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THE EFFECT OF TECHNOLOGY-APPLIED APPROACH ON THERMODYNAMICS LEARNING OUTCOMES

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ABSTRACT

This study investigated the effect of technology-applied approach toward the process of thermodynamics lecture and the learning outcomes of students. The object of this study was the technology-applied approach, and the restricted contents taught were the zero and first law of thermodynamics. The subject of this study was the 3rd semester physics students of Faculty of Mathematics and Natural Sciences, Manado State University, Indonesia. The hypothesis test with $\alpha = 0.05$ obtained $t_{stat} = 6.186$ and $t_{critical} = 2.028$, therefore the test statistic fall within the critical area. Based on the differences test of two averages, the pre-test and post-test result using technology-applied approach was higher than the conventional one. The learning approach using technology applications was affected the learning outcomes of thermodynamics, since it introduced the physical symptoms and made students familiar with the principles and concepts of the laws of thermodynamics, where the technology tools was role as the supporting media of learning tools.

KEYWORDS: learning outcomes; learning tools; physical symptoms; technology-applied approach; thermodynamics learning.

1. INTRODUCTION

In the educational field the educators take the role to create appropriate learning process in order to optimize learners' learning outcomes. One of the factors that determine the achievement of learning outcomes is the ability of lecturers in designing and applying teaching materials, and organizing lectures. Learning system uses a learning model approach to improve student learning outcomes.

Learning systems needs to be placed between content, contextual knowledge, pedagogy, and technology (Ramma et al., 2017) also need to encourage the emergence of different reasoning, problem solving, and critical thinking (Hannafin et al., 1997). The approach or teaching model intended here is as a teaching pattern that provides the process of specification and creation of specific environmental situations that stimulate students to interact so that there is a special change in their behavior. An effective learning environment will support the individual's intention to find and solve problems through the use of available resources and learning tools (Edwards, 1995).

Physics is a branch of science that plays an important role to the development of science and technology. Given the high dependence on technology in the 21st century, the role of technology in education is getting attention (Bridges et al., 2012; Bridges et al., 2015; Lu et al., 2014; Beswick, 1990). For that as a lecturer in efforts to improve the quality of students must have the right strategy and high creativity, particularly in the management of lectures that are effective and efficient; then one of the efforts is to apply methods, approaches and learning models in accordance with the characteristics of the material and learners or a variety of information and choose the potential learning resources used in the learning process (Gure, 2016; Freire, 1993). Appropriate learning strategies will greatly affect the level of performance and learning outcomes (Ross and Salisbury-Glennon, 2003; Dwijayanto et al., 2017).

Department of physics as one of the organizers of higher education who take on the mission of education and teaching science, responsible in improving the quality of education and teaching of physics for students as teacher or non-teacher candidates so that they have deep understanding about the concept or principle of physics and its technology application will be more motivate and improve student learning effort.

Student-centered learning environments and technology-based learning will provide a deeper understanding of the cognitive aspects of learning tasks (Hannafin, 1989), and provide problem-solving skills in authentic contexts, and elicit flexible thinking and knowledge skills (Spiro et al., 1991). Physics learning process with technology application approach is hoped useful in building and strengthening academic competence of physics teacher and non-teacher candidate in order to get wide and deep insight and comprehensively integrate understanding about the concept or principle of physics and its application. This learning process approach the will be more effective since the students understand better by the application with the concept of physics he studied.

The active role of students in teaching and learning process should be supported by appropriate approach and media that can support the success of learning and expected goals. The integration of technology in several disciplines has been extensively studied (Wong and Day, 2002; Chen and Chen, 2012; Karacilli and Korur, 2014). Technology can be an appropriate medium for educators to improve students' thinking level, which is a key element of skills in the 21st century (Shelly et al., 2012). The selection of subjects (i.e. thermodynamics course) as the object of applying the learning model with the technology-applied approach is based on the consideration particularly since the application of technology products related to thermodynamic quantity is very wide in public life such as: flatiron, water dispenser, refrigerator, air conditioner, etc. as household appliances that are found around the student environment and also in repaired service. This technology product lacks the attention of educators as a source of actual physics learning in thermodynamic lectures. This course is strategic in forming and stimulating contextual scientific competence of physics teacher candidate.

The rapid development of technology influenced the evolution of student-centered learning environments (Strommen and Lincoln, 1992). The technology of a student-centered learning system will facilitate the understanding of abstract concepts through concrete experience. The use of technology tools such as thermodynamic learning will make it easier for students to obtain real-time temperature data through the temperature graphics of various objects. This technology tool provides experience to learners as a cognitive requirement in learning tasks (Lewis et al., 1993).

The application technology-applied approach to thermodynamics lecture is intended to give the students an opportunity to know more real benefit of thermodynamics concept which they learned with the working principle of existing machines in their environment. In the lecturing model with the approach of technology application involved in three stages of learning process that is: learning in class, learning in laboratory, learning outside of lecture room (service garage, in geothermal power plant, etc) supported by lecture package. Achievement of learning objectives is monitored through evaluation of learning outcomes. Academic monitoring of learning achievement has significant correlation with the metacognition (Sperling and Howard, 2010). The evaluation should be based on theoretical assumptions, scientific reasoning test, and academic performance (Romiszowski, 2016).

Based on the concepts mentioned above, the author designed a research to characterize the effect of technology-applied approach of the thermodynamics learning results.

2. METHOD

This research was an experimental research. In this study design there were two groups assigned randomly, grouped into two classes, and the total respondence were 20 students for each classes. The two classes were treated differently by the material given. The two classes were distinguished by treated the class A using a technology-applied approach and class B with conventional methods. The test instrument was validated through panelist assessment with the reliability coefficient of inter-rater test of learning outcomes using Hoyt formula with result was 0.875. The reliability coefficient was obtained using Cronbach alpha formula and the result was 0.92.

Descriptive statistical analysis was used to analyze the data. The t-test was used to test the hypothesis by applying prerequisite test included normality test by using Lilliefors test and homogeneity test by Bartlet test. The research design is shown in Table 1.

This research was started by giving pre-test then followed by using technology-applied approach. The steps were as follows:

- The topic of thermodynamic course was arranged so it would be developed through experimental activities with its technology-applied approach. This is adapted to the availability of tools or machines (by the faculty team).
- Formulated the principal of subject matter of the activity. (by the faculty team).
- Formulated alternative activities and benchmark implementation of activities and targets to be achieved in activities.
- Evaluated and set up support facilities (e.g. experimental equipment, machines or tool services, teaching equipment, supporting books, other information sources such as internet, and others).
- Prepared problem sets (e.g. materials, forms of activities, targets, etc.) to be submitted to students, included the implementation setting of group activities, for each topic that has developed.

- Student discussed the design of activities and examples of activities (by lecturers and students). Pre-test is implemented to measure the mastery of concepts and physical principles related to the topic of activity.
- Implemented student activities, where lecturer would serve as the intructor- supervisor - monitor - evaluator.
- Formulated the results and discussed the results through teaching by students in groups that include: results observation, interpretation (physical observation results), association concepts with data, working principle of tools or machines, problems related to the malfunction of tools or machines, evaluation related to explanation of the anomaly of observations or calculations with the theory and explanation of the relationship of observations with the theory. Monitor evaluation and constraints is done by the student.

3. RESULTS

The learning process with the technology-applied approach is expected to develop the students' self-sufficiency potential to prepare graduates who have the competence required by the employment either as teachers and non-teachers. It is in accordance with the actual learning pattern of learning for life and school for work. Technology as a product as well as process, which can be used in developing learning experiences can be used as a solution in solving certain practical objectives.

Thermodynamics lecture that was integrated with its application of the concept is based on the strategic considerations of the course in its application to tools or machines that are widely available in surrounding, so that the purpose of this lecture can be achieved well and understand the physical symptoms and simultaneously can conduct experiments in the laboratory or in workshops.

The result of pre-test and post-test data of experiment and control class is shown in Table 2 and 3. Based on the hypothesis testing criteria, the hypothesis H_0 is rejected if the test statistic falls on the critical area. From result of hypothesis test with t-test, at the $\alpha = 0.05$, $t_{stat} = 6.186$ is obtained, while $t_{critical} = 2.028$, so $t_{stat} = 6.186 > t_{critical} = 2.028$ which means the test statistic falls within the critical area. This shows that there is not enough evidence to accept H_0, therefore it can be concluded that H_0 is rejected and H_1 is accepted, that is $\mu_1 > \mu_2$.

Based on the test of the two average differences, the average difference of pre-test and post-test of student group taught with technology-applied approach is higher than the students taught without technology-applied approach. The average of post-test outcomes of the thermodynamics learning in the experimental class is 76.55 with the maximum 95.00 whereas the minimum score achieved is 50.00 and the average post-test of learning result of thermodynamics of control class is 52.18 with the maximum score 87.50 and minimum score 25.00.

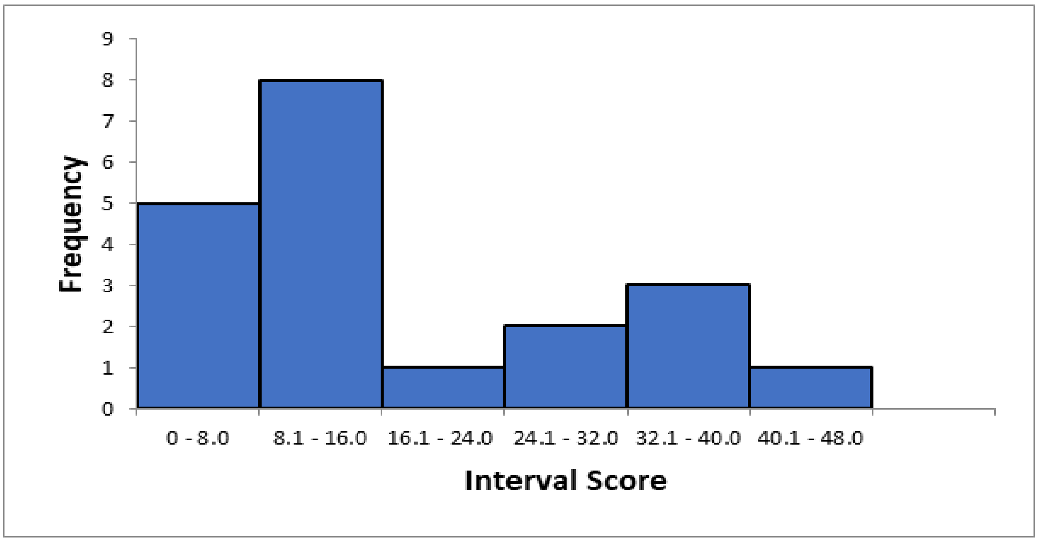

Figure 1: Histogram of experimental class' pre-test.

The frequency distribution of students' achievement in pre-test and post-test of experimental class is shown in Table 4 and Table 5 respectively, and the control class is shown in Table 6 and Table 7. The distribution of experimental class' interval scores is exhibited as histogram in Figure 1 and Figure 2. The histogram of pre-test and post-test of control class is shown in Figure 3 and Figure 4 respectively.

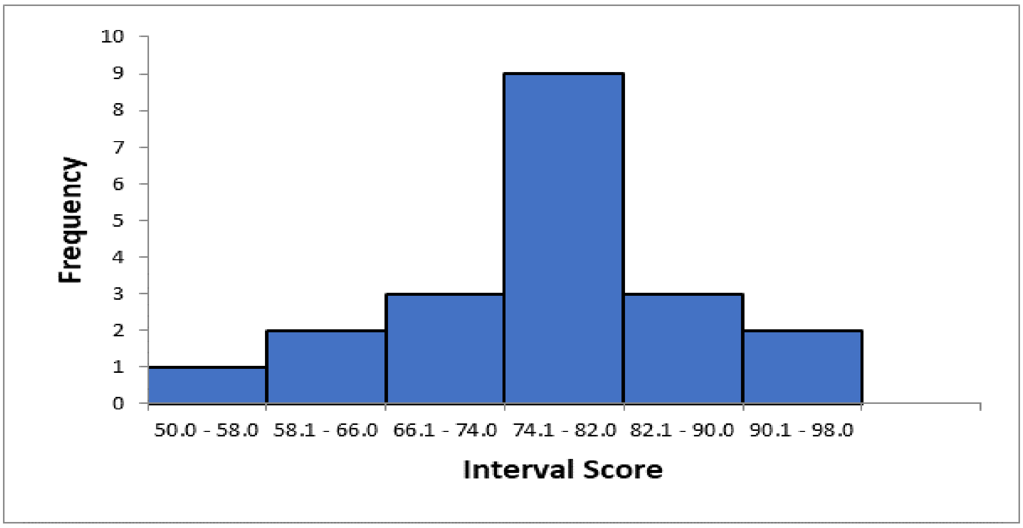

Figure 2: Histogram of experimental class' post-test.

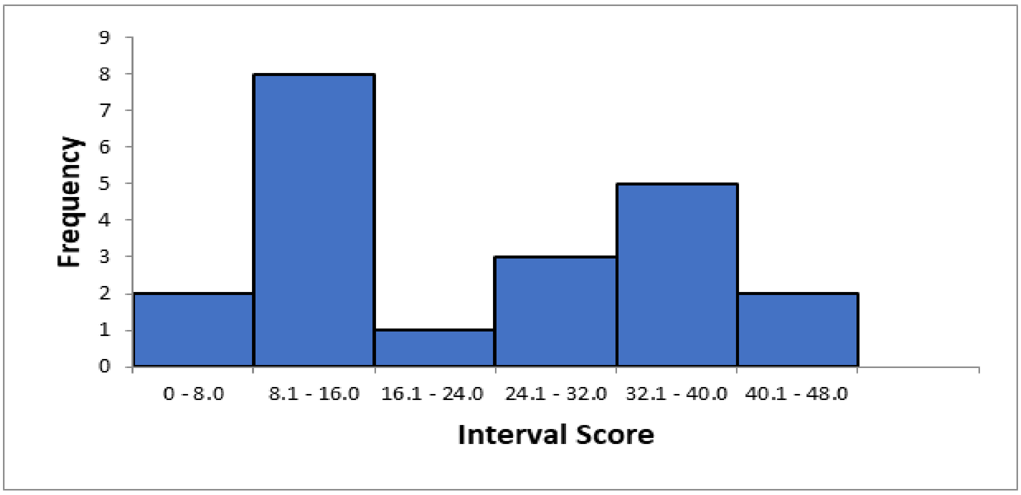

Figure 3: Histogram of control class' pre-test.

From the results of the observations and test results given, the level of understanding of students about the principles and concepts of thermodynamics law with a technology-applied approach is better compared to the conventional approach. The average learning outcomes of thermodynamic group of students who was taught with technology-applied approach is higher than the learning result of thermodynamic of student group which was taught with conventional approach. Students who were taught using this approach more understand and solve problems efficiently.

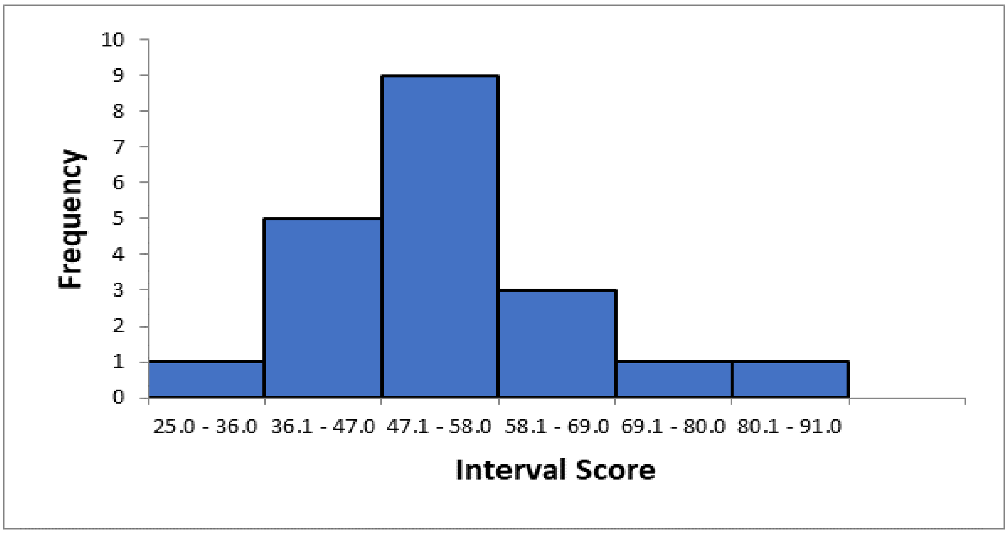

Figure 4: Histogram of control class' post-test.

Table 1: Research design.

Class	Pre-Test	X	Post-Test
A	T1A	X	T2A
B	T1B	X	T2B

Table 2: Summary of result data of pre-test – post-test of experimental class (Class A).

Statistics	Statistics Value		
	Pre-test	Post-test	Difference |post-test – pre-test|
Minimum score	0	50.00	50.00
Maximum score	75.00	95.00	20.00
Total (∑)	402.50	1454.50	1052.00
Average (x)	20,13	76.55	56.42
Variance (s^2)	191.63	118.12	73.51
Standard deviation (s)	13.84	10.87	2.97

Table 3: Summary of result data of pre-test – post-test of control class (Class B).

Statistics	*Statistics Value*		
	Pre-test	*Post-test*	*Difference |post-test – pre-test|*
Minimum score	0	25.00	25.00
Maximum score	45.00	87.50	42.50
Total (∑)	435.00	1043.50	608.50
Average (x)	21.78	52.18	30.40
Variance (s^2)	172.49	190.46	17.97
Standard deviation (s)	13.13	13.80	0.67

Table 4: Pre-test frequency distribution of experimental class.

No.	*Interval Class*	*Absolute Frequency*	*Relative Frequency (%)*	*Cumulative Frequency (%)*
1	0 - 8.0	5	25	25
2	8.1 - 16.0	8	40	65
3	16.1 - 24.0	1	5	70
4	24.1 - 32.0	2	10	80
5	32.1 - 40.0	3	15	95
6	40.1 - 48.0	1	5	100
	Total	20	100.00	

Table 5: Post-test frequency distribution of experiment class.

No.	*Interval Class*	*Absolute Frequency*	*Relative Frequency (%)*	*Cumulative Frequency (%)*
1	50.0 - 58.0	1	5	5
2	58.1 - 66.0	2	10	15
3	66.1 - 74.0	3	15	30
4	74.1 - 82.0	9	45	75
5	82.1 - 90.0	3	15	90
6	90.1 - 98.0	2	10	100
	Total	20	100.00	

Table 6: Pre-test frequency distribution of control class.

No.	*Interval Class*	*Absolute Frequency*	*Relative Frequency (%)*	*Cumulative Frequency (%)*
1	0 - 8.0	2	10	10
2	8.1 - 16.0	8	40	50
3	16.1 - 24.0	1	5	55
4	24.1 - 32.0	3	15	70
5	32.1 - 40.0	5	25	95
6	40.1 - 48.0	1	5	100
	Total	20	100.00	

Table 7: Post-test frequency distribution of control class.

No.	**Interval Class**	**Absolute Frequency**	**Relative Frequency (%)**	**Cumulative Frequency (%)**
1	25.0 - 36.0	1	5	5
2	36.1 - 47.0	5	25	30
3	47.1 - 58.0	9	45	75
4	58.1 - 69.0	3	15	90
5	69.1 - 80.0	1	5	95
6	80.1 - 91.0	1	5	100
	Total	20	100.00	

A correlation between technology integration, technology introduction, pedagogy, and learning content is needed in learning process (Harris et al., 2009). The integration of content and processes simultaneously in the design of learning activities offers an opportunity to enhance students' experience in authentic activities, and thus can understand deeper content (Edelson, 2001). The use of technology products in teaching and learning activities if only used as a tool then produces less good learning, than if using it as a tool of technology and cognitive tools (Jonte, 2003).

4. CONCLUSIONS

The conclusions of this study is the thermodynamic learning outcomes of students who were taught by technology-applied approach is higher than the students who were taught with conventional approach. The technology-applied approach learning is a factor that influences the learning outcome of thermodynamics, and the technology-applied approach of thermodynamics can make students recognize the principles and concepts of the laws of thermodynamics through the tools of technology, in this case as a learning tools supporting media.

Based on the above conclusions, the following suggestions are given: the application of technology in the lecture of thermodynamics significantly influences the improvement of learning outcomes, the lecturers should make the approach of technology application as the learning approach for the thermodynamics course, for the physics teachers who teach about the laws of thermodynamics in schools, since the approach of technology application significantly influences the learning outcomes in understanding the concept or principles of thermodynamics law and the physical symptoms. The researchers recommend various models or approaches for further research in enriching the learning strategy to be used as a reference in the teaching and learning process.

REFERENCES

1. Akyol G, Sungur S and Tekkaya C "The Contribution of Cognitive and Metacognitive Strategy Use to Students' Science Achievement", Educational Research and Evaluation, 2010; 16(3); 1-21.
2. Beswick N Resource-Based Learning, Heinemann, 1990.
3. Bridges S M, Botelho M G, Green J and Chau A C M Multimodality in Problem-Based Learning (PBL): An Interactional Etnography. In Problem-Based Learning in Clinical Education: the Next Generation, Bridges S M, McGrath C P and Whitehill T. (Eds.), Springer, 2012.
4. Bridges S, Green J, Botelho M G, Tsang P C S Blended Learning and PBL: An Interactional Etnographic Approach to Understanding Knowledge Construction in-Situ. In Essential Readings in Problem-based Learning, Walker A, Leary H, Hmelo-Silver C and Ertmer P A (Eds.), Purdue University Press, 2015.
5. Chen C H and Chen C Y "Instructional Approaches on Science Performance, Attitude and Inquiry Ability in a Computer-Supported Collaborative Learning Environment", Turkish Online Journal of Educational Technology – TOJET, 2012; 11(1): 113-122.
6. Dwijayanto F, Setyosari P and Dwiyogo W D "Effects of Problem Based Learning Strategy and Achievement Motivation on the Student", International Journal of Science and Research (IJSR), 2017; 6(6): 707-713.
7. Edelson D C "Learning for Use: A Framework for the Design of Technological-Supported Inquiry Activities", Journal of Research in Science Teaching, 2001; 38(3): 355-385.
8. Edwards L D "The Design and Analysis of a Mathematical Microworld. Journal of Educational Computing Research", 1995; 12(1): 77-94.

9. Freire P Pedagogy of the Oppresed: New Revised 20th Anniversary Edition, Continuum, 1993.
10. Gure G S "M-Learning: Implications and Challenges", International Journal of Science and Research (IJSR), 2016; 5(12): 2087-2093.
11. Hannafin M J and Land S M "The Foundation and Assumptions of Technology-Enhanced Student-Centered Learning Environments", Instructional Science, 1997; 25(3): 167-202.
12. Hannafin M J "Interaction Strategies and Emerging Instructional Technologies: Psychological Perspectives", Canadian Journal of Educational Communication, 1989; 18: 167-179.
13. Harris J, Mishra P and Koehler M "Teachers' Technological Pedagogical Content Knowledge and Learning Activity Types: Curriculum-Based Technology Integration Reframed", Journal of Research on Technology in Education, 2009; 41(4): 393-416.
14. Jonassen D What Are Cognitive Tools?. In Cognitive Tools for Learning, Kommers P and Mandl H (Eds.), Springer-Verlag, 1992.
15. Jonte B Physics Learning and Microcomputer Based Laboratory (MBL) Learning Effects of Using MBL as a Technological and as a Cognitive Tool. In Science Education Research in the Knowledge-Based Society, Psillos D et al. (Eds.), Kluwer Academic Publishers, 2003.
16. Karacalli S and Korur F "The Effects of Project-Based Learning on Student's Academic Achievement, Attitude, and Retention of Knowledge: The Subject of "Electricity in Our Lives"", School Science and Mathematics, 2014; 114(5): 224-235.
17. Lewis E, Stern J and Linn M "The Effect of Computer Simulations on Introducing Thermodynamics Understanding", Educational Technology, 1993; 28(11): 8-12.
18. Lu J, Bridges S and Hmelo-Silver C E Problem-Based Learning. In Cambridge Handbook of the Learning Sciences, Sawyer K. (Ed.), Cambridge University Press, 2014.
19. Opitz A, Heene M and Fischer F, "Measuring Scientific Reasoning – a Review of Test Instruments", Educational Research and Evaluation, 2016; 23(3-4): 78-101.
20. Ramma Y, Bholoa A, Watts M and Nadal P S "Teaching and Learning Physics Using Technology: Making a Case for the Affective Domain", Education Inquiry, 2017; 9(2): 210-236.
21. Romiszowski A J Designing Instructional Systems: Decision Making in Course Planning and Curriculum Design, Routledge, 2016.

22. Ross M E and Salisbury-Glennon J D "Situated Self-Regulation: Modelling the Interrelationships Among Instruction, Assesment, Learning Strategies and Academic Performance", Educational Research and Evaluation, 2003; 9(2): 189-209.
23. Shelly G, Gunter G and Gunter R Teachers Discovering Computers: Integrating Technology in a Connected World, 7th Edition, Cengage Learning, 2012.
24. Sperling R A and Howard B C "Metacognition and Self-Regulated Learning Constructs", Educational Research and Evaluation, 2010; 10(2): 117-139.
25. Spiro R, Feltovich P, Jacobson M and Coulson R "Cognitive Flexibility, Constructivism, and Hypertext: Random Access Instruction for Advanced Knowledge Acquisition in Ill-Structured Domains", Educational Technology, 1991; 5: 24-33.
26. Strommen E and Lincoln B "Constructivism, Technology, and the Future of Classroom Learning", Education and Urban Society, 1992; 24: 466-476.
27. Wong K K H and Day J R "A Comparative Study of Problem-Based and Lecture-Based Learning in Junior Secondary School Science", Research in Science Education, 2002; 39(5): 625-642.