E-Learning Impacts on Critical Thinking Skills in Science Learning

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Abstract: ***Learning in the 21st-century demands learning outcomes which are relatively different to the previous ones; they are well-known as 4C (collaboration, critical thinking, creativity, and communication). The rapid development of information and communication technology makes information in various needs easier to be accessed. This new requirement drives to the needs of learning innovation development. Theory, concept and cooperative or collaborative learning practice are believed by educators to have significant benefits on the development and the enhancement of student capabilities and skills on the various educational level. This research aims to find out how online cooperative learning implemented with various applications influences the increase of critical thinking skills as one of higher order thinking skills. The research method used was quantitative research with the ANOVA method. The data used was secondary data obtained from previous analyses conducted by the researcher together with students. The research stages started by tracing the results of previous studies and re-tabulated them following variables to be researched. Next, the preconditioning test on the results obtained was done to be used on the selected statistical analysis. From the outcome of this research, it can be concluded that there is an influence of online cooperative learning implementation towards critical thinking skill enhancement of secondary school students. In this research, it appears that the highest averages of critical thinking skill score are obtained for blended learning (79.08), discussion facilitated PhET (77.03), TPS with OER (69.87) sequentially for the top three. From the deviation score, the lowest deviations are PBL using OER (6.34), discussion facilitated PhET (6.66), and blended learning (6.67) sequentially from the lowest. Besides, there is a difference of influence among various strategies of online cooperative learning. With F-test, it seems that there is a significant influence of learning strategy towards the performance or critical thinking skill score with a significant level of 5%. Blended learning has an influence which is significantly not different (0.961) to discussion facilitated PhET. PBL using OER has an impact which is significantly not different (0.134) to Student Worksheet. However, with others, the influence is significantly different on the enhancement of critical thinking skills.***

Keywords : education, cooperative learning, innovation, learning strategy, mobile learning, mobile technology, science learning.

I. INTRODUCTION

Recently, a significant change occurs on the awareness of teachers to utilize ICT in learning particularly mobile learning. This phenomenon is a part of the implication where wireless and mobile technologies rapidly develop in recent years [1],[2]. This technology becomes cheaper with the higher capability and smaller size. It makes educators or teachers realize that digital technology presents opportunities for different forms of learning; including the relationship between teachers and students, teachers and teachers, students and students, and students with teaching materials or competence [3].

In another side, the development of the learning system also experiences a significant change after the launching of various concepts of 21st-century learning. What some aspects become focuses on developing student competence to be able to live in their era. Through UNESCO, 4C (collaboration, critical thinking, creativity, and communication) were launched as the concept underlying the student competence enhancement. This concept is then adapted and adopted by numbers of countries to do change and reformation on the system of education and learning.

Along with it, since 2013, the researcher has conducted various researches focusing on higher order thinking skill enhancement particularly critical thinking skills in different research approaches. The results have not been integrally viewed that unify comprehensive analysis of the researches. The in-depth analysis of the researches results will underlie the policy development in learning following student needs nowadays.

From the problem background discussion, some problems that can be identified are the comprehensive analysis (meta-analysis) on the research results to find out the influences of online learning towards the critical thinking skill has not been done and the absence of the policy and recommendation related to online learning strategies those are relevant with student characteristics of the 21st century. Therefore the problem formulation is how is the influence of online cooperative learning towards the enhancement of critical thinking skill of secondary school students?

This research aims to find out the influence of online cooperative learning towards the enhancement of critical thinking skill of secondary school students and to find out if there is a difference of influence among various strategies of online cooperative learning. Some limitations on this research are this research is research with secondary data from previous studies conducted by the researcher and factors outside variables of learning strategies, and critical thinking skills are not considered.

The benefits of this research are to obtain the complete overview about online learning on physics at secondary school, to develop a policy that is relevant with student needs in the 21st-century learning, and to improve teacher's belief related to the utilization of ICT in learning at school.

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II. THEORETICAL BACKGROUND

A. Mobile learning definition

Mobile learning (m-learning) is a part of electronic learning or e-learning that opens more extensive opportunities in mobile and more capabilities for student learning. Thus, m-learning can be defined differently to e-learning related to the mobility of students as learners [4],[5]. This learning can be done anywhere by students whenever they have the available mobile technology [6],[7]. The perspectives of mobile technology can be grouped into four those are: techno-centric, focus on e-learning, formal education components, and student-centered learning [3],[4],[8],[9]. Nowadays, the emphasis on technology at school is to ensure the effective learning implementation with new opportunities and to drive better learning performances [5],[7],[10].

B. Higher Order Thinking Skill

Higher order thinking skill or HOTS is a concept used in educational reform at various institutions based on particular learning taxonomy such as Bloom's Taxonomy. The idea of this concept is that several types of learning for specific knowledge need higher cognitive processing than other knowledge [11]. In Bloom's Taxonomy, skills of doing analysis, evaluation, and synthesis to obtain or create new knowledge are considered to have a higher level compared to the ability to memorize facts and concepts. Thus, it requires different learning strategies or methods. Higher order thinking skills involves skill to decide a complicated matter requiring critical thinking skills and problem-solving [12]. Higher order thinking is hard to teach, but more beneficial for the future since it will always be used to manage a new situation [5],[13].

Research on how people learn shows that active learning will be more effective than just a face-to-face lecture. Refer to [14] in their study elaborate four methods to implement active learning those are: backward instructional design; encouraging students to learn not only facts; giving student unstructured problems to be solved; and supporting students to speak, write and collaborate. In the developed media, reference showing efficacy, suggestion and link to learning sources are provided, so students can actively learn.

Many strategies can be used in enhancing higher order thinking skills. Some of the principles in learning that support the enhancement of HOTS are to teach a concept of a concept, tell and show, move from concrete to abstract and go back, teach steps for learning concept, start from basic to sophisticated, connect the concepts, teach inference, a picture is worth a thousand words, explain mapping concept and graphic organizer, make method and answer of calculating, caring approach, problem identification, encourage questions, think with analogy, parable, and metaphor; teach component from learning process, consider individual evaluation [14]-[16].

C. Cooperative Learning

Cooperative learning is not only an act of dividing learners into groups and giving them group assignments. A learning activity becomes cooperative learning when the learning atmosphere provided is also oriented for activities supporting each other, so they develop together in interpreting a phenomenon they learn. Several essential elements need to be noticed in implementing cooperative learning those are positive interdependence, individual accountability, face-to-face interaction, social skill and small group, and group process [17],[18].

According to [18]-[20] this learning gives a positive influence. Teachers can direct the positive interdependence by making a group assignment that makes every group member depend on other and get interested in working together in order to finish the assignment well. Individual accountability can be obtained when every group member understands the learning materials and complete group assignment together. It can be achieved by giving an exam or asking students to present their performance as the contribution in group assignment. Interaction among group members needs to be encouraged by using a variety of relevant media so every member can acknowledge other members well. This interaction can be done by promoting the discussion of the learning concept, conveying the idea and view towards the learning materials to each other, and sharing knowledge. Group experiences should ensure opportunities for every group member to bring up leadership skill and oral communication. The group also needs to be encouraged to measure their performance well as a part of achieving the learning goals.

Cooperative learning on science teaching now very well develops. This learning strategy seems to give opportunities for improving student achievement. As information and communication technology continuously evolves, many kinds of research are conducted by utilizing technology for implementing cooperative learning. The examples are cooperative learning with e-learning, wiki, remote learning activity, and mobile learning [20]-[22]. All those efforts are primarily developed to obtain the optimal learning outcomes.

Learning physics should not be only learning to know, but also learning to do, learning to be and learning to live together. Through the process of learning to recognize, students are expected to have understanding and reasoning in physics (what, how and why) as the basis to continue their study and or to implement in the daily life; the process of learning to do is expected to give students opportunities to possess skill and to encourage students in studying physics; through the process of learning to be, students are expected to understand, respect or appreciate the values and concepts of physics shown through attitudes of tenacious, hard-working, patient, discipline and confident; while the process of learning to live together is expected to give students opportunities to study and cooperate, respect each other's opinion, accept different views, and learn to convey impression and share idea with others, so students are expected to socialize and communicate in physics.

The lack of student's ability in understanding the concepts of physics in learning is a frequent problem in physics learning. However, this ability plays a vital role in the success of learning. The assumption that physics is hard and abstract becomes the general reason for the lack of student's ability in understanding the concepts of physics at class so that it can decrease the students' confidence in learning physics.

The cooperative learning model is one of the learning models that involves learning to know, learning to do, learning to be, and learning to live together [13],[18]. This learning model can help students in developing positive attitudes in learning physics and decrease or even eliminate

anxiety towards physics that many students experience. Interaction within a group can help students accept other students who have different abilities and backgrounds. Also, the importance of peer-relationship should not be underestimated. Peer encouragement to achieve a better academic achievement can motivate students well, make students ready with their task, have full attention during the learning process and develop thinking skills [23]-[26].

D. Critical Thinking Skills

Critical thinking only deliberately and systematically processes information to make a better decision and generally understand things better. Critical thinking requires the implementation of various intellectual tools on a variety of information. Thinking critically about information involves conceptualization, analysis, synthesis, and evaluation. Information can come from sources such as observation, experience, reflection, though, and communication [27]. With those things, students are expected to develop belief and good attitudes in daily life. Hence, students can automatically think critically in various activities. If students think critically, students can deliberately use intellectual tools to achieve a more accurate conclusion than one that is automatically done by the brain.

There are five critical thinking skills which are essential to be developed: analytical, communication, creativity, open-minded and problem solving [12],[24],[28].

1. Analytical. One part of critical thinking is the ability to carefully check something, whether it is a problem, a set of data or text. People with analytical skill can check information, then understand the meaning and what it represents.
2. Communication, people often need to share conclusion to other parties or groups. The ability to communicate with others in various ideas are included in critical thinking skills. This skills will also happen when involving in thought sharing within a group. In this case, students need to work with other students and effectively communicate to finding a solution for a complex problem.
3. Creativity. Critical thinking often involves several levels of creativity. Students may need to view the information patterns or find solutions that have never been thought by other. All of these involve creativity.
4. Open minded. To think critically, students should ignore assumption or judgment, and only analyze the information given. Students need to act objectively and evaluate the idea without bias.
5. Problem-solving. Problem-solving is another essential critical thinking skill that involves problem analysis, producing the solution, implement it and evaluate the result. In the real situation, someone is not only expected to think information critically, but also provide a practical solution.

III. METHOD

A. Research Design

This research used a qualitative research design with secondary data. Data were obtained from thesis researches of postgraduate students at Physics Education at UAD guided by the researcher since 2013 related to critical thinking and online cooperative learning in various strategies. The dependent variable is an essential thinking skill. The independent variable is online cooperative learning.

B. Learning Strategy

In this research, there were eight strategies implemented. The following is a brief explanation of each strategy learning activities.

Blended learning was done by combining classroom learning and e-learning. Learning management system used was Google Classroom. In classroom learning, the teacher facilitated the discussion process among students about particular problems or phenomenon. On e-learning activity, the teacher provided the learning materials, assignments, exercises and forum for discussion.

Problem-based learning with learning sources from OER (Open Educational Resources) was done in the classroom, where the teacher gave problems to solve in a group. In the process of problem-solving students searched for sources of information and knowledge related to the issue directly from the internet. Hence, technology-enhanced learning situation can develop.

The teacher prepared student Worksheet. Students studied and practiced the questions developed by the teacher. With this student worksheet, students study independently in a particular time.

Think Pair Share facilitated OER is a part of cooperative learning. However, in this learning, students in a group search for sources to share knowledge through the internet (OER). It is different from conventional TPS where learning sources have been determined on the guideline or books prepared by the teacher. In think-pair-share strategy, the teacher acted as a facilitator and gave a question or a problem to students. Students were given an adequate amount of time to do brainstorming. After that, the teacher asked them to work in pair and share their idea. When students started to share their thought and view, each of them learned to view different thinking perspective among their friends. Thus, student learning was developed by idea formation and articulation.

Direct Lesson. This learning is known as lecture learning. The teacher presented learning material and students paid attention. After that, exercises were given to students. In this learning, the teacher's ability in explaining plays an important role.

Demonstration with simulation. In this learning, the teacher demonstrated physics phenomenon by using PhET simulation following the teaching materials. In the demonstration process, the teacher gave opportunities for discussion and question-answer between teacher and students to make sure the understanding of materials and phenomenon learned by using simulation.

C. Instrumentation

Data obtained from the research was tabulated following variables used by postgraduate students. Then, it was grouped based on the type of variables. Data of critical thinking was obtained by giving questions about critical thinking to students. These questions were previously tested for their validity and reliability.

Dependent variable measured was higher order thinking skills. The number of questions was nine which meets higher order thinking skills. These

nine questions consist of some indicators as following: three analysis questions, three evaluation questions, three creation questions. Questions number 1, 2, and 7 included in analysis indicator. Questions number 3, 4, and 9 involved in the evaluation questions. Questions number 5, 6, and 8 included in creation indicator. After the items were tested, the result was analyzed to find out the validity, reliability and difficulty index. The questions which met the criteria were used for the research of higher order thinking skills and ones which had not reached the criteria were fixed or thrown out. The calculation result was seen from the correlation score. Based on the outcome of validity analysis, seven items were valid those are questions number 1, 2, 3, 4, 5, 7, and 9. Two items were not valid those are questions number 6 and 8. Based on the result of instrument reliability calculation, r-square is 0.714 which means the instrument is reliable and can be used as a data collection instrument.

Table- I: Structure of Critical Thinking Skill Questions

No	Material	Type of Question		Number
		C3	C4	
1	Work	1	3, 4, 6	4
2	Energy	2, 5	7, 8	4
3	Power	9	10	2

Remark:
C3: Implementation
C4: Analysis

Table- II: Rubric for Critical Thinking Skill Test Scoring

Student response towards questions or problems	Score
Aspects: Determining and justifying concepts	
Did not answer questions or answers incorrectly, did not meet expectation.	0
Explains only concepts used, but correctly	1
Explains concepts used correctly but less complete and gives incorrect reasoning	2
Explains concepts used correctly but less comprehensive and gives correct reasoning	3
Explains concepts used completely and correctly but gives less complete reasoning	4
Explains concepts used completely and correctly and gives correct reasoning	5
Aspects Generalization	
Did not answer questions or answers incorrectly, did not meet expectation.	0
Completes only supporting data but it is complete and correct	1
Completes supporting data completely and correctly but determines general rule incorrectly	2
Completes supporting data and determines general rule completely and correctly but without explaining how to obtain them or the explanation is incorrect	3
Completes supporting data and determines general rule completely and correctly but the explanation on how to get them is less complete	4
Completes supporting data and determines general rule, also describes how to achieve them completely and accurately	5
Aspects: Problem Solving	
Did not answer questions or answers incorrectly, did not meet expectation.	0
Identifies only questions (what is known, questioned, element adequacy), but correctly	1
Identifies items (what is known, questioned, element adequacy) accurately, but the model made or problem-solving is incorrect. Or answers correctly but without explanation	2
Identifies questions (what is known, questioned, element adequacy) precisely but displays errors on the model made, so the problem solving, and the result is incorrect or answers correctly, but the explanation is incorrect	3
Identifies questions (what is known, questioned, element adequacy) accurately and makes the model precisely, but problem-solving displays errors on the calculation so the result is incorrect or answers correctly but displays errors on the explanations	4
Identifies questions (what is known, questioned, element adequacy) correctly and makes the model and solve the problem correctly or answers correctly and both statements are correct	5

D. Analysis Technique

By considering the particular variables, the technique of analysis used was cross-sectional parametric statistical analysis technique by using ANOVA. The assumption of this technique is that the dependent variable has normal distribution and homogenous, and data has small standard error.

IV. RESULT AND DISCUSSION

In this discussion, interpretation of information from data processing with inferential statistic will be seen. The effect of the descriptive statistical process can be used to see two important things which are average score and standard deviation for each learning strategy. The result is shown on the following table.

Table- III: Descriptive Statistic of CTS

	N	Mean	Std. Dev.	Std. Error	Min.	Max.
Blended Learning	24	79.08	6.67	1.36	69.00	96.00
PBL using OER	26	60.34	6.34	1.24	50.00	71.00
Student Worksheet	26	54.07	7.54	1.47	42.00	67.00
TPS using OER	47	69.87	10.03	1.46	44.00	92.00
Direct Lesson	47	45.74	12.14	1.77	28.00	76.00
Discussion facilitated PhET	32	77.03	6.66	1.17	62.00	85.00
Total	202	63.22	15.32	1.07	28.00	96.00

From the table above, the focus can be seen on the mean of the measurement result of critical thinking skills and deviation score. The highest averages are obtained for blended learning strategy (79.08), discussion facilitated PhET (77.03), and TPS using OER (69.87) sequentially for the top three. From deviation score, the lowest deviations are PBL using OER (6.34), discussion facilitated PhET (6.66) and blended learning (6.67) sequentially from the lowest. The result can also be seen in the following figure.

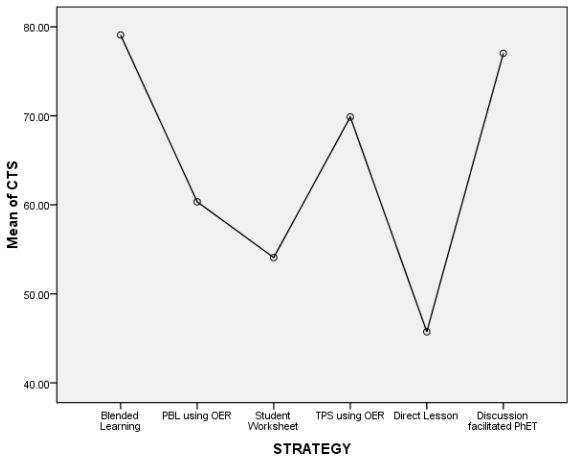

Fig.1. CTS average score for each strategy

Statistical analysis is further to find out whether there is an influence on the learning strategies towards the critical thinking skills. The following table shows the result of variant analysis for all learning strategies. The figure also shows that there is a tendency that learning facilitated with technology will give better influence on critical thinking skills. To find out how the impact of these learning strategies is, variant analysis with F-test or ANOVA is applied, and the result is shown on the following table.

Table- IV: Analysıs of Varıance

	CTS				
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	30964.822	5	6192.964	74.684	.000
Within Groups	16252.703	196	82.922		
Total	47217.525	201			

From the table above, it can be seen that with F-test there is a significant influence of learning strategies towards outcomes or the score of critical thinking skills with a significance level of 5%. To know more detail on the comparison of each learning strategy, post hoc analysis with Tukey HSD model was done, and the result is shown on the following table.

Table- V: Post Hoc Analysıs

(I) STRATEGY	(J) STRATEGY	Mean Difference (I-J)	Std. Error	Sig.
Blended Learning	PBL using OER	18.73718*	2.57767	.000
	Student Worksheet	25.00641*	2.57767	.000
	TPS using OER	9.21099*	2.28460	.001
	Direct Lesson	33.33865*	2.28460	.000
	Discussion facilitated PhET	2.05208	2.45894	.961
PBL using OER	Blended Learning	-18.73718*	2.57767	.000
	Student Worksheet	6.26923	2.52559	.134
	TPS using OER	-9.52619*	2.22567	.000
	Direct Lesson	14.60147*	2.22567	.000
	Discussion facilitated PhET	-16.68510*	2.40429	.000
Student Worksheet	Blended Learning	-25.00641*	2.57767	.000
	PBL using OER	-6.26923	2.52559	.134
	TPS using OER	-15.79542*	2.22567	.000
	Direct Lesson	8.33224*	2.22567	.003
	Discussion facilitated PhET	-22.95433*	2.40429	.000
TPS using OER	Blended Learning	-9.21099*	2.28460	.001
	PBL using OER	9.52619*	2.22567	.000
	Student Worksheet	15.79542*	2.22567	.000
	Direct Lesson	24.12766*	1.87846	.000
	Discussion facilitated PhET	-7.15891*	2.08701	.009
Direct Lesson	Blended Learning	-33.33865*	2.28460	.000
	PBL using OER	-14.60147*	2.22567	.000
	Student Worksheet	-8.33224*	2.22567	.003
	TPS using OER	-24.12766*	1.87846	.000
	Discussion facilitated PhET	-31.28657*	2.08701	.000
Discussion facilitated PhET	Blended Learning	-2.05208	2.45894	.961
	PBL using OER	16.68510*	2.40429	.000
	Student Worksheet	22.95433*	2.40429	.000
	TPS using OER	7.15891*	2.08701	.009
	Direct Lesson	31.28657*	2.08701	.000

From the table above, it can be seen that some learning strategies are not significantly different. Blended learning has an influence which is significantly not different (0.961) to discussion facilitated PhET. PBL using OER has an impact which is significantly not different (0.134) to Student Worksheet. However, with others, the influence is significantly different on the enhancement of critical thinking skills.

V. CONCLUSIONS

There is an influence of online cooperative learning implementation towards the critical thinking skill enhancement of secondary school students. In this research, the highest averages of critical thinking skill score are obtained for blended learning strategy, discussion facilitated PhET, and TPS using OER respectively for the top three. There is a difference in influence among various online cooperative learning strategies. Blended learning has an impact which is significantly not different to discussion facilitated PhET. PBL using OER has an influence which is significantly not different to Student Worksheet. However, with others, the impact is significantly different on the enhancement of critical thinking skills. In general it implied that the technology enhnced learning has high opportunity for improve student learning achievement.

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REFERENCES

1. M. Alqahtani, and H. Mohammad, “Mobile Applications' Impact on Student Performance and Satisfaction,” *TOJET: The Turkish Online Journal of Educational Technology*, 2015, vol. 14, no. 4, pp. 102-112.
2. D. Sulisworo, “Conceptual Model Identification of Personal Learning Environment,” in *Innovation and Development in Teaching and Learning*, 2014, (pp. 37-41). Perak, Malaysia: UMM.
3. M. E. Babiker, “For Effective Use of Multimedia in Education, Teachers Must Develop their Own Educational Multimedia Applications, *TOJET: The Turkish Online Journal of Educational Technology*, 2015, vol. 14, no. 4, pp. 62-68.
4. H. M. Tal, and M. Gross, “Teaching Sustainability via Smartphone-Enhanced Experiential Learning in a Botanical Garden,” *International Journal of Interactive Mobile Technology*, 2014, vol. 8, no. 1, pp. 10-15.
5. P. Thinley, J. Reye, and S. Geva, “Tablets (iPad) for M-Learning in the Context of Social Constructivism to Institute an

Effective Learning Environment," *International Journal of Interactive Mobile Technology*, 2014, vol. 8, no. 1, pp. 16-20.
6. H. Mohammad, A. Fayyoumi, and O. AlShathry, "Do We Have to Prohibit the Use of Mobile Phones in Classrooms?" *International Journal of Interactive Mobile Technology*, 2015, vol. 9, no. 2, pp. 54-57.
7. H. S. Ebrahim, K. Ezzadeen, and K., & A. K. Alhazmi, "Acquiring Knowledge through Mobile Applications," *International Journal of Interactive Mobile Technology*, 2015, vol. 9, no. 3, pp. 71-74.
8. C. H. Chen, S. H. Chen, G. J. Hwang, and T. C. Yang, "Factors influencing teachers' adoption of a ubiquitous technology application in supporting teacher performance," *International Journal of Mobile Learning and Organisation*, 2010, 4(1), 39-54.
9. A. Crampton, A. T. Ragusa, and H. Cavanagh, "Cross-discipline investigation of the relationship between academic performance and online resource access by distance education students," *Research in Learning Technology*, 2012, vol. 20, pp. 1-13.
10. A. Kukulska-Hulme, "Mobile Usability in Educational Contexts: What have we learnt?" *International Review of Research in Open and Distance Learning*, 2007, vol. 8, no. 2, pp. 1-12.
11. C. M. Crawford, and M. S. Smith, "Rethinking Bloom's Taxonomy: Implicit Cognitive Vulnerability as an impetus towards higher order thinking skills," In *Exploring Implicit Cognition: Learning, Memory, and Social Cognitive Processes*, 2015, (pp. 86-103). IGI Global.
12. C. S. Hengand Y. Ziguang, "Framework of Assessment for the Evaluation of Thinking Skills of Tertiary Level Students," *Advances in Language and Literary Studies*, 2015, vol. 6, no. 5, pp. 67-72.
13. B. FitzPatrick, and H. Schulz, "Do Curriculum Outcomes and Assessment Activities in Science Encourage Higher Order Thinking?" *Canadian Journal of Science, Mathematics and Technology Education*, 2015, vol. 15, no. 2, pp. 136-154.
14. E. L. Dolan, and J. P. Collins, "We must teach more effectively: here are four ways to get started," *Molecular biology of the cell*, 2015, vol. 26, no. 12, pp. 2151-2155.
15. B. Moore, J. Styron, and K. Miller, "Modeling Evidence-Based Application: Using Team-Based Learning to Increase Higher Order Thinking in Nursing Research," *Systemics, Cybernetics and Informatics*, 2015, vol. 13, no. 3, pp. 83-88.
16. G. M. Saido, S. Siraj, B. Nordin, A. Bakar, and O. S. Al Amedy, "Higher Order Thinking Skills among Secondary School Students in Science Learning," *Malaysian Online Journal of Educational Sciences*, 2015, vol. 3, no. 3, pp. 13-20.
17. S. Mehta, and A. K. Kulshrestha, "Implementation of Cooperative Learning in Science: A Developmental-cum-Experimental Study," *Education Research International*, 2014, pp. 1-7.
18. R. M. Gillies, and M. Boyle, "Teachers' reflections on cooperative learning: Issues of implementation," *Teaching and Teacher Education*, 2010, vol. 26, pp. 933-940.
19. O. P. Ajaja, and O. U. Eravwoke, "Effects of Cooperative Learning Strategy on Junior Secondary School Students Achievement in Integrated Science," *Electronic Journal of Science Education*, 2010, vol. 14, no. 1, pp. 1-18.
20. E. Zakaria, T. Solfitri, Y. Daud, and Z. Z. Abidin, "Effect of Cooperative Learning on Secondary School Students' Mathematics Achievement," *Creative Education*, 2013, vol. 4, no. 2, pp. 98-100.
21. M. Tsay, and M. Brady, "A case study of cooperative learning and communication pedagogy: Does working in teams make a difference?" *Journal of the Scholarship of Teaching and Learning*, 2010, vol. 10, no. 2, pp.78-89.
22. D. Sulisworo, and F. Suryani, "The Effect of Cooperative Learning, Motivation and Information Technology Literacy to Achievement," *International Journal of Learning & Development*, 2014, vol. 4, no. 2, pp. 58-64.
23. E. H. Kim, and H. S. Yang, "The Use of the ARCS Motivation Model in Mobile Learning Apps Design," *Journal of Digital Convergence*, 2015, vol. 13, no. 4, pp. 69-79.
24. C. Mega, L. Ronconi, and R. De Beni, "What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement," *Journal of Educational Psychology*, 2014, vol. 106, no. 1, pp. 121-131.
25. J. Hattie, and H. Timperley, "The power of feedback," *Review of educational research*, 2007, vol. 77, no. 1, pp. 81-112.
26. P. C. Sun, R. J. Tsai, G. Finger, Y. Y. Chen, and D. Yeh, "What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction," *Computers & Education*, 2008, vol. 50, no. 4, pp. 1183-1202.
27. D. R. Garrison, T. Anderson, and W. Archer, "Critical thinking, cognitive presence, and computer conferencing in distance education," *American Journal of distance education*, 2001, vol. 15, no. 1, pp. 7-23.
28. K. D. Strang, "Can online student performance be forecasted by learning analytics?" *International Journal of Technology Enhanced Learning*, 2016, vol. 8, no. 1, pp. 26-47.

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