducted to find out whether these two classes were similar. After finding out the condition of the two classes, a homogeneity test was performed. The design of this study uses the static class comparison pattern, which is to see the differences in the results of the posttest between the experimental class and the control class as presented in Table 1.

Table 1. Research Design

Class	Number	Pretest	Treatment	Posttest
Experimental	5	Test	Inquiry with ISO	Test
Control	5	Test	Inquiry	Test
Total Class	10			

In the experimental class, with a total of 5 classes, the learning stages were preceded by a pretest and then learning was carried out by the Inquiry approach together with the ISO media method. A posttest was also carried out. Whereas in the control class, with a total of 5 classes, the learning stages were preceded by a pretest and then learning was carried out by the Inquiry approach without the ISO media. A posttest was also carried out.

3. Results

Innovative Smart Orbital (ISO) is a learning media that is smart and fun, and which is in the form of a star or orbit travel. The ISO game is a modification of the snakes and ladders game. These modifications are found in the game board, dice and rules of the game. The ISO media is used when the teacher has finished explaining a subject or chapter in relevant Physics topics. The use of this media aims to improve the cognitive skills of students on the concept of heat transfer.

3.1 Innovative Smart Orbital (ISO) Board

A Smart Orbital Board is a square board game with a size of 40 x 40 cm. This board game consists of 49 boxes which are of the same size. Each box has a picture that has a specific purpose. The box contained in the Orbital Well consists of 5 bonus images, 5 penalty images, 3 pictures containing concepts, 3 pictures containing knowledge (memories), 3 images containing understanding, 3 images containing applications, 3 images containing analysis, 3 images containing synthesis and 3 images containing evaluation.

The astronaut plans to carry out a mission to the lunar planet and is on a smooth journey. Suddenly the aircraft's engine is broken and falls off, as far as 20 miles from the landing point. The NASA astronauts survives and are not injured, but the spaceship is heavily damaged. The astronauts are faced with the problem of how to re-join the aircraft.

The step to be taken by NASA astronauts is to walk 20 miles to the planned landing point. At the landing site, they can contact the operator of the aircraft to send a rescue aircraft. Before walking for 20 miles, the astronaut examined the plane that was badly damaged. The examination aims to find items that can be carried as provisions on the way. It turns out that there are 10 types of goods that are still intact and can be used. These ten items are 5 useful items and 5 less useful items based on importance and needs. These ten items are shown in Table 2.

Table 2: Items on the ISO Board

No	Types of uses	Types of goods	Reason
1	Useful	Oxygen tube	The main tool of life breathing is that there is no air on the moon.
2		Clean water	The main life tool after air for body metabolism.
3		Moon Map	The main directions and nothing else.
4		Food	To make a living for a while until a certain period.
5		Solar FM radio	The main communication tools.
6	Less Useful	Pistol FN-45	Perhaps the eruption can be used as a body thrust.
7		Milk Powder	Cannot be drunk because you need water and air to dissolve it.
8		Heater	The surface of the moon on the bright side is already hot, so it is not needed.
9		Magnetic	Not useful because the magnetic field of the moon is different from the earth.
10		Compass Matches	Not useful because in the month there is no air (oxygen) on the moon.

Source: Human Synergy, Michigan, USA (Wibowo, 2010)

Helpful goods in ISO function as a rise in score through an orbit with a blue circular shape, as shown in Figure 1. Less useful goods in ISO function as a reduction in score through the orbit in a red circular shape, as shown in Figure 1. An orbital board consist of 49 boxes, each of which has different function. The orbital board consists of several components namely the start box [Box 1], the material (bonus, punishment and Physics concepts) boxes, the finish box [Box 49], the ISO frame board and the orbit or the path that must be taken to reach the destination, as shown in Figure 1.

The use of ISO media in the learning process is clarify the presentation of the message so that it is not too verbal (in the form of mere written or oral words). The ISO media is able to overcome the limitations of learning space because learning can be done from anywhere. It can also help to overcome students' passive attitudes. It also inculcates a sense of responsibility as they have the feeling that they are leading a NASA mission to the moon. The ISO learning media can be used as a channel of communication between the teacher and students so that the teaching objectives are achieved. However, it is very time-consuming to create such media for each topic. Moreover, some students have difficulties to follow the rules of the game.

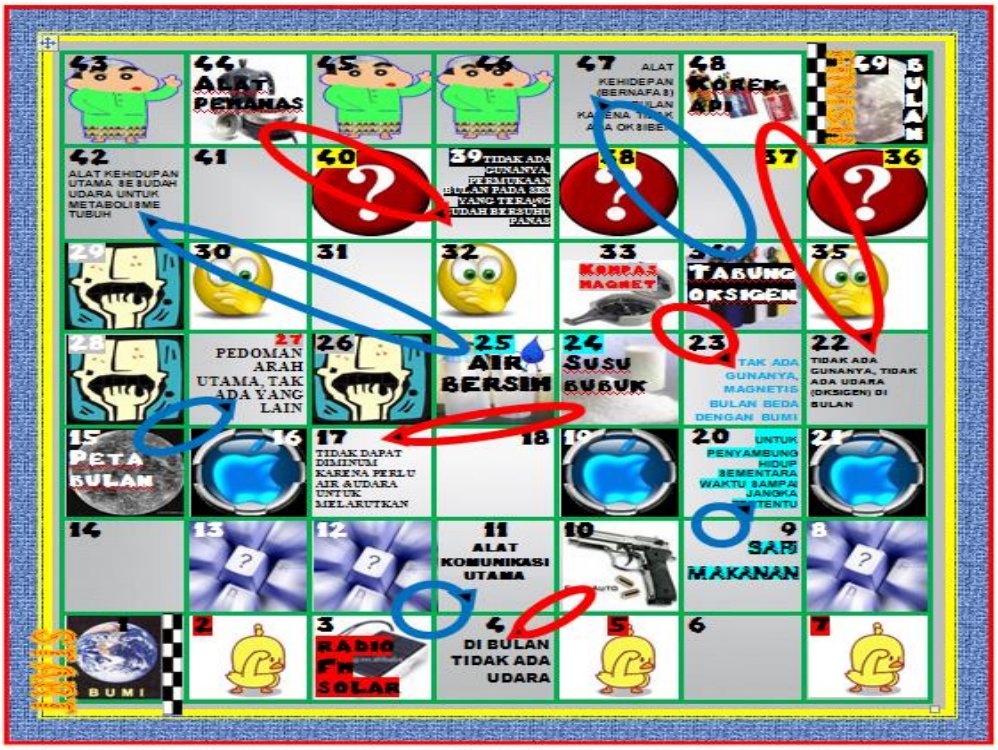


Figure 1. ISO Board

3.2 Smart Dice

Smart dice are cube-shaped dice and there is a measurement unit on each surface, as shown in Figure 2(a) and 2(b). A common dice has numbers or dots on its surfaces. The unit found on each surface of a smart dice shows the value (or range) of the steps that must be taken. The smart dice are made of wood or rubber.

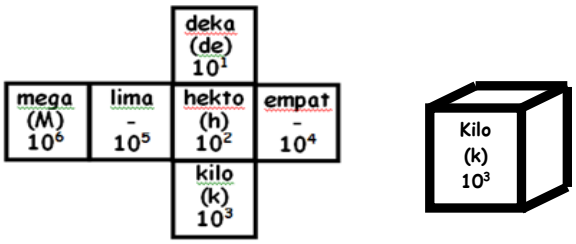


Figure 2. Smart dice design

3.3 Orbital Well

The Orbital Well is a tool that is made of paper and consists of a hollow cylinder, as shown in Figure 3(a) and 3(b). In the Orbital Well game, there is an image that contains bonuses, penalties, concepts and Physics materials. During the game, the orbital well is placed next to the ISO board with the state of the orbital well standing parallel to the ISO board. The orbital well is a function to take water or oil. An orbital well is also a tool that contains concepts, materials and answers to problems. If the player cannot answer the question contained in the face of a cylindrical orbital well, then the player can take answers from the inside of the well.

(a) (b)

Figure 3. (a) Orbital Well front view and (b) Orbital Well back view

3.4 Smart Orbital game rules

The rules of the game in ISO are almost the same as the rules of the snakes and ladders game. The rules of the ISO game are as follows:

a. Games are played by 2 to 5 players and players determine the order of play.
b. Players who get first place roll the dice and play first.
c. The first player runs the astronauts into the box corresponding to the Physics unit obtained when throwing the smart dice. For example, in an ISO game, the player is considered an astronaut. If the player throws a smart dice and gets a kilo (10^3), then the astronaut will walk forward 3 steps on the ISO board. Likewise, if an astronaut throws a smart dice and gets a Mega (10^6), he will move forward 6 steps.
d. After stopping at the box corresponding to the Physics unit number, the player is presented with concepts, questions, bonuses that must be worked on.
e. If the player lands on a cell where he must answer the question on the face of the cylindrical orbital well, but cannot answer it, then he can take the help of the answers contained on the inside of the well. This is possible when the player has been unable to answer a question twice.
f. After the first player finishes, then the second player continues in accordance with the sequence.
g. If the player gets a bonus, it will go through the ascending orbital trajectory and has the right to roll the dice again. A bonus is obtained if the player can answer the questions provided on the face of the orbital well.
h. If the player gets a penalty, for example, if he cannot answer the question on the face of the orbital well tube, then he will go down the orbit and he will lose the right to roll the dice on the next turn. The player loses the opportunity only once and can resume the ISO game again after another player has has his turn.
i. If an astronaut stops in an empty box, then the player can take a break, followed by the next sequence of astronauts to roll the smart dice.
j. The player is declared the winner if he has reached the landing point on the moon which is No. 49 on the ISO board.

4. Results and Discussion

The use of ISO media in learning can increase students' interest, creativity and level of activity in the classroom. Each student has different characteristics in terms of their capacity to capture and understand the materials that are presented to them. The midterm test scores in semester I of 2019/2020 from the Natural Sciences class VII were used in this study. The results are shown in Table 3.

Table 3: Comparison of Middle Semester Deuteronomy (MSD) Data with Learning Outcomes of Experimental and Control Classes

Class	Indicator	MSD	Cognitive Skill
Control Class	Students	28	28
	The highest score	92	76
	Lowest Value	40	43
	Mean	69	62
	Variance	12.75	10.53
	Standard Deviation	3.57	3.24
Experimental Class	Students	29	29
	The highest score	90	83
	Lowest Value	32	60
	Mean	63.41	74
	Variance	11.14	6.23
	Standard Deviation	3.33	2.50

From Table 3, we can see that the mean MSD score in the experimental group was 63.41 before ISO was used. After using ISO as a Physics learning media, the score rose to 74. Thus, the use of ISO media as a learning media in the experimental class positively affected the learning process.

Table 4: Test Results Normality Test Posttest Value

Class	$\chi 2$ count	$\chi 2$ Table	Criteria
Experimental Class	6.82	7.81	Normal
Control Class	7.74	7.81	Normal

A normality test has been carried out to find out whether the data is normally distributed or not. A normality test is also conducted to determine whether to use parametric statistics or nonparametric statistics. In the normality test, the formula used is the Chi-Square test. Population criteria are homogeneous if the calculated value for $\chi 2$ is smaller or equal to the $\chi 2$ table-value. From Table 4, we can see that $\chi 2$ count for each data is smaller than $\chi 2$ table values. Thus, the data is normally distributed and therefore parametric statistics must be used. If the sample in this study is declared normal based on the calculation with the normality test, then the calculation of the increase in cognitive skills is then performed as shown in Figure 4.

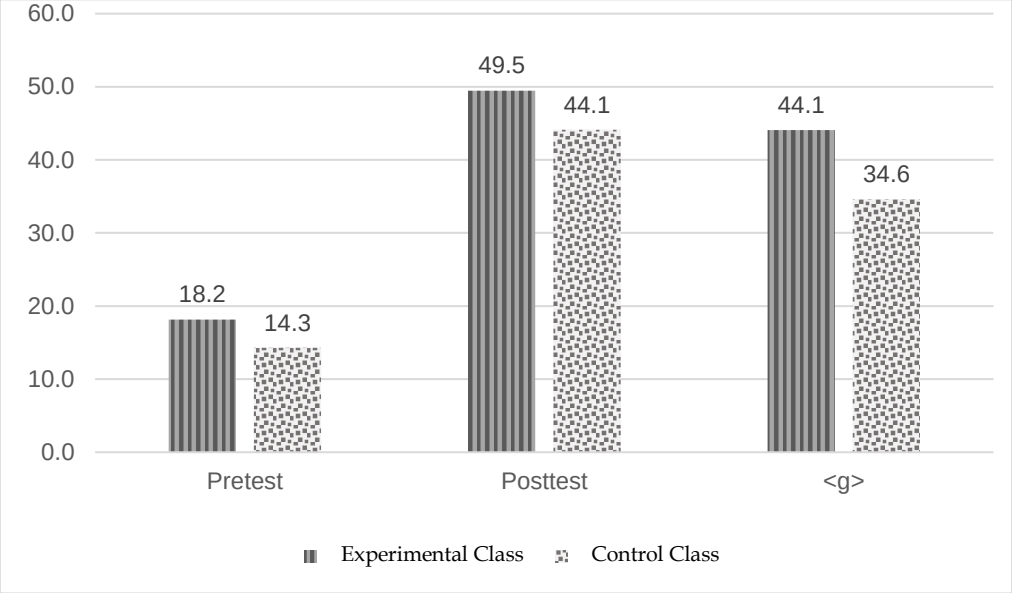


Figure 4. Pretest Score, Posttest Score and Normalized gain score <g> Cognitive Skill

Figure 4 shows the pretest scores, the posttest test scores and the normalized gain score scores <g> cognitive skill by students after applying inquiry with ISO for Physics learning. The posttest experiment class score of cognitive skills of students before learning was 18.2 from the ideal score of 60. The score of the posttest of cognitive skill of students after learning was 49.5 from the ideal score of 60. The normalized gain score <g> of the experimental class was 0.44. This falls in the medium increase category (Hake, 1999).

The posttest score of the control class was 14.3 while the score of the posttest was 44.1. The normalized gain score <g> of the experimental class was 0.34. This falls in the low increase category (Hake, 1999). The results of this study are in line with research conducted by Alsawaier (2018). Thus, the use of ISO media as a learning medium can influence the value of cognitive skills in the experimental class compared to the control class. Based on the data presented in Figure 4, the use of ISO as a Physics learning media on the subject of heat and heat transfer can affect cognitive skills. This effect is in the form of increased learning outcomes. The value of the MSD I class in the experimental group has increased from 63.41 to 74 after using ISO as a Physics learning media. Learning media also provides experiences that are not easily obtained through other materials and makes the of learning deeper. The ISO game makes students able to learn while playing. During games, students feel motivated (Syawaluddin et al., 2020). Students actively participate in learning as it is not one-way. Instructional media is very supportive of students in their memory and understanding (Talarico, Kraha, Self & Boals, 2019). Every learning activity is emphasized to facilitate students in understanding the subject matter. The media acts as a transfer that transmits messages from the sender to the recipient of the message (information receiver). This message is a Physics concept that has been studied and is repeated using media.

Learning in the control group using the lecture method produced different results. From Table 2, we can see that students experience a decrease in learning outcomes. The value of MSD I has been reduced from 69 to 62. This decrease is caused by students in the control group not understanding the materials because they were based on traditional lectures only. The students were not motivated in learning Physics in the classroom. Many feel sleepy when following lessons in this way, although the session may be interspersed with questions and answers. Only certain students remain fully active during the whole duration of a class session. Therefore, the use of instructional media can arouse motivation and stimulate learning activities and even have some positive influences on student psychology (Wijekumar et al., 2019; Graham, Kiuhara, Harris & Fishman, 2017). Learning in the control group has decreased. This is due to the difference in the use of the questions used at MSD I and the questions at the posttest. This difference occurs because some students have difficulty answering questions in the form of descriptions as students are accustomed to multiple choice questions.

Application of ISO as a media of learning Physics can improve comprehension and memory. The ability to remember and understand material can have a positive impact on learning outcomes. The ability of students to improve learning outcomes is influenced by motivation (Aşıksoy & Özdamlı 2016). Motivation is what trains students' memory and understanding. One of the powers possessed by humans is memory. Memory can be trained through reading and memorization. The teacher functions as a facilitator for learning activities in the experimental group. The teacher's role is to provide direction and guidance to students to find their own concepts. Conclusions material that has been studied is made jointly by students and the teacher gives emphasis. The existence of student activity can improve student understanding so that the learning outcomes.

5. Conclusion

Learning media can enhance the learning process and can enhance the cognitive skills of students. A moderate increase in scores was achieved in the cognitive skills on the concept of heat transfer for the experimental class compared with the control class. However, the use of learning media such as ISO (Innovative Smart Orbital) can increase students' interest in the learning of Physics concepts. Based on this research, our recommendation is as follows: use appropriate games to teach difficult concepts while recognizing that there are certain concepts that can be difficult to learn via this approach and identify students who may not appreciate this style of learning so that alternative solutions could be devised in such situations. This research was limited to the teaching of heat transfer concept in the Physics subject. Thus, there is a broad range of research that can still be done in this field. For example, other researchers may use the ISO approach to teach other subjects. Student motivation, independence and critical thinking skills may also be studied in more depth.

6. References

Al Said, R. S., Du, X., Al Khatib, H. A. H. M., Romanowski, M. H., & Barham, A. I. I. (2019). Math Teachers' Beliefs, Practices, and Belief Change in Implementing Problem Based Learning in Qatari Primary Governmental School. *Eurasia Journal of Mathematics, Science and Technology Education,* 15(5). doi:10.29333/ejmste/105849

Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *International Journal of Information and Learning Technology*, *35*(1), 56–79. doi:10.1108/ijilt-02-2017-0009

Arango-López, J., Cerón Valdivieso, C. C., Collazos, C. A., Gutiérrez Vela, F. L., & Moreira, F. (2018). CREANDO: Tool for creating pervasive games to increase the learning motivation in higher education students. *Telematics and Informatics,* 38, 62-73. doi:10.1016/j.tele.2018.08.005

Aşıksoy, G., & Özdamlı, F. (2016). Flipped Classroom adapted to the ARCS Model of Motivation and applied to a Physics Course. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(6), 1589-1603. doi:10.12973/eurasia.2016.1251a

Chotimah, S., Bernard, M., & Wulandari, S. M. (2018). Contextual approach using VBA learning media to improve students' mathematical displacement and disposition ability. *Journal of Physics: Conference Series,* 948. doi:10.1088/1742-6596/948/1/012025

Darman, D. R., Suherman, Anriani, N., Wibowo, F. C., Faizin, M. N., Samsudin, A., … Siswanto. (2019). Effectiveness of learning support of asset (assessment simulation test) for reconstruction Physics conception. *Journal of Physics: Conference Series,* 1280. doi:10.1088/1742-6596/1280/5/052063

Gan, B., Menkhoff, T., & Smith, R. (2015). Enhancing students' learning process through interactive digital media: New opportunities for collaborative learning. *Computers in Human Behavior*, 51, 652–663. doi:10.1016/j.chb.2014.12.048

Graham, S., Kiuhara, S., Harris, K. R., & Fishman, E. (2017). The relationship between strategic behavior,motivation, and writing performance with young, developing writers. *Elementary School Journal,* 118, 82–104. doi:10.1086/693009

Hake, R. R. (1999). Analyzing Change/Gain Scores. [Online]. Retrieved from http://lists.asu.edu/cgi-bin/wa?A2=ind9903&L=aera-d&P=R6855 [12 July 2019].

Herro, D., & Quigley, C. (2016). Exploring teachers' perceptions of STEAM teaching through professional development: implications for teacher educators. *Professional Development in Education, 43*(3), 416–438. doi:10.1080/19415257.2016.1205507

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting Education in "Educational" Apps. *Psychological Science in the Public Interest*, *16*(1), 3–34. doi:10.1177/1529100615569721

Hong, J. C., Hwang, M. Y., Szeto, E., Tsai, C. R., Kuo, Y. C., & Hsu, W. Y. (2016). Internet cognitive failure relevant to self-efficacy, learning interest, and satisfaction with social media learning. *Computers in Human Behavior*, 55, 214–222. doi:10.1016/j.chb.2015.09.010

Kariippanon, K. E., Cliff, D. P., Lancaster, S. L., Okely, A. D., & Parrish, A. (2017). Perceived interplay between flexible learning spaces and teaching, learning and student wellbeing. *Learning Environments Research, 21*(3), 301-20.

Morales-Martinez, G. E., Lopez-Ramirez, E. O., Garcia-Duran, J. P., & Urdiales-Ibarra, M. E. (2018). Cognitive Constructive – Chronometric Techniques as a Tool for the E-Assessment of Learning. *International Journal of Learning, Teaching and Educational Research, 17*(2), 159-176. doi:10.26803/ijlter.17.2.10

Mustamin, Ahmad, A., Jasruddin, Syam, A., & Fitriani. (2019). The Effect of Academic Services Quality toward the Cadets Learning Motivation at Politeknik Ilmu Pelayaran Makassar. *International Journal of Learning, Teaching and Educational Research, 18*(10), 128-141. doi:10.26803/ijlter.18.10.8

Shadiev, R., Hwang, W. Y., Huang, Y. M., & Liu, T. Y. (2017). Facilitating application of language skills in authentic environments with a mobile learning system. *Journal of Computer Assisted Learning, 34*(1), 42–52. doi:10.1111/jcal.12212

Shinn, T., & Joerges, B. (2002). The Transverse Science and Technology Culture: Dynamics and Roles of Research-technology. *Social Science Information, 41*(2), 207–251. doi:10.1177/0539018402041002003

Sun, J. C. Y., & Wu, Y. T. (2016). Analysis of Learning Achievement and Teacher–Student Interactions in Flipped and Conventional Classrooms. *The International Review of Research in Open and Distributed Learning*, *17*(1), 79-99. doi:10.19173/irrodl.v17i1.2116

Syawaluddin, A., Rachman, S. A., & Khaerunnisa. (2020). Developing Snake Ladder Game Learning Media to Increase Students' Interest and Learning Outcomes on Social Studies in Elementary School. *Simulation & Gaming*. doi:10.1177/1046878120921902

Talarico, J. M., Kraha, A., Self, H., & Boals, A. (2019). How did you hear the news? The role of traditional media, social media, and personal communication in flashbulb memory. *Memory Studies*, *12*(4), 359-376. doi:10.1177/1750698017714835

Tom Dieck, M. C., Jung, T. H., & Tom Dieck, D. (2018). Enhancing art gallery visitors' learning experience using wearable augmented reality: generic learning outcomes perspective. *Current Issues in Tourism*, *21*(17), 2014-2034. doi:10.1080/13683500.2016.1224818

Wehn, U., & Montalvo, C. (2018). Knowledge transfer dynamics and innovation: Behaviour, interactions and aggregated outcomes. *Journal of Cleaner Production*, 171, 56–68. doi:10.1016/j.jclepro.2016.09.198

Wibowo, F. C., Suhandi, A., Rusdiana, D., Darman, D. R., Ruhiat, Y., Denny, Y. R., … Fatah. (2016). Microscopic Virtual Media (MVM) in Physics Learning: Case Study on Students Understanding of Heat Transfer. *Journal of Physics: Conference Series*, 739. doi:10.1088/1742-6596/739/1/012044

Wibowo, F. C., (2010). Orbital Smart (SO) As A Physics Learning Media on the concept of heat transfer (Thesis). Physics education, Semarang State University.

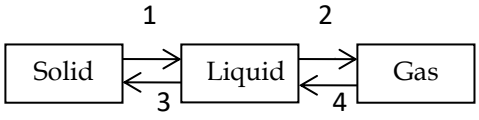
Wibowo, F. C., Budi, A. S., Iswanto, B. H., Suherman, S., Darman, D. R., & Guntara, Y., (2019). Mobile Digital Education (MDE) for increasing competence of students based on E-Characters Mental Revolution (E-CMR). Journal of Physics.: Conference Series. 1402 066075. doi:10.1088/1742-6596/1402/6/066075

Wijekumar, K., Graham, S., Harris, K. R., Lei, P. W., Barkel, A., Aitken, A., Ray, A., & Houston, J. (2019). The roles of writing knowledge, motivation, strategic behaviors, and skills in predicting elementary students' persuasive writing from source material. *Reading and Writing*, 32, 1431-1457. doi:10.1007/s11145-018-9836-7

Appendix

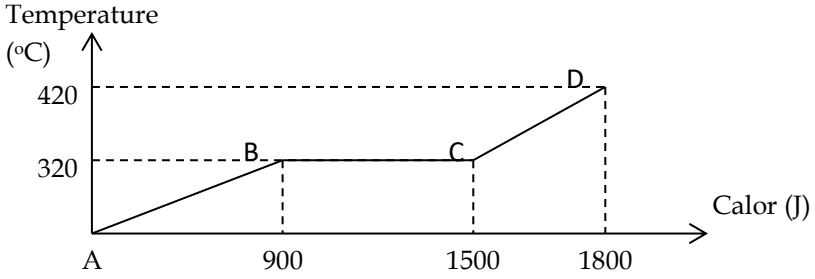
Cognitive Skills Test
(60 Question)

1. Phase transition that releases heat in the diagram below is ….



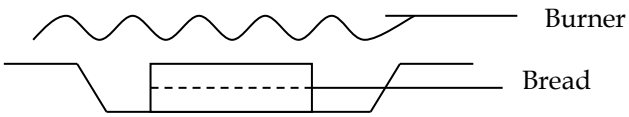
   a. 1 and 2
   b. 2 and 3
   c. 3 and 4
   d. 1 and 4

2. A solid substance weighing 25 grams is heated. The heat graph for the temperature is depicted in the following figure



   The melting point of the solid is .... °C
   a. 0
   b. 120
   c. 320
   d. 420

3. A piece of bread is placed under an electric burner that is burning red to make toast



   How does the heat energy reach bread?
   a. only conduction
   b. conduction and convection only
   c. convection and radiation alone
   d. radiation alone

4. The flask prevents heat transfer by:
   1. Radiation 3. Conduction
   2. Convection
   The correct statement is ....
   a. 1 and 3
   b. 1 and 2
   c. 2 and 3
   d. 1, 2 and 3

5. Air must be allowed to circulate freely around the back of a refrigerator. Why is that?
   a. To prevent conduction
   b. To help convection
   c. To help evaporation
   d. To prevent radiation

6. The form of energy that moves due to temperature differences is ...
   a. Calories
   b. Radiation
   c. Heat
   d. Conduction

7. One kilocalorie is equivalent to ...
   a. $0{,}45 \times 10^3$ joule
   b. $4{,}2 \times 10^3$ joule
   c. 42×10^3 joule
   d. 420×10^3 joule

8. An object if given heat will experience ...
   a. change in form and mass of matter
   b. changes in size and mass of substances
   c. changes in temperature and size of substances
   d. changes in temperature and form of substances

9. The heat energy absorbed by a substance depends on the factors below, except ...
   a. The mass of substances
   b. Type of substance
   c. The size of the substance
   d. Temperature rise

10. The heat unit in the International System (SI) is ...
   a. calories
   b. kilocalories
   c. joules
   d. Kwh

11. If an object with a different temperature is touched, then ...
   a. heat flows from a low temperature object to a high temperature object
   b. heat flows from high temperature objects to low temperature objects
   c. Low-temperature objects release heat
   d. High-temperature objects have a temperature increase

12. Aluminum beams have a mass of 0.4 kg experiencing a temperature increase from 20^oC to 40^oC. if the heat type is $900J/kg^oC$, then the heat received by aluminum is ...
   a. 560 joule
   b. 1800 joule
   c. 7200 joule
   d. 3600 joule

13. Known heat type of water $4200\ J/kg^oC$, if 84000 J heat is given into 5 kg of water, the temperature of the water will increase by ... ^oC
   a. 1
   b. 2
   c. 3
   d. 4

14. Iron with a mass of 4 kg is heated from 20^oC to 70^oC. if it is known that the heat type of iron is $460J/kg^oC$, the energy needed is ...
   a. 9.200 J
   b. 32.300 J
   c. 92.200 J
   d. 394.000 J

15. The water is raised in temperature of 20^{o}C to 60^{o}C which has a heat capacity of 4200 J/kg^{o}C requires as much heat as 840,000 J, then the mass of water is ...
    a. 50 kg
    b. 5 kg
    c. 0,5 kg
    d. 0,05 kg
16. Heat of 21,000 joules of given to 5kg of water with 4,200 J/kg^{o}C type heat. the temperature rise is ...
    a. 1^{o}C
    b. 5^{o}C
    c. 10 ^{o}C
    d. 25^{o}C
17. To raise the temperature of sea water to 1^{o}C, it needs 3900 joules of heat. If the type of seawater is 3.9 x 103 J/kg^{o}C, the mass of sea water is ...
    a. 100 kg
    b. 10 kg
    c. 1 kg
    d. 0,1 kg
18. Aluminium heat 0.21 kcal / kg^{o}C, this means ....
    a. heat of 1 kcal is needed to raise the temperature of aluminum by 1^{o}C
    b. heat of 1 kcal is needed to raise 0.21 kg, aluminum temperature of 1^{o}C
    c. heat of 0.21 kcal is needed to raise the aluminum temperature by 1^{o}C
    d. heat of 0.21 kcal is required to raise the temperature of 1 kg of aluminum by 1 ^{o}C
19. A piece of iron and a piece of aluminium with the same mass are given the same heat, it turns out that the temperature rise of the two substances is different. The difference in temperature rise is caused by ...
    a. Different types of heat
    b. different density
    c. the density is different
    d. different specific gravity
20. When alcohol is dropped on the skin of the hands, the hands will feel cold, because ...
    a. alcohol seeps into the skin
    b. alcohol releases heat into our skin
    c. alcohol evaporates while giving heat to our skin
    d. alcohol evaporates after absorbing heat from our skin
21. To cook 4 kg of ice at its melting point, as much as 13.28 x 10^{5} J. heat energy is needed…
    a. 3,32 x 10^{5} J/kg
    b. 3,33 x 10^{5}J/kg
    c. 4,2 x 10^{5} J/kg
    d. 42 x 10^{6} J/kg
22. 5 kg of water is heated from 0^{o}C to 100^{o}C so that it boils and evaporates. If the water vapor is 2.3 x 106 J/kg, the heat needed to evaporate is ...
    a. 11,6 x 10^{6} J
    b. 12,6 x 10^{6} J
    c. 13,6 x 10^{6} J
    d. 14,6 x 10^{6} J

23. In accordance with problem number 19, the heat of the melting solid is ...

a. 24×10^3 J/kg
c. 60×10^3 J/kg
b. 36×10^3 J/kg
d. 72×10^3 J/kg

24. One way to speed up evaporation is ....

a. Minimize the evaporation field
b. Minimize solution crystals
c. Increase the temperature
d. Add pressure to the surface

25. Azas Black states that ....

a. the amount of heat released is smaller than the amount of heat received
b. the amount of heat released is greater than the amount of heat received
c. the amount of heat released is the same as the amount of heat received
d. heat flows from an object with a low temperature to an object with a high temperature

26. If the temperature of the water whose mass is 200 grams is increased from 20°C to 100°C, then the heat needed is .... (heat type water 1 cal/g°C)

a. 4 kkal
c. 20 kkal
b. 16 kkal
d. 24 kkal

27. A piece of iron has a mass of 0.2 kg and a specific heat of 0.11 kcal / kg°C. If the temperature drops from 75oC to 25oC then a lot of heat is released ...

a. 0.22 kcal
c. 1.10 kcal
b. 0.55 kcal
d. 1.65 kcal

28. Dry air is very easy to suck water vapor. Therefore, by flowing dry air over the surface of the liquid which evaporates, the evaporation process ...

a. not happening
c. slowed down
b. accelerated
d. late

29. From the following statement the truth is ...

a. The boiling point of pure water is higher than the boiling point of salt water at the same pressure
b. The boiling point of pure water is the same as the boiling point of salt water at the same pressure
c. At 1 pressure the boiling point of pure water is lower than salt water
d. At 1 pressure the boiling point of pure water is higher than salt water

30. To convert 0.5 kg of water into water vapor all at its boiling point is needed as much heat .... If the heat of water evaporation is 100 cal/kg.
    a. 50 cal
    b. 1000 cal
    c. 150 cal
    d. 200 cal
31. To convert 0.5 kg of water into water vapor all at its boiling point requires as much heat as if ... If the heat of water evaporation is 100 cal/kg.
    a. 50 cal
    b. 1000 cal
    c. 150 cal
    d. 200 cal
32. To convert 0.5 kg of water into water vapor all at its boiling point requires as much heat as ..... If the heat of water evaporation is 100 cal/kg.
    a. 50 cal
    b. 1000 cal
    c. 150 cal
    d. 200 cal
33. Statements relating to changes in the boiling point of water are correct ....
    a. Cooking water in the mountains boils faster because the air pressure is less than 1 atmosphere
    b. Cooking water in the mountains boils more slowly because the air pressure is less than 1 atmosphere
    c. Cooking water on the beach with the mountains will boil together
    d. Mamasak water on the beach will boil faster because the air pressure is 1 atmosphere
34. Energy of 160 calories is given to a piece of ice, if the ice melts all at its melting point. What is the mass of ice if the ice melt is 80 cal/kg ....
    a. 0,2 Kg
    b. 2 Kg
    c. 20 Kg
    d. 240 Kg
35. A piece of aluminum whose mass is 200 grams is heated to a temperature of 80^{o}C, then immediately dropped into a vessel containing 100 grams of water at 20^{o}C. Ignore heat exchange for the container and the surrounding environment. Calculate the final temperature of the mixture when thermal equilibrium is reached ... (Aluminum heat type 900 J/kg^{o}C and water 4200 J/kg^{o}C).
    a. 30^{o}C
    b. 34^{o}C
    c. 36^{o}C
    d. 38^{o}C
36. How much heat must a heater give to heat 2 kg of water at 100 oC? (known for water vapor of 2260 kJ / kg)
    a. 1130 kJ
    b. 4520 kJ
    c. 4,520 kJ
    d. 11,30 kJ

37. Metal is much easier to conduct heat compared to other solids because ....
    a. in metals there are many free electrons
    b. the particles in the metal are denser
    c. the particles in the metal are more tenuous
    d. smoother metal surface
38. Metal is much easier to conduct heat compared to other solids because ....
    a. in metals there are many free electrons
    b. the particles in the metal are denser
    c. the particles in the metal are more tenuous
    d. smoother metal surface
39. If black and white clothes are dried together, black clothes will dry faster than white clothes because of the black colour….
    a. absorbs a lot of heat
    b. slightly radiating heat
    c. emits a lot of heat
    d. absorbs a little heat
40. The statements below are true, except ....
    a. air flow in the chimney is heat transfer, by convection
    b. heat transfer at the end of a heated iron bar, by radiation
    c. transfer of heated water in the kettle, by convection
    d. heat transfer at the end of a heated copper rod, by conduction
41. 200 grams of lead sample at 110oC were put into a calorimeter containing 300 grams of water at 18oC. if the heat type of lead is 140 J / kg_oC and the heat type of water is 4200 J / kg^oC, the final temperature of the mixture when the thermal balance is reached is ....
    a. 10^oC
    b. 15^oC
    c. 20^oC
    d. 25^oC
42. A piece of ice is put into a vessel then heated. Ice turns into water. When constantly heated, the water boils and evaporates. What are your conclusions about the relationship between heat and changing forms of matter?
    a. melting and yawning requires heat
    b. yawn and condense requires heat
    c. freezes and melts releasing heat
    d. melting and condensing releases heat

43. In a lighted room, our bodies feel warm. There we get heat from the lamp by means of convection and radiation. The following factors cause it, except ...

a. heat emitted from lights in all directions

b. heat can move without intermediates

c. air flow occurs in the room

d. the air is good enough to spread the heat

44. Data:

1. Boil water over the embers
2. Walking on a hot afternoon
3. Heats the end of the metal on the ember
4. Stay near a campfire

Which is the heat transfer by radiation is a number ....

a. 4 c. 2

b. 3 d. 1

45. Below are examples of changing forms that we often find in everyday life:

1. Water turns to ice
2. Water turns to steam
3. Candles melt when heated
4. Ice turns to water

Which one is included in the melting event ...

a. 1 and 2 c. 3 and 1

b. 2 and 3 d. 3 and 4

46. Rini treats guests who come to her house on a hot afternoon with ice syrup placed on the glass jug in Figure 1.

Figure 1 Figure 2

After a while, Rini saw water points appearing on the outside of the teapot wall. Figure 2. Where did the water come from? And why are the water dots on the outside of the teapot?

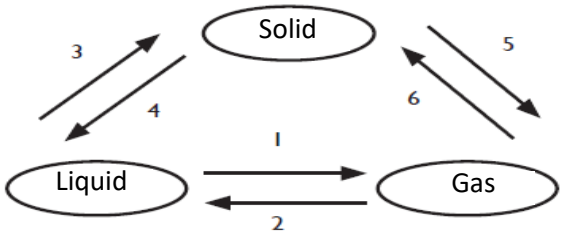
a. From the liquid in the glass, because the drink inside the glass pitcher can penetrate the outer wall of the teapot.

b. From the condensation of air at the border on the outside of the glass teapot, because the temperature of the air decreases the water points will arise

c. From the condensation of air at the border on the outside of the glass pitcher, because the temperature of the air rises there will be points of water

d. From the evaporation of air at the border on the outside of the glass pitcher, because the temperature of the air decreases there will be points of water

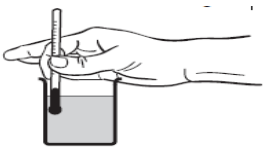
47. Pay the figure changes in form below

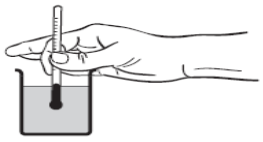


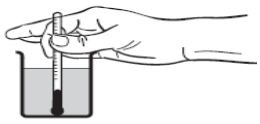
Changes in the form of substances that release heat in the diagram are ....

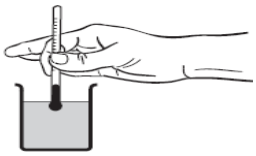
a. 1, 3, and 6
b. 2, 3, and 6
c. 1, 4, and 6
d. 2, 3, and 5

48. Two types of heat sources are usually available at the Science Laboratory, namely electric heating plates and burners. Didi plans a study to test which of these heat sources heats water faster. He poured 200 mL of water into the same two containers and recorded the initial temperature of the water in each container. Where should Didi place the thermometer to read the thermometer properly during the study?

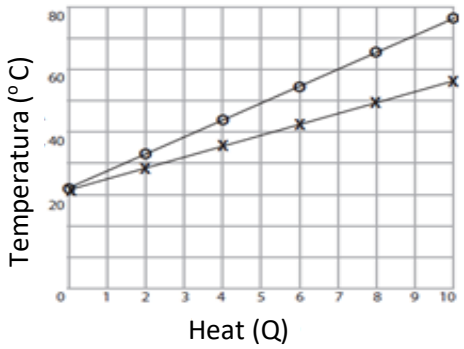
a. 

c. 

b. 

d. 

49. Based on question No. 47, Didi uses the results of his research to draw a graph as shown below.



O: Bunsen burner
X: Electric Heating Plates

Based on the information in the graph above, which heat source can heat up water faster?

a. Bunsen burner
b. Electric Heating Plates
c. Bunsen burners and electric heating plates are just as fast
d. Not both

50. The picture below shows two blocks of ice placed in two containers. The second ice beam was put in a plastic filled with air.

Ice Block 1

Ice Block 2 wrapped in plastic

Which block of ice will melt more slowly?

a. Ice block 1, because plastic retains heat from the ice out into the environment
b. Ice beam 2, because the plastic holds the heat from the ice out into the environment
c. Ice Block 1, because plastic absorbs heat from ice
d. Ice block 2, because plastic gives heat from ice

51. Several substances with the same mass, heated for 2 minutes at a joint temperature of 27 ° C. Obtained data as follows:

Substance type	Area (m2)	Length (m)	Final temperature (° C)	ΔT (°C)
Iron	0,01	0.5	32	5
Copper	0,01	0.5	36	9
Silver	0,01	0.5	42	15

Based on the above data it can be said ...

a. Iron absorbs more heat than copper and silver
b. Copper absorbs more heat than iron and silver
c. Silver absorbs more heat than iron and copper
d. Copper conducts little heat

52. Heat can move by conduction, convection and radiation.

Consider the following question!

1. Conduction is the transfer of heat through intermediates accompanied by the transfer of particles
2. Convection is the transfer of heat through an intermediate accompanied by the transfer of particles
3. Radiation is heat transfer without the need for intermediates

The correct statement about heat transfer is a number ...

a. 1 and 2
b. 2 and 3
c. 1 and 3
d. 1, 2 and 3

53. Most cooking utensils are made of aluminum. What properties does aluminum have that are used for cooking equipment?

a. conduct heat
c. generate heat
b. absorb heat
d. inhibits heat

54. The following events that show heat transfer by conduction are ....

a. house ventilation
b. heating up the electric iron
c. melting polar ice caps
d. radiating sunlight to the earth

55. Pay attention to the following factors!

1. solid
3. gas
2. liquid
4. vacuum

Factors that affect heat transfer by convection are ....

a. 1 and 2
c. 2 and 4
b. 2 and 3
d. 1 and 3

56. If the black cloth and white cloth are dried together, the black cloth dries faster than the white cloth because ....

a. Black cloth absorbs more heat than white cloth
b. Black cloth releases heat less than white cloth
c. Black cloth emits less heat than white cloth
d. Black cloth absorbs and releases heat

57. Thermos prevent heat transfer by:

a. 1. radiation
3. conduction
b. 2. convection

The correct statement is ...

a. 1 and 3
c. 2 and 3
b. 1 and 2
d. all right

58. Solid objects such as metals cannot produce heat by convection, because ...

a. The number of particles making up solids is very large
b. the particles in the solid are close together
c. The particles in the solid material are held firmly in place
d. The particles always move randomly

59. Look at the picture of the open fire below!

Every position around the fire will receive heat, at which position the heat received is due to radiation ...

a. 1 and 2
b. 2 and 3
c. 2 and 3
d. 1 and 4

60. You don't feel too hot when you hold your fingers close next to the candle flame, but you will immediately feel very hot when you hold your fingers close to the candle flame. This happened because ...

a. air convection flow occurs from the top of the flame continues to the side
b. air convection flow occurs from various directions to the fire
c. air convection flow occurs from the side of the flame continues upward
d. radiant heat from the candle flame occurs mostly upward