

Research Article

Implementing of subject jigsaw learning model and its impact on students' achievement in Embryology course



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ABSTRACT

Subject jigsaw has been identified as one of alternative model to teach difficult materials such as embryology. This study aimed to analyze the impact of the subject jigsaw model on students' achievement. This quasi-experimental study employed post-test only control group design. As many as 84 students from the fifth semester in Biology Department of IAIN Batusangkar were involved as the sample. They were grouped in three classes which were taught using subject jigsaw model, jigsaw model, and conventional (control). The instruments were observation sheet and test. The cooperative skills and student learning outcome data were analyzed using ANOVA and least significance difference (LSD). The results showed that cooperative skills of students, at beginner, intermediate, and advanced levels, who learn with subject jigsaw are higher than those learning with successive Jigsaw of 3.10, 3.21, and 2.99. Furthermore, the students' learning outcomes, who taught with subject jigsaw were significantly different from other treatments ($F = 28.590$; p -value < 0.05). Based on the LSD results showed that the students' achievement on subject jigsaw model was better than the others. Thus, subject jigsaw model is recommended to implement in embryology course.



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INTRODUCTION

The characteristics of biology studies that refer to factual (Hung, Hwang, Lin, Wu, & Su, 2013), theoretical (Freidenreich, Duncan, & Shea, 2011), and conceptual learning (Abdullah, Parris, Lie, Guzdar, & Tour, 2015) are also simultaneously confronted with macro and micro-sized materials and are dynamic in nature (Orcajo & Aznar, 2005). The typology of biology studies makes learning nature more interesting and challenging at the same time (Fleischner et al., 2017). These challenges are not only experienced by students, such as learning difficulties (Fauzi & Fariantika, 2018), but also on how the teacher designs meaningful and memorable learning for students (Iversen, Pedersen, Krogh, & Jensen, 2015). These problems have at least been widely used as a

basis for learning research (Gay, Mills, & Airasian, 2012; Guleker, 2015), including efforts to apply 21st-Century learning models in accordance with the character of student learning and the material being studied (Haviz, 2018; Hsieh, 2014; Scott, 2015).

Jigsaw implementation is not mere a learning method but also an effort that can be done to measure the success of biology learning (Slavin, 2012). (Oakes, Hegedus, Ollerenshaw, Drury, and Ritchie, 2019) found that the jigsaw method increases knowledge about anatomy by involving group work, peer-led learning, minimal supervision, and leads to increased student performance and learning motivation. While other research also reports that various biology topics such as ecology (Asshoff, Düsing, Winkelmann, & Hammann, 2019; Smith & Chang, 2005), microbiology (Jasti, Hug, Waters, & Whitaker, 2014), anatomy (Koprowski & Perigo, 2000), biology developmental (Haviz, 2015) that are taught with jigsaw have a positive impact on students' understanding, interest in learning, and thinking ability including cognitive (Bennett, 2016) and metacognitive awareness (Palennari, 2016).

On the other hand, modifications to the jigsaw model are mostly done by researchers such as jigsaw II (Aronson & Bridgeman, 1979), jigsaw III (Stahl & VanSickle, 1992), jigsaw IV (Holliday, 2000), reverse jigsaw (Hedeen, 2003), and subject jigsaw (Doymus, 2008). Subject jigsaw, according to (Doymus, Karacop, & Simsek, 2010) is indicated to be able to provide the learning experience needed to solve problems in accordance with the topic being studied. Various steps modification in the jigsaw model, apart from being an improvement effort, are also due to adjustments to the various characteristics of students and the topics studied (Haviz, 2015; Smith & Chang, 2005). Furthermore, some researchers believe that the accuracy of the selection of learning models and topics determines student learning success (Akker, Bannan, Kelly, Nieveen, & Plomp, 2010; Plomp & Nieveen, 2013).

Meanwhile, the topic of embryology learning is also faced with a complex study topic because it involves small material on embryonic development (Burns, 2010). These characteristics according to (Dudek, 2011; Haviz, 2018) cause embryology learning achievements are relatively low. These problems need to be anticipated by designing the use of learning methods that activate students' thinking skills (Bensley & Spero, 2014; Guleker, 2015; Larsson, 2017). In addition, students' cooperative skills also need to be facilitated so that, independently, the students are able to build effective discussion rooms with their peer-partners (Hsieh, 2014; Scott, 2015).

This study aims to analyze the impact of the implementation of the subject jigsaw model on students' achievement. Student learning outcomes include cooperative skills and embryological learning outcomes. The results of this study can be used as consideration in solving problems in embryology learning.

METHOD

This experimental study used post-test only control group design (Creswell, 2014). The independent variable was subject jigsaw group (SJG) while the dependent variable was cooperative skill and students' achievement. The treatment groups that included SJG, jigsaw group (JG), and conventional method as control group (CG). As much as 84 students, from the fifth semester - academic year of 2017/2018 Department of Biology Education IAIN Batusangkar-Indonesia, was participate as a subject. The participants were grouped into three classes, each class consisted of 28 students. The students group are based on three characteristics; average achievement index, score of the previous course (anatomy), and their background knowledge.

This experimental study used the different of treatment was written at Table 1. SJG consists of home group (HG) and expert group (EG). HG members are determined based on the sub-topics studied, making it possible to have several different sub-topics in the same group. Furthermore, each HG member is grouped in one group with the same sub-topic discussion (EG) (Doymus, Karacop, & Simsek, 2010). The procedure to making of HG and EG on SJG class written in Figure 1.

Students in the JG class are grouped according to the results of the initial assignment. The students are divided into groups according to the large amount of material being studied. Students who study in expert groups return to the home group to share information. In this group, students do not work on worksheets in the guidelines. Observer observes students' cooperative skills in the learning process. Formative evaluation is not conducted at the end of each sub-topic but at the end of the embryology topic. Whereas in the CG class, students are not grouped into study groups. Students only apply the learning method as usual. Formative evaluation is not done after each class meeting but at the end of all meetings. The post-test was carried out after all embryology topics were studied.

Table 1. The treatment difference of applying jigsaw technique in Embryology course

No	Subject Jigsaw Group (S/JG), N=28	Jigsaw Group (JG), N=28	Control Group (CG), N=28
1	The student was grouping by initial task result and sub-topics	The student was grouping by initial task result	There is no grouping of students
2	Students work on worksheets in the student guidelines	Students did not work on worksheets in the student guidelines	The student did not worksheets in the student guidelines
3	The student was applied the syntax of cooperative learning	The student was applied the syntax of cooperative learning	The student was applied of conventional method
4	Formative evaluation was conduct after meeting the class	Formative evaluation was not conduct after meeting the class	Formative evaluation was not conduct after meeting the class
5	Post-test	Post-test	Post-test

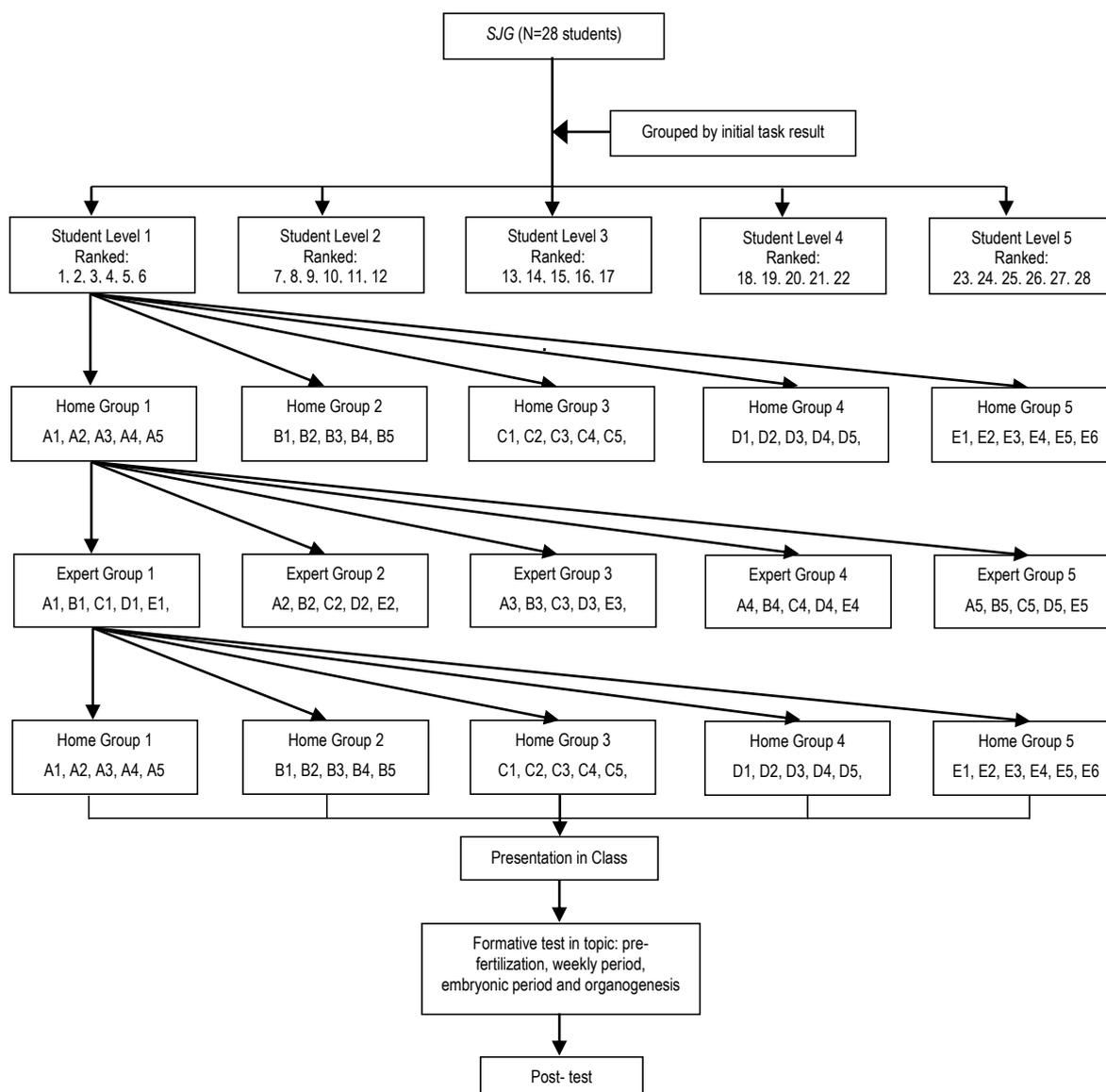


Figure 1. Grouping procedure of HG and EG members at S/JG

Data collection uses a instrument developed by [Haviz \(2016\)](#). The result of the validity and reliability of the test score on Cronbach's alpha were 76.69 and 81.50, while the Levene's test showed that the instrument was homogeneous and normal (P value 0.129 > 0.05). This study also uses student guidelines and is only used by

members in SJG. The all of the students on SJG, JG and CG studied the context of embryology: pre-fertilization, weekly period, embryonic period and organogenesis (Dudek, 2011). The embryological context was studied during 16 meetings and were taught by the same lecturer.

The cooperative skills and learning outcome were analyzed using descriptive statistics. The results of the analysis of cooperative skills score (Table 2) refer to (Haviz, 2016). Furthermore, the difference in the average student achievement was analyzed using ANOVA and continued with the LSD test ($\alpha = 0.05$) to determine the best results of the three treatments.

Table 2. Level of cooperative skills

Mean scores	Level of cooperative skills	Level
$x \geq 3.10$	highly practical/very good	Advance
$2.40 < x \leq 3.09$	practical/good	Advance
$1.60 < x \leq 2.40$	quite practical/pretty good	Intermediate
$0.80 < x \leq 1.60$	less practical/less good	Beginner
$x \leq 0.80$	impractical/not good	Beginner

RESULTS AND DISCUSSION

The results showed that the students' who learned to use SJG, the cooperative skills score were higher than those who learned using JG (Figure 2). The students' cooperative skills in SJG are higher at all levels, i.e., beginner (3.10), intermediate (3.21), and advance (2.99). Furthermore, these results also show that at the beginner and intermediate levels in the SJG class are classified as highly practical/very good ($x \geq 3.10$), whereas in the JG class, the cooperative skill level at beginner, intermediate, and advance is classified as practical / good respectively amounted to 3.01, 2.98, and 2.82.

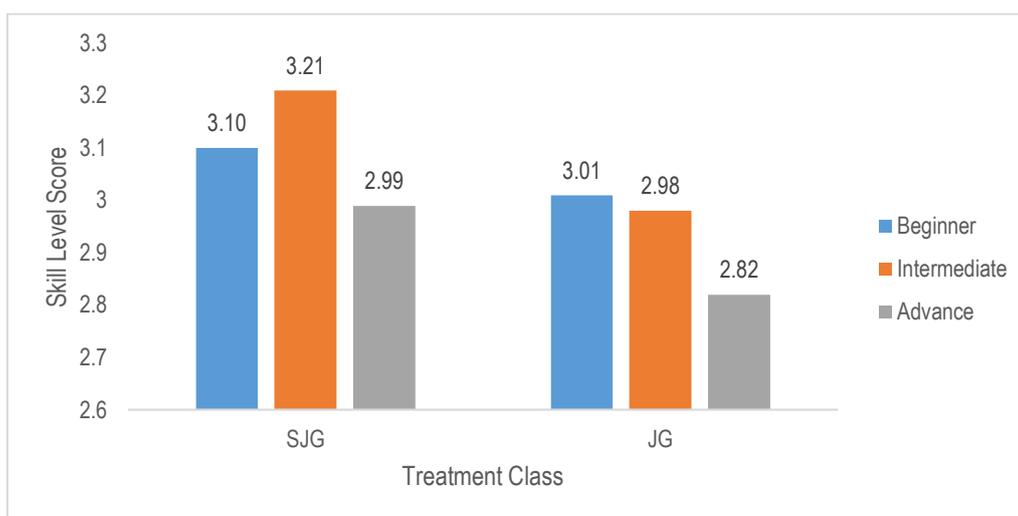


Figure 2. Cooperative of student skills on embryology course

The results also showed that mean of students' achievement in the SJG class was higher than the other two treatment classes (Table 3). Descriptive analysis shows that the average in the SJG class is higher (80.32) compared to JG (73.57) and CG (64.82). Furthermore, the prerequisite test results, normality and homogeneity, showed that the data of the three treatment classes were spread normally and homogeneously (> 0.05), so that parametric analysis (ANOVA) was continued.

Table 3. Descriptive statistics for student achievement scores

Groups	N	$\bar{x} \pm SD$
SJG	28	80.32 \pm 5.69
JG	28	73.57 \pm 5.34
CG	28	64.82 \pm 10.79

The ANOVA test results (Table 4) show that there are differences in students' achievement in the three treatment classes (Sig < 0.05). These results indicates the difference in student learning outcomes within SJG,

JG, and CG classes. Furthermore, the LSD test results with a significance level of 0.05 indicate that students in the SJG class have better learning outcomes than the JG class, as well as student learning outcomes in the JG class are better than the CG class.

Table 4. ANOVA result for student achievement post-test scores

Source	Sum of squares	df	Mean square	F	Sig.
Between groups	3382.167	2	1691.083	28.590	.000
Within groups	4791.071	81	59.149		
Total	8173.238	83			

The findings of this research indicate that implementing jigsaw, as a cooperative learning, in the SJG and JG classes affects the cooperative skills of students and learning outcomes. The division of groups based on the results of the initial assignment and sub-topics that have been applied in the SJG group has a significant effect than the division of the JG groups which is only based on previous learning outcomes. This finding also shows that SJG treatment has influenced the emergence of cooperative student activities, where this activity also affects student learning outcomes.

The implementation of SJG and JG in Embryology course plays a direct role in improving cooperative skills and student achievement (Haviz, 2015, 2016). The principles of cooperative learning that are applied in small groups (Bellanca et al., 2010; Slavin, 2014), provide more space for students to take on the role and work together as a learner (Cetindamar & Hopkins, 2008; Jasti et al., 2014). Social interactions that occur in learning activities affect how students master the material (Pang, Lau, Seah, Cheong, & Low, 2018; Shin, Lee, & Ha, 2017). Some researchers believe that cooperative attitudes can grow with a pattern of habituation in the learning process (Scott, 2015; Triyanto, 2018). Cooperative attitudes such as togetherness in the learning process (Hedeen, 2003; Slish, 2005), responsibilities (Bennett, 2016), perceptions of the same learning goals (Slavin, 2012), fair distribution of responsibilities (Haviz, 2015), appreciation (Oakes et al., 2019), and leadership (Bennett, 2016) always emerge and grow in student learning interactions (Karaçöp, 2016). On the contrary, these results were not found in the CG class. The conventional learning design does not place students in study groups (Madhuri, Kantamreddi, & Prakash-Goteti, 2012). In other words, students learn independently and there is no significant interaction between students. This learning design has an impact not only on social skills but also on student learning outcomes (Domopolii & Rahman, 2019; Pang et al., 2018). Students in CG classes are not accustomed to learning that involves holistic activities.

Cooperative learning was a specific strategy used to achieve learning objectives designed as well with specific instructional design (Bennett, 2016; Roger & Johnson, 2002). This strategy was social learning concerning the aspect of individual responsibility in achieving specific objectives. This way of learning is conducted base on motivational theory (Slavin, 2012). These result study argue that cooperative learning way is not just based on motivational theory, but it is clearly supported by other learning theories such as cognitive, constructivism and behaviorism (Haviz, 2016). These fact is based on the findings of this research. Embryology material used in this research was classified as one of difficult materials in which to be mastered with high critical thinking skill requirement (Burns, 2010; Dudek, 2011). As part of developmental of biology course, embryological material contains many processes, facts, theories, and concepts (Dudek, 2011). Only by applying specific ways of learning and learning materials, it can be mastered as well (Guleker, 2015). Those specific learning methods are at least based on constructivism, behaviorism and cognitivist (Ertmer & Newby, 2013; Iversen et al., 2015; Palennari, 2016). It is also supported by the correlation between facts of learning with those three theories (Yusof, Hassan, Jamaludin, & Harun, 2012).

Nowadays, with technological developments and social shifts (Thompson, 2011), including a culture of learning in schools (Iversen et al., 2015), it is possible to form a multidisciplinary learning community (Ahmadi & Yulianto, 2017; Lawless & Brown, 2015). These changes will eventually produce a new paradigm of integration of theories in learning designs that are adaptive to the values of cooperative skills (Akker et al., 2010; Ertmer & Newby, 2013; Thompson, 2011). Finally, cooperative learning is one area of extraordinary educational theory, research and practice. The results of this study indicate that cooperative learning influences students' learning achievement in Embryology. The application of cooperative syntax in this study makes good student learning outcomes in the experimental class (Huang, Liao, Huang, & Chen, 2014). Good Embryology learning outcomes is begin with good cooperative activity that students have (Bennett, 2016; Chatila & Husseiny, 2017). This explanation is the relationship between theory, research, and practice in embryology learning.

CONCLUSION

This study concluded that cooperative skill of SJG and JG members were not different from one to another, the cooperative skill of these groups was in a good level. The student achievement of SJG member was better than SJ, while SJ was better than CG. Further, it can be concluded that JCL effected toward student learning achievement in Embryology course. The researchers believe that further study toward the cooperative skill of the members in each group is needed to be conducted. The enhancement of the cooperative learning use on the learning activities that required high-order thinking skill is needed to be done.

REFERENCES

- Abdullah, C., Parris, J., Lie, R., Guzdar, A., & Tour, E. (2015). Critical analysis of primary literature in a master's-level class: Effects on self-efficacy and science-process skills. *CBE Life Sciences Education*. doi: <https://doi.org/10.1187/cbe.14-10-0180>
- Ahmadi, A., & Yulianto, B. (2017). Descriptive-analytical studies of literacy movement in Indonesia, 2003-2017. *International Journal of Humanities and Cultural Studies*, 4(3), 16–24. Retrieved from <http://www.ijhcs.com/index.php/ijhcs/index>
- Akker, J. van den, Bannan, B., Kelly, A., Nieveen, N., & Plomp, T. (2010). An introduction to educational design research. *Proceedings of the Seminar Conducted at the East China Normal University, Shanghai (PR China), November 23-26, 2007*, 129. doi: <https://doi.org/10.1097/ACM.0000000000000508>
- Aronson, E., & Bridgeman, D. (1979). Jigsaw group and the desegregated classroom: In pursuit of common goals. *Personality and Social Psychology Bulletin*, 5(4), 438–446. doi: <https://doi.org/10.1177/014616727900500405>
- Asshoff, R., Düsing, K., Winkelmann, T., & Hammann, M. (2019). Considering the levels of biological organisation when teaching carbon flows in a terrestrial ecosystem. *Journal of Biological Education*, 0(0), 1–14. doi: <https://doi.org/10.1080/00219266.2019.1575263>
- Bellanca, J., Brandt, R., Barell, J., Darling-Hammond, L., Dede, C., Dufour, R., ... Seif, E. (2010). 21st century skills: Rethinking how students learn. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 1–27). Solution Tree Press. Retrieved from http://www.edugains.ca/resources21CL/Research/Readings/21stCenturySkills_Re-ThinkingHowStudentsLearn.pdf
- Bennett, B. (2016). Assessment and cooperative learning: The missing think. In *Leadership of Assessment, Inclusion, and Learning* (pp. 45–85). Springer. doi: <https://doi.org/10.1007/978-3-319-23347-5>
- Bensley, D. A., & Spero, R. A. (2014). Improving critical thinking skills and metacognitive monitoring through direct infusion. *Thinking Skills and Creativity*, 12, 55–68. doi: <https://doi.org/10.1016/j.tsc.2014.02.001>
- Burns, E. R. (2010). “Anatomizing” reversed: Use of examination questions that foster use of higher order learning skills by students. *Anatomical Sciences Education*, 334(December), 330–334. doi: <https://doi.org/10.1002/ase.187>
- Cetindamar, D., & Hopkins, T. (2008). Enhancing students' responsibility towards society through civic involvement projects. *Innovations in Education and Teaching International*, 45(4), 401–410. doi: <https://doi.org/10.1080/14703290802377273>
- Chatila, H., & Husseiny, F. Al. (2017). Effect of cooperative learning strategy on students' acquisition and practice of scientific skills in biology. *Journal of Education in Science, Environment and Health (JESEH)*, 3(1), 88–99. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1125794.pdf>
- Creswell, J. W. (2014). *Research design. Qualitative, quantitative, and mixed methods approaches* (Third). Sage Publisher. Retrieved from <http://books.google.com/books?id=bttwENORfhgC&pgis=1>
- Domopolii, I., & Rahman, S. R. (2019). The effect of STAD learning model and science comics on cognitive students achievement. In *International Conference on Mathematics and Science Education (ICMScE 2018)* (pp. 1–6). doi: <https://doi.org/10.1088/1742-6596/1157/2/022008>
- Doymus, K. (2008). Teaching chemical bonding through jigsaw cooperative learning. *Research in Science and Technological Education*, 26(1), 47–57. doi: <https://doi.org/10.1080/02635140701847470>
- Doymus, K., Karacop, A., & Simsek, U. (2010). Effects of jigsaw and animation techniques on students' understanding of concepts and subjects in electrochemistry. *Educational Technology Research and Development*, 58(6), 671–691. doi: <https://doi.org/10.1007/s11423-010-9157-2>
- Dudek, R. W. (2011). *Embryology* (Fifth). Philadelphia: Lippincott Williams & Wilkins. Retrieved from <https://epdf.pub/queue/brs-embryology-5th-edition.html>

- Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, 24(3), 55–76. doi: <https://doi.org/10.1002/piq.21143>
- Fauzi, A., & Fariantika, A. (2018). Courses perceived difficult by undergraduate students majoring in biology. *Biosfer*, 11(2), 78–89. doi: <https://doi.org/10.21009/biosferjpb.v11n2.78-89>
- Fleischner, T. L., Espinoza, R. E., Gerrish, G. A., Greene, H. W., Kimmerer, R. W., Lacey, E. A., ... Zander, L. (2017). Teaching biology in the field: Importance, challenges, and solutions. *BioScience*, 67(6), 558–567. doi: <https://doi.org/10.1093/biosci/bix036>
- Freidenreich, H. B., Duncan, R. G., & Shea, N. (2011). Exploring middle school students' understanding of three conceptual models in genetics. *International Journal of Science Education*, 33(17), 2323–2349. doi: <https://doi.org/10.1080/09500693.2010.536997>
- Gay, L. R., Mills, G. L., & Airasian, P. (2012). *Educational research: competencies for analysis and application*. Boston: Pearson. Retrieved from <http://englishlangkan.com/produk/E Book Educational Research L R Gay Pearson 2012.pdf>
- Guleker, R. (2015). Instructional strategies to foster critical thinking: Self-reported practices of the faculty in Albania. *International Journal of Teaching and Education*, III(4), 6–14. doi: <https://doi.org/10.20472/TE.2015.3.4.002>
- Haviz, M. (2015). Cooperative learning model on developmental of biology. *American Journal of Educational Research*, 3(10), 1298–1304. doi: <https://doi.org/10.12691/education-3-10-14>
- Haviz, M. (2016). Designing and developing the integrated learning model on embryology. *Transylvanian Review*, XXIV(7), 1043–1052. Retrieved from <http://transylvanianreviewjournal.org/index.php/TR/article/view/2998>
- Haviz, M. (2018). Computer-assisted biology learning materials: Designing and developing an interactive CD on spermatogenesis. *IOP Conference Series: Materials Science and Engineering*, 335(1). doi: <https://doi.org/10.1088/1757-899X/335/1/012081>
- Hedeon, T. (2003). The reverse jigsaw: A process of cooperative learning and discussion. *Teaching Sociology*, 31(3), 325–332. doi: <https://doi.org/10.2307/3211330>
- Holliday, D. C. (2000). *The development of Jigsaw IV in a secondary social studies classroom*. Educational Resources Information Center (ERIC). Retrieved from <http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED447045%5Cnhttp://catalogue.nla.gov.au/Record/5675112%5Cnhttp://www.eric.ed.gov/PDFS/ED447045.pdf>
- Hsieh, T. L. (2014). Motivation matters? The relationship among different types of learning motivation, engagement behaviors and learning outcomes of undergraduate students in Taiwan. *Higher Education*, 68(3), 417–433. doi: <https://doi.org/10.1007/s10734-014-9720-6>
- Huang, Y., Liao, Y., Huang, S., & Chen, H. (2014). A Jigsaw-based cooperative learning approach to improve learning outcomes for mobile situated learning. *Educational Technology & Society*, 17(1), 128–140. doi: <https://doi.org/10.2307/jeductechsoci.17.1.128>
- Hung, P. H., Hwang, G., Lin, Y., Wu, T., & Su, I. (2013). Seamless connection between learning and assessment- applying progressive learning tasks in mobile ecology inquiry. *Educational Technology and Society*, 16(1), 194–205. Retrieved from <https://eric.ed.gov/?id=EJ1016359>
- Iversen, A., Pedersen, A. S., Krogh, L., & Jensen, A. A. (2015). Learning, leading, and letting go of control: Learner-led approaches in education. *SAGE Open*, 5(4), 1–11. doi: <https://doi.org/10.1177/2158244015608423>
- Jasti, C., Hug, B., Waters, J. L., & Whitaker, R. J. (2014). How do small things make a big difference? Activities to teach about human–microbe interactions. *The American Biology Teacher*, 76(9), 601–608. doi: <https://doi.org/10.1525/abt.2014.76.9.6>
- Karaçöp, A. (2016). Effects of student teams-achievement divisions cooperative learning with models on students' understanding of electrochemical. *International Education Studies*, 9(11), 104–120. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1118579.pdf>
- Koprowski, J. L., & Perigo, N. (2000). Cooperative learning as a tool to teach vertebrate anatomy. *The American Biology Teacher*, 62(4), 282–284. doi: <https://doi.org/10.2307/4450896>
- Larsson, K. (2017). Understanding and teaching critical thinking—A new approach. *International Journal of Educational Research*, 84(December 2016), 32–42. doi: <https://doi.org/10.1016/j.ijer.2017.05.004>
- Lawless, K. A., & Brown, S. W. (2015). Developing scientific literacy skills through interdisciplinary, technology-based global simulations: GlobalEd 2. *Curriculum Journal*, 26(2), 268–289. doi: <https://doi.org/10.1080/>

09585176.2015.1009133

- Madhuri, G. V., Kantamreddi, V. S. S. N., & Prakash-Goteti, L. N. S. (2012). Promoting higher order thinking skills using inquiry-based learning. *European Journal of Engineering Education*, 37(2), 117–123. doi: <https://doi.org/10.1080/03043797.2012.661701>
- Oakes, D. J., Hegedus, E. M., Ollerenshaw, S. L., Drury, H., & Ritchie, H. E. (2019). Using the jigsaw method to teach abdominal anatomy. *Anatomical Sciences Education*, 12(3), 272–283. doi: <https://doi.org/10.1002/ase.1802>
- Orcajo, T. I., & Aznar, M. M. (2005). Solving problems in genetics II: Conceptual restructuring. *International Journal of Science Education*, 27(12), 1495–1519. doi: <https://doi.org/10.1080/09500690500186584>
- Palennari, M. (2016). Exploring the correlation between metacognition and cognitive retention of students using some biology teaching strategies. *Journal of Baltic Science Education*, 15(5), 617–629. Retrieved from http://www.scientiasocialis.lt/jbse/files/pdf/vol15/617-629.Palennari_JBSE_Vol.15_No.5.pdf
- Pang, C., Lau, J., Seah, C. P., Cheong, L., & Low, A. (2018). Socially challenged collaborative learning of secondary school students in Singapore. *Education Sciences*, 8(24), 1–10. doi: <https://doi.org/10.3390/educsci8010024>
- Plomp, T., & Nieveen, N. (2013). *Educational design research. Part A: An introduction. Educational Design Research*. Enschede: SLO - Netherlands Institute for Curriculum Development. doi: https://doi.org/10.1007/978-1-4614-3185-5_11
- Roger, T., & Johnson, D. W. (2002). An overview of cooperative learning (pp. 1–20). Retrieved from http://digsys.upc.es/ed/general/Gasteiz/docs_ac/Johnson_Overview_of_Cooperative_Learning.pdf
- Scott, C. L. (2015). *The futures of learning 2: What kind of learning for the 21st Century?* Retrieved from <http://unesdoc.unesco.org/images/0024/002429/242996E.pdf>
- Shin, S., Lee, J.-K., & Ha, M. (2017). Influence of career motivation on science learning in Korean high-school students. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(5), 1517–1538. doi: <https://doi.org/10.12973/eurasia.2017.00683a>
- Slavin, R. E. (2012). Cooperative learning and achievement: Theory and research. *Handbook of Psychology, Second Edition*. doi: <https://doi.org/10.1002/9781118133880.hop207008>
- Slavin, R. E. (2014). Cooperative learning and academic achievement: Why does groupwork work? *Anales de Psicología*, 30(3), 785–791. doi: <https://doi.org/10.6018/analesps.30.3.201201>
- Slish, D. (2005). Assessment of the use of the jigsaw method and active learning in non-majors, introductory biology. *Bioscene: Journal of College Biology Teaching*, 31(4), 4–10. Retrieved from http://papa.indstate.edu/amcbt/volume_31/v31-4p4-10.pdf
- Smith, J. I., & Chang, L. (2005). Teaching community ecology as a jigsaw: A collaborative learning activity fostering library research skills. *The American Biology Teacher*, 67(1), 31–36. doi: [https://doi.org/10.1662/0002-7685\(2005\)067\[0031:tceaaj\]2.0.co;2](https://doi.org/10.1662/0002-7685(2005)067[0031:tceaaj]2.0.co;2)
- Stahl, R. J., & VanSickle, R. L. (1992). *Cooperative learning in the social studies classroom: An invitation to social study*. Retrieved from <https://files.eric.ed.gov/fulltext/ED361243.pdf>
- Thompson, C. (2011). Critical thinking across the curriculum: Process over output. *International Journal of Humanities and Social Science*, 1(9), 1–7. Retrieved from http://www.ijhssnet.com/journals/Vol._1_No._9_Special_Issue_July_2011/1.pdf
- Triyanto, T. (2018). Enhancing student scientific attitudes towards civic education lesson through inquiry-based learning. *Journal of Education and Learning (EduLearn)*, 12(2), 207–213. doi: <https://doi.org/10.11591/edulearn.v12i2.8489>
- Yusof, K. M., Hassan, S. A. H. S., Jamaludin, M. Z., & Harun, N. F. (2012). Cooperative Problem-based Learning (CPBL): Framework for integrating cooperative learning and problem-based learning. *Procedia - Social and Behavioral Sciences*, 56(1cthe), 223–232. doi: <https://doi.org/10.1016/j.sbspro.2012.09.649>