Research Article

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Creative Skills: Flipped Classroom by Applying an Interleaving Technique for Product Design Students

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Abstract

This research had the objective to compare the learning results with the creative ideas in product design work for product design student groups by using new and old teaching models. The group sampling comprised senior student groups of the Department of Design Education, King Mongkut's Institute of Technology Ladkrabang totaling 60 people that were classified into two learning groups: 1. The group that used the teacher-centered method totaling 30 people,and 2.the integration learning group of STEM and flipped classroom totaling 30 people. The learning assessment of the creative ideas used the thinking skills test for the product design with the reliability value for Kr-20 that had a difficulty value of (p)=0.436, discrimination value of (r)=0.359, reliability value for KR-20=0.7657 or 76%, and the Cronbach's alpha coefficient that was equal to 0.7286 or 72%. In comparing the result, it was found that the effectiveness for the new teaching model emphasized the integration with multiple teaching techniques by measuring the score level values of the creative ideas that had a higher level than the original teaching model, which used the teacher-centered method. This had a statistical significance level of .05. Moreover, this showed the result of the satisfaction assessment of the students, who learned by using the integration teaching technique of STEM and a flipped classroom to be an excellent level (mean=4.47; SD=0.579), including the happiness relationship during the study (mean=4.65; S.D.=0.483), which had a statistical significance level of .05.

Keywords: *Creative skills, flipped classroom, product design, interleaving*

1. Introduction

The creative skills of product design student groups are a significant aspect for the potential development in product design after graduation. Moreover, this curriculum has the aim to create a learning procedure model for promoting the creative skills of the students to gain the most effectiveness. However, nowadays, the teaching method has emphasized creative skills by repeated practice to generate the memorization skill inside the brain and the body for product design students. Furthermore, this learning method is essential and utilizes a long period of time to conduct practice with the limitation on applying the creative skills to solve the problems in designing in various and complicated ways. In addition, this original teaching method has involved creative ideas by focusing on repeated practice without having any differences or special thinking stimulation procedures, including the past sensation of the problem-solving method of product design. For this

case, this was based on the original practice method to use past solutions with a recent achievement, so the students would have the problem-solving method by applying the original one to be practiced or be successful. Therefore, the students were more likely to use a successful problem-solving method of product design in the past that they had experienced. As a consequence, the teacher-centered method or the original one aimed at practicing creative idea skills by gaining the knowledge from the teachers on the one side and emphasizing the repetitiveness. In contrast, this could not promote the students to diversely learn about the problem-solving method for product design, including memorizing the contents as the accepted theory at an international level before integrating in suitable ways. Additionally, the stimulation method of flexible thoughts would connect the problem-solving ideas to be integrated with the intellectual knowledge in multiply ways until resulting in creative ideas for the student groups with effectiveness.

Furthermore, during 2020-2021, every country in the world faced the severe pandemic of the Coronavirus Disease 2019 (COVID-19) with more than 219 million infected people and more than 4.55 million deaths around the world (Tsallis & Tirnakli, 2021; Karlinsky & Kobak, 2021). Moreover, this severe health crisis has affected education at every level in the world to experience the problems of the development of online learning procedures that require students to study online at home. Hence, this has become a major problem for learning that has required using creative ideas, especially for product design students by studying the theories and practices before gaining the product results that the students could apply into the product design procedures at suitable levels. Thus, this would account for the immense problems for the teacher with the curriculum of product design, so it would be necessary to develop a teaching method for gaining the appropriate effectiveness, including generating stimulation to gain a proficient learning result by promoting creative ideas for the students. Consequently, they would have a thinking procedure that would be suitable for the twenty-first century and would rapidly change the teaching development method based on a technology adaptation program (Akçayır & Akçayır, 2018; Egwutvongsa, 2021).

With regards to the application of a teaching technique for planning the teaching contents and a suitable teaching method, there is a high trend to generate stimulation for gaining a higher level of intellectual development skills through creative ideas (Li & Chu, 2018). Thus, the utilization of a flipped classroom as the core curriculum for product design has a high opportunity to create a learning method with the integration of the theory contents and YouTube application. This could respond to the learning requirements (Bishop & Verleger, 2013) before entering the classroom through the Zoom application by presenting about the studied subjects and gathering information to solve the problems from assignments, including the sending of homework through the Line application every time. In the part of the development of practical skills, this would be conducted with the cooperation of industrial factories to aid the students in participating in real-world work inside these industrial product design factories. Therefore, this would result in the integrated learning of multiple teaching methods through a knowledge contribution channel, including promoting the knowledge and learning flexibility with stimulation for gaining diverse experiences. As such, joining in the classroom activities would be compared to the students' stimulation for interleaving or integrated learning between the science principles and the thinking procedures by emphasizing the intellectual skills in the learning design programs. Later, the teachers would use the halting technique or interrupting technique during the study, so this would have halting spans for 30 minutes during the shorter learning mediation before undertaking stimulation by applying the distributed learning method. Then, the teachers would interrupt the students with the learning content to produce the inspiration of creative ideas, including describing stories by using an innovation method in terms that the current successful world-class creative innovators have performed. Finally, the teaching procedure would have the requirements to stimulate the gaining of proficient learning results from the development of the flexible thinking procedure, which would connect to the different works of product design in the current product markets. Finally, this method would turn to be the starting point for the product design students to become outstanding future creative innovators.

2. Methodology

2.1 Research Objectives

To compare the learning result of the creative ideas in product design work for product design student groups between the new and old teaching models.

2.2 Research Framework

According to the creative learning method of a flipped classroom, this could be achieved with the essentiality to use the students' intellectual skills. Moreover, a suitable designing practice skills would be based on the teaching technique integrated with an effective technology application. Moreover, the teaching with a flipped classroom would stimulate the flipped thinking skills from learning and practicing from the contents of the principles and involved theories before entering the classrooms. After that, the students would use the knowledge and integrate it with the design practices by searching for the problem-solving method in the product design with the assignments, and finally would be stimulated with interactive activities and brainstorming knowledge with their bodies to express into behavior in the classroom from the application (Shaw & Patra, 2022; Sugandini et al., 2022). Table 1 displays the various parts of the research framework.

Table 1: Research framework.

STEM (Reinholz et al., 2021)	➢ Determining with the Contents of Creative Ideas with Science, Technology, Engineering and Mathematics	
Learning from a Situation (Dong et al., 2021)	Flipped Classroom (Howell, 2021)	Interleaving (Yan & Sana, 2021)
➢ Knowledge always occurs from situations. ➢ Situations stimulate intellectual skills. ➢ Humans have always learned to make the changes for intellectual structures. ➢ The changes of intellects can stimulate additional development of the problem-solving skills. ➢ The good opportunity comes from searching with the designing problems by stimulating the prepared conditions.	➢ Active learning must come from the obvious learning plan. ➢ An interaction method should be made. ➢ The determining of the contents and exercising of a suitable project should be regulated. ➢ Applying multiple applications should be emphasized. ➢ Alternating between the practices in the work, the classrooms, and the theories into the homework done at home should be performed.	➢ Inserting other factors during the study would result in longer memorization. ➢ Alternating the knowledge presentation procedures during the study could increase the strength in the memorizing procedure. ➢ Changing the learning environment could stimulate the readiness to solve the problems as good opportunities.

2.3 Research Scope

The research scope was classified to be the teaching contents for producing creative idea skills by applying the STEM principle, which is divided into science, technology, engineering, and mathematics, as well as other subjects. Then, the teachers arranged for the contents to be the subject goals by emphasizing the integration of the knowledge and stimulation for the learners to gain flexible skills while studying, including using the teaching method from situations with a flipped classroom, interleaving, and other programs (Table 2).

Then, this was applied with the teaching methods to be combined with stimulating the learning for creative ideas with the product design student groups. This was a challenge for using with the

STEM teaching method in the classroom, as the teachers wanted to create a positive atmosphere. Later, the students were active all the time in the classroom until being capable of memorizing the contents and the learning resulted in one-15 times in each class with good effectiveness.

Table 2: Determining the work plan of the learning procedure for creative products.

Learning Method in a Normal Classroom	**Knowledge Reinforcement Technique**	**Learning Result**
Flipped Classroom: The learning method with normal contents in a subject would be used for the teaching programs in the normal classrooms for the product design students.	*Integration Technique*: A learning method would be used for the teachers to insert the knowledge contents from the different ideas during the learning in each class.	*Learning Result*: Increased development would be shown from the problem-solving skills in product design.
Contents in Normal Learning: The basic principles of industrial product design: - Principles and Designing Theories - Industrial Product Components - Designing Influences to Our Humans	*Integration Contents*: Innovative thinking for successful creative innovators: - Flexible Thinking Procedure - Different Idea Procedure - Creative Thinking Procedure	*Skills*: - Planning to Solve the Found Problems - Designing with the Problem-solving Method - Presenting the Product Designs - Taking Assessment with the Problem-solving Guidelines
Teaching Method: Flipped Classroom - Learning with the principles and outside the classroom theory at home by using the YouTube application. - Consultation of the details for the learning contents in the Line application. - Setting up classroom activities by using the designing skill practice method.	*Insertion Method with Contents*: While the students are learning the normal contents, the teacher would insert the additional contents every 30 minutes, including adding special contents while the students have shorter mediation by stimulating them to be more interested.	*Assessment Method*: The determination of the tests and questions in product design would be made under the problem conditions for the students to present their different problem-solving skill guidelines for the present time. *Learning Goals*: The creative ideas of innovations would be presented under the STEM principle.

For this study, the work plans were determined from the design procedures with creative ideas in the classroom, including the teaching technique by integrating the intellectual knowledge skills and working skills at a suitable level based on the STEM principle as the main part. After that, this was divided into the details of the appropriate teaching method for each subject (Table 3).

Table 3: Determining the learning contents to stimulate creative ideas for the students.

Learning	**Teaching Subject of Learning Integration**	**[1]**	**[2]**	**[3]**
1. Science	Learning from material properties to design products.	✓	✓	
	Learning by forming a method and chemical material properties to design products.			✓
	Learning from biomechanics to apply in product design.	✓		✓
2. Technology	Applying a machine to create forming an industrial manufacturing system.			✓
	Applying a three-dimensional forming machine to create with a computer.			✓
	Applying a computer to make creative work with a three- dimensional design.		✓	✓

Learning	Teaching Subject of Learning Integration	[1]	[2]	[3]
3. Engineer	Analyzing of customers' requirements before designing the products by using a quality function deployment technique.	✓	✓	
	Analyzing with the Analytic Hierarchy Process (AHP) technique.	✓	✓	
4. Mathematics	Calculating the customers' sizes by using an arithmetic mean, median, mode and percentile in the product design.	✓		✓
	Applying basic statistical analysis in product design.	✓		✓

*Integration of the Teaching Techniques: [1] Flipped Classroom; [2] Interleaving; [3] Learning from Situations.

3. Scope

The sample population comprised 60 senior students of design education in the School of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang from the registered student numbers in the academic year 2021.

For the group sampling, the 60 participants were classified into two learning groups separated from the student lists made by the Registration and Processing Office (Table 4).

Table 4: Determining with the learning test scope for students.

Group	n	Teaching Method in the Classroom	[1]	[2]	[3]
Control Group	30	Original learning pattern with the teacher-centered method			
Experimental Group	30	Learning with the STEM pattern integrated with science, technology, engineering, and mathematics	✓	✓	✓

*Teaching Technique Integration: [1] Flipped Classroom; [2] Interleaving; [3] Learning from Situations.

The research tool was a skills test from the product design ideas; the researcher created the creative idea test with 30 subjects before bringing the test to be checked by three experts for selection with only 20 subjects. After that, the test was used for the first time to conduct an analysis of the difficulty value and discrimination value before choosing to use with only 11 subjects. Later, the test was used with the 11 subjects for the second time to find the reliability value of Kr-20 that showed the difficulty value of (p)= 0.436 at a moderate level and discrimination value of (r)= 0.359. Additionally, the creative ideas with the test of 11 subjects presented the reliability value of KR-20=0.7657 or 76%, including Cronbach's alpha coefficient that was equal to 0.7286 or 72% by applying with the reliability value to be calculated as the formula of Kuder-Richardson (KR-20) before making the data analysis and using for the research statistical values; such as, the mean, standard deviation, t-test independent, and correlation.

4. Results

This study showed that learning during the Coronavirus Disease 2019 pandemic had altered the learning method of the product design students in Thailand from the past (Adelabu & Alex, 2022; Zhou et al., 2020). Therefore, the learners and teachers would have to adapt by applying the learning patterns through online media at the present time and also possibly in the future. However, the online teaching method may contribute to the ineffectiveness of gaining experience from using intellectual and practical skills for the students, while it would also have the limitations on the original teaching method because of the changes from the pandemic (Kassaye et al., 2020; Zeng et al., 2020). Hence, in this research, this required the development of the teaching method in the subject of product design for the students in the Department of Design Education, King Mongkut's Institute of Technology Ladkrabang to produce effective results by promoting the integration of creative and flexible ideas and systematic thinking at a suitable level. Thus, the students would have good intellectual skills that would be congruent with the global requirements in the twenty-first century as shown by the teaching method development attributions:

[1] According to the learning method in the experimental group, this should increase the flipped classroom for the teachers by using the intellectual skills in YouTube and the Line application with the theory contents, while the students would be at home. This would include participation in the lecture to produce the intellectual skills with the response between the teachers and the students through the Line application for asking questions, or when the students had some problems outside the classroom.

[2] According to the learning inside the classroom, the teachers should use the integrated teaching technique with the interleaving stimulation in the virtual classroom through the Zoom application, especially for the lectures and teaching activities. This would include increasing the achieved world-class innovation artist contents and modern innovation inventing procedures to make positive results for the world at the present time and also possibly in the future, or every 30 minutes.

[3] According to the learning outside the classroom, this was related to a study tour and working experience of product design in industrial plants. The teachers could apply the learning from the situations to stimulate empathy with a creative atmosphere after noticing from the production procedures of the professional designers. In this regard, this should have the participation from the entrepreneurs in the industrial plants and large establishments for giving creative product knowledge and applying it with the integrated STEM learning method, which consists of the integrated method of science, mathematics, engineering and technology to conduct the operation in a real-world situation.

From the above information, the teachers could apply the new teaching method into the research steps with the learning component development in each unit: 1. Studying Documents, 2. Exercises in the Classroom, 3. Exercises outside the Classroom, 4.Lecturing Contents Clip in the YouTube application, and other documents.

Figure 1: The new teaching method with multiple patterns.

Table 5: Effectiveness comparison with new and old teaching methods in the classroom.

Effectiveness in Teaching	New Method		Old Method		Comparison		Paired Samples		
	Mean	S.D.	Mean	S.D.	t	Sig.	Correlation	Sig.	
1) Learning from material properties to designing products	4.71	0.463	3.90	0.601	7.667	0.000*	0.038	0.792	4
2) Learning for forming a method and chemical material properties to designing products	4.69	0.469	2.82	0.654	17.162	0.000*	0.077	0.593	5
3) Learning from biomechanics to apply in designing products	4.39	0.603	3.59	0.669	6.582	0.000*	0.061	0.669	10
4) Using a machine in the forming step to manufacture in an industrial system	4.53	0.542	4.42	0.608	0.962	0.170	0.203	0.153	7
5) Using a forming machine in three-dimensional products with computer	4.27	0.593	4.12	0.600	1.138	0.131	0.046	0.774	11

Effectiveness in Teaching	New Method		Old Method		Comparison		Paired Samples		
	Mean	S.D.	Mean	S.D.	t	Sig.	Correlation	Sig.	
6) Using a computer to design three-dimensional work	4.75	0.440	2.71	0.672	16.722	0.000*	0.191	0.180	2
7) Analysis of customers' requirements before designing products with a quality function deployment technique	4.49	0.543	3.51	0.784	7.382	0.000*	0.012	0.934	9
8) Using the analytic hierarchy process	4.53	0.612	2.98	0.648	10.583	0.000*	0.377	0.006	8
9) Calculating from the customers' body sizes from an arithmetic mean, median, mode, and percentile in product design	4.75	0.440	3.14	0.566	16.519	0.000*	0.063	0.661	3
10) Analysis of the basic statistics to apply in product design	4.69	0.510	2.53	0.758	18.478	0.000*	0.180	0.207	6
11) Thinking integration with the calculation of the body size in the product design	4.76	0.428	3.82	0.910	6.419	0.000*	0.203	0.153	1
Total	**4.58**	**0.540**	**3.46**	**0.923**	**23.73**	**0.000***	**-0.087**	**0.041**	

According to the results from the creative skills test of the two student groups, it was found that the teaching effectiveness in the new method had a higher level assessment score from the creative skills of the students than the original teaching method from the three levels of differences, which had a statistical significance level of .05: 1. Thinking integration with body size calculation in creative design, 2. using computer in three-dimensional design, and 3. calculating from the customer body sizes with an arithmetic mean, median, mode, percentile into product design, and other methods.

Then, it showed the result that the new teaching method could be applied with multiple techniques; such as, STEM teaching integrated with a flipped classroom and interleaving for stimulating creative ideas with good effectiveness. In this case, the creativity was based on the intellectual knowledge in many fields to stimulate different ideas, while arousing each unit to promote the excitement with the new learning method, including increasing long memorization (Egwutvongsa & Setvisat, 2021).

Figure 2: Practice result in the creative product test for the students with the new learning method.

Table 6: The new method assessment result in the teaching satisfaction and the relationships between happiness and satisfaction with the classroom learning (n=30).

Satisfaction Assessment Result	Mean	S.D.	Satisfaction Level	Happiness in Learning (Mean=4.65; S.D.=0.483)		
				Correlation	Sig.	Relationship
1] Having fun and excitement with the contents while studying	4.69	0.469	Most	0.205	0.149	No
2] Participation in experiments for product design in the industrial plants	4.57	0.501	Most	0.434	0.001	Yes

Satisfaction Assessment Result	Mean	S.D.	Satisfaction Level	Happiness in Learning (Mean=4.65; S.D.=0.483)		
				Correlation	Sig.	Relationship
3] Having alertness in joining a classroom	4.59	0.497	Most	0.383	0.006	No
4] Having attention of the teachers	3.94	0.580	Excellent	-0.004	0.977	No
5] Knowledge creation of the calculation with the product design	4.47	0.504	Excellent	0.203	0.153	No
6] Knowledge creation of technology with the product design	4.43	0.575	Excellent	0.344	0.014	Yes
7] Knowledge creation of science with the product design	4.65	0.522	Most	0.289	0.040	Yes
8] Knowledge creation of engineering with the product design	3.92	0.771	Excellent	0.139	0.330	No
9) Having thinking skills integrated into the creative products	4.16	0.418	Excellent	0.181	0.205	No
10) Learning to make interesting and challenging feelings	4.69	0.510	Most	0.273	0.053	No
11) Feeling confident with the transferred knowledge	4.47	0.578	Most	0.249	0.078	No
Overall satisfaction to the new learning method	**4.47**	**0.579**	**Most**	**0.238**	**0.000**	**Yes**

From the satisfaction assessment for the new learning method from the student groups, it was found that the students had an excellent level of satisfaction to the new learning method (mean=4.47; S.D.=0.579). Furthermore, this had a relationship with a statistical significance level of .05, as the happiness while the students were studying, and the fun and excitement with contents while studying had the satisfaction at the most level (mean=4.69; S.D.= 0.469). This included learning with an interesting and challenging feeling that had the satisfaction at the most level (mean=4.69; S.D.= 0.510), and knowledge creation with science and product design had the satisfaction also at the most level (mean=4.65; S.D.= 0.522).

Figure 3: Happiness and joyfulness in learning with students' stimulation for continuous requirements.

The assessment summary from the new teaching method showed that the student groups had the satisfaction with the learning attributions by gaining fun and excitement feelings in the experiment test and alertness from the real practices in the flipped classroom. Furthermore, this focused on basic knowledge creation with the readiness before entering the virtual classroom or joining the real-world work at the establishments or industrial plants, which affected the students with interesting and challenging feelings. In this regard, the learning attributions were based on the varieties of the teaching techniques as the influencing force to prepare the product design contents in each unit, including practicing on the assigned product design project in each time. Thus, according to the satisfaction assessment of the students, this had the satisfaction in the most level to the new teaching

method, which conformed to the situation of the Coronavirus 2019 pandemic with the student learning pattern to be improved with suitability. In the same way, according to the alteration of studying face to face to online teaching, this could not be managed as one way to create intellectual knowledge skills or working skills with good effectiveness. However, the teaching should be integrated with multiple techniques that would be congruent to the learning objective attributions in each time to make the excitement and challenge by being continuously stimulated or practiced in the establishments as the integration learning method for gaining good memorization for the students in the future.

5. Conclusions

According to the creation of the environment, it could stimulate to have continuous alertness in learning (Cheng et al., 2019) with great potential in the academic field by giving vital knowledge that could be applied with creative product design work. In this case, this would be accountable as the learning method that would create the creative ability for the students and apply the creative idea skills to be adapted with the solutions (Jaeger & Adair, 2014). This was based on multiple techniques to stimulate gaining new and challenging feelings during the study (Rohrer, 2012; Wamalwa & Masibo, 2020), and this method could be an aspiring development after using the new learning pattern with the students congruently with the concept of the development of the learning procedure in the twenty-first century integrated with the psychology method to be a more suitable way (Kehinde, 2021; Roediger & Pyc, 2012; Egwutvongsa et al., 2021).

In addition, the teaching technique of STEM was applied with science, technology, engineering and mathematics by using with the creative idea skills of the students. Moreover, this was divided into the transferred knowledge with the teaching technique of the flipped classroom and interleaving that the teachers had increased for additional knowledge during the virtual classroom. This became the inspiration for making efforts with success (Findlay-Thompson & Mombourquette, 2014). In the same way, during the practice period, the students came to join in the real-world work with the establishments or industrial plants, which was good opportunities to face and be frequently stimulated by the problems. Hence, this involved the creation of a suitable environment for learning by stimulating creative ideas and intellectual skills to be applied as problem-solving guidelines.

From the results of the comparison from the creative idea skills test to make product design solutions for the students between the new and the old learning methods, it was found that the students' score level of the new learning method was higher than the original one or with the teacher-centered method, which had a statistical significance level of .05. For this study, the students were trained with good practice and prepared for alternating each time until gaining the intellectual skills and high level of flexibility. Additionally, the interleaving technique could give broader knowledge for making longer memorization with proficient effectiveness differently from the original learning method or with the teacher-centered method. Unfortunately, this showed that after studying with the original learning method, the students could present the product design guidelines in a reduced way (Emaliana, 2017; Zohrabi et al., 2012), and this always waited for the teachers to give the knowledge as only one side (Dowaliby & Schumer, 1973). In the same way, this made their time in the classroom to have the benefit of only memorizing the contents from the concepts and the designing theory as the one method. As such, the students would gain the opportunity for testing or learning from their experiences at a reduced level (Mascolo, 2009; Tolulope Ijisakin et al., 2021), which was due to the lack of stimulation for gaining any new developments. In the same way, this could support some shy students to share creative ideas after using the teaching of STEM in the learning method until they could analyze the problems integrated with the STEM techniques before the last summary.

After that, this went to the creative product design step, which the students practiced making the creative products with the system from using the learning technique of STEM. This could stimulate them to have systematic thinking from the solutions before presenting flexible and creative

guidelines to become the first step of product designing as a modern innovation in the future. Moreover, the integration of a flipped classroom with interleaving contributed to the students have alertness from the stimulation in the classroom all the time by testing and presenting the product design guidelines. This was based on the assistance from the industrial plants and the establishments for the real-world practice. Similarly, this applied the teaching method of the flipped classroom to assist the students in understanding about the contents and the product design theory from the clips in the YouTube application that the teachers had uploaded the file before the class. Thus, provided that the student had any relevant questions to ask about the classroom contents, the teachers could participate by giving the knowledge with the requirements. In the same way, the satisfaction assessment level of the students to the new learning method showed that they had a satisfaction in the most level, which had a statistical significance level of .05. The result of the occurrence of happiness during the study for this subject was at the most level, and the result from the new learning method gained the effect with good effectiveness in product design work from the real application.

In addition, the occurrence of happiness during the study for the students directly affected the learning satisfaction by stimulating to gain the efforts on frequently searching for the potential development in the design work (Bullough, 2011; Csikszentmihalyi, 2014). Moreover, learning with happiness could contribute to the hope or positive psychology by stimulating humans to act without getting tired or being worried until creating happiness. In this case, the joyfulness and fun feeling could come from the learning to stimulate the students to have a positive feeling (Casinillo & Casinillo, 2020). As such, this feeling would be the creativity base for the product design students to invent modern innovations or be a happiness source for everyone from creating a good mindset before transferring to other people with an outstanding and convenient design. Thus, product design learning with happiness would always contribute to better potential with mediation by being applied with the assigned guidelines with the learning skill of STEM, which comprised science, technology, engineering, and mathematics. In this case, this could solve multiple problems and be adapted with a higher level of skills than using with the original learning method or the teacher-centered method. As a result, learning with the old method had a high tendency to lack the designing guidelines and the varieties of the presentation after testing with the creative idea learning assessment, including reducing the level of happiness and gaining a negative feeling in the future (Al-Rahamneh, 2022; Chuang et al., 2014; Rego & Cunha, 2009; Révolo Acevedo et al., 2022; Egwutvongsa, 2021; Lertchamchongkul et al., 2022).

Therefore, learning with multiple techniques of a flipped classroom and interleaving for product design students could develop the creative idea skills. This would come from the stimulation of the inspiration to be interested in the contents that the teachers had determined as the nature of the needs, expectations, and responsiveness. Thus, they reacted by creating a joyful feeling and the challenges with the problems and questions from the teachers (Omar et al., 2013). As a result, this showed that the new learning method directly affected the long memorization inside the brain after continuously practicing with the problem-solving skills on creative ideas (Bhatti, 2021; Bustamante et al., 2015; Obi et al., 2021). Additionally, this was similar to the memorization with the body's touch that the students could automatically express their behavior on the product design guidelines that had good effectiveness.

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