

## Mind Mapping in Learning Models: A Tool to Improve Student Metacognitive Skills

<https://doi.org/10.3991/ijet.v15i06.12657>

Dyah Astriani

Universitas Negeri Malang, Malang, Indonesia  
Universitas Negeri Surabaya, Surabaya, Indonesia

Herawati Susilo <sup>(✉)</sup>, Hadi Suwono, Betty Lukiati

Universitas Negeri Malang, Malang, Indonesia  
herawati.susilo.fmipa@um.ac.id

Aris Rudi Purnomo

Universitas Negeri Surabaya, Surabaya, Indonesia

**Abstract**—This study aimed to measure the role of mind mapping in learning models to improve students' metacognitive skills. The study used a pre-experimental one group pre-test post-test design, involving 33 students of science teacher candidates, Science Education Study Program, Universitas Negeri Malang, Malang, Indonesia, for three meetings. The instruments used were a mind map assessment rubric and a metacognitive skills essay questions as many as 15 questions alongside with its assessment rubric. Students were given a pre-test before learning activities and the same post-test consists of essays related to metacognitive skills. Research data were analyzed descriptively and quantitatively using a t-test and correlation analysis. The results showed: (1) there was increasing scores over mind mapping skills in the average by each meeting, namely score of 13.91 (Enough), 15.39 (Enough), and 18.18 (Good); (2) the paired t-test results showed the value of  $t = 9.196$ , with a significance of  $0.000 < 0.05$ ; and (3) the results of the influence analysis of 0.552 showed that mind mapping with metacognitive skills was correlated by moderate criteria. To conclude, the mind mapping applied in the syntax of learning models can improve the metacognitive skills of students as science teacher candidates.

**Keywords**—Mind mapping, learning model, metacognitive skills

### 1 Introduction

The challenge of education in Indonesia is to produce human resources with global competitiveness. Education in the 21st century requires students to have skills that can support their activities in the world of work. The skills needed include problem-solving skills, communication, and metacognitive skills [1]. Metacognitive relates to activities of organizing information, experiences, goals, and strategies that support

learning such as solving problems and making decisions [2]. In learning, students are trained in metacognitive skills to become individuals who are independent, having the motivation, able to choose learning strategies, and responsible for learning progress and good decision-makers [3, 4, 5, 6].

Research that examines metacognitive skills has been done, especially related to learning outcomes [7, 8, 9, 10, 11, 12, 13]. Research that has been conducted by various methods shows that there is a positive relationship between metacognitive skills and learning outcomes. Student metacognitive skills do not appear by themselves but require a training process to make it a habit [14]. Based on these statements, it is necessary to plan an appropriate learning process with activities and structured learning environments that can train metacognitive skills [15,16]. Lesson planning to practice metacognitive skills in this study was carried out using mind mapping learning strategies as one of the syntaxes of the learning model.

According to Buzan [17], mind mapping is one of the effective and creative ways to map and record information to make it stored properly in memory. The activity of making mind maps allows to express managing information by using colors, images and symbols, involving the right and left brains to work together so that information is organized, easy to remember, and easy to understand, so that the information belongs to the students themselves [18, 19, 20, 21]. Mind mapping in accordance with the workings of the human brain, interlocked, connecting one concept with other concepts so as to create meaning in a concept [22].

The important thing in learning is connecting concepts with phenomena in daily life. Knowledge about nature and its symptoms can be learned in Natural Sciences (IPA). Environmental conditions that change and impact on living things are also studied in science, especially ecology. In a recent development, ecology also discusses the structure and function of ecosystems and their problems. Hence, students can practice analyzing and finding solutions for the arising problem. Ecological problems such as environmental pollution, changes in environmental functions, the extraordinary growth of one organism that it disturbs other organisms [23], can be used to practice metacognitive skills. This is related to the interdisciplinary nature of Ecology, meaning that information is needed from various interrelated fields. Students practice choosing relevant information to the material discussed, determine the purpose of learning the material, and reflect on their thinking activities by drawing conclusions through ecological problems.

Metacognitive skills are important to train students because they help to monitor cognitive activities, such as planning, monitoring, and evaluating the learning process [24]. Practicing metacognitive skills can be done using learning strategies such as mind mapping. This strategy can help to build knowledge, increase student interest to learn independently [25]. So, in this study, mind mapping is used as the initial syntax for the learning model developed. Students must read the material first, and the results are outlined in the form of mind maps. It can also provide students with the initial provision to attend lectures. The results showed that students' interest in reading the course material to prepare for further lectures was still very low, which had an impact on students' initial knowledge during the lecture, still lacking [26].

Based on the background description, it shows that metacognitive skills are one of the factors that play a role in the success of student life. Therefore, this metacognitive skill needs to be trained in learning by using mind mapping learning strategies. The purpose of this study was to measure the role of mind mapping as one of the syntaxes in learning models to improve the metacognitive skills of students as science teacher candidates.

## **2 Overview**

### **2.1 Mind mapping**

Mind mapping that is a technique for visualizing relationships between concepts, is a reflective tool, which allows students to play colors and make pictures in mapping material [27]. Structured pictures and diagrams are easier to understand than just words, and able to describe complex topics, so students can focus on choosing the main ideas needed to summarize effectively the lesson [28,29]. Using mind mapping makes a long list of information organized in the form of colorful, regular, and easy-to-remember diagrams [30,31,18]. Using colors and images in mind maps will make learning more fun, make it easier to organize ideas, interpret concepts, encourage brainstorming, improve memory, and facilitate understanding so the learning becomes meaningful [20,28,32,33,34].

The mind map preparation begins by reading from various sources. Then students determine the main concepts and sub-concepts, described as branches of the main concepts [35]. The application of mind mapping is more effective when it is combined with other techniques, such as illustrations using, color and line play, since the combination will help build thought processes, so it can improve cognitive memory up to 32% [36, 37, 38]. A good mind map can be in the form of drawings using paper and pencil, produced through student involvement in the processing of material information in depth, thereby adding to the learning experience, understanding of the material, and as an effort to build student's knowledge itself [21, 39, 40]. For teachers, mind mapping can be used to map teaching resources to prepare and monitor lectures [41].

The results show that mind mapping is a creative way of guiding and directing students in learning to remember the main concepts and create a learning environment to help processing information [40, 42].

### **2.2 Metacognitive skills**

Metacognitive activities are basically thinking activities about thinking, such as planning, prediction, reflection, and evaluation of actions taken, so they can control activities consciously about their own cognitive processes [3, 43, 44]. Metacognitive skills have a contribution to cognitive learning outcomes and learning success, so these skills need to be trained on students [45, 46]. This skill training requires a

structured learning environment to support the development of high-level cognitive skills from science students, such as problem solving and metacognitive [47, 48, 49].

Keiichi's research [50] states that metacognitive skills have an important role in solving problems. Students will be more skillful at solving problems if they have metacognitive skills. Metacognitive skills can be trained by reading, especially when determining the main idea of a passage. During the reading, there is a self-regulated learning process by which it enhances metacognitive skills through information sharing activities both in-groups and in-class discussion [2, 51, 52, 53, 54]. The results of other studies show that if metacognitive skills are trained through inquiry and a well-designed learning environment, it can affect high-level thinking skills, improve metacognition abilities and learning outcomes, also grow students' independence in learning [5, 14, 11, 12, 55, 56, 57].

### **2.3 Learning model**

The learning model describes the learning environment that guides the teacher to achieve certain learning outcomes through the teacher's activities when implementing the model [58, 59, 60]. Based on the model definition according to experts, in this study, the intended learning model is a guide for lecturers in behaving to provide learning experiences and environment to students. The learning model is designed based on student characteristics and the need to achieve certain learning outcomes. According to Arends [61], the characteristics of the learning model are:

- Having a theoretical and empirical foundation that is explicitly compiled by the developer
- Designed to achieve certain learning outcomes
- Having the syntax or stages of learning
- Managing the learning environment, so the objectives learning is achieved.

## **3 Method**

This research was a pilot project without using a comparison class to see the role of mind mapping strategies in learning models to improve metacognitive skills. The research design used was the One Group Pre-test Post-test Design. The research used 33 students of second-year science teacher candidates, the academic year of 2017/2018, Universitas Negeri Malang. The instrument used was a mind map assessment rubric and 15 questions with metacognitive skills essay questions along with their assessment rubrics. Previous essay questions had been validated empirically. Calculation of validity using Biserial correlation results, scored 0.60 (valid) and reliability result using Cronbach's Alpha results scored 0.67 (high). Data obtained from the mind map scores three meetings and metacognitive skills test results before and after learning. Mind map scores are defined by the criteria 0-10: less; 11-15: enough; 16-20: good; 21-25: very good. A paired t-test was employed to measure the significance of mind-mapping towards metacognitive skills. Also, the

strength of mind mapping towards metacognitive skills was measured using correlation analysis.

#### 4 Findings and Discussion

Research activities by applying mind mapping in the syntaxes of learning models to practice metacognitive skills were done by giving the task of reading material to students before attending lectures in class. The results of the reading activities in the form of mind-mapping at each meeting as shown in Figures 1 and 2.

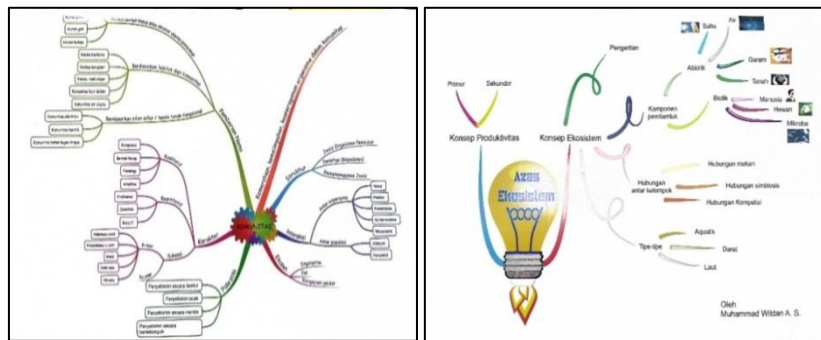


Fig. 1. Student mind map of ecosystem (left) and community (right)

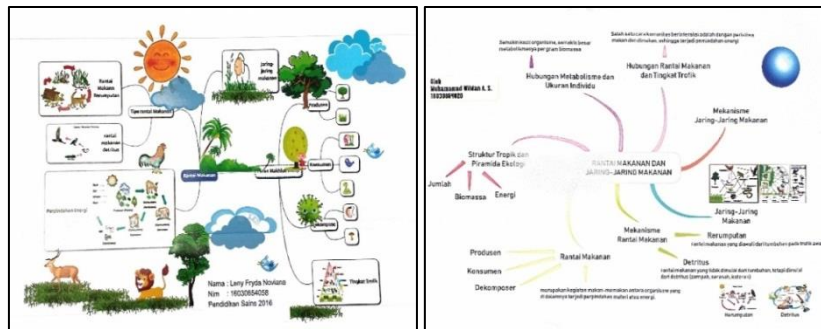


Fig. 2. Student mind map of the food chain (left) and the food web (right)

Figures 1 and 2 illustrated the mind map of the material of the ecosystem, the community, the food chain, and the food web. The completeness of mind maps showed the reading activities done before making the mind map ran effectively. Mind maps that were arranged contain keywords and symbols that were meaningful in accordance with the material, associated with curved lines and various colors. Students had to determine the main concepts from various sources of reading, the sub-

concepts, and information that supports [27]. In this study, on each meeting, students had to create a mind map as a result of reading the material before beginning the lecture. Mind maps would be given a score based on the assessment rubric. A mind map score for each meeting was presented in Table 1.

**Table 1.** Average Mind Map Scores for Each Meeting

Material	Average	Criteria
Community	13.91	Enough
The ecosystem	15.39	Enough
Food chains and food webs	18.18	Good

The main branches and levels below were given a different color to make it easier to recognize the main concepts and sub-concepts, using variations of curved lines and each subject line were given keywords. This technique provided space for students to capture the essence of concepts by writing keywords and linking one concept with another concept [62, 63]. Mind mapping is a process that begins learning. Mind mapping that has been arranged was presented in front of the class, to orient students on the material being studied and identify information that is not relevant to the material. The outline of the material contained in a student's mind map was learned through discussion in learning.

Students are given the same metacognitive skills essay test, before and after learning. Examples of metacognitive skills tests used are shown in Table 2.

**Table 2.** Examples of Metacognitive Skill Questions Used

Indicators	Questions
Determine the destination (Metacognitive Skill 1)	Provided articles from newspapers from sources: <a href="https://internasional.kompas.com/read/2017/03/23/12302411/warga.australia.selatan.kewalahan.hadapi.serbuan.kaki.seribu">https://internasional.kompas.com/read/2017/03/23/12302411/warga.australia.selatan.kewalahan.hadapi.serbuan.kaki.seribu</a> about <i>millipede</i> attacks in an area that causes problems for the population. Based on the article, why does the millipedes' movement towards houses need to be anticipated?
Write down relevant information (Metacognitive Skill 2)	Millipedes' attacks cause problems for the population, because they cause disgust, distinctive odors, and crowding on the railroad tracks that cause slippery. Write down the relevant information to help solve the problem of millipedes' attacks!
Make conclusions (Metacognitive Skill 3)	Based on the problems caused by <i>millipedes</i> , write conclusions about how to deal with millipedes' attacks!

The results of students' metacognitive skills tests compared between the pretest and posttest scores were shown in Table 3.

**Table 3.** Comparison of Pre-test and Post-test Scores for Each Metacognitive Skill Indicator

Indicators	Activity	N	Score Average	SD
Determine the destination	Pre test	33	2.0	0.5
	Post test	33	3.0	0.4
Write down relevant information	Pretest	33	1.9	0.4
	Posttest	33	2.3	0.3
Make Conclusion	Pre test	33	2.0	0.5
	Post test	33	2.7	0.3

The data in Table 3. showed that metacognitive skills had increased mean scores from pretest to posttest, and decreased standard deviation from pretest to posttest. Indicators writing goals were very important to practice. Students who are able to set goals in learning by choosing and using learning strategies will achieve success in learning [64]. Learning requires relevant information and the skills to choose the information that is in accordance with the main concepts, so a knowledge that is interconnected will be obtained. Knowledge mapping using mind mapping can train students to organize information by making connections between concepts, thereby helping to build knowledge, increase student involvement, and focus on learning [65, 66].

Another metacognitive skill being trained was making conclusions. This indicator was trained by connecting images and information from the material being studied. Matching images and information in a mind map will help in drawing conclusions [35]. It was concluded that a learning process by making representations from sources of information [67]. The descriptive calculation of the results of the metacognitive skills test is presented in Table 4.

**Table 4.** Results of Descriptive Statistics

	N	Minimum	Maximum	Mean	SD
Pretest	33	23.30	63.30	49.08	9.45
Post test	33	53.30	76.70	65.54	5.55

The results of the metacognitive skills test with the average pretest metacognitive skills were 49.08 (SD = 9.45) and the average post-test of metacognitive skills was 65.54 (SD=5.55). The data showed that there was an increase in the average metacognitive skills of prospective science teacher students in Ecology lectures by a learning model that implements mind mapping in its syntax. The mind map was a product of reading the material before the lecture begins. The course material was read, the main concepts were selected, and their supporting explanations were set forth in the form of mind maps, so they were easier to learn. The activities related to marking the main concepts and giving symbols accompanied the reading process. This was related to reading is an effective activity to practice metacognitive skills [68]. The main concepts and details supporting the main concepts interrelated, realized in the form of mind maps so that it became a whole concept [35,69]. The mind mapping activity was chosen because it made it easy to make a summary of the

material and facilitate students to remember the knowledge and linkages of supporting information [27,63].

Based on the comparison of the pretest and posttest values and the calculation of descriptive statistics, the significance of the role of mind mapping in the learning model was known by conducting a paired t-test presented in Table 5.

**Table 5.** Paired t-test Results

	Mean	S.D	Std. Error Mean	t	df	Sig. (2-tailed)
Post test_Metakognitif – Pre test_Metacognitive	16.46	10.28	1.78	9.196	32	.000

Paired t-test results with a significance level of 0.05 in Table 5 show the value of  $t = 9.196$ , with a significance of  $0.000 < 0.05$ , it can be stated that mind mapping played a significant role in learning models to improve metacognitive skills. The correlation of mind mapping to metacognitive skills in learning was shown in Table 6.

**Table 6.** Correlation Analysis of Mind Mapping on Metacognitive Skills

		Mind Mapping	Metacognitive Skill
Mind Mapping	Pearson Correlation	1	<b>.552*</b>
	Sig. (2-tailed)		.001
	N	33	33
Metacognitive Skill	Pearson Correlation	<b>.552*</b>	1
	Sig. (2-tailed)	.001	33
	N	33	

\*Correlation is significant at the 0.01 level (2-tailed)

The results of the correlation analysis showed a positive relationship between mind mapping with metacognitive skills, with a correlation of 0.552 moderate criteria [70]. This showed that mind mapping played a key role in practicing metacognitive skills in learning. The better students made mind maps, the more the students' metacognitive skills increase. Indeed, mind mapping allowed students to do a series of academic activities that enhance the learning by themselves through reading, underlining the main concepts, choosing the relevant information, and drawing a conclusion from the material being studied. As an inevitable result, mind mapping can be highly integrated with learning models to encourage students' ability to map thoughts, explore relationships between information, improve thinking skills, stimulate creative thinking, and generate brilliant ideas [71, 72, 73].

## 5 Conclusion

Based on the results of the analysis and discussion, Mind mapping can be used as a strategy to train metacognitive skills through learning, because it significantly influences the results of the metacognitive skills test, shown by improved metacognitive skills test results. Based on the role of mind mapping of the



metacognitive skills shown in this study, mind mapping is used as a syntax in the learning model.

## 6 Acknowledgement

I would like to thank BUDI-DN scholarship program to support my study at Universitas Negeri Malang. I also show my special thanks to Mrs. Novida Pratiwi, the lecturer of Ecology Course, Universitas Negeri Malang, for giving permission to use her class for conducting this research. Last but not least, I would like to thank the Head of Science Education Program of Universitas Negeri Malang. Likewise, the author's gratitude goes to Universitas Negeri Surabaya that has provided opportunities for me to take the doctoral program.

## 7 References

- [1] Greenstein, L. (2012). *Assessing 21st century skill: A Guide to Evaluating Mastery and Authentic Learning*. United States: Corwin
- [2] Flavell, J. H. (1979). Metacognitive and Cognitive Monitoring: A New Area of Cognitive Developmental Inquiry. *American Psychologist*, 34: 906-911. <http://dx.doi.org/10.1037/0003-066X.34.10.906>
- [3] Livingstone, J.A. (2003). Metacognition: An Overview diakses melalui <https://files.eric.ed.gov/fulltext/ED474273.pdf> 25 Mei 2019
- [4] Tan, O.S. 2004. *Enhancing Thinking Problem Based Learning Approached*. Singapura: Thomson
- [5] Kipnis, M& Hofstein, A. (2007). The Inquiry Laboratory as a Source for Development of Metacognitive Skill. *International Journal of science and Mathematic Education*, 6(3): 601-627. <https://doi.org/10.1007/s10763-007-9066-y>.
- [6] Dawson, T. L. (2008). *Metacognition and Learning in Adulthood*. Prepared in response to tasking from ODNI/CHCO/IC Leadership Development Office, Developmental Testing Service, LLC.
- [7] Basith, A. (2010). *Hubungan Keterampilan Metakognitif dan Hasil Belajar Mata Pelajaran IPA pada Siswa Kelas IV SD dengan Strategi Pembelajaran Jigsaw dan Think Pair Share (TPS)*. Skripsi tidak diterbitkan. Malang: Universitas Negeri Malang. <https://doi.org/10.24114/esjpsd.v7i1.6407>
- [8] Tseng, K.H, Cheng, C.C, Chuen, Y.R. dan Cheng, C.Y. (2010). *University Students Perspective in Nanotechnology Learning: Assessing The Relationship Between Concept Mapping and Metacognition*. Joint International IGIP-SEFI Annual Conference 2010, 19th-22nd September 2010, Trnava, Slovakia.
- [9] Singh, Y.G. (2012). Metacognitive Ability of Secondary Students and Its Association with Academic Achievement in Science Subject. *International Indexed & Referred Research Journal*, 4(39).
- [10] Ardila, C. (2013). *Hubungan Keterampilan Metakognitif terhadap Hasil Belajar Biologi dan Retensi Siswa Kelas X dengan Penerapan Strategi Pemberdayaan Berpikir Melalui Pertanyaan (PBMP) Di SMAN 9 Malang*. Skripsi tidak diterbitkan. Malang: Universitas Negeri Malang. <https://doi.org/10.33387/j.edu.v17i1.1082>

- [11] Malahayati, E. N., Corebima, A. D., Zubaidah, S. (2015). Hubungan Keterampilan Metakognitif dan Kemampuan Berpikir Kritis dengan Hasil Belajar Biologi Siswa SMA dalam Pembelajaran *Problem Based Learning (PBL)*. *Jurnal Pendidikan Sains*, 3 (4): 178-185. <https://doi.org/10.21009/jps.061.01>
- [12] Pratiwi, I., Suratno, Iqbal, M. (2016). Peningkatan Kemampuan Metakognisi dan Hasil Belajar Siswa dengan Pendekatan Keterampilan Proses Melalui Think Pair Share pada Siswa Kelas X-3 SMAN Yosowilangun Lumajang Tahun 2014/2015. *JURNAL EDUKASI UNEJ*, III (2): 22-28. <https://doi.org/10.19184/jukasi.v3i2.3525>
- [13] Rosyida, F., Zubaidah, S., Mahanal, S. (2016). Keterampilan Metakognitif dan Hasil Belajar Kognitif Siswa dengan Pembelajaran Reading Concept Map-Timed Pair Share (Remap-TMPS). *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 1( 4): 622—627. <https://doi.org/10.26740/jrpd.v2n2.p195-203>
- [14] Iskandar, S.M. (2014). Pendekatan Keterampilan Metakognitif Dalam Pembelajaran Sains di Kelas. *ERUDIO*. 2( 2): 13-20, ISSN: 2302-9021. <https://doi.org/10.18551/erudio.2-2.3>
- [15] Hollingworth, R.W. & McLoughlin, C. (2001). Developing Science Students' Metacognitive Problem Solving Skills Online. *Australian Journal of Educational Technology*, 17(1): 50-63. <https://doi.org/10.14742/ajet.1772>
- [16] Sengul, S& Katranci, Y. (2012). Metacognitive Aspects of Solving Function Problems. *Procedia-Social and Behavioral Sciences* 46: 2178 – 2182. 10.1016/j.sbspro.2012.05.450
- [17] Buzan, T. 2009. *Buku Pintar Mind Mapping*. Gramedia. Jakarta
- [18] Masnaini, Copriady, J., & Osman, K. (2018). Cooperative Integrated Reading and Composition (CIRC) With Mind Mapping Strategy and its Effects on Chemistry Achievement and Motivation. *Asia-Pacific Forum on Science Learning and Teaching*, 19(1):1-18
- [19] Windura, T. (2011). *Peta Minda Langkah Demi Langkah*. Kuala Lumpur: BS Print (M) Sdn.Bhd
- [20] Dhindsa, H.S., Kasim, M. & Anderson, O.R. (2010). Constructivist-Visual Mind Map Teaching Approach and the Quality of Students Cognitive Structures. *Jurnal Science Education Technology*, 2 (3), 1-15. DOI: 10.1007/s10956-010-9245-4.
- [21] Novak, J.D, & Musonda, D. (2001). A Twelve-Year Longitudinal Study of Science Concept Learning. *American Educational Research Journal*, 28 (1):117-153. <https://doi.org/10.1007/s11165-004-3431-4> <https://doi.org/10.3102/00028312028001117>
- [22] Ku, T. D., Shih, J.L., & Hung, S.H. (2014). The Integration of Concept Mapping in a Dynamic Assessment Model for Teaching and Learning Accounting. *Educational Technology & Society*, 16 (1): 141–153
- [23] Ramlawati., Hamka, L., Saenab, S., Yunus, S.R. (2017). Sumber Belajar Penunjang PLPG 2017: Bab 6 Ekologi. Kementerian Pendidikan dan Kebudayaan-Direktorat Jenderal Guru dan Tenaga Kependidikan, 1-23. <https://doi.org/10.17509/manajerial.v18i1.16271>
- [24] Ramadhanti, D., Ghazali, A.S., Hasanah, M., Harsiati, T. (2019). Students' Metacognitive Weaknesses in Academic Writing: A Preliminary Research. *International Journal of Emerging Technologies in Learning* 14(11): 41-56. <https://doi.org/10.391/ijet.v14i11.10213>
- [25] Ren, Y., Jiang, X. (2019). A Mind Map Teaching Mode for Sports Anatomy Based on 3D Body. *International Journal of Emerging Technologies in Learning* Vol. 14, No. 10: 4-17. <https://doi.org/10.3991/ijet.v14i10.10776> <https://doi.org/10.3991/ijet.v14i10.10776>
- [26] Bahri, A & Idris, I. S. (2017). Teaching Thinking: Memberdayakan Keterampilan Metakognitif Mahasiswa melalui PBLRQA (Integrasi Problem-based Learning dan

- Reading, Questioning, & Answering). Diakses melalui: [http://eprints.unm.ac.id/11573/1/Prosiding tanggal 10 Juni 2019](http://eprints.unm.ac.id/11573/1/Prosiding_tanggal_10_Juni_2019)
- [27] Farrand, P., Hussain, F., & Hennessy, E. (2002). The Efficacy of the ‘Mind Map’ Study Technique. *Medical Education*, 36(5): 426–431. <https://doi.org/10.1046/j.1365-2923.2002.01205.x>
- [28] Davies, M. (2011). Concept Mapping, Mind Mapping and Argument Mapping: What Are The Differences and Do They Matter? *Higher Education*. 62(3): 279-301. <https://doi.org/10.1007/s10734-010-9387-6>
- [29] Leopold, C., & Leutner, D. (2012). Science Text Comprehension: Drawing, Main Idea Selection, and Summarizing as Learning Strategies. *Learning and Instruction*, 22(1): 16-26. <https://doi.org/10.1016/j.learninstruc.2011.05.005>
- [30] Wilson, K., Copeland-Solas, E., & Guthrie-Dixon, N. (2016). A Preliminary Study on The Use of Mind Mapping as A Visual-Learning Strategy In General Education Science Classes for Arabic Speakers in The United Arab Emirates. *Journal of the Scholarship of Teaching and Learning*, 16(1): 31-52. <https://doi.org/10.14434/josotl.v16i1.19181>
- [31] Fadhilaturrehmi. (2017). Penerapan Metode Mind Mapping Untuk Meningkatkan Hasil Belajar Mahasiswa Semester Iima PGSD. *Jurnal Cendikia: Jurnal Pendidikan Matematika*, 1(1): 112–121. <https://doi.org/10.24114/jh.v7i1.6578>
- [32] Chin SF, Norhayati M. (2011). Teacher-Centered Mind Mapping vs Student-Centered Mind Mapping in the Teaching of Accounting at Pre-U Level—An Action Research [J]. *Procedia Social and Behavioral Sciences*. <https://doi.org/10.1016/j.sbspro.2010.10.034>
- [33] Adodo, S.O. (2013). Effect of Mind-Mapping as a Self-Regulated Learning Strategy on Students’ Achievement in Basic Science and Technology. *Mediterranean Journal of Social Sciences*, 4(6): 163-172. <https://doi.org/10.5901/mjss.2013.v4n6p163>
- [34] Liu, Y., Zhao, G., Ma, G., Bo, Y. (2014). The Effect of Mind Mapping on Teaching and Learning: A Meta-Analysis. *Standard Journal of Education and Essay*, 2(1): 017– 031. ISSN: 2310-7545
- [35] Hariyadi, S., Corebima, A.D., Zubaidah, S., & Ibrohim. (2018). Contribution of Mind Mapping, Summarizing, and Questioning in the RQA Learning Model to Genetic Learning Outcomes. *Journal of Turkish Science Education*. 15(1), 80-88. doi: <http://doi.org/10.12973/tused.10222a>
- [36] Holliday, W.G. (2000). Text Book Illustration: Fact or Filler? *Journal Science Teacher*, 57 (9): 27-29.
- [37] Toi, H. 2009. Research on How Mind Map Improves Memory. *Paper*. Dipresentasikan dalam The International Conference on Thinking, tanggal 22 – 26 Juni 2009. Kuala Lumpur.
- [38] Tasiwan. (2016). Transformation of The Students’ Inquiry Capability Through Mindmap Educative by Using Game Observation Normatively (Megono) Learning Model. *Jurnal Pendidikan IPA Indonesia*, 5(1): 123-133. DOI: <https://doi.org/10.15294/jpii.v5i1>
- [39] Ainsworth, S., Prain, V., & Tytler, R. 2011. Drawing to Learn in Science. *Science*, 333(6046):1096-1097. <https://doi.org/10.1126/science.1204153>
- [40] Mason, L., Lowe, R., & Tornatora, M. C. (2013). Self-Generated Drawings for Supporting Comprehension of a Complex Animation. *Contemporary Educational Psychology*, 38(3), 211-224. <https://doi.org/10.1016/j.cedpsych.2013.04.001>.
- [41] Edwards, S., & Cooper, N. (2010). Mind Mapping as a Teaching Resource. *The Clinical Teacher*, 7(4): 236-239. <https://doi.org/10.1111/j.1743-498x.2010.00395.x>
- [42] Spencer, J. R., Anderson, K. M., & Ellis, K. K. (2013). Radiant Thinking and The Use of The Mind Map in Nurse Practitioner Education. *The Journal of Nursing Education*, 52(5): 291-293. <https://doi.org/10.3928/01484834-20130328-03>

- [43] Weinert, F. E. & Kluwe, R. H. (1987). *Metacognition, Motivation, and Understanding*. Hillsdale, New Jersey: Lawrence Erlbaum Associates Publishers.
- [44] Moore, K.C. (2004). *Constructivism & Metacognition*. Retrieved from <http://www.tier1.performance.com/Articles/constructivism.pdf>.
- [45] Bahri, A. & Corebima, A.D. (2015). The Contribution of Learning Motivation And Metacognitive Skill on Cognitive Learning Outcome of Students Within Different Learning Strategies. *Journal of Baltic Science Education*, 14(4), 487-500. ISSN 1648–3898.
- [46] Djuanda, M. (2016). *Urgensi Metakognitif dalam Meningkatkan Mutu Pembelajaran di Madrasah* (Urgency of Metacognition in Improving the Quality of Learning in Madrasah). Retrieved January 28, 2016, from Office of Religious Training Center in Jakarta. The Ministry of Religious Affairs. Web site: <http://bdkjakarta.kemenag.go.id/index.php?a=artikel&id=884>, <https://doi.org/10.31227/osf.io/gs2we>
- [47] Barouch, D. H. (1997). *Voyages in Conceptual Chemistry*. Sudbury, Mass: Jones & Bartlett Publishers.
- [48] Sleet, R., Hager, P., Logan, P., & Hooper, M. (1996). *Broader Skill Requirements of Science Graduates*. Sydney: University of Technology, Sydney.
- [49] Bucat, B., & Shand, T. (1996). *Thinking Tasks in Chemistry, Teaching for Understanding*. Perth: University of Western Australia.
- [50] Keiichi, Shigematsu. (2000). Metacognition in Mathematics Education. Mathematics Education in Japan. Japan: JSME, 2000.
- [51] Collins, N. (1994). *Metacognition and Reading to Learn*. (Online), ([http://www.ed.gov/databases/ERIC\\_Digests/ed376427.html](http://www.ed.gov/databases/ERIC_Digests/ed376427.html)), diakses 19 Mei 2016.
- [52] Setiawan, D. (2015). *Hubungan Antara Minat Baca terhadap Keterampilan Metakognitif pada Pembelajaran Biologi Berbasis Reading Concept Map Think Pair Share Kelas X SMA Negeri di Kota Malang*. Tesis tidak diterbitkan. Malang: Pascasarjana Universitas Negeri Malang. <https://doi.org/10.31227/osf.io/ym96e>
- [53] Antika, L. T., Corebima, A. D., dan Zubaidah, S. (2015). *Pengaruh Pembelajaran Biologi berbasis Reading-Concept Map-STAD terhadap Keterampilan Metakognitif dan Hasil Belajar Kognitif Siswa Kelas X SMA Malang*. Prosiding Seminar Nasional Pendidikan Biologi, Symposium on Biology Education (Symbion) di Universitas Ahmad Dahlan Jogjakarta pada tanggal 4 April 2015. <https://doi.org/10.24127/bioedukasi.v1i1.179>
- [54] Setiawati, H & Corebima, A.D. (2018). Improving Students' Metacognitive Skills through Science Learning by Integrating PQ4R and TPS Strategies at A Senior High School in Parepare, Indonesia. *Journal of Turkish Science Education*, 15(2): 95-106. <http://doi.org/10.12973/tused.10233a> <https://doi.org/10.18535/ijsshi/v4i5.09>
- [55] Mahdavi, M. (2014). An Overview: Metacognition in Education. *International Journal of Multidisciplinary and Current Research* (2): 529-535. ISSN: 2321-3124. Available at: <http://ijmcr.com>
- [56] Listiana, L., Susilo, H., Suwono, H., Suarsini, E. (2016). Contributions of Metacognitive Skills toward Students' Cognitive Abilities of Biology through the Implementation of GITTW (Group Investigation Combined with Think Talk Write) strategy. *Prosiding ICTTE FKIP UNS 2015*, 1(1). ISSN: 2502-4124 <https://doi.org/10.18510/hssr.2019.7370>
- [57] Haryani, S., Amanda, M. H., Wardani, S. (2018). Metacognition Ability of Students through Discovery Learning Practice Guide on Acid-Base Practicum. *International Conference on Mathematics and Science Education*. Vol 3 | P-ISSN 2655-2361, E-ISSN 2655-3252
- [58] Joyce, B., Weil, M., & Calhoun, E. (2009). *Models of teaching, eight edition*. New York: Pearson Education Inc.

- [59] Gunter, M. A. , Estes, T.H., Mintz, S.L. (2010). *Instruction A Models Approach. Fifth Edition*. Boston: Pearson Education.
- [60] Eggen, P. D., & Kauchak, D. P. (2012). *Strategies and Models for Teachers: teaching Content and Thinking Skills. Sixth Edition*. Boston: Pearson Education.
- [61] Arends, R.I. (2012). *Learning to Teach, Ninth Edition*. New York: McGraw-Hill.
- [62] Buzan, (2015). Mind mapping: Scientific Research and Studies. Diakses tanggal 16 September 2019 <https://b701d59276e9340c5b4d-ba88e5c92710a8d62fc2e3a3b5f53bbb.ssl.cf2.rackcdn.com/docs/Mind%20Mapping%20Evidence%20Report.pdf>
- [63] Evrekli, E., Balim, A. G., & Inel, D. (2009). Mind Mapping Applications in Special Teaching Methods Courses for Science Teacher Candidates and Teacher Candidates' Opinions Concerning The Applications. *Procedia - Social and Behavioral Sciences*, 1(1): 2274–2279. <http://doi.org/10.1016/j.sbspro.2009.01.400>
- [64] Blackwell, L.S., Trzesniewski, K.H., and Dweck, C.S. (2007). Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A longitudinal Study and an Intervention. *Child Development*, 78(1): 246-263. <https://doi.org/10.1111/j.1467-8624.2007.00995.x>
- [65] O'Connor, R. C. (2011). The integrated motivational-volitional model of suicidal behavior. *Crisis: The Journal of Crisis Intervention and Suicide Prevention*, 32(6), 295-298. <https://doi.org/10.1027/0227-5910/a000120>
- [66] Solas, E. C., & Wilson, K. (2015). Lessons Learned and Strategies Used While Teaching Core-Curriculum Science Courses to English Language Learners at a Middle Eastern University. *Journal of Turkish Science Education*, 12(2): 81-94. <http://doi.org/10.12973/tused.10142a>
- [67] Stein, G.C., Strzalkowski, T & Wise, G.B. (2000). Interactive, Text-Based Summarization of Multiple Documents. *Computational Intelligence*, 16(4): 606-613. <https://doi.org/10.1111/0824-7935.00131>
- [68] Pintrich, P. R. (2016). The Role Of Metacognitive Knowledge In Learning , Teaching , and Assessing. 5841(April): 219–225. DOI:[10.1207/s15430421tip4104\\_3](https://doi.org/10.1207/s15430421tip4104_3)
- [69] Peet, R.V. D. (2001). Mind Mapping, Concept Mapping en Concept Webbing. *Onderwijs en gezondheidszorg*, 25(5): 23–27. <https://doi.org/10.1007/bf03071243>
- [70] Sugiyono. (2014). *Metode Penelitian Pendidikan, Pendekatan Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta.
- [71] Davis, B., Sumara, D., & Luce-Kaper, R. (2000). *Engaging minds: Learning and teaching in a complex world*. Mahwah, NJ: Lawrence Erlbaum Associates.
- [72] Buzan, T. (2012). *Mind Mapping: Scientific Research and Studies*. London: Think Buzan Ltd.
- [73] Zubaidah, S., Fuad, N.M., Mahanal, S., & Suarsini, E. (2017). Improving Creative Thinking Skills of Students through Differentiated Science Inquiry Integrated with Mind Map. *Journal of Turkish Science Education*, 14(4): 77-91. <http://doi.org/10.12973/tused.10214a>

## 8 Authors

**Dyah Astriani** was a lecturer at Universities Negeri Surabaya, Ketintang St., Surabaya 60231, Indonesia. She is now a Doctoral student at Universitas Negeri Malang, Indonesia. (E-mail: [dyhastriani@unesa.ac.id](mailto:dyhastriani@unesa.ac.id) ).

**Herawati Susilo**. Professor, Researcher, Universities Negeri Malang, Semarang St. 5, Malang 65145, Indonesia. (E-mail: [herawati.susilo.fmipa@um.ac.id](mailto:herawati.susilo.fmipa@um.ac.id)).

**Hadi Suwono.** Professor, Researcher, Universities Negeri Malang, Semarang St. 5, Malang 65145, Indonesia. (E-mail: [hadi.suwono.fmipa@um.ac.id](mailto:hadi.suwono.fmipa@um.ac.id) ).

**Betty Lukiati.** Doctor, Researcher, Universities Negeri Malang, Semarang St. 5, Malang 65145, Indonesia. (E-mail: [betty.lukiati.fmipa@um.ac.id](mailto:betty.lukiati.fmipa@um.ac.id)).

**Aris Rudi Purnomo** was a lecturer at Universities Negeri Surabaya, Ketintang St., Surabaya 60231, Indonesia (Email: [arispurnomo@unesa.ac.id](mailto:arispurnomo@unesa.ac.id))

Article submitted 2019-12-08. Resubmitted 2020-01-07. Final acceptance 2020-01-09. Final version published as submitted by the authors.