ICEE-2

The Student Cognitive Load in Teaching and Learning of Plant Tissue Using the Time-Based Resource Sharing Model

Maya Amelia Febriani ✉[1], A. Rahmat [2], E. Nuraeni[3]

[1]Program Magister Pendidikan Biologi, Sekolah Pascasarjana, Universitas Pendidikan Indonesia.
[2]FPMIPA, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Jawa Barat, Indonesia
✉ mayaameliafebriani@upi.edu

Abstract. One of the successes teaching and learning can reduce students' cognitive load. The principle of applying cognitive load theory is using working memory which can be managed by a cognitive treatment through refresh memory from the psychological model of the Time-Based Resource Sharing Model (TBRS Model). The research method used is pre-experiment was aim to determine students' cognitive load in teaching and learning of plant tissue using the TBRS model. The total cognitive load consists of Intrinsic Cognitive Load (ICL) measured by task complexity worksheet, Extraneous Cognitive Load (ECL) measured by subjective rating scale, Germane Cognitive Load (GCL) measured by the cognitive system level 2 dan 3 (Marzano & Kendal, 2007), and interview as secondary data. The participants were 36 science students of Senior High School. The bivariate correlation test showed correlation between ECL and GCL is positive but not significant (0,171; a > 0.05); ECL and ICL is positive but not significant (0,073; a > 0.05); ICL and GCL is negative but not significant (-0,104; a > 0,05). From these data, the formation of students' cognitive schemes described GCL is not clearly influenced by ICL or ECL so students still have a cognitive load. The results of student interviews showed this cognitive load does not consequence by the TBRS model but from the other factors such as difficult material and material presented partially. In addition, this situation also supported by the results of a questionnaire showed that students helped by refresh memory in the TBRS model. So there is still a cognitive load on students not due to malfunction of the TBRS model but due to other factors that have been explained above.

Keywords: Cognitive Load, Time-Based Resource Sharing Model, Plant Tissue

INTRODUCTION ~ Learning process is related to ability of memory to receive information. Limited memory capacity makes a person will be load if they have to receive a lot of information. That is explained of cognitive load theory. Cognitive load theory is a psychological theory that aims to predict learning outcomes by taking into account the abilities and limitations of human cognitive architecture (Plass, J.L., Moreno R., & Brünken, R. 2010).

The material in biology subjects focus of this research is plants tissue contained in the class XI syllabus. This material was chosen because it can be used as a basis for studying plant organs, biotechnology, taxonomy and others. In addition, there are many scientific terms that require strong memory and accurate understanding. This material can be meaningful learning if students can organized their working memory efficiently, so that cognitive load can be overcome. Meissner and Bogner (2013) state, a good teaching and learning process is learning be able to provide tasks that can achieve ICL enough, reduce ECL, and increase GCL.

The success of teaching and learning in this material plant tissue can be known based on the total cognitive load consist of instrinsic cognitive load as a described of ability to receive and process

information, extraneous cognitive load as a described of students' mental effort in facing learning, and the germane cognitive load as a described of cognitive schemes final owned by students.

To be able to overcome students cognitive load, needed a cognitive treatment can facilitate students in managing working memory, the TBRS model (Time-Based Resource Sharing Model) is expected become alternative to overcome this problem. The TBRS model is a psychological treatment that utilizes students' resources of working memory in receiving, processing (integrating prior knowladge with new knowladge), and preserving information (Barrouillet *et al*, 2009). TBRS model is a new treatment in cognitive load theory, especially in biological studies. Therefore, from the explanation, the researcher plans to implementation research by title " The Student Cognitive Load in Teaching and Learning of plant tissue using the Time-Based Resource Sharing Model."

METHOD

This research is pre-experiment. The study design used a posttes only control group. Correlation variables examined in this study is cognitive load elements including ICL (Instrinsic Cognitive Load) measured by task complexity worksheet adapted from Brunken et al (2010) and developed based on four information processing standards framework Marzano et al (1993) which include: identification of information components, interpretation of information, analysis of information relevance, and application of information. ECL (Extraneous Cognitive Load) measured by subjective rating scale from Brunken et al (2010) with seven choices of answers from very helpful until very unhelpful. GCL (Germane Cognitive Load) measured by the reasoning test level 2 dan 3 framework Marzano & Kendal (2007): level 2 (comprehension) consists of integrating dan symbolizing, level 3 (analysis) consists of matching, classifying, generalizing, and specifying. That three instruments are given at the end of the lesson. ICL, ECL, and GCL scores are interpreted into student grades using the following formula:

$$\text{Student score} = \frac{\text{Score obtained}}{\text{Maximum score}} \text{x } 100$$

Then the score is categorized according to Arikunto categorization (2013): 80-100 very good, 66-79 good, 56-65 enough, 40-55 less, and 30-39 failed. In addition, the secondary data obtained from interviews. The participants in this research were 36 science students of Senior High School. TBRS model is applied in teaching and learning as refresh memory at the beginning of learning, core and closing learning activities by displaying images and videos. In addition, the teacher also provides statements and questions during the learning process to make it easier for students to recalling prior knowledge to be used in construct cognitive schemes.

ICEE-2

RESULT

Before being tested correlational, student learning outcomes data either ICL, ECL or GCL previously tested of normality to see the distribution of data. The normality test used is Shapiro-Wilk. The three components of cognitive load have normally distributed data namely ICL (0.125 > 0.050), ECL (0.060 > 0.050), and GCL (0.060 > 0.050) can be seen in table 1.

Table 1. Normality of each component of cognitive load

Beban kognitif	Shapiro-Wilk		
	Statistic	df	Sig.
ICL	0,952	36	0,125
GCL	0,941	36	0,054
ECL	0,942	36	0,060

After being tested for normality, the three components of cognitive load are tested for linearity. The results test of them is linear. GCL & ICL (0,690 > 0.050), GCL & ECL (0,802 > 0.050), and ICL & ECL (0,417 > 0.050) can be seen in table 2.

Table 2 Linearity of the three components of cognitive load

Komponen beban kognitif	Linearity
GCL & ICL	0,690
GCL & ECL	0,802
ICL & ECL	0,417

Because the three components of cognitive load have data distributed normally and linear, the correlational test used Pearson test with the provisions if sig value > 0,05 then the data have a significant correlation, and otherwise. The three components of cognitive load can be seen on table 3.

Because the three components of cognitive load have data distributed normally and linear, the correlational test used Pearson test with the provisions if sig value > 0,05 then the data have a significant correlation, and otherwise. The three components of cognitive load can be seen on table 3.

Table 3. Correlations between components of cognitive load

		ICL	GCL	ECL
ICL	Pearson Correlation	1	-0,104	0,073

	Sig. (2-tailed)		0,545	0,672
	N	36	36	36
GCL	Pearson Correlation	-0,104	1	0,171
	Sig. (2-tailed)	0,545		0,319
	N	36	36	36
ECL	Pearson Correlation	0,073	0,171	1
	Sig. (2-tailed)	0,672	0,319	
	N	36	36	36

Table three showed the correlation between ECL and GCL is positive but not significant (0,171; a > 0.05) which indicates students have a cognitive load and ECL contributed to GCL. While the correlation between ECL and ICL is positive but not significant (0,073; a> 0.05) which showed students have a cognitive load but the contribution of ECL to ICL is not clear. And correlation between ICL and GCL is negative but not significant (-0,104; a > 0,05) which showed students have a cognitive load but the contribution of ICL to GCL is not clear. This cognitive load category refers to Munandar (2012). From these data, the formation of students' cognitive schemes described GCL is not clearly influenced by ICL or ECL, so students still have cognitive load.

From the results of interviews with several students, it can be concluded that the plant tissue material is quite difficult material to understand and has a lot of memorization. Errors in the technique of presenting material that are partially (separate from the material of plant organs) also make students get partial information (only plant tissue).

DISCUSSION

From the results of the explanation above, students still have cognitive load possibility not due to the malfunction treatment TBRS model but more due to the complex and difficult of the material to understand by students and technique error in the presentation of material made partially. This is appropriated with Kalyuga (2010), Sweller (2010), and Scharfenberg (2010) that the high complexity of material is caused by too much interactivity of new information elements that makes students difficult in learning, even though material that has a high level of interactivity element requires a reduction in ICL to provide room for working memory in construct a knowledge scheme (Morrienboer & Sweller, 2005).

Technique error in the presentation of material made partially because separate from the material of plant organs, this is called the split attention situation according to Kalyuga (2011) one of the factors make cognitive load is the students' attention divided by distance or time. From the results of ECL correlation data with GCL positive but not significant showed students have a cognitive load

and ECL contributed to GCL. According to Rejeki (2012) one of the factors influencing to ECL is internal factors of students who are different in understanding learning material.

The correlation between ICL and GCL negative but not significant showed students have a cognitive load but the contribution of ICL to GCL is not clear. According to Survani (2014) although not significant, but negative correlation value can be showed ECL's decrease can be affect for GCL.

ICL's decrease can be seen from the results of students' ability to receive and process information well (Rahmat & Hindriana, 2014). When viewed from the average value of ICL, ECL and GCL in plant tissue learning, the average ICL is 76 good category, ECL 31 is low (expected), and GCL 70 good category. from that data showed average ICL score of students is good category that is equal to 76. This showed that the majority of students are able to receive and process information well. Relationship between cognitive load and treatment TBRS model is located in the working memory of students (student resources) which is often defined in cognitive psychology as a system aimed at receiving and processing information simultaneously (Barrouillet & Camos, 2015; Barrouillet et al, 2004).

In this TBRS model, the main principle is the existence of refresh memory can be used to bring back the prior knowladge owned by students (Puma, 2018). Refresh memory is very influential on working memory (Baddeley, 2006). The most important thing in this model is to organize limited resources in the form of working memory that must be shared between processing and storage. Therefore, to avoid loss of memory, the focus of student attention must be directed through refresh memory before all information is lost (Camos, 2017).

The ability of students good enough to receive and process information is the result of refresh memory from the TBRS model. Same as the results of the questionnaire analysis of student responsed to the sustainability of learning using TBRS, the majority of students gave responses 1 (very helpful) and 2 (helpful).

From the explanation above, the results of the correlation test between cognitive loads indicate that students still have cognitive loads. But the possibility of cognitive load is not due to the unsuccessful TBRS model as described above. According to de Jong (2010), if a learning task or activity requires cognitive capacity that exceeds its limits, then learning will be blocked. Therefore, this preliminary research can be an illustration for further research, so that learning is more effective and cognitive load can be overcome. According to Kalyuga (2011), an effective and efficient learning must be able to build a learning condition where students' working memory is stored based on their capacity so that students do not experience overload memory. As a

reference for further research, this is very important to attention and consider learning strategies and interactivity of information elements in order to students easily constructed cognitive schemes and information obtained is stored in long-term memory.

CONCLUSION

Teaching and learning of plant tissue by using Time-Based Resource Sharing Model still produced students cognitive load. But the possibility of cognitive load is not due to malfunction of treatments from TBRS model by refresh memory, but rather due to complexity of the material and the technique of presenting material that are partially because separate from the material of plant organs.

ACKNOWLEDGMENTS

The authors would like to thank all parties involved in this research. Thank you to the school that has granted the research permission, as well as all the research subjects who have helped in this research.

REFERENCES

Arikunto, Suharsimi. (2013), Dasar-dasar Evaluasi Pendidikan, Jakarta: Bumi Aksara.

Baddeley, A., and Repovs, G. (2006). The Multi-Component Model Of Working Memory: Explorations In Experimental Cognitive Psychology, Neuroscience. 139(1): 5-21.

Barrouillet, P., and Camos, V. (2015). Working memory: loss and reconstruction. New York: Psychology Press.

Barrouillet, P., Bernardin, S., and Camos, V. (2004) "Time constraints and resource sharing in adults' working memory spans", Journal of Experimental Psychology: General, 133, 83–100.

Brunken, R., Seufert, T., and Pass, F. (2010). "Measuring Cognitive Load", in Plass, J., L, Moreno R., and Brunken, R., (eds), "Cognitive Load Theory" (181-202), Cambridge: Cambride University Press.

Barrouillet, P., Camos, V., Gavens, Nathalie., Vergauwe, Evie., Gaillard, Vinciane. (2009). Working Memory Span Development: A Time-Based Resource-Sharing Model Account. Developmental Psychology, vol. 45, no. 2, p. 477-490

Camos, Valérie. (2017) Domain-Specific Versus Domain-General Maintenance in Working Memory: Reconciliation Within the Time-Based Resource Sharing Model, Psychology of Learning and Motivation, Volume 67.

De jong, T. (2010) Cognitive load theory, educational reserch, and instructional desain: some food for thought, Instructional science, 38, 105-134.

Kalyuga, S. (2011). Informing: A Cognitive Load Perspec-tive, Informing Science: The International Journal of an Emerging Transdiscipline, 14 (1): 33-45.

Marzano, R, J., and John S., Kendall. (2007). The New Taxonomy of Educational Objectives Second Edition, United States of America: Corwin Press.

Marzano, R, J., Pickering, D., and McTighe, O. (1993). Assessing Student Outcomes, Performance Assesment Using The Dimension of Learning, Alexandria: Association for Supervision and Curriculum Development.

Meissner and Bogner. (2013). Towards Cognitive Load Theory as Guideline for Instructional Design in Science Education, World Journal of Education, Vol, 3, No 2.

Merrienboer, Van, J, J, G., & Sweller, John. (2005). Cognitive Load Theory and Complex Learning: Recent Development and Future Direction, Educational Psycology Review, 17, 147-178.

Munandar, R, R. (2015). Pengelolaan Beban Kognitif Siswa Sesuai Gaya Belajar dan Sosial Ekonomi Menggunakan Pembelajaran Two Stay Two Strey pada Materi Klasifikasi Spermatophyta, Thesis, Jurusan Pendidikan Biologi Sekolah Pascasarjana Universitas Pendidikan Indonesia, Bandung.

Plass, J, L., Moreno, R., and Brünken, R, (Eds). (2010). Cognitive Load Theory. Cambridge: Cambride University Press.

Puma, Sébastien., Nadine, Matton., Pierre-Vincent, Paubel., and André, Tricot. (2018). Cognitive Load Theory and Time Considerations: Using the Time-Based Resource Sharing Model, Educ Psychol Rev,

Rahmat, A., & Hindriana, A, F. (2014). Beban kognitif Mahasiswa dalam Pembelajaran Fungsi Terintegrasi Struktur Tumbuhan Berbasis Dimensi Belajar, Jurnal Ilmu Pendidikan.

Scharfenberg, F, J., and Bogner, F, X. (2010). Instructional efficiency of changing cognitive load in an out – of - school laboratory, *International Journal of Science Education*, 37, (13), hlm 1678-168.

Survani, Rifki. (2014). Pengukuran kognitive load mahasiswa biologi pada perkuliahan anatomi tumbuhan yang berbasis kuantitatif literacy. Thesis, Jurusan Pendidikan Biologi Sekolah Pascasarjana Universitas Pendidikan Indonesia, Bandung.

Sweller, J. (2010).Cognitive Load Theory: Recent Theoretical Advances. Australia journal for education technology",