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Using 5E Learning Cycle-Based Laboratory Activity in Improving Students' Problem Solving Skills on Mixture Separation Topic

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Abstract: Using 5E learning cycle-based laboratory activity in improving students' problem solving skills on mixture separation topic. Objectives: The aim of this study was to describe the effectivity of laboratory activity on mixture separation topic based on 5E learning cycle to improve students' problem solving skills. **Methods**: This quasi-experimental study was carried out in the SMPN 33 Bandar Lampung by using the matching only pretest-posttest control group design. The 7th-D and the 7th-E grade were used as experimental and control classes, respectively, which they were obtained by using purposive sampling technique. **Findings:** The effectivity of 5E learning cycle-based laboratory activity measured based on the n-gainand the effect size values. The n-gain value of experimental and control classes were in medium (0.52) and low (0.29) categorized, respectively. The effect size value was in large categorized (0.67). **Conclusion:** These results indicated that 5E learning cycle-based laboratory activity could be effective to improve students' problem solving skills to separate of mixture.

Keywords: problem solving skills, laboratory activity, 5E learning cycle.

Abstrak: Menggunakan aktivitas laboratorium berbasis learning cycle 5E dalam meningkatkan keterampilan pemecahan masalah siswa pada topik pemisahan campuran. Tujuan: *Penelitian ini bertujuan untuk mendeskripsikan efektivitas aktivitas laboratorium berbasis siklus belajar 5E pada materi Pemisahan Campuran dalam meningkatkan keterampilan pemecahan masalah siswa.* ***Metode:*** *Penelitian ini merupakan kuasi eksperimen yang telah dilaksanakan di SMPN 33 Bandar Lampung dengan menggunakan desain the matching only pretest-posttest control group.Dengan teknik purposive sampling diperoleh kelas 7D dan 7E sebagai kelas eksperimen dan kontrol.* ***Temuan:*** *Efektivitas aktivitas laboratorium berbasis siklus belajar 5E diukur berdasarkan nilai n-gain dan ukuran dampak.Nilai n-gain di kelas eksperimen berkategori sedang (0,52) dan di kelas kontrol berkategori rendah (0,29). Nilai ukuran dampak berada dalam kategori besar (0,67).* ***Kesimpulan****: Hasil tersebut mengindikasikan bahwa aktivitas laboratorium berbasis siklus belajar 5E efektif dalam meningkatkan keterampilan pemecahan masalah siswa dalam pemisahan campuran.*

Kata kunci: *keterampilan pemecahan masalah, aktivitas aboratorium, siklus belajar 5E.*

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INTRODUCTION

The era of globalization is closely related to challenges and competition (Baygin, Yetis,Karaköse, &Akin, 2016;Benešová, Hirman, Steiner, & Tupa, 2018; . In connection with that, a nation must develop and improve the quality of human resources (Marjan, Arnyana, Setiawan, & Si, 2014; Benešová & Tupa, 2017). This is related to the emergence of increasingly complex problems and the large level of competition in various aspects. Education has a very central role in improving the quality of human resources which will be the main foundation for a nation to compete. In line with that, formal education is one vehicle in building quality human resources through various subjects, one of which is Science Education (Integrated Science) which contributes to building high quality human resources (Regulation of the Minister of Education and Culture, 2016; Apriyani, Fadiawati, & Syamsuri, 2019). Based on the result of the International Association for the Evaluation of Educational Achievement (IEA) and the National Center for EducationStatistics (NCES) Trends in International Mathematics and Science Study (TIMSS) has shows that in 2015, Indonesia was ranked 44th out of 47 countries (IEA, 2019; NCES, 2019). Result of the Organization for Economic Cooperation and Development's (OECD's) Program for International Student Assessment (PISA) has shown that in 2015, Indonesia was ranked 69th out of 76 countries (OECD, 2018). This becomes a parameter that the quality of Indonesian education still bad compared to other countries and was a portrait of the low level of students' thinking skills.

The low result in TIMSS and PISA because the questions tested are contextual questions, demanding reasoning, argumentation and need creativity in its completion (OECD, 2018; IEA, 2019; NCES, 2019). PISA questions are very demanding problem solving abilities (Research Center of Education, 2016). A student is said to be able to solve a problem if he can apply the knowledge previously obtained into a new situation that has not been know. Thus, the low achievement of Indonesian students in the TIMSS and PISA study shows the low problem solving skills of Indonesian students (Arimbawa, Sadia, & Tika, 2013).

The causes of low problem solving skills of students is also sourced from the implementation of learning that still apply conventional methods, where learning activities are still centered on teachers and students tend to be passive (Simon, 1975; Foshay & Kirkley, 2003). The result of structured interview towards seventeen science teachers in Lampung indicates that all of teachers still used lecture method (conventional method) while teaching science especially mixed separation topic and not yet trained problem solving skills. So students need a learning process that can make them become active and trained in their thinking skills.

One of the means of learning that teachers can use to train students to think in the learning process is learning accompanied by laboratory activities (LAs) (Duangpummet, Chaiyen, &Chenprakhon, 2019; Bancual & Ricafort, 2019). LAs is an important activity in science education that teaches students "how to learn". With LAs, the learning process will be student-centered, where students are given the opportunity to conduct research and not rely on the teacher as a source of information in learning (Kibirige, Osodo, & MGiba, 2014). The existence of LAs is very possible because of the application of various science process skills as well as the development of scientific attitudes that support the process of acquiring knowledge (scientific products) in students. This is how it appears how LAs have a very important position in science learning because through LAs students have the opportunity to develop and apply thinking skills, scientific attitudes in order to gain knowledge (Duangpummet, Chaiyen, &Chenprakhon, 2019; Lohajinda, Pathumsara, & Teeka, 2019).

One of the basic competencies (BC) of knowledge in science in the 7th grade at secondary school is "understanding the concepts of mixed and single substances (elements and compounds), physical and chemical properties, physical and chemical changes in daily life" with basic competence of skills is "presenting the results of the Investigation or work about properties of the solution, physical change and chemical change or mixed separation"(Regulation of the Minister of Education and Culture, 2018). When viewed from the BC, students are faced with real problems until finally students can solve the problem based on the results of the investigation, considering that in everyday life is often faced with problems related to the separation of the mixture for example to purifying substances, separating impurities and others.

Learning models that are suitable for learning are accompanied by LAs, one of which is the 5E Learning Cycle (5E-LC). 5E-LC is a learning model that allows variations in teaching and provides opportunities for a rich learning environment to be organized. This is because each "E" is part of the process of helping students learn and experience in connecting previous knowledge with new concepts, this model consists of: engagement, exploration, explanation, elaboration, and evaluation (Rodriguez, Allen, Harron, & Qadri, 2019; Robertson, Dunlap, Nivens, &Barnett, 2019). In the engagement stage, students were given contextual problems related to the separation mixtures, such as filtration, sublimation, and distillation. Contextual problems that were given to students is intended so that students were able to formulate and solve problems. In the exploration stage, students' LAs can be observed in this stage. Students conduct investigate of phenomena to develop problem-solving skills to test a hypothesis. In the explanation stage, students were allowed to demonstrate their abilities related to conceptual understanding, thinking skills, and process skills that are demonstrated by laboratory activities to separate mixtures. In the elaboration stage, students were asked to deduce information obtained based on experimental data in the hope that new experiences will be obtained. In the last stage, evaluation, students evaluate their LAs during learning mixture separation topics.

Some research results show that a LAs by using 5E-LC model can improve student's learning outcomes (Karsli & Ayas, 2012; 2014). Based on the description, in this paper we would to describe the effectivity of LAs on mixture separation topic based on 5E-LC to improve students' problem solving skills.

METHOD

This quasi-experimental study was implemented in SMPN 33 Bandar Lampung by using the matching onlypretest-posttest control group design. Samples in this study are students in the the 7th grade-D and the 7th grade-E which they were obtained by using purposive sampling technique. The 7th grade-D used as the experimental class which was given treatment LAs using 5E-LC. In other hands the 7th grade-E used as the control class with conventional learning. The problem solving skills in this study were measured by a test instrument, which consisted of ten essay questions. The tests are carried out before (pretest) and after (posttest) interventions.

The effectivity of 5E-LC-based LAs measured based on the n-gain and the effect size values. The n-gain value is interpreted according to Hake's Standard (Hake, 1998). The effect size value is interpreted according to Cohen's Standard (Minium, King, & Bear, 1993). Effect size is the magnitude of the average difference between the two intervention groups (control and experiment). Effect size is important to calculate, because the p value only informs whether there is an effect / impact, while the effect size can inform the size of the impact (Sullivan and Feinn, 2012)

RESULT AND DISCUSSION

The n-gain and Effect Size

The problem solving skills in this study were measured by a test instrument, which consisted of ten essay questions. The tests are carried out before (pretest) and after (posttest) interventions, in the control and experimental classes. The average pretest and posttest score of problem solving skills students in both classes are shown in Figure 1.

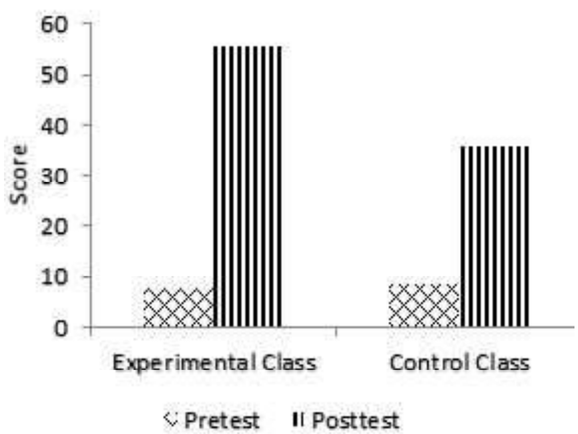


Figure 1. The average pretest and posttest score of problem solving skills students in the experimental and the control classes

Based on Figure 1, the average pretest score of problem solving skills students in the experimental and the control classes were 7.75 and 8.42, respectively. Statistically, students both in the experimental and the control classes were considered to have the same initial problem solving skills. Thus, both classes can be used as research classes. In the other hands, the average posttest score of problem solving skills students in the experimental and the control classes were 55.52 and 35.75, respectively. Statistically, problem solving skills students in the experimental class was higher than the control class.

The amount of improving problem solving skills is shown by n-gain. n-gain is obtained by calculating the difference between the posttest and pretest scores, then dividing it by the difference between the maximum score and the pretest score (Hake, 1998). The n-gain value of problem solving skills students in both classes are shown in Figure 2.

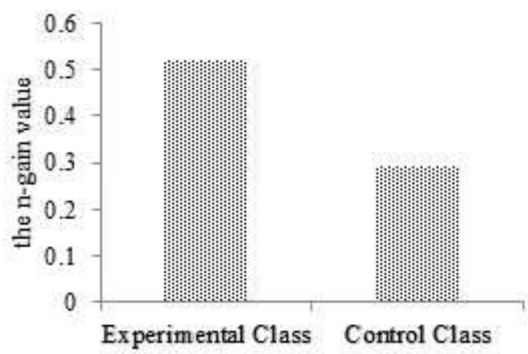


Figure 2. The average n-gain value of problem solving skills students in the experimental and the control classes

Based on Figure 2, the average n-gain value of problem solving skills students in the experimental and the control classes were 0.52 and 0.29, respectively. According to Hake's Standard, the experimental class in medium categorized and the control class in low categorized. In other hands, from the effect size test obtained a result of 0.67. According to Cohen's Standard, the effect size value in large categorized.

Teacher's and Students' Responses to LA based 5E-LC

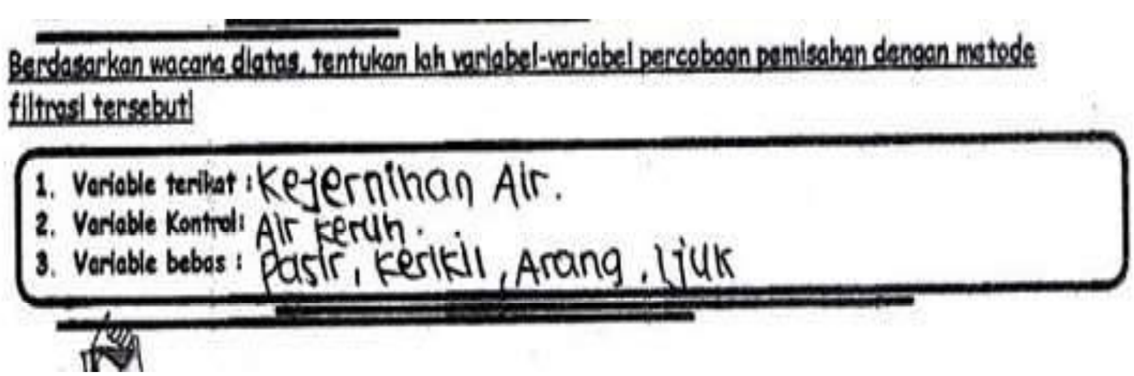
The results of the teacher's response to learning that implemented a 5E-LC mixed LAs program to improve problem solving skills by 100% with the criteria of "very high" with this percentage can be seen that the laboratory activity program is interesting to be applied by the teachers. The same thing can be seen from the positive response of the students as a whole to LAs using 5E-LC on mixed separation material that is equal to 98.48% with the criteria of "very high", based on the percentage of student responses that can be found to be happy with the learning material, student worksheets, and familiar with the stages of problem solving.

Improving Problem Solving Skill

The effectiveness of the mixed LAsusing 5E-LC to improve students' problem solving skills in this study based on the n-gain and effect size data can occur due to several main factors, one of which is each stage of the 5e-LC syntax trained problem solving. The problem solving process trained is (1) formulating a problem; (2) developing temporary answers (hypotheses); (3) testing the hypothesis; (4) develop and draw conclusions; and (5) make apply conclusions to new data or experiences (Beyer, 1995).

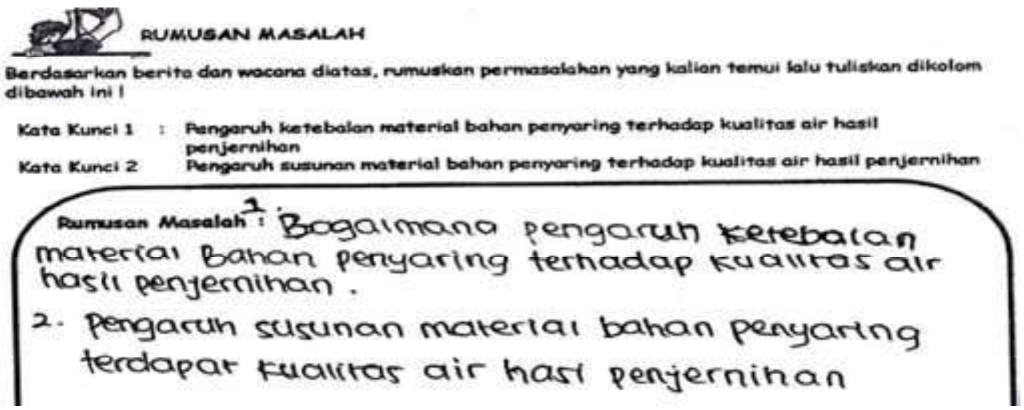
The ability to form a problem is the initial stage of the problem solving process that is trained in the engagement stage in an effort to improve problem solving skills. The purpose of this engagement stage is to attract students' attention and interest. Students are asked to focus on a situation and problem that involves content and abilities that are the purpose of teaching. Every beginning of learning students are given a student worksheet that contains discourse/news, from the discourse it is expected that students can determine the variables on the problem to facilitate the first problem solving process, namely formulating the problem. This is done considering that one of the characteristics of the problem is the relationship between two or more variables (Fraenkel, Wallen, & Hyun, 2012). The 1st to 5thLAs of students did not experience difficulties in determining bound variables, control variables, and independent variables. Examples of student answers in determining the variables are in Figure 3.

The existence of these variables students then formulate a problem based on the discourse presented on the student worksheet. On the 1st and 2nd student worksheets, almost all students in the experimental class did not find it difficult (Figure 4) because the student worksheets were given keywords to make it easier to formulate the problem. On the 3rd student worksheets, students formulate the problem longer because there are no keywords, while on the 4th and 5th student worksheets, students are already getting used to formulating problems without keywords.


Berdasarkan wacana diatas, tentukan lah variabel-variabel percobaan pemisahan dengan metode filtrasi tersebut!

1. Variable terikat : Kejernihan Air.
2. Variable Kontrol: Air keruh.
3. Variable bebas : Pasir, kerikil, Arang, ijuk

Figure 3. Student answers in determining variables


RUMUSAN MASALAH

Berdasarkan berita dan wacana diatas, rumuskan permasalahan yang kalian temui lalu tuliskan dikolom dibawah ini !

Kata Kunci 1 : Pengaruh ketebalan material bahan penyaring terhadap kualitas air hasil penjernihan

Kata Kunci 2 Pengaruh susunan material bahan penyaring terhadap kualitas air hasil penjernihan

Rumusan Masalah : 1. Bogaimana pengaruh ketebalan materiai Bahan penyaring terhadap kualitas air hasil penjernihan.

2. Pengaruh susunan materiai bahan penyaring terdapat kualitas air hasi penjernihan

Figure 4. Formulation of problems made by students on the 1st student worksheets (filtration)

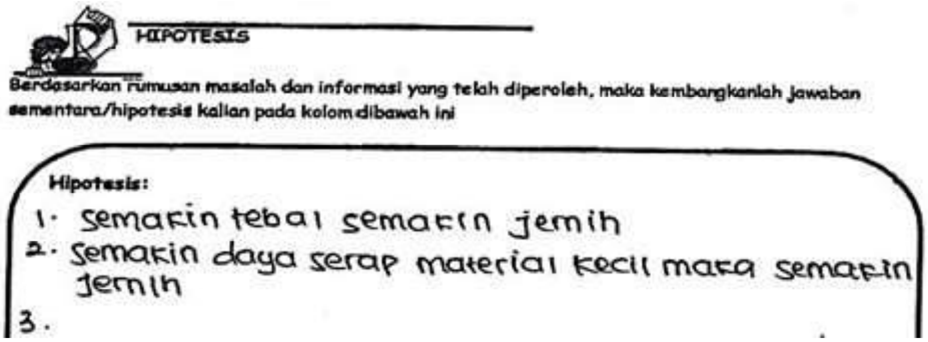
Students' ability to formulate these problems can improve problem solving skills. That to improve problem solving skills there are several ways to disclose problems that can be done such as: problems with open answers, problems expressed using oral, nonverbal problems, using diagrams, graphs and images, raising problems that do not use numbers, using analogies, and using student problem formulation (Riedesel, 1990).

This stage of engagement does not only train students' ability to formulate problems, in this case students are also trained to construct their minds on the material being taught and connect it to the problems found in everyday-life so that students will know more about the meaning of the material being taught. This is consistent with Ausubel's learning theory of meaningful learning, which states that meaningful learning is a process of linking new information with concepts that are relevant and contained in one's cognitive. In addition, the engagement stage is a major factor in improving organizational performance (Markos & Sridevi, 2010) and is the key to improving student learning outcomes (Fredricks et al., 2011).

Learning in the experimental class shows students more active than the control class, where the experimental class is more enthusiastic in learning when reading discourses that contain problems close to everyday-life. Students have great curiosity when reading the discourse. That through engagement, students will be more active in the learning process (Fredricks et al., 2011).

The exploration phase is trained in the process to solve the problems, namely developing temporary answers (hypotheses) and testing hypotheses, namely by carrying out LAs. In addition, on the student worksheet, students are also asked to find information, control variables, write LA programs, determine tools and materials, and write down experimental data by discussing between group members. In the first LAsstudents were not well coordinated because they were not used to conducting group discussions during learning. Some students who sat in the back seemed still reluctant to immediately work on the student worksheets that had been distributed, so the teacher came to the group and gave instructions so they could do it.

Writing hypotheses in the first LA was also not well described by students (Figure 5). Controlling the variables in the first LA is good enough, but students seem lazy to write on the student worksheet, it is also seen in the design of the experimental procedure and determination of tools and materials. Filtration LA (the 1st) shows that students are not used to discussing questions on student worksheets.


HIPOTESIS

Berdasarkan rumusan masalah dan informasi yang telah diperoleh, maka kembangkanlah jawaban sementara/hipotesis kalian pada kolom dibawah ini

Hipotesis:
1. semakin tebal semakin jemih
2. semakin daya serap materiai kecil maka semakin jemih
3.

Figure 5. Writing hypotheses by students on the 1st student worksheets (filtration)

Different things can be seen when the LAs are running, students are very enthusiastic in asking, trying, and seeing what LAs are shown in Figure 6. Most of the LAs using 5E-LC are carried out by students, so students are given more opportunities to make own experience. As a result, students' cognitive abilities towards things that have been learned are better than students who tend to listen and imitate the things that their teacher does. The LAs of mixed separation based on 5E-LC that have been carried out in accordance with the theory expressed by Piaget'stheory which states that knowledge is formed by students in dealing with the environment or object being studied (Ginsburg & Opper, 1998).

Figure 6. Enthusiastic students in laboratory filtration activities

LAs carried out at this exploration stage improve students' problem solving skills in this study which is supported by n-gain and effect size described above. Experimental activities in LAs are part of the learning process. LAs can make concepts that were originally abstract to be more concrete and easier to learn. In addition, LAs can train students to think scientifically and creatively, make observations, collect and analyze data, and solve problems (Bancual & Ricafort, 2009). By conducting LAs students can find their own facts and can associate experiences that are full of symbols and calculations obtained in the learning process (McMahon, McMahon, &Khomtchouk, 2019). Experiments in the laboratory (LAs) are not just activities to prove or match theories that have been given in class, match reactions with theories but prioritize the process of scientific thinking with the emergence of questions related to the material being studied (Nugroho, Budiasih, Sukarianingsih, 2013).

The problem solving process that is trained in the next stage (explanation) is developing and drawing conclusions. In the explanation stage, students build their own knowledge and re-express the concepts they have acquired during the exploration stage. At this stage, students make presentations to explain the results of the experiments obtained and conduct discussions to express the arguments of each group and give reasons logically based on the results obtained (Simon, 1975; Foshay & Kirkley, 2003).

Explanation in the 1st LAs, it seems that students are not used to arguing/explaining what they did at the exploration stage. Still in the 2nd LAs students tend to be passive and shy in discussion. The activity of students in the explanation stage begins to increase seen in the 3rd LAs, students where students have begun to be able to construct knowledge at the exploration stage to be explained. The increase also occurs in the 4th and 5th LAs. Communication of students in group discussions at the explanation stage increases with increasing ability to explain, this occurs because in this LA applied cooperative learning (Stensvold & Wilson, 1990). That through cooperative learning that is carried out effectively and performs a careful assessment of every communication that occurs in each student activity both individually and in groups, can develop communication skills in solving the problems encountered (Simon, 1975; Foshay & Kirkley, 2003).

In the elaboration stage, students practice solving new problems on the student worksheets. Students are involved in a group discussion that discusses a new situation or problem so students can apply the concepts that have been found before. Students develop the findings obtained in the exploration stage to be used in solving the problems at the elaboration stage.

Elaboration on the 1st LAs, students have not been accustomed to reconstructing their knowledge obtained at the stage of exploration and explanation. Students only seek information from learning sources, so the teacher seeks to train students to associate the knowledge that has been obtained in the previous stage. This happened in the 2nd LAs, students were still getting used to elaborating. Increased elaboration began to appear in the 3rd LAs and so on. Students are used to constructing knowledge from the previous stage. Solutions in solving problems at the elaboration stage are getting better. This shows that problem solving skills increase by training the problem solving process.

Elaboration stage, involves several student abilities, such as the ability to organize, analyze, generalize, and conduct evaluations. When students complete practice questions related to the concepts obtained at the exploration stage, students will use cognitive or intellectual abilities. The elaboration activities carried out in each lesson will familiarize students to organize, analyze, generalize and evaluate material or concepts obtained in the previous stage. This activity will develop problem solving skills. It because of an activity cognitive related thoughts (Simon, 1975; Ginsburg & Opper, 1998; Foshay & Kirkley, 2003)

In the evaluation stage students are invited to recall activities that have been carried out during the learning process (Bybee et al., 2006). At this stage students are asked to give suggestions based on the obstacles they face during LAs. Evaluation of the 2nd LAs, students have well provided suggestions for problem solving in accordance with the conditions/ conditions they are facing. This shows that problem solving skills have begun to increase.

Improved problem solving skills are caused by being trained in problem solving skills through a problem solving process. The process of solving problems that are trained is to formulate problems, hypothesize, test hypotheses, conclude, and apply conclusions to new experiences. The students learn to recognize a problem, characteristics of solutions, find relevant information, build strategies to find solutions, and implement selected strategies. It accustoms students to solve problems. By familiarizing students in problem solving activities, it is expected that the ability to solve various problems will increase (Borthick & Jones, 2000).

CONCLUSION

Based on the results of research and discussion, it was concluded that LAs using 5E-LC effective in improving problem solving skills on mixture separation topic. The average of improving of students' problem solving skills was medium criterion. The effect size value of students' problem solving skills was large category. Suggestion that can be given are science teachers need to learn their students with laboratory activities using the 5E learning cycle, so that their problem solving skills can be trained. In addition, further researcher needs to use LAs using 5E-LC on similar material characteristics.

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