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The Application of Fuzzy Delphi Technique in Evaluating the Appropriate Arrangement of the Teaching Activity Model Elements using I-Think Maps in the Development of Future Thinking Skills

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ABSTRACT

This study discussed the application of fuzzy Delphi technique in evaluating the appropriate arrangement of the teaching activity model elements using i-think maps to develop future thinking skills among secondary school students in learning the Malay language. The process of evaluating the appropriate arrangement of the elements in this teaching activity model was based on the confirmation evaluation of the Richey internal model (2005) aimed to determine the integrity of each model element, the process of developing the teaching activity model and the use of this model in designing lessons. There were 18 experts involved in evaluating the model and they were selected based on the purposive sampling and consisted of only secondary school teachers who teach the Malay language subject. The evaluation included 23 items, the list of elements in the model, that required consensus and the percentage of experts' approval. The data was analyzed using the triangular requirements of fuzzy numbers and the fuzzy evaluation process conditions. The findings discovered that all the arrangement of elements in the model was accepted with a threshold value 'd' not exceeding 2.0 (d≤ 0.2), the percentage of expert consensus exceeded 75% and the fuzzy score value exceeded 0.5 to determine the acceptance and rejection of the items. Overall, all the panels of experts agreed on the arrangement of teaching activities model elements using i-think maps that has been designed to develop future thinking skills.

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INTRODUCTION

Future thinking skills are one of the Higher Order Thinking Skills (HOTS). Future thinking skills or futuristic thinking was first introduced through the implementation of PPPM 2013 2025 (Mustaffa & Ghani, 2020). Although future thinking skills are not elaborated and explained in the Secondary School Standard Curriculum (KSSM), its aspect in fostering HOTS at the secondary school level is very important and should be emphasized in the development of students' thinking skills. Apart from this, HOTS has been stated and explained in detail in KSSM for educators to implement them in the teaching and learning process (TnL). Hence, future thinking skills should be focused in the country's educational transformation to be in line with developed countries. The emphasis is especially important because the integration between 21st century skills and future thinking skills is related to the development and advancement of science and technology in the future. This is in line with the statement by Siew and Rahman (2019) that incorporating future thinking skills into the curriculum is the latest educational transformation in education reform in most developed countries.

Hasan & Mahamod (2016) examined the teachers' perceptions of HOTS and discovered that in terms of their understanding of HOTS, it is at a moderate level. Moreover, another study conducted by Isnon and Badusah (2017) also revealed that the competency of Malay language teachers who apply HOTS, in terms of their knowledge and understanding in TnL, is still at a moderate level. From these findings, it is evident that lack of resources for references is the constraint among Malay language teachers to integrate HOTS in learning (Isa & Mahamod, 2021). Therefore, guidelines, such as how to use the model, will make it easy for teachers to conduct their teaching as the requirement of ability in producing a young generation who are skillful in future thinking skills to further enhance the quality of education in line with the universal needs, that is to create a workforce who are capable to compete and skillful.

LITERATURE REVIEW

The 21st Century Learning requires teachers who are capable in various skills as they are the most important implementers to ensure the success of educational goals. In fact. they have important roles in implementing classroom teaching activities to ensure the active involvement of all students in the TnL process. In the implementation of 21st Century Learning, it requires teaching activities that are able to develop HOTS among school children. This is important because teaching is an overall process that involves planning, implementation, evaluation and feedback activities (Wahid, 2020). Subra et.al (2019) stated that citizens with future thinking are capable of producing a progressive society who constantly move forward and scientifically.

The paradigm shift in students thinking, which is future thinking skills, is needed to produce students who are able to think of the future and out of the thinking box. As Smith (2014) affirmed, future thinking skills do not only prepare students to face failure but also aims to achieve advancement and innovations. In fact, the culture of encouraging higher order thinking skills among school children is an important part in developing the higher order thinking skills. Hence, students are able to master future thinking skills based on how often they apply their thinking skills in solving problems critically, thus produce a generation with intellectual development in line with the aspiration of the National Education Philosophy that is creating balanced human capital. In this context, productive teachers should have future thinking skills by implementing cognitive-based, critical thinking-based and futuristic-based activities in their teaching and learning process to secondary school students (Sualman, 2018).

Various challenges and situations in the world now require students who are skillful in dealing with them. In fact, education in this country needs to meet the needs with changes to produce a balanced human capital especially in terms of thinking. In 2012, a significant survey on the role of critical thinking skills and students learning styles was conducted by Ghazivakili et.al (2012) using a questionnaire distributed to 216 students from Alborz University. They discovered that learning styles, critical thinking and academic performances were related. Another study conducted by Law, Lee and Chow in 2002 highlighted the characteristics of innovative pedagogical practices related to the characteristics of effective learning practices of the 21st century. It is evident that students are more positive, able to think critically and to learn from various sources.

Concerning this, teachers need to be skillful in various aspects, especially in the terms of teaching and learning delivery pedagogical skills and inculcating good values in moulding students' personalities.

Future thinking skills or futuristic thinking has started to receive attention lately. The era of technological changes currently, especially in taking the challenges of the Industrial Revolution 4.0 wave, has changed the mindset to ensure that goals and objectives are achieved as desired. According to Vidergor (2018), building future thinking skills needs to involve illustrating issues using i-think maps. Other researchers, Yusop and Mahamod (2015) stated that teachers should apply HOTS in the teaching and learning of Malay language writing in classrooms. Based on the problem, a teaching activities model using i-think maps can be used as a guide to teachers, especially in the teaching of higher order thinking skills such as future thinking skills. It is evident from the research findings that there are constraints among Malay language teachers to integrate HOTS in learning because lack of source for references (Isa & Mahamod, 2021). Therefore, teachers need a guideline to develop students' thinking skills.

Using teaching aids such as thinking tools using i-think maps, enable students to improve their future thinking skills. According to David et.al (2020), i-think maps encourage students' active thinking. Based on the explanation before, it is important that teachers should focus on the integration of future thinking skills in the TnL process assisted by i-think maps in the Malay language learning at secondary school-level. Overall, a guideline using a model facilitates teachers to guide and implement the TnL processes related to future thinking skills in learning the Malay language and at the same time achieve teaching goals.

TEACHING ACTIVITIES MODEL USING I-THINK MAPS TO DEVELOP FUTURE THINKING SKILLS

The teaching activities model using i-think maps to improve future thinking skills for secondary schools in the learning of the Malay language has been developed as a result from expert voting using the Concept Star software through the Interpretive Structural Modelling (ISM) process. Evaluating the appropriate arrangement of the model elements is conducted using the fuzzy Delphi technique to ensure the goal of its implementation in TnL is achieved. The list of the model elements is illustrated in Table 1.

Table 1: List of the Model Elements

No.	Items/Elements of the Model
1	Students express their existing knowledge on i-think maps to develop interest in generating ideas.
2	Students receive an introduction to learning topics (concept/theme/content).
3	Students listen to explanations from teachers about using eight types of i-think maps based on examples of issues provided.
4	Students receive the introduction to the eight types of i-think maps.
5	Students form groups for discussions.
6	Students receive group assignments activities and listen to instructions presented by teachers.
7	Students discuss in groups to complete tasks.
8	Students receive guidance on the evaluation criteria for the activities to fulfil the requirements of the assignments.
9	Students use various resources to obtain information in generating ideas.
10	Students share ideas to complete the assignments.
11	Students receive an explanation on the evaluation criteria for the group work from the teacher.
12	Students compare original ideas and new ideas using i-think maps.
13	Students use new ideas to complete assignments.
14	Students from other groups provide feedback to the group that is giving their presentation.

15	Students develop i-think maps based on group information and ideas.
16	Students present their group results with a clear pronunciation and correct intonation.
17	Students make amendments to the group work results using i-think maps.
18	Students complete writing activities based on timelines and future scenarios built using i-think maps.
19	Students produce future scenarios using i-think maps.
20	Student build timelines using i-think maps.
21	Student develop build a development model product or a future model using i-think maps.
22	Student conduct self-reflections on the learning content.
23	Students create learning metacognition that causes a change in ideas and the application of future thinking.

PURPOSE OF THE STUDY

This study aimed to identify expert consensus on the appropriate arrangement of elements that should be included in the teaching activity model using i-think maps to improve future thinking skills of students in Malay language learning using fuzzy Delphi technique at secondary school-level.

RESEARCH OBJECTIVES

There are three research objectives as follows:

1) Obtain the percentage results of the evaluation agreement for each arrangement of elements in the teaching activity model using i-think maps to improve future thinking skills based on consensus and agreement of the evaluation experts.

2) Obtain the results of the threshold 'd' evaluation value for each arrangement of element in the teaching activities model using i-think maps to improve future thinking skills based on consensus and agreement of the evaluation experts.

3) Obtain the results of the fuzzy score evaluation (defuzzification) for each arrangement of elements in the teaching activities model using i-think maps to improve future thinking skills based on consensus and agreement of the evaluation experts.

METHODOLOGY

This study employed the fuzzy Delphi technique introduced by Kaufmann and Gupta in 1988 and this method is a combination between the fuzzy set of theories and the Delphi Method introduced by Murray, Pipino dan Gigch (1985) (Saleh, 2016). The Fuzzy Delphi method was used in evaluating the appropriate arrangement of elements in a model developed because according to Siraj et.al (2021), FDM serves as a robust decision-maker.

Purposive sampling was used in the selection of experts to evaluate the model and only involved secondary school teachers who teach the Malay language subject. Witkin (1995) suggested that experts in the Delphi method are 10 to 50 people. While according to Adler and Ziglio (1996) in Jamil and Noh (2020) if experts shows high uniformity or is homogeneous, then the suitable number experts ranges from 10 to 15. Therefore, a total of 18 experts evaluated the model based on the recommendations of Adler and Ziglio (1996) involving Malay language teachers. Furthermore, Ocampo et.al (2018) stated that the number of experts in a study does not have to be large because there is no strong relationship between the number of experts and the quality of the results produced. The experts' selection criteria to evaluate the model in this study was determined based on several criteria set by past studies by several experts in Jamil and Noh (2020):

a) An individual is considered an expert in a field if he has more than 5 years of experience (Berliner, 2004a; 2004b). The Malay language teachers who have been teaching for more than five years are selected as experts to evaluate the model.

b) An individual is considered an expert when he has high knowledge and skills in a particular field (Swanson & Holton, 2008). The experts involved in this study have academic qualifications of at least a Bachelor's Degree in the field of education.

c) An individual is considered an expert when he is able display commitments to a study (Delbecq et.al, 1975). The experts involved in the evaluation phase of the model in this study should be ready to commit in the implementation of the model evaluation process.

d) An expert must be able to provide the input and information required by a study (Pill, 1971; Oh, 1974). The experts in the model evaluation phase are able to provide necessary information in accordance with the objectives of the study.

The panel of experts' evaluation agreement was based on a 7-point Likert scale: Strongly Disagree (1), Strongly Disagree (2), Disagree (3), Moderate Agree (4), Agree (5), Strongly Agree (6) and Strongly Agree (7). The data was analyzed using triangular fuzzy numbers and fuzzy evaluation process requirements. The Triangular Fuzzy Number is arranged with values of m1, m2 and m3 (Jusoh & Yusoff, 2015). The number of Fuzzy scale agreement level is in odd numbers and the data obtained is more accurate if the Fuzzy scale is higher. Figure 1 illustrates the Fuzzy scale agreement level.

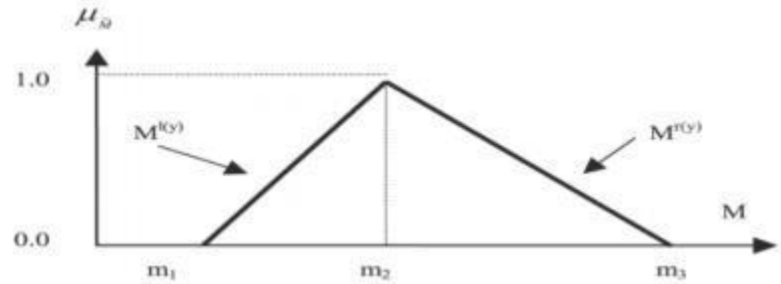

Figure 1. Fuzzy scale agreement level. Adapted from Jusoh & Yusoff, 2015

The data analysis using Microsoft Excel software begins with the calculation of threshold 'd' values to determine the agreement and unanimity level of the expert panels on the questionnaire items evaluation applicability of the teaching activity model. Calculation of threshold value 'd' used the following formula (Jusoh & Yusoff, 2015):

$$d(\tilde{m},\tilde{n}) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]}$$

Next, to determine the consensus decision of the experts who evaluated the model, the value of de-fuzzification was employed. From the analysis, the first requirement that must be fulfilled is if the threshold 'd' value is equal to 0.2 or less than the value, it indicates all the panel of experts who evaluated the model have consensus and unanimity to determine the decision (Cheng & Lin, 2002). As for the second requirement, the percentage value of the group expert unanimity must be equal to or exceed 75% to determine whether the items are accepted or rejected (Jamil & Noh, 2020; Chu & Hwang, 2008; Murry & Hammons, 1995). Next, the third requirement, the expert unanimity is determined based on the value of the fuzzy score that must be equal to 0.5 or exceed the value to determine whether the items are accepted or rejected (Jamil & Noh, 2020). From the three requirements, it can be concluded that the threshold value 'd' should not exceed 2.0 ($d \leq 0.2$), the percentage of unanimity should be 75% or higher and the fuzzy score value should equal or exceed 0.5 for to determine the acceptance and rejection of the questionnaire items to evaluate the teaching activity model. If the threshold value exceeds 2.0, the percentage is less than 75% and the value of the fuzzy score is less than 0.5, then the Fuzzy Delphi technique must be implemented again, namely the second round involving no unanimity among experts until the experts reach unanimity by fulfilling the three requirements.

RESEARCH FINDINGS AND DISCUSSION

The findings of the study involved three parts: the results of consensus percentage, the threshold 'd' value results and the fuzzy score evaluation results (defuzzification) for the teaching activity model using i-think maps to improve future thinking skills based on consensus and agreement of the evaluation experts.

Results of Evaluation Agreement Percentage of Each Element Arrangement

The statistics in Table 2 display the agreement percentage results analysis of the expert agreement for each element in the model.

Table 2: Expert Agreement Percentage Results

	ITEM																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Bilangan Item d ≤ 0.2	18	17	17	18	17	17	17	17	18	18	18	17	18	18	16	17	17	18	17	17	17	17	18
Peratus Setiap Item d ≤ 0.2	100.0%	94.4%	94.4%	100.0%	94.4%	94.4%	94.4%	94.4%	100.0%	100.0%	100.0%	94.4%	100.0%	100.0%	88.9%	94.4%	94.4%	100.0%	94.4%	94.4%	94.4%	94.4%	100.0%

Table 2 illustrates the findings of the appropriate arrangement analysis of the model elements based on the consensus and agreement percentage for each element in the teaching activity model. The use of i-think maps to improve future thinking skills consists of 23 elements of teaching activities. There are 9 elements that obtain 100% of expert agreement: Element 1 *Students express existing knowledge related to i-think maps to develop interest in generating ideas*, Element 4 *Students receive the introduction to the eight types of i-think maps*, Element 9 *Students use various resources to obtain information in generating ideas*, Element 10 *Students share ideas to complete the assignments*, Element 11 *Students receive an explanation on the evaluation criteria for the group work from the teacher*, Element 13 *Students use new ideas to complete assignments,* Element 14 *Students from other groups provide feedback to the group that is giving their presentation*, Element 18 *Students complete writing activities based on timelines and future scenarios built using i-think maps* and Element 23 *Students create learning metacognition that causes a change in ideas and the application of future thinking*. Next, the elements that obtained more than 90.0% of expert agreement are Element 2 *Students receive an introduction to learning topics (concept/theme/content)*, Element 3 *Students listen to explanations from teachers about using eight types of i-think maps based on examples of issues provided*, Element 5 *Students form groups for discussions*, Element 6 *Students receive group assignments activities and listen to instructions presented by the teacher*, Element 7 *Students discuss in groups to complete assignments*, Element 8 *Students receive guidance on the evaluation criteria for the activities to fulfil the requirements of the assignments*, Element 12 *Students compare original ideas and new ideas using i-think maps,* Element 16 *Students present their group results with a clear pronunciation and correct intonation,* Element 17 *Students make amendments to the group work results using i-think maps*, Element 19 *Students produce future scenarios using i-think maps*, Element 20 *Students build timelines using i-think maps*, Element 21 *Students develop build a development model product or a future model using i-think maps* and Element 22 *Students conduct self-reflections on the learning content*. While only Element 15, *Students develop i-think maps based on group information and ideas,* obtained more than 80.0% of expert agreement. Based on the research findings, the unanimity percentage value of the group expert has exceeded 75% indicating the appropriate arrangement of the elements is accepted.

Threshold 'd' Value Evaluation Results for Each Arrangement of Element

Table 3 shows the Threshold 'd' value evaluation analysis results for each arrangement of elements in the model.

Table 3: Threshold ‘d’ Value Result

No.	Items / Elements	***Triangular Fuzzy Numbers Requirements***		**Expert Agreement Decision**
		***Threshold,* d Value**	**Percentage of Expert Panel Agreements, %**	
1	Students express their existing knowledge on i-think maps to develop interest in generating ideas.	0.081	100.0%	ACCEPT
2	Students receive an introduction to learning topics (concept/theme/content).	0.114	94.4%	ACCEPT
3	Students listen to explanations from teachers about using eight types of i-think maps based on examples of issues provided.	0.145	94.4%	ACCEPT
4	Students receive the introduction to the eight types of i-think maps.	0.071	100.00%	ACCEPT
5	Students form groups for discussions.	0.118	94.44%	ACCEPT
6	Students receive group assignments activities and listen to instructions presented by the teacher.	0.124	94.44%	ACCEPT
7	Students discuss in groups to complete assignments.	0.118	94.44%	ACCEPT
8	Students receive guidance on the evaluation criteria for the activities to fulfil the requirements of the assignments.	0.150	94.44%	ACCEPT
9	Students use various resources to obtain information in generating ideas.	0.104	100.00%	ACCEPT
10	Students share ideas to complete the assignments.	0.119	100.00%	ACCEPT
11	Students receive an explanation on the evaluation criteria for the group work from the teacher.	0.102	100.00%	ACCEPT
12	Students compare original ideas and new ideas using i-think maps.	0.155	94.44%	ACCEPT
13	Students use new ideas to complete assignments.	0.133	100.00%	ACCEPT
14	Students from other groups provide feedback to the group that is giving their presentation.	0.129	100.00%	ACCEPT
15	Students develop i-think maps based on group information and ideas.	0.177	88.89%	ACCEPT
16	Students present their group results with a clear pronunciation and correct intonation.	0.123	94.44%	ACCEPT
17	Students make amendments to the group work results using i-think maps.	0.155	94.44%	ACCEPT
18	Students complete writing activities based on timelines and future scenarios built using i-think maps.	0.109	100.00%	ACCEPT

19	Students produce future scenarios using i-think maps.	0.150	94.44%	ACCEPT
20	Students build timelines using i-think maps.	0.145	94.44%	ACCEPT
21	Students develop build a development model product or a future model using i-think maps.	0.150	94.44%	ACCEPT
22	Students conduct self-reflections on the learning content.	0.170	94.44%	ACCEPT
23	Students create learning metacognition that causes a change in ideas and the application of future thinking.	0.144	100.00%	ACCEPT

Table 3 illustrates the results of the threshold 'd' value using the triangular fuzzy numbers requirements. Based on the analysis, it can be concluded that the result of the threshold 'd' value of all elements in the model is less than 0.2 ($d \leq 0.2$) indicating that all evaluation expert panels are assumed to have consensus and unanimity in making decision (Cheng & Lin, 2002).

Fuzzy Score Evaluation Results (Defuzzification) for Each Arrangement of Element

Table 4 illustrates the fuzzy score evaluation (defuzzification) analysis results for each element in the model.

Table 4: Fuzzy Score Results (Defuzzification)

No.	**Items / Elements**	***Fuzzy Evaluation Process Requirements***				**Expert Agreement Decision**
		m1	**m2**	**m3**	***Fuzzy* Score *(A)***	
1	Students express their existing knowledge on i-think maps to develop interest in generating ideas.	0.733	0.906	0.989	0.876	ACCEPT
2	Students receive an introduction to learning topics (concept/theme/content).	0.744	0.906	0.978	0.876	ACCEPT
3	Students listen to explanations from teachers about using eight types of i-think maps based on examples of issues provided.	0.700	0.872	0.961	0.844	ACCEPT
4	Students receive the introduction to the eight types of i-think maps.	0.722	0.900	0.989	0.870	ACCEPT
5	Students form groups for discussions.	0.711	0.883	0.972	0.856	ACCEPT
6	Students receive group assignments activities and listen to instructions presented by the teacher.	0.722	0.889	0.972	0.861	ACCEPT
7	Students discuss in groups to complete assignments.	0.711	0.883	0.972	0.856	ACCEPT
8	Students receive guidance on the evaluation criteria for the activities to fulfil the requirements of the assignments.	0.733	0.889	0.967	0.863	ACCEPT
9	Students use various resources to obtain information in generating ideas.	0.778	0.928	0.989	0.898	ACCEPT
10	Students share ideas to complete the assignments.	0.767	0.917	0.983	0.889	ACCEPT

11	Students receive an explanation on the evaluation criteria for the group work from the teacher.	0.733	0.900	0.983	0.872	ACCEPT
12	Students compare original ideas and new ideas using i-think maps.	0.700	0.867	0.961	0.843	ACCEPT
13	Students use new ideas to complete assignments.	0.711	0.878	0.972	0.854	ACCEPT
14	Students from other groups provide feedback to the group that is giving their presentation.	0.744	0.900	0.978	0.874	ACCEPT
15	Students develop i-think maps based on group information and ideas.	0.733	0.883	0.956	0.857	ACCEPT
16	Students present their group results with a clear pronunciation and correct intonation.	0.767	0.917	0.978	0.887	ACCEPT
17	Students present their group results with a clear pronunciation and correct intonation.	0.744	0.894	0.967	0.869	ACCEPT
18	Students complete writing activities based on timelines and future scenarios built using i-think maps.	0.744	0.906	0.983	0.878	ACCEPT
19	Students produce future scenarios using i-think maps.	0.733	0.889	0.967	0.863	ACCEPT
20	Students build timelines using i-think maps.	0.722	0.883	0.967	0.857	ACCEPT
21	Students develop build a development model product or a future model using i-think maps.	0.733	0.889	0.967	0.863	ACCEPT
22	Students conduct self-reflections on the learning content.	0.733	0.883	0.961	0.859	ACCEPT
23	Students create learning metacognition that causes a change in ideas and the application of future thinking.	0.733	0.889	0.972	0.865	ACCEPT

Based on Table 4, the fuzzy score evaluation (defuzzification) of each arrangement of elements using the fuzzy evaluation process requirements with a fuzzy score value exceeding 0.5 to determine the acceptance and rejection of questionnaire items (Jamil & Noh, 2020) evaluate the appropriate arrangement of elements in the teaching activities model developed. The research findings of the analysis also discovered that all expert panels involved in model evaluation agreed to the arrangement of activities in the teaching activity model because they achieved a high fuzzy score of more than 0.80.

In conclusion, all elements in the teaching activities model developed are accepted by all model evaluation experts and are suitable to be used in learning that applies future thinking skills. In fact, based on these three requirements, the threshold value of 'd' does not exceed 2.0 ($d \leq 0.2$), while the percentage of agreement exceeds 75% and the fuzzy score exceeds 0.5 determine the acceptance and rejection of the questionnaire items evaluating the appropriate arrangement of elements in the teaching activity model using i-think maps to improve future thinking skills of secondary school students in learning the Malay language.

CONCLUSION

Overall, the research findings reveal the results of expert unanimity and agreement as a study sample and also expert consensus in evaluating the appropriate arrangement of elements in the teaching activities model developed through the application of fuzzy Delphi techniques. In addition, these findings have revealed that all items were accepted based on the unanimity and agreement of the model evaluation expert panels because the percentage of expert agreement or unanimity exceeds 75%, the threshold 'd' value is less than 0.2 ($d \leq 0.2$) and the fuzzy score value (defuzification) exceeds the score value of 0.5 determine the acceptance and rejection of items. Thus, this explains that the model developed, the Teaching Activity Model using the I-think Maps to Improve Future Thinking Skills, has a high consensus or unanimity between the group experts of model evaluation. Moreover, the contribution of this study is the development of the 21st Century Learning model that emphasizes on the student-centered TnL method focusing on the 21st century skills that include communication, collaborative, creativity, critical thinking and pure value and ethics.

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