Journal of Engineering Science and Technology
Special Issue on AASEC2019, February (2020) 11 - 21

COLLABORATIVE TEACHING IN HEAT TRANSFER FOR SLOW LEARNER STUDENTS

AGUS PRATOMO ANDI WIDODO[1,2,*], ACHMAD HUFAD[1], SUNARDI[1], ASEP BAYU DANI NANDIYANTO[3]

[1]Departemen Pendidikan Khusus, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung, Indonesia
[2]Pendidikan Khusus, Universitas Lambung Mangkurat Indonesia, Jl. Brigjen H. Hasan Basri, Kota Banjarmasin, Indonesia
[3]Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung, Indonesia

*Corresponding Author: andi.pkh.student@upi.edu

Abstract

The aim of this study was to develop a method to teach heat transfer to slow learner students. The study used a single-subject research approach with A-B design (baseline and intervention) in the special need elementary school in Banjarmasin. The subject of this study was three slow learner students. Teaching experimental demonstration methods for explaining heat transfer phenomena (i.e., conduction, convection, and radiation) were done. Teaching process was completed by explaining several laws in physics to students. The teaching process was also done by collaborating between special teachers and regular teachers. The results of the study revealed that subjects requiring cognitive understanding and difficult subjects can be taught to slow learner students. The successful achievement cannot be separated from a collaboration between regular teachers and special teachers. Special teachers play a role in conveying instructions to be simple and concrete. A quiet learning atmosphere in the absence of other audio-visual stimuli, besides experimental media, can make slow learner students more focused. The repetition factor of the subject matter by special teachers during the learning activities is very helpful because the characteristics of the slow learners are more likely to have short-term memories.

Keywords: Education, Heat transfer, Radiation, Repetition, Slow learner, Teaching.

1. Introduction

Heat transfer is a part of the science taught in elementary school [1]. This heat learning lesson is very useful for everyday life, so it is important to be taught at the elementary school level. The right learning approach helps facilitate students in understanding the concepts learned [2]. This is a challenge for teachers to bring up a good understanding of students. This is not only lessons in school but also it relates to its application in the realistic world. It takes the right method so that heat transfer learning can be more concrete and simpler. The teacher should design learning for his students [3]. Good learning fosters curiosity and creativity of students. This competency can be formed if the teacher can package the lessons well. The use of learning media is a necessity to make it happen. Moreover, accompanied by experimental demonstrations will make students more enthusiastic. The existence of science teaching in elementary schools is still a lot of attention and criticism [4].

Researches on heat conductivity are classified as very high at high levels and very less at the basic level, whereas for sustainability research is required in early regeneration. For this reason, we need new generations who have an interest in heat transfer phenomena. This generation can be grown by introducing an experimental demonstration of heat transfer of objects. Teachers must use visual media to get the attention of slow learner children [5]. Science teaching needs to be promoted to schools [6]. Teachers must have sufficient confidence and knowledge to provide science learning [7].

Slow learner students usually have a combination of various obstacles in learning [8]. The challenge is to teach these lessons to children with special needs, specifically for children who are slow to learn. With the intellectual level under the child in general, it makes the difficulties in understanding of slow learner children. Although the experimental demonstration of heat transfer lessons must be formed as more concrete and simpler, slow learner students tend to have a concrete learning style and need help for success in learning [9]. Researches into teaching objects to heat lessons in learning that involve slow learner children is very rare. Reports discussed only on the development level of children. In fact, the academic is potential for learning and it needs to be optimized as far as what the child follows because education is the right of all children without exception.

The implementation of inclusive education requires supporting components, one of which is a special teacher. Its role is very important for slow learner children, by collaborating with regular teachers in class. Collaborative teaching is working with other teachers in an inclusive learning environment. The teacher's positive attitude is crucial to promoting inclusive education [10]. The main task of the teacher is specifically to identify, assess academic and developmental abilities. Other tasks, to be a liaison for class teachers so that teaching is easy to understand, and special teachers also carry out the improvement process if the mastery of slow learner children to the lessons given is still low. Teachers need pedagogical skills in the learning process [11]. School challenges to help some students who are at risk like this [12]. The aim of this study is to develop methods to teach heat transfer lessons to slow learner students.

2. Logical Framework of Heat Transfer Lessons

Figure 1 shows the illustration of heat transfer process on an object. In regular students, understanding the concept of heat transfer of objects will be easily formed through experimental demonstrations. They understand that the heat can be presented as conduction, convection, and radiation [13].

Figure 1(a) is the principle of heat that can propagate metal objects although not as profoundly as the understanding of conduction of solid objects in physics lessons is influenced by changes in temperature, cross-sectional area, and the object length. Indeed, they will feel the change in metal objects to heat slowly. The principle of conduction can be represented as Fourier's Law [13]:

$$q = \left(\frac{k}{s}\right) A.dT \tag{1}$$

where q is the heat transfer (W or J/s), k is the thermal conductivity of material (W/m.K), s is the material thickness (m), A is the heat transfer area (m^2), and dT is the change in temperature (°C).

Figure 1(b) is the illustration of convection, in which normal students understand that liquid objects can deliver heat. The principle of convection was described the Newton's Law of Cooling, which can be expressed as [13,14]

$$q = h.A.dT \tag{2}$$

where h is the convective heat transfer coefficient of the process ($W/(m^2.°C)$).

Figure 1(c) shows that gas/ air objects can also deliver heat through the radiation process, in which the transfer of heat in the form of electromagnetic waves. The expression of radiation is using the Stefan-Boltzmann Law as [13,14]

$$q = \sigma.A.T^4 \tag{3}$$

where σ is the constant ($5.6703\ 10^{-8}$ (W/m^2K^4).

Explanation above heat phenomena is more difficult to teach to students who are slow to learn. They need a long time and special treatment to understand.

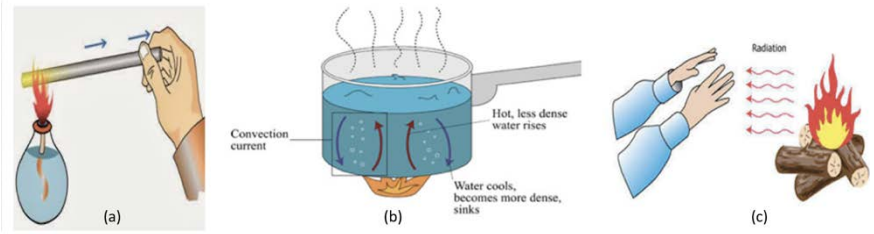

Fig. 1. Illustration of heat transfer [15].

3. Method

This study used the single-subject research method with A-B design (baseline and intervention) to accommodate limited research subjects. The participants involved were three slow learner students in elementary school in Banjarmasin, South Kalimantan, Indonesia with the initials X, Y, and Z. Because the learning

settings were together with regular students, the participants were accompanied by a special teacher who collaborated with the class teacher. To facilitate the delivery of lessons, i.e., heat transfer phenomena, teaching was carried out by experimental demonstrations.

To find out a comprehensive profile of participants, we collected student demographic to ensure the standard teaching for students [16]. IQ level data, assessment of academic learning outcomes (Indonesian Language, Social Sciences, Science, Islamic Religion, Mathematics) and demographic data. Data regarding student IQ levels are obtained through documentation of test results. Demographic data and academic learning outcomes were collected through interviews with regular teachers. The collected data is used to develop research instruments. Analysis of the ability of slow learner students is simplified in the scale of the score from 0 to 6. The scale score is 0 (very bad), 1 (bad), 2 (poor), 3 (good enough), 4. (good), 5 (very good) and 6 (superior).

In short, the analysis was done in ten meetings. The first until the fourth meetings were conducted to look for baseline data (A), namely the understanding of slow learner students (pre-test) for fifteen minutes for each meeting (through interviews). The fifth to the tenth meetings were intervened (B), namely teaching accompanied by experimental demonstrations for 30 minutes and ended with a post-test for fifteen minutes for each meeting (through interviews). Collaborative teaching was carried out by regular teachers and special teachers. Regular teachers taught the whole students while the special teacher specifically focused on slow learner students. Special teachers repeated learning materials that has not been mastered by slow learner students.

Interventions were carried out by teaching about heat transfer on solid, liquid, and gas objects. In addition, teachers also explained the use of objects in understanding heat transfer and application in realistic uses, such as pan for cooking, clothes ironing, and how the blanket works). After that an experimental demonstration was carried out on the heat transfer of objects, along with the repeated repetition of teaching, 6th meetings with one repetition, 7th meeting with two repetitions, 8th meeting with three repetitions, 9th meeting with four times repetition, and 10th meeting with five repetitions.

The experimental demonstrations were carried out with plastic handle Teflon pot (transparent glass lid with 16-cm diameter, 8-cm high, 1.2-L volume). 0.8 L of water was then provided for six demonstrations. Chopsticks made from iron, aluminum, plastic, and wood. Then, we also used 250 g of margarine and 24 pieces of beans. Detailed experiments are shown in Fig. 2.

In short, experimental demonstration was done by boiling water until it boils. Students were then asked to observe the process. Slow learner students were instructed to hold their hands closer to the pot until they feel warm, while at the same time, they were interviewed. The initial demonstration was the same as the main demonstration, which was encroached on to enter four pieces of various kinds of chopsticks until partially submerged in hot water. The tip of the non-submerged chopsticks in the temple with margarine to put green beans. Slow learner students were asked to observe the sequence of chopsticks whose green beans fall.

Fig. 2. Demonstration process [17, 18].

4. Results and Discussion

4.1. Demographic data of slow learner students

Figure 3 shows the demographic data of a slow learner student. There are six information displayed from students aged 13 to 14 years old regarding the diagnosis of a slow learner, cognitive development, motor development, understanding receptive language, and expressive language. This information is very important to know because it describes the extent to which students' IQ abilities will be traced to later understanding of teaching. Slow learner students have an IQ level of 71-89 which makes them have various obstacles [19].

Student X shows level 3 so that the abilities to think, make abstract, and imagine are good enough. Cognitive development was very closely related to language and visual-motor [20]. The language of students' expressive abilities was at level 2, showing that the ability to express information in spoken language is still at a low level. Problems with language development often occur at the age of 2-5 years [21]. Motor development for student Y is better than other slow learner students. Motor development relates to coordination of motion between muscles and nerves [22]. Children's receptive language shows in level 3, meaning the ability to receive instruction from the teacher is at a good enough level. Receptive language ability is the same as other slow learner students at level 2, which is poor. Student Z has fine motor skills and gross motor skills are good enough. Factors that affect motoric development include genetics, prenatal, postnatal, history of birth, and stimulation [23].

Conclusions from previous observations, the level of students' ability has been described. If the classification from the high level to the lowest level is done, the researcher concludes the sequence is Y, X, and Z.

Figure 4 shows the level of understanding of children in the subject. There are five subjects which are observed namely Indonesian Language, Social Sciences, Science, Islamic Religion and mathematics. This information is very important to know the readiness of students to experiment.

Student X understood the Indonesian Language at level 3. Language acquisition relates to the cognitive level of students [24]. Student Y also have problems with abstract and symbolic concepts as a basis for mathematics learning [25]. Students Z have a good understanding of science. There are often misconceptions about science lessons because of the wrong approach [26].

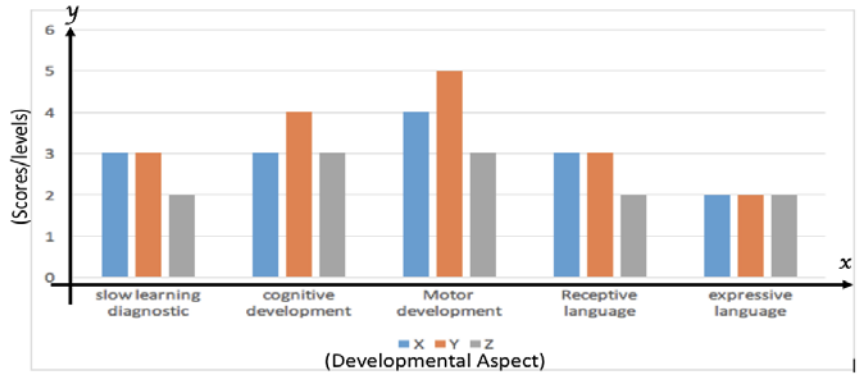

Fig. 3. Demographic data for slow learner students.

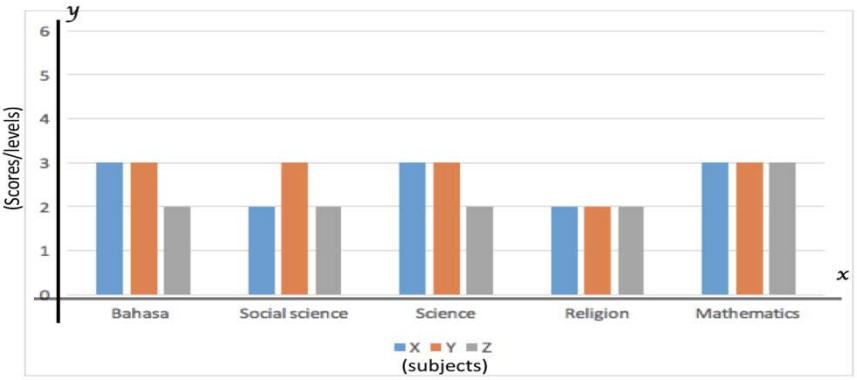

Fig. 4. Level of student understanding of subjects.

4.2. Heat transfer phenomena learned to students

The students have new experience with heat transfer demonstrations. Students observed the movement of beans because of the conductive process on solid objects. When the water is heated, the student feels heat. As is known, the result of the derivative of equation (3) is

$$T = \sqrt[4]{\frac{a}{\sigma.A}} \tag{4}$$

The difference in heat will be felt according to distance. The closer to the heat source, students will understand will feel a higher temperature difference. Radiation is greatly influenced by the distance of objects.

Furthermore, the principle of convection is done by boiling water. Students understand convection by watching the movement of boiling water bubbles. Water will receive heat from a heater made of metal. As is known from the formula to (2), we can reduce to

$$dT = \frac{q}{h.A} \tag{5}$$

We explain to students that the greater the area, the faster the water will boil. We also conducted an experiment to conduct the conduction principle by using the conductor object (iron and aluminum) and insulator object (plastic and wood). The principle of conductor and insulator is also discussed, why it can be different. From equation (1) explained the principle of temperature change, we can make it

$$dT = \frac{q}{\left(\frac{k}{s}\right)A} \tag{6}$$

From equation (6), we explained that there are factors *k* or value of conductivity. To make it short in explanation and because students are still sixth graders in elementary school, we explained that conductors are materials that have a solid atomic density and a solid electron arrangement (although that is actually explained in the discussion of differences in atomic numbers and material properties in periodic systems in advanced subject's science in senior high school in Indonesia). Therefore, conductors have the property to conduct heat easily.

4.3. Teaching process

Demographic and IQ level data provided a basic description of the abilities of slow learners. Experimental demonstration methods were applied to attract students. Students have limited abilities regarding symbolic and abstract. Experimental demonstration methods can be done to increase the successfulness of learning in the classroom [27]. The experimental demonstration method is one of the methods that lead to learning goals [28]. This method begins with giving examples and continuing with students doing independently [29].

The ability of students, in general, is very low, so that good collaboration is needed. Learning does not only focus on critical thinking activities but also collaboration [30]. Collaborative teaching provides pedagogical and intellectual excellence [31]. Collaboration between general teachers and special teachers is needed to help slow learner children in the class. The heat transfer learning process is obtained as follows:

- The initial meeting of learning was done by a conventional method (lecture method). Students were not interested and often turned attention to other objects.
- When carrying out the initial experimental demonstration, students began to show tools and materials to be used. Students' attention began to be focused and curious about the experiments that will be conducted.
- When further demonstrations were carried out, students were very interested and attentive with concentration.
- The results showed that IQ intelligence was not the only factor that determined students' understanding. The right learning methods can also improve the understanding of slow learners.

Learning for slow learner students requires special methods, so students are motivated and focused. Experimental demonstration methods improve student understanding. To find out the understanding level of students, the teacher gave five questions about heat transfer. In Table 1, we compared students' understanding of teaching conditions without experimental demonstrations (*Wo*) with teaching with experimental demonstrations (*W*).

Table 1. Question about heat transfer without (Wo) / with (W) experimental demonstration.

Questions	Students Comparison					
	1		2		3	
	Wo	***W***	***Wo***	***W***	***Wo***	***W***
Do You Know About Heat?	2	3	2	4	1	2
Will Heat Transfer On An Object If It Interacts?	2	3	2	3	1	2
Mention Objects That Can Deliver Heat?	1	2	2	4	1	2
Are There Objects That Are Difficult To Deliver Heat?	1	2	2	3	1	2
How Does Heat Deliver ?	1	2	1	2	1	2

* Note: Comparison of students in understanding heat transfer, *Wo* = Without experimental, and *W* = Experimental

To test the repetition effect, we conducted a test of heat transfer in students. The repetition of lessons was done for five times. Each repetition was taken data about the understanding of students, in which the results are as shown in Fig. 5. At the time of the first repetition, student X has an understanding of level 2. When the repetition of 2-4 times, it increased the understanding level to level 3. In the last session for repetition, student X occupies level 4. Student Y is at level 3 during the first repetition. After repetition 2-4 times, student comprehension increased at level 4. Understanding student Y after 5 times of repetition make it increases again to level 5. The understanding level of student Z is at level 2 on repetitions 1-3 times. On repetition 3-5 times, students' understanding increased at level 3. The results of the observations showed that the repetition of lessons provided an increase in understanding of slow learner students. The effects of lessons repetition are very strong in the learning process [32]. Experimental demonstration learning has been shown to improve understanding of heat transfer [33]. Experimental teaching in heat transfer needs to be promoted to schools [34]. This informs that any difficult subjects can be transferred to any students. The main idea is how teachers make good strategies [35, 36].

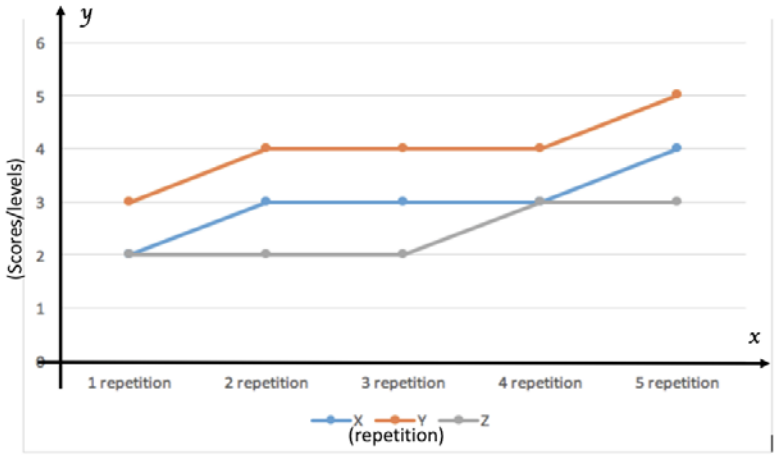

Fig. 5. Effects of repetition on understanding heat transfer lessons for slow learner students.

5. Conclusion

The results of the study showed that subjects that require cognitive understanding can be taught to slow learner students. The successful teaching can be achieved but it requires the collaboration of regular teachers and special teachers. Special teachers play a role in conveying instructions to be simple and concrete. A calm learning atmosphere in the absence of other stimuli makes the slow learner students more focused. Experimental demonstration learning has been shown to improve comprehension of heat transfer for conduction, convection, and radiation. Lessons remedial techniques by special teachers during learning activities are very helpful. This remedial overcomes the weak short-term memory of slow learner children.

References

1. Budiarti, Y.; and Suprihatin, S. (2017). Pengaruh model pembelajaran sain teknologi masyarakat (stm) terhadap 3. kemampuan soft skill mahasiswa. *Promosi: Jurnal Program Studi Pendidikan Ekonomi*, 5(2), 131-144.
2. Nehru, N.; and Syarkowi, A. (2017). Analisis desain pembelajaran untuk meningkatkan literasi sains berdasarkan profil penalaran ilmiah. *Wapfi (Wahana Pendidikan Fisika)*, 2(1), 20-24.
3. Rakhmawan, A.; Setiabudi, A.; and Mudzakir, A. (2015). Perancangan pembelajaran literasi sains berbasis inkuiri pada kegiatan laboratorium. *Jurnal Penelitian dan Pembelajaran IPA*, 1(1), 143-152.
4. Chaffin, A.J.; and Harlow, S.D. (2005). Cognitive learning applied to older adult learners and technology. *Educational Gerontology*, 31(4), 301-329.
5. Furtak, E.M.; Seidel, T.; Iverson, H.; and Briggs, D.C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: a meta-analysis. *Review of Educational Research*, 82(3), 300-329.
6. Alper, J. (1994). Scientists return to the elementary-school classroom. *Science*, 264(5160), 768-770.
7. Zhang, C.; and Chen, X. (2012). Use of multimedia in gross infective pathogen experimental teaching. *Procedia Engineering*, 37, 64-67.
8. Malik, S. (2009). Effect of intervention training on mental abilities of slow learners. *International Journal of Educational Sciences*, 1(1), 61-64.
9. Ediger, M. (2002). Reading and the slow learner. Retrieved September 25, 2019, from https://files.eric.ed.gov/fulltext/ED469152.pdf
10. McLeskey, J.; Waldron, N.L.; and Redd, L. (2014). A case study of a highly effective, inclusive elementary school. *The Journal of Special Education*, 48(1), 59-70.
11. Cardona, C.M. (2009). Teacher education students' beliefs of inclusion and perceived competence to teach students with disabilities in Spain. *Journal of The International Association of Special Education*, 10(1), 33-41.
12. Shaw, S.R. (2010). Rescuing students from the slow learner trap. *Principal Leadership*, 10(6), 12-16.
13. Susanto, H.; and Irawan, D. (2017). Pengaruh jarak antar pipa pada kolektor terhadap panas yang dihasilkan solar water heater (swh). *Turbo: Jurnal Program Studi Teknik Mesin*, 6(1), 84-91.

14. Abdurrahman, A.; Umam, R.; Irzaman, I.; Palupi, E.K.; Saregar, A.; Syazali, M.; and Adi, L.C. (2019). Optimization and interpretation of heat distribution in sterilization room using convection pipe. *Indonesian Journal of Science and Technology*, 4(2), 204-219.
15. Latif, M. (2019). 3 Cara perpindahan panas. Retrieved September 25, 2019, from http://maslatip.com/3-cara-perpindahan-panas.html.
16. Nandiyanto, A.B.D.; Asyahidda, F.N.; Danuwijaya, A.A.; Abdullah, A.G.; Amelia, N.; Hudha, M.N.; and Aziz, M. (2018). Teaching "nanotechnology" for elementary students with deaf and hard of hearing. *Journal of Engineering Science and Technology* (*JESTEC*), 13(5), 1352-1363.
17. SimWiki. (2019). What is heat transfer? Retrieved September 29, 2019, from https://www.simscale.com/docs/content/simwiki/heattransfer/whatisht.html.
18. Ruff, Bess. (2019). How to do a simple heat conduction experiment. Retrieved September 29, 2019, from https://www.wikihow.com/Do-a-Simple-Heat-Conduction-Experiment.
19. Novitasari, N.; Lukito, A.; and Ekawati, R. (2018). Slow learner errors analysis in solving fractions problems in inclusive junior high school class. In *Journal of Physics: Conference Series*, 947(1), 012035, 1-6.
20. Dhamayanti, M.; and Herlina, M. (2016). Skrining gangguan kognitif dan bahasa dengan menggunakancapute scales (cognitive adaptive test/clinical linguistic & auditory milestone scale-cat/clams). *Sari Pediatri*, 11(3), 189-98.
21. Dewanti, A.; Widjaja, J.A.; Tjandrajani, A.; and Burhany, A.A. (2016). Karakteristik keterlambatan bicara di klinik khusus tumbuh kembang rumah sakit anak dan bunda harapan kita tahun 2008-2009. *Sari Pediatri*, 14(4), 230-234.
22. Wahyuningsri, W.; Yudiernawati, A.; and Meylia, M. (2017). Stimulasi perkembangan motorik halus pada anak todler. *Jurnal Keperawatan Terapan (E-Journal)*, 3(1), 50-55.
23. Ananditha, A.C. (2017). Faktor-faktor yang berhubungan dengan perkembangan motorik kasar pada anak toddler. *Jurnal Keperawatan Muhammadiyah*, 2(1), 113-118.
24. Sukirman, S. (2012). Hubungan antara perkembangan kognitif anak dan pemerolehan bahasa (tinjauan pembelajaran bahasa). *Ulul Albab: Media Aktualisasi Fikir Dan Zikir*, 14(1), 76-92.
25. Wulandari, S.; and Prasetyaningrum, S. (2018). Media stamp game untuk meningkatkan kemampuan berhitung anak slow learner di sekolah dasar. *Psympathic: Jurnal Ilmiah Psikologi*, 5(2), 131-148.
26. Abdillah, L A., Sari, I.N., and Indriani, D.E. (2018). Computer science student's simulation in capturing tacit knowledge by using ngt for reducing traffic jam. *arXiv preprint arXiv:1807.06082*, 1463-1467.
27. Rofian, R. (2017). Penerapan metode pembelajaran demostrasi pada pendidikan seni rupa di sekolah dasar. *Malih Peddas (Majalah Ilmiah Pendidikan Dasar)*, 6(2), 173-181.
28. Prayogi, S.; and Yuanita, L. (2018). Critical inquiry-based learning: a model of learning to promote critical thinking among prospective teachers of physic. *Journal of Turkish Science Education (TUSED)*, 15(1), 43-56.

29. Kusumawardani, I.D. (2015). Penerapan metode demonstrasi pada mata pelajaran ipa untuk meningkatkan hasil belajar siswa kelas v sekolah dasar. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar*, 2(3), 1-11.
30. Shibley, I.A. (2006). Interdisciplinary team teaching: Negotiating pedagogical differences. *College Teaching*, 54(3), 271-274.
31. Leavitt, M. (2006). Team teaching: benefits and challenges. speaking of teaching. *The Center for Teaching and Learning, Stanford University*, 16(1), 1-3.
32. Utami, W.H.; Susilawati, E.; and Salam, U. (2016). The effectiveness of repetition and role play in teaching speaking. *Jurnal Pendidikan Dan Pembelajaran*, 5(3), 1-10.
33. Sarada, S.N.; Raju, A.S.R.; Radha, K.K.; and Sunder, L.S. (2010). Enhancement of heat transfer using varying width twisted tape inserts. *International Journal of Engineering, Science and Technology* (*JESTEC*), 2(6), 107-118.
34. Mydin, M.O. (2013). Modeling of transient heat transfer in foamed concrete slab. *Journal of Engineering Science and Technology* (*JESTEC*), 8(3), 326-343.
35. Haristiani, N.; and Firmansyah, D.B. (2016). Android application for enhancing Japanese JLPT N5 kanji ability. *Journal of Engineering Science and Technology* (*JESTEC*) (special issue), 11, 106-114.
36. Al-Najar, H.; and El-Hamarneh, B. (2019). The effect of education level on accepting the reuse of treated effluent in irrigation. *Indonesian Journal of Science and Technology*, 4(1), 28-38.