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CREATIVITY TOWARDS DESIGN BASED LEARNING IN STEM EDUCATION

Kreativitas Pada Pembelajaran Berbasis Desain Dalam Pendidikan Stem

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Abstract: Creativity is a key component in the last century skills and has been highlighted in curricular research globally especially in Indonesia. This research therefore aimed at analyzing and identifying perspectives of creativity by pre-service teachers when a likely solution step was generated in the DBL. Three separate design based learning activities were undertaken by 13 female and 11 male pre-service teachers. Two separate methods have been used for analysis of data gathered from pre-service teachers' writings and drawings, half-structured interviews, and field notes. In quantitative study of pre-service teachers' works and in exploring the notions of creativity, fluency, flexibility, and originality. In this study descriptive analysis was used. In semi-structured interviews and field notes the findings of the descriptive analysis included quality analyses. Description analysis showed the highest showed in creativity and flexibility, but the lowest was originality. The findings of content analysis further showed a variety of factors influencing the uniqueness of pre-service teachers ideas including exposure of people to ideas, knowledge of design based learning and the prototyping of pre-service teachers' ideas. The study results might enhance the usage of DBL to help educators and researchers understand the strengths and limits of their pupils through the creativity and STEM education.
Keyword: Design based learning, learning model, creativity, and STEM Education

Abstract: Kreativitas adalah komponen kunci dalam keterampilan abad terakhir dan telah disorot dalam penelitian kurikuler secara global terutama di Indonesia. Oleh karena itu penelitian ini bertujuan untuk menganalisis dan mengidentifikasi perspektif kreativitas oleh guru pra-jabatan ketika langkah solusi yang mungkin dihasilkan dalam DBL. Tiga kegiatan pembelajaran berbasis desain yang terpisah dilakukan oleh 13 guru prajabatan perempuan dan 11 laki-laki. Dua metode terpisah telah digunakan untuk analisis data yang dikumpulkan dari tulisan dan gambar guru prajabatan, wawancara setengah terstruktur, dan catatan lapangan. Dalam studi kuantitatif karya guru pra-jabatan dan dalam mengeksplorasi gagasan kreativitas, kelancaran, fleksibilitas, dan orisinalitas. Dalam penelitian ini digunakan analisis deskriptif. Dalam wawancara semi-terstruktur dan catatan lapangan, temuan analisis deskriptif termasuk analisis kualitas. Analisis deskripsi menunjukkan kreativitas dan fleksibilitas yang paling tinggi, tetapi yang terendah adalah orisinalitas. Temuan analisis isi lebih lanjut menunjukkan berbagai faktor yang mempengaruhi keunikan gagasan guru prajabatan termasuk paparan orang terhadap gagasan, pengetahuan tentang pembelajaran berbasis desain dan pembuatan prototipe gagasan guru prajabatan. Hasil studi dapat meningkatkan penggunaan DBL untuk membantu pendidik dan peneliti memahami kekuatan dan batas siswa mereka melalui kreativitas dan pendidikan STEM.
Kata Kunci: Pembelajaran berbasis desain, model pembelajaran, kreativitas, dan Pendidikan STEM

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INTODUCTION

Many creative definitions were offered in the literature. The leader of the notions Guilford (1950) characterized creativity as "the greatest attributes of creative individuals". Further, creativity "is the way to education and the solution of the most important human issues". An important pieces of literature also illustrate the fact that creativity is viewed as a capacity to generate high-quality, innovative products (Kaufma and Sternberg, 2007).

Creativity in today's educational environments is considered a crucial engine of civilizations (Hennessey and Amabile 2010). Educational system in Indonesia refers to pupils learn how to explore and approach open air issues in schools focusing on creativity, dealing with nations which are changing and preparing them for ever changing professions and skills in the production of innovations, findings and artistic results (Kress and Rule 2017). Creative training can increase the creative thinking of students, as well as the fact that younger children have shown more creative than the older children (Conradty and Bonger 2018).

LITERATURE REVIEW

1. STEM education and creativity

The curriculum in scientific education is considered an essential element of the 20th century abilities and stressed in Indonesia and other nations. The literature generally stresses that creative thinking has to be encouraged in schools (Denson 2015). STEM teaching approach may improve teachers' ability to address real world problems, and is defined by a mix of two or more disciplines (Sanders 2009).

Harris and Bruin (2018) stated that STEM Education focuses on creativity and proposed experimental study to identify strategies to make STEM Education more creative. Henriksen (2014) has another theoretical research which says that STEM's interdisciplinary character allows students to use its knowledge from a variety of disciplines in order to develop a new product, based on the integration of science, mathematics, engineering and technology. STEM training is therefore one of the most significant methods to creative development. In STEM education, Nemiro et al. (2017) works together with 194 primary school children, adopted robots during the three-year term. The students worked intensively on open-ended robotics problems in this exploratory observational research. Robot-

ics can increase the inventiveness of pupils, they discovered. In addition, they emphasized that new methods or techniques of evaluating or examining creativity in STEM education are needed. Research involving 95 high school pupils in and outside the classroom environment has been done by Biçer et al. (2017). This study evaluated students' opinions of the requirements in STEM for creativity and computational design utilizing engineering design procedures.

2. Creativity in STEM education through design based learning

For STEM Instruction for Real Life Challenges, DBL depends on the real-world integration of engineering with classroom applications (Felix 2010). In order to cope with these questions, students need to get science, math and technology through engineering principles which make science and mathematics true. The DBL technology makes it difficult for students to build a knowledge base, include students into the design process and increase knowledge (Altan, 2017).

Design Engineering is a technique which was detailed on various models in the corresponding subject literature (Brunsell 2012). The basic design phase starts with problem identification (Brunsell 2012). The problem in design usually begins with a scenario in real life. In this phase, engineers identify the problem, (qualities or properties to be incorporated in successful designs) and (difficulties or barriers to effective design) constraints for difficulty resolution (Hynes et al. 2011).

Only if the problem is properly stated can a successful solution be discovered. Students also endure the same technique with well defined issues as engineers. After the problem has been resolved, students might take time to thoroughly understand the challenge and define design standards and limits to avoid good student design (Brunsell 2012). The second phase of the design process which demands most creative thought is the creation of viable solutions (Valjak 2017). Students should offer as many recommendations for solving the problem based on the criteria and restrictions (Brunsell 2012). Third, the biggest way forward is to choose. In this example, students discuss how each solution fulfills the requirements of the issue (Hynes et al. 2011). Lee et al (2011) suggested examining other approaches and how a designer or problem solver might tackle comparable challenges.

This observation integrates both these design and creative phases with the development of different concepts and the optimum decision. Participants must create and test their solutions based on problem based in a prototype which is the final resolution report or model. At the end, students exchange ideas and results for feedback with other students, such engineers (Mentzer 2011).

Several engineering studies have emphasized the relevance of the arts of creativity (Kowaltowski et al. 2010) as well as other research projects in the fields of creativity (Syukri et al. 2017). Keana (2016) presented STEM as a technique for increasing creativity.

The poorly defined design problems and product-oriented design learning processes match the nature of creativity. The Siew (2017) study revealed that the STEM Engineering Process can be used to encourage creativity, problem resolution and thought among rural high school students. This technique is used to promote creativity. In another study, results showed that a creative product is dependent on the expertise of STEM preservice teachers (Mayasari et al. 2016). In each idea, Mayasari et al. (2016), discovered that after 15 design classes correspondingly, the flexibility, fluency, originality and the elaboration of participants' products increased. In another study, the output of the students was evaluated using the principles of fluency, flexibility, originality and elaboration based on creative thinking evaluations (Chasanah et al. 2017). The survey indicated that the notion that students obtain the greatest rating for their goods was elaboration.

Syukri et al. (2017) showed that DBL activities display creativity ideas in the prototype of their solutions for preservice teachers and the original technical prototypes of the students have got the lowest scores in the concepts of creativity. The effects of investigative questioning methods on creativity in DBL have been explored by Hathcock et al. (2015). In both experimental and control groups, they have carried out design oriented tasks. However, they also utilized research-based interrogation methods in the experimental

RESEARCH METHOD

This study was based on a qualitative and quantitative (Mixed Method) approach to a case study design. The case studies are regarded to be the kind of study the research carries out in depth with the help of a range of data gathering

techniques, exploring a program, an event, an activity, a process and/or one or more persons. Case studies are the chosen method when questions about "how" or "why" are raised, the researcher has limited influence over occurrences and focused on a current phenomena in a setting of real life. Identifies four different categories of case studies: single, multi-colored, and multi embedded designs.

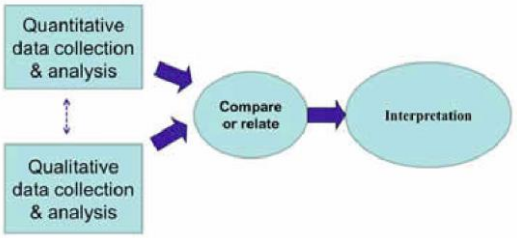

Figure 1. Research Methodology

The investigated example was the creativity components of student-generated ideas in developing feasible DBL solutions. The analytical unit was the student groups. The solutions of the group have been evaluated on the basis of the creative components.

1. Research Sample

24 randomly selected pre-service teachers from 54 candidates from Universitas Esa Unggul in Indonesian participated in this study. The participants were between 18 and 22 years old. 54 percent of the participants are female and 46 percent male. All students were very successful with a GPA of 3.0-3.8 out of 4. For 80 percent of participants, the average monthly household income was medium socioeconomic and at least one parent had a secondary education. The socio economic status of the pupils was low with a household income of less than US$ 300 per month, and parents without high school diplomas.

In this study the students were allocated 6 groups of 4 individuals in each category. They wrote on paper instructor names in advance to decide who went to which group to allocate pre-service teachers to groups, reportedly. The researchers gave a great deal of information. Each group was dubbed the eagles, canaries, lions, bears, monks and whales.

2. Instruments and Procedure

As part of a significant project, statistics were collected for STEM education for precautionary instructors. This initiative was funded by the University. The project aimed to enhance concepts and proficiency in these scientific, technology, engineering and mathematics areas of pre-service teachers. Three DBL activities gathered data from this survey were participating in 24 students. Three workshops were completed at 14 sessions in 1 semester.

These three exercises were created for pre-service teachers majoring elementary school education. The engineering design process and the implementation in the classroom (design based training) of the technical design process was taken into account by Brunsell (2012). Design challenges were initially recognized using this technique and needs and constraints were taken into account. The actual world situation, several ways and more than one field associated with these problems might be handled. Instructions for implementing and training the DBL process were subsequently prepared. Three experts assessed the work. Two professionals evaluated the exercises for their appropriateness to DBL. The other expert reviewed the exercises for creative thinking growth and an assessment of innovative issues. The experts claimed all three exercises are acceptable for pupils in real life to do the DBL procedure. On the other hand, the specialists contributed to the quality of the activity. The typographical mistakes of the three experts have been rectified. Apart from these adjustments, the use of a language to promote creative thinking and prevent students from leading them to a certain technique for thinking was an important comment for the first exercise. The first step in this exercise was to clarify the requirements of the DBL test technique such as do not allow cats and dogs dry. Only the last action received positive input.

The researchers looked at the pre-service teachers throughout their work and did not only make designs, but also gained the information and skills necessary to tackle the problems of design in STEM areas. The students needed the benefit of their current knowledge, science, technology and maths to deal with these design challenges. The activities used for DBL techniques are: (1) Helping people with visual disabilities in traffic, (2) Don't let cats and dogs dehydrate, and (3) An environment for birds to live in.

3. Data Sources

In the second stage of DBL, the writings and drawings of the pre-service teachers gave quantitative information, which led to the creation of feasible solutions. A field notes from researchers and semi-structured interviews have taken the quality component of the data into account.

a. Writings and drawings of the pre-service teachers

The investigators asked the groups to write down, draw up or explain any feasible approach of addressing the design challenge. Preservice teachers have to communicate their ideas as comfortably as feasible. Some pre-service teachers provide just written replies, and some students characterize their selections using little side remarks. Therefore, as part of quantitative data sources the researchers used the writing of instructors and their drawings to provide their future answers.

In researching on its potential answers, researchers invited pre-service teachers to act quietly and independently. They were encouraged to put down their thoughts for possible solutions on paper before professors presented their views. This was because they did not impose their own ideas on the group and stopped the entire creative process of the group. They did the same. All solutions that each group member thought separately were listed by the lecturer in the same group.

b. Semi structured interviews

As part of the data collecting method, the researchers have used semi structured interviews to clarify the response and to obtain further detailed information on the subject using several samples (Given 2008). In order to identify the substance of the semi structured interviews, the researchers examined the purposes, context of the activities and age of the participants and created three questions. These three questions were then assessed by two experts on the basis of the adequacy of the study, the activities setting and the age range of the participants. After these questions had been validated by the specialists, the last data collection included: 'What are your issues when you build viable solutions,' ' What may be the reasons why you have encountered these problems?' and 'What did that experience do you do?' These interviews with the participants took done in the classroom and lasted around 20 minutes each interview.

4. Data Analysis

The data sources included field notes, semi structured student interviews and participants essays. In descriptive and contents analyzes of the data in two sections. Sketches and drawings of the

participants were analyzed using descriptive analysis in the first phase. The participants can find more than one answer (fluency), various sorts of solutions (flexible), unique and original solutions (original) and have to develop their solutions on the basis of the literature (elaboration). Therefore, the researchers evaluated they papers on the basis of the number of solutions they have written, their unique and distinctive responses, the amount of information they have provided and how often they have been descripted with their thoughts. The pre-service teachers received 1 fluency point for every solution. However, these responses were examined for flexibility and only those that differentiated them from the previous one and were not solely based on the previous one were given 1 item. The researchers examined solutions for all groups for the originality score, comparing each solution to solutions from other groups and assigned 1 point per solution unique to the total sampling. for each solution. And each alternative for development was awarded 1 point by researchers, which was explained more thoroughly and the reader may consider the final outcome.

The second section used content analysis to assess the findings of descriptive analysis with field notes and semi-Structured interviews. The semi-structured interview data has been assessed with a deductive technique. The scientists studied the data, determined the model of the code and labeled the codes. Three questions were identified including difficulties, causes and experiences. Each of these codes is finally related to design principles based on their creative input.

RESULTS AND DISCUSSION

This study was conducted to investigate approaches in the development of feasible DBL solutions through creativity. The results were based on research questions and creative concepts in pre-service teachers' responses and creative ideas were provided under subheadings.

The goal of this study was to address issues regarding the extent to which their creativity is shown while generating forward looking DBL solutions and what they feel constitutes DBL. Based on the findings of the report, highest frequency of invention followed by elaboration, flexibility and originality was obtained by developing practical DBL solutions. Alt-

hough fluency is the most frequent answer. A solid assessment of the creativity of fluency is not sufficient. Since creativity comprises three other notions, including adaptation, originality and production, creativity must be a creative person in all four concepts (Guilford, 1950). The researchers revealed that it was difficult for them to create new solutions following a correct answer that affected ideas for flexibility and originality when they analyzed the causes of the low frequency in three concepts other than fluency. This research helps understand the nature of the possible solutions phases of DBL.

At this step, the designer was asked to find as many choices as possible to provide the best response to create a prototype that is consistent with the smooth creative conception. Based on our findings, fluency levels were plainly comparable for the first two activities. But, with regard to flexibility and creativity. Meanwhile, the frequency decreased from first to second activity. Due to the awareness of students that many responses were expected to be generated in the first two tasks, their fluency was high. On the other hand the third activity has generated concepts which are simple to turn into a prototype as it understands the notion of enhancing a design. In other words, during the first two activities they focused on the number of the answers, whereas the third focus was on the practicality of the solution. Through their third activity, they learned that just a few solutions had to be produced which could become a prototype and ceased to generate more alternatives. This finding conforms to the research carried out by Syukri et al (2017), who discovered the smallest size of originality across all conceptions of creativity, which showed the equivalence of fluency and flexibility, above and beyond originality and elaboration.

Another reason for their lack of novelty might be that most of these activities have been done in a small school environment. In this classroom they were positioned close together. Thus, while some researchers have tried to prevent inaccurate ideas, since the pre-service teachers or group proposes a solution to an acute issue in a small classroom environment. Those early thinking can easily affect other pre-service teachers.

As both of the they mentioned in the field by stating it loudly, the other students generally ceased reflecting on any other unique ideas once a student or group plant a solution inside the thoughts of other students. This can either be because they are worried that their initial thoughts

are being criticized or they are suffering from a brainstorm. For these reasons, the learners generated just the original answers and then ceased generating further solutions. If DBL is applied in educational institutions, the pupils should be placed as far as they can in a training setting and minimal interaction should be assured while generating prospective solutions to reduce interaction with each others ideas.

The participants could discuss in depth their solutions throughout the development process. When researchers revisited their field notes, they could explain these findings. They consider that the children have sufficient competence to design solutions which represent their outcomes when they were chosen from the high grade. They also consider that a reason for the high developmental level is that the children were aware that the ideal approach for each participants would be to select from the choices given.

In half structured interviews and reports about pre-service teachers' impression of future DBL solutions while researchers addressed the second question. In the initial semi structured interview method, they stated solutions and prototypes were significant obstacles. Their lack of general education course experience in these types of activities might better explain this finding. In general education classrooms, especially youngsters are encouraged to make a success of science and mathematics generally enough to answer a problem correctly so that they earn a high degree. In other words, in typical classrooms kids were urged to provide a good answer rather than create alternative and innovative solutions. Therefore, they have not been used to develop and execute other ideas. Since it is tough to produce several or two solutions while still creating the same concepts with smaller modifications, it is also difficult to build various sorts of solutions that harm fluency, flexibility and creative uniqueness. This study conclude that focusing on the right solution alone reduces the learners' originality and inventiveness. Since creativity is one of the talents necessary for success in the 21st century. Educators should study lessons that inspire learners to respond accurately and innovatively.

In this area, the results of field notes are supported by students' statements on developing solutions similar to those unknown and bored by such design procedures. Finally, remarks from students on teamwork experiences, further ideas, the

resolution of real-life problems, unique thoughts and detailed ideas would indicate how DBL's work in these sectors contributes to students' creativity in terms of fluency, originality and development. Several studies stated that the creativity of students can enhance via the DBL process (Syukri et al. 2017). The findings of this study are confirmed in perspective of DBL as a means to implementation of STEM education by studies showing that STEM education has become creative (Harris and Bruin 2018).

Before reproducing present work, future researchers should examine several consequences of this study. First, researchers should ensure that the training environment is enough to encourage the creative thinking of the students in the selection of design projects. Mobile workstations, for example “can help create a learning atmosphere”. During each working session, pupils can sit separately and not be impacted by other pre-service teachers' opinions and then join the desks in a working group for them to work with groups. Educators should do that as well as in order to prevent students from hesitating to follow this norm alone. The educators must clearly justify the rule of no communication throughout each activity.

The educators should remind the students that they talk about the solutions they have developed when they meet their group members. Secondly, the scientists or researchers did not meddle in the process with a blanket reply to all pupils inquiries. However, future scientists could attempt to encourage students, in order to analyze the shift in creative thought in the DBL process to generate the most possible solutions while developing unique ideas with comprehensive descriptions. Researchers in literature have shown that, after 15 design lessons, originality in participants' goods is thus boosted in each idea (Syukri et al. 2017).

Therefore, pupils may be expected to display high levels of innovative thinking following an instructional method. Thirdly, DBL should be used in accordance with the regular curriculum to acquaint pupils with such educational activity. Fifth, while STEM projects may be considered a way to foster creativity, longitudinal designs are more appropriate for literature Those can be claimed that they can be used to create, solve problems and think via engineering design (Siew 2017).

CONCLUSION

This article shows the highest description of creativity and flexibility,

but the lowest is originality. The findings of further analysis show various factors that influence the uniqueness of preservice teachers' ideas including people's exposure to ideas, knowledge of design-based learning and prototypes of preservice teacher ideas. The study results can increase the use of DBL to help educators and researchers understand students' strengths and limits through creativity and STEM education..

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