ANALYSIS DIMENSIONS OF CREATIVITY IN STEM INTEGRATED PROJECT-BASED LEARNING

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Abstract

This study was aimed to analyze the dimensions of creativity in integrated project-based learning in Science, Technology, Engineering, and Mathematics (STEM). The research method uses descriptive statistical analysis. This research was conducted on students of the Physics Education Study Program in Banjarmasin. The research subjects consisted of 24 physics teacher prospective students programming Applied Physics courses. Data obtained through tests, questionnaires and interviews. Data were analyzed by calculating the normality test, difference test, andn gain. The results showed the order of increasing the percentage ofn gainin the creativity dimension from the lowest to the highest, namely the person dimension, the press dimension, the product dimension, and the process dimension. The strength of this research is to train the creativity of prospective teacher students through project creation by integrating STEM fields that combine cognitive, affective, and psychomotor abilities by exploring the problems that exist in their neighborhood. Further research on the dimensions of creativity in other learning models is needed to explore student creativity continuously and sustainably in order to produce quality resources.

Keywords: dimensions of creativity, project-based learning, STEM

INTRODUCTION

Education in 21th century has the prominent challenge caused by the global economic situation focusing on the innovation and creativity (Susilowati *et al*., 2020). Creativity is the main competency that have to be had individually, organizationally, or nationally to survive in this global competition. The innovatively creative change is the basic form of creativity. Generally, creativity recognizes as the cognitive ability that is able to produce meaningful new idea based on new perspectives. (Sternberg, 2012). While, Guilford (Reisman, 2013) interpreted creativity as the ability consisting fluency, flexibility, originality, and elaboration. The creative features are marked by the ability in possessing broad perspective, the ability to cope with the risk along with all the consequences, strong faith possession toward the problems (Tsai, 2015; Triyono *et al*., 2017).

Psychologists measured creativity level based on three dimensional criterion known as "3P" consisting of person, process, and product. The following, grown up, in which creativity is the pivoting point to observe the individual and environmental supporting individual to be creative agent (Guillasper *et al*., 2020; Amabile, 2018). The growth is known as the creativity dimension "4P" consisting of persons, process, press, and product (Inchamnan *et al*., 2012).

Person dimension elaborates about individual creativity in one population. This dimension focused on individual characteristic consisting personality, distinctive thought, motivation, knowledge, and emotional intelligent (Tsai, 2015).

Creativity features consist of basic skills, creativity skills, and motivation. Basic skills consist of technical skill, knowledge, and distinct aptitude. The creativity skill is personality connecting with with creativity, those are self-discipline, tolerance, and the ability to cope with the risk. The Motivation consists of extrinsic and intrinsic motivation (Amabile, 2018). Dimension of person feature with curiosity, talkative, a lot of idea, open minded, artsy, stern, imaginative, original, adaptive, and elaborative (Munandar, 2012).

The dimension of process is a learning step to be in creative thinking. This step is different with the process of increasing creative thinking process which is the constituent's step constituting mental activity. Creative thinking indicator is constituted from flexibility, originality, and elaboration (Reisman, 2013). Fluency is the ability to find the idea. More of the idea that can be found, more creative the person to manifest the best among the idea found. Flexibility is the ability to overcome the problem by using appropriate approach. Originality pivots to the unique respond, rarely happening, and distinct (Klavir *et al.*, 2011). Elaboration is the ability to parse the problem specifically. The habit to think creatively is afektif approach consisting motivation, self-confidence, ready to deal with challenge, imagination, and curiosity (Chen *et al.*, 2019; Wiyarsi & Çalik, 2019). To think creatively becomes one of the creativity consisting creative thing king, creative behavior, creative act, and creative product (Maintjes & Grosser, 2010).

Press dimension is an interaction between living being and their environment. (Amabile, 2018; Winarno *et al.*, 2019). Environment affecting generally belongs to a tradition (family background, organization, and culture) specifically (Runco & Albert, 2010). One of the way to increase the creativity can be reach by creating professionally conducive social environment. Creativity effort identification consist of autonomy, resources, freedom, appropriate role model, innovation, and constructive criticism (Amabile, 2018). The activities barrier such as bureaucrat, time limit, non-constructive evaluation, and unfair rivalry (Inchamnan, 2012). Press dimension consists of internal encouragement and external encouragement. Internal encouragement consist of high curiosity, the eagerness to try new things, having a lot of idea, being questioners, working independently. The external encouragement consist of openness, independency, responsibility, distinctive expressive, flexibility in countering problem, multilingual, and on one's own initiative (Clark, 2015, p. 383). Product dimension is translated as creative product character originally distinctive from common products. The creative product can be an idea, solution, and performance. Creative product can be tangible or intangible. Tangible product is for sale invention. Intangible product likes methodology, character building, and service development (Isaken *et al.*, 2011). *Creative Product analysis Matrix (CPAM)* is an assessment instrument of creativ product developed by Besemer & O'Quin (Kuan-Chen, 2018). This creative product assessment consists of novelty, resolution, elaboration, and synthesis. Novelty assumed as the product originality referring to its concept, process, and material used to create the product. Resolution is the level of product clarity to overcome issues. Elaboration and synthesis are the form of product's scheme (Cahya *et al.*, 2019; Reis & Peters, 2020).

That Creativity dimension suits to be applied in learning of Science, Technology, Engineering, and Mathematics (STEM). This learning characteristic is

creative learning based model applying theory in daily basis activity focusing in contextual learning (Komalasari *et al.*, 2014; Ambarini, 2017) through complex activity by integrating inter-discipline subjects of Science, Technology, Engineering, and Mathematics (Gonzalez & Kuenzi, 2012). In this creative learning based model stated to be useful in enhancing 21th century training ability including creativity (Sloug & Milam, 2013) by integrating STEM (Sanders, 2012). The learning procedures based on project consists of planning, creating, and the steps of project based learning model which is categorized into six categorization, those are; essentials, Planning, scheduling, monitoring, assessing, and evaluating (Putri *et al.*, 2017).

Essential question relating with daily life has open characteristics with more than one correct answers in tackling the problem. Then, planning step sues students to be fully active in their drafted project. Later on, in scheduling step, it obligate students to cope with their scheduled timeline and their scheduled project working. After preceding step, there is monitoring issues that have to be conduct accordingly by the students. Monitoring the project progression that is conducted by the students through motivation reiteration given in students working group. Assessment which is conducted can be given in form of feedback and assistance in order to achieve the goal. The evaluation procedure aims to give reflection based on what student did (Plucker & Makel, 2010).

STEM integration in project based learning is one of learning approach innovation. Sanders (2012) stated that STEM integrated project based learning is one learning approach elaborating learning among STEM's subject. That contradicts previous statement saying that integrated STEM learning is Multi-discipline learning standard where STEM is conducted as integrated learning activity without considering STEM Subject as partial constituent but as intact integration (Brown *et al.*, 2011). STEM integrated learning is conducted in every education level. It is applied from pre-school to higher education including in formal and non-formal education (Gonzalez & Kuenzi, 2012).

STEM integrated project based learning is able to extract students ability by identifying and solving the problems creatively by applying Science, Technology, Engineering, and Mathematics concept (Bybee, 2013). That learning can lead the learning goal to fulfilling UNESCO's four pillars of learning pre-condition, those are; Learning to know, learning to do, learning to live together, and learning to be (Nurhidayati & Kustini, 2018).

This learning theory underlies this research among constructivism learning theory built since Socrates stating that teacher and students have to be interactively communicating and elaborating the hidden knowledge through questioning (Damayanti *et al.*, 2020; Winarno *et al.*, 2020). This theory is supported by Gagne, Ausebel, Piaget, Lewin, Kohler, Koffka. In spite of constructivism theory stating that knowledge is a negotiation result affected by culture, social and environment (Ernest *et al.*, 2016; Sholahuddin *et al.*, 2020). Later on, this adult learning theory stated that adult learning is expected to emerge independency (Kamil, 2012; Susilowati *et al.*, 2018). Those theories suit to be applied in integrated project based learning to elaborate creativity dimension of teacher candidate.

This research aims to analyze creativity of teacher candidate in STEM integrated project based learning. In order to achieve research efficiency and effectivity, ergo

the questions in this research is proposed to know creativity dimension's efficacy of person, press, process and product in This research aims to analyze creativity of teacher candidate in STEM integrated project based learning. In order to achieve research efficiency and effectivity, ergo the questions in this research is proposed to know creativity dimension's enhancement of person, press, process, and product in STEM integrated project based learning.

METHOD

This is pre-experimental research that be conducted by applying integrated project based learning. The elaboration of the data analysis used descriptive analysis. Participants are 24 of Physics teacher candidates of public university that take Applied Physics course.

Project-based learning conducted in this research covered some steps, those are: issues identification, proposing idea, project design making, project execution, project evaluation, and product reflection. In project execution making, product have to be evaluated in Science, Technology, Engineering and Mathematics perspective.

The creativity dimension of teacher candidate consist of person, process, press and product. The person dimension data were received through person dimension attitude interval gathering from the beginning to the end of the learning and creative character test charging. Person dimension indicators incudes curiosity, high response interest, openness, risk taking ability, tolerance, self-confident, and intuitive. The data analysis technique uses descriptive statistical analysis by accounting answer mean percentage and cost mean.

Process dimension data was received from creative thinking ability gained form pretest and posttest. The indicator of the process dimension is apropos fluency, flexibility, originality and elaboration. The rubrical Likert interval creative thinking skill data analysis technique, was counted by using the improvement of gain and percentage classified with low, medium, and high level (Hake, 2007).

Press dimension data were received from interview and questionnaire relating with the environment. Press dimension indicator consist of creativity encouragement, creativity barriers, and motivation. This data analysis technique used statistic descriptive analysis through percentage mean answer counting, mean, cost, and gain.

Product data is achieved from rubric ally product assessment. The indicator of the product dimension consists of the novelty, relevance, and effectivity. The technique of the data analysis through rubrical Likert interval creative thinking skill, is counted with gain and percentage of the mean cost classified into high, medium, and low.

Based on the data analysis technique, four of the creative dimension data which obtained. Then, it is achieved the creativity dimension's improvement from the lowest to the highest interval, next it is analyzed based on descriptive statistical analysis.

FINDING AND DISCUSSION

Steps in the learning model had been conducted well and been observed through learning implementation sheet. The observation result shows that the project based learning steps consisting issues identification, idea postulation, idea elaboration, project design making, project implementation, project evaluation, and product reflection has fully been conducted. Issue identification was elaborated from the living environment issue. In this learning step is also integrated with STEM accordingly with the topic.

The creativity dimension applied in this research is viewed from persons,

process, product and press dimension. The improvement of teacher candidate student in this STEM integrated project based learning is explained with this following descriptive statistic. Shapiro-Wilk Normality test (SW) analysis is stated in Table 1.

Those normality test result analysis before underwent a treatment resulted P>0.05, Skewness price in between 1- until 1, Zskewness and Zkurt in between -1.96 until 1.96, therefore it can be cocluded that person, process, product, and press dimension as a normal distribution creativity dimension. Kurtosis is accounted to state the high and low of the data distribution relatively to the normal data distribution (Blanca *et al.*, 2017; Wulansari & Winarko, 2017). Instead of the preceding information there is a data showing abnormal distribution. It is showed by posttest data with price P=0.000<0,.05, Skewness price=1.0400>1,

and Zskewness=2.155. That happens because of of production dimension has bigger skewness therefore it has abnormal distribution (Widhiarso, 2017). That phenomena happened because of the teacher candidates have different competition. There was once that made finished product, but there was also unfinished product which needed to be conducted by trial and error before it perfectly worked.

An descriptive statistical analysis in creativity dimension showed in Table 2 is needed to recognize the teacher candidate student's creativity change through STEM integrated based learning. This change shows creativity dimension improvement of the physics lecture candidate students. That had been showed by highest result percentage before underwent process dimension treatment (74.07%), and the lowest result percentage before underwent

Table 1.
Creativity Diemension's Normality Test Results

Dimensi Kreativitas		SW	P	Skewness	Kurtosis	Zskew	Zkurt	Distribusi
Person	*Pretest*	0.904	0.064	0.122	-1.247	0.317	-1.332	Normal
	Posttest	0.923	0.243	0.566	-0.065	0.156	-0.043	Normal
Process	*Pretest*	0.925	0.253	0.153	-0.812	0.434	-0.941	Normal
	Posttest	0.921	0.216	-0.503	-0.024	-1.178	-0.254	Normal
Product	*Pretest*	0.921	0.216	-0.504	-0.152	-1.174	-0.166	Normal
	Posttest	0.855	0.000	1.0400	0.280	2.155	0.245	Not Normal
Press	*Pretest*	0.936	0.524	0.330	0.631	2.155	0.240	Normal
	Posttest	0.934	0.540	0.253	-0.765	0.455	-0.834	Normal

Table 2
Creativity Dimension's Statistical Descriptive Analysis

Kreativitas	N	Pretest			Posttest		
		Mean	%	SD	Mean	%	SD
Person	24	96.313	66.92	5.603	104.336	72.35	8.321
Process	24	53.024	74.07	9.425	67.204	93.10	3.010
Product	24	42.560	58.79	3.102	61.321	81.99	2.101
Press	24	65.423	68.98	5.333	76.560	80.12	5.023

product dimension treatment (58.79%). After underwent a treatment, the percentage of the teacher candidate creativity dimension improved from the highest to the lowest result, those are: process dimension (93.10%, product dimension (81.99%), and press dimension (80.12%) and person dimension (72.35%). This uniqueness happened in product dimension before underwent treatment located in the final process. after it underwent a treatment, improved, and it raised to the second level which is higher than person dimension and process dimension. The phenomena happened because after process dimension it underwent a treatment, teacher candidate student got an understanding for product criteria that had to be fixed based on the trial experiment conducted. Thou, the resulted product can be used appropriately and accordingly based on the creativity level (Kuan-Chen, 2018).

Paired t-test used in person, process, and press has normal distribution. Product dimension has abnormal data distribution, therefore, it applied Wilcoxon parametric distribution (Solidayah, 2015). It happened because product used from project implementation depended on the teacher candidate student creativity level according to knowledge, skill and manner possessed. T-test creativity dimension analysis result

of the teacher candidate student before and after STEM's Integrated project based learning is stated in Table 3.

The result of t-test analysis states that person, process, and press dimension has t-test price as follows, -5.62; -9.13; and -11.33 showing that t price has higher result than t_{tabel} ($\alpha=0.05$; df=23) with 0.000 significance. Nonparametric t-test of product dimension resulted Wilcoxson t-test result as much as $t=433 > t_{table}$ ($\alpha=0.05$; $N=23$) with 0.000<0.05 significance level. From test result analysis, it can be stated that there is significant differentiation between creativity before and after undergoing STEM treatment.

Product dimension underwent higher product average price improvement as much 18.434 with 22.541% percentage improvement. Process dimension possessed 14.131 average price with 17.3015% percentage improvement. Press dimension has 11.415 average price with 10.410% percentage improvement. Person dimension has 8.310 with 5.106% percentage improvement.

The average increase of Before and after normalizing STEM's integrated project based learning model stated as in Figure 1. Person dimension has 66.92% average price before learning treatment and 72.35% average price percentage after learning treatment. This n-gain of the person

Table 3

Creativity Dimension's T-Test Result (N=24, df=23)

Dimension	Pre/Post	Mean	%	SD	Test	P	Keterangan
Person	*Pair 1* *Person-pPerson*	-8.310	5.106	7.51	t = -5.62	0.000	significant
Process	*Pair 2* *Process-pProcess*	-14.131	17.305	8.36	t = -9.13	0.000	significant
Product	*Pair 3* *Product-pProduct*	-18.434	22.541	4.33	t = 433	0.000	significant
Press	*Pair 4* *Press-pPress*	-11.415	10.410	5.40	t=-11.33	0.000	Significant

Figure 1
Creativity Dimension's Bar Diagaram
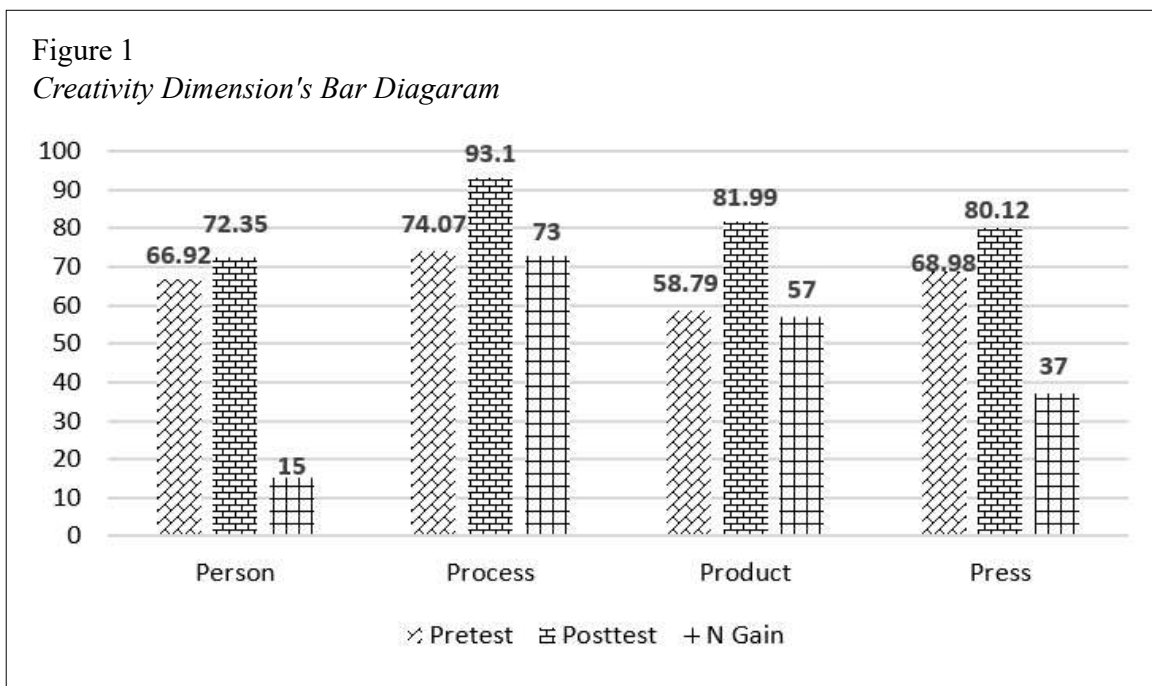
dimension increasement is 15% or 0.15 categorized low. Person dimension valued teacher candidate's creative personality characteristic consisting of strong will, high curiosity, open minded, dare to take a risk, tolerance and flexible, confident, and also intuitive. Strong will is the prominent trigger in someone who possess high creativity. High curiosity becomes a trigger to get an answers in creative life. Open minded to the problem solving leads to the creativity progression. Dare to take the risk in for all the activity that has been done is an experience aiming to the perfectness.

Flexibility and tolerance in a flexible character to solve the problem. Self-confident improve the individual confidence to improve his/her quality. Intuitive is the basic spontaneity skill to comprehend something rationally (Amabile, 2018).

Person dimension increasement is the lowest increasement. This happened because of its relation to the creative personality which does not take long to change (Putra, 2017). The character of the

teacher candidate is a steady, in which it is impossible to turn only in six months. This creative habit need continue and simultaneous effort. The researchers find a method to train this creative habit by creating creative group accommodation (Muntenau *et al.*, 2010), the development of creative environment interaction and creative barrier minimalization (Maemunah & Maryuningsih, 2013), involving creative work effectivity as the main feature, also competence, meaningfulness, and choice (Susilowati *et al.*, 2020).

Process dimension has 74.07% average price percentage before a learning treatment and 93.10% average price percentage after the learning treatment. N gain process dimension average improvement is 73% or 0.73 which has high categorization. Process dimension explores creativity aspects of the teacher candidate consisting fluency, flexibility, originality, and elaboration. In the project implementation, fluency happens if the project is planned accordingly and appropriately. Flexibility means that the

implementation does not depend on the scheduled time. Originality is elaborated from information processing according to the experience, ergo it emanates new idea. Inter friendship elaboration and environment are required to support the achievement goal in a project making (Reisman, 2013).

The features affecting creativity consist of the basic skill, creative skill, and motivation (Amabile, 2018). This skill consists of knowledge, technical skill, and specific aptitude. The knowledge relating with the project worked by teacher candidate. The weak technical skill possessed is caused by the infrequent intensity of integrated project based learning conducted by the teacher candidate which is required shop tool using expertise. (Kim *et al.*, 2013).

Product dimension possesses 58.79 average price percentage before undergoing a treatment and 81.99% mean price percentage after undergoing treatment. N gain mean improvement of the product dimension is 57% or 0.57 identified has low categorization. This product is resulted from STEM's Integrated project based learning in the form of tools or prototype. It is also

being elaborated in Science, Technology, Engineering and mathematics according to the resulted product, ergo it generates meaningful learning for human being life. As the result of the preceding statement, it can be concluded that incorporating cognitive, affective, and psych motoric aspect of the teacher candidate in learning design designed in accordance with student characteristic and material characteristics. Product dimension is the final result of the person and process dimension (Utomo, 2018). Therefore the resulted product profiles the sequential process in teacher candidates' character building that is very useful to use in their daily life. The final product produced is an student creation to tackle the problem in issue identification happening in the beginning of STEM's integrated project based learning. Creativity product integrated with STEM is showed as in Figure 2. Creativity Dimensions of STEM Integrated Product ASSA as shown in Table 4.

Press dimension possesses Mean price before learning treatment is 68.98% and mean price percentage after learning

Figure 2
Biomass Stove with Sawdust Fuel

Table 4
Creativity Dimensions of STEM Integrated Product ASSA

STEM Integration	Description
Science	Chemistry: wood composition is 50% carbon, 6% hydrogen, 0,04-0,10% Nitrogen, 0,20 – 0,50% ashes, and the rest composition is oxygen. The wood's chemistry composition is variative, it is caused by growth factors, climate, and location (in stem or branch), and wood sawdust which has 4.046 kal/gram caloric value
	Biology: wood plant can be classified into two categorization, those are Gymnospora- plant which is ordinary known as softwood, and angiospora- plant which is ordinary known as hardwood
	Pyshic: air speed enlargement on stove causes the temperature of the reactor increase. The greater the air speed, then the greater also the fire temperature degree resulted, thus it causes the intensity of burned gas intensity. That burned gas intensity also increases the heat released when gas burned
Technology	Sawdust waste caused a lot of problem in the handling process, it let to be rotten, stacked, and burned, all of the efforts implemented has negative effect to the environment. One of the possible way to handle it, is by converting it into creative populist useful worth product, so the product produced can be easily socialized to the society. The evaluation result shows that some of that waste treatment has prospective results, as the example of the applicative technology that can be applied satisfiedly is converting wood processing's industrial waste into briquettes, powdered charcoals, charcoals briquettes, active carbon, and compost charcoals. The alternative technology used to utilize biomass waste is previewed from energy source perspective used in biomass stove using charcoals powder as the alternative energy substitutes kerosene and gas.
Engineering	Engineering technique used is by applying biomass stove coating engineering consisting from 3 layers with 16 cm, 17 cm, and 25 cm diameters, as well as adding 25 cm biomass stove' top cover
Mathematics	1. Net Energy (P_{out}): $$P_{out} = \frac{m_W \cdot c_p \cdot (T_f - T_i)}{t}$$ 2. Energy Combustion (P_{in}): $$P_{in} = \frac{m_{bt} \cdot LHV}{t}$$ 3. Stove efficiency (η): $$\eta = \frac{P_{out}}{P_{in}} \; x \; 100\%$$

treatment is 80.12%. The average improvement of press dimension's n gain is 37% or 0.37 which is in medium categorization. Press dimension is creativity dimension which is affected by surrounding. In this research, learning design focuses on teacher candidate creativity by minimalizing their creativity barrier. That learning design is, inter allia to open the teacher candidates opportunity widely in

asking and realizing ideas, every teacher candidates is obliged to appreciate their friends ideas, giving trust and responsibility to the teacher candidates to actualize ideas, lecturer role as supervisor in encouraging and motivating teacher candidates to develop their drafted project. The interaction concepts consist of interaction encouragement toward the creativity and interaction barriers in response to creativity. Creativity barriers comes from internal and external factors that can obstruct creative ideas or innovations coming from family, friends, society, organization, and even in educational environment. In this research, there are some barriers that can be seen as obstruction factors in STEM's integrated project based learning.

CONCLUSION

The creativity dimension of the teacher candidates in STEM's Integrated project based learning consists of person, process, press, and product. The sequential improvement of creativity dimension's n gain in this learning activity stated from the highest to the lowest is described as follows, person dimension has 0,15; press dimension has 0,37; product dimension has 0,57, and process dimension has 0,73. Person dimension explores teacher candidates pivoting to their strong will, interest, curiosity, issues openness, risk taking ability, tolerance and flexibility, confident, and intuition. Process dimension explores teacher candidates creativity aspects consisting their creativity encouragement, creativity barriers, and motivation. Product dimension explores teacher candidates creativity aspect consisting novelty, effectivity, and relevance.

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