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The Role of Multi-dimensional Curriculum Design in Improving Higher-Order Thinking Skills

Anita Yosepha*, Mohammad Ali,
Dinn Wahyudin and Rusman
Department of curriculum development,
Universitas Pendidikan Indonesia, Bandung, Indonesia

Abstract. The purpose of this study was to investigate the effectiveness of a multidimensional curriculum in improving the students' high-level thinking skills in middle and elementary schools. The method used was the experimental method with a quasi-experimental design by testing a multidimensional curriculum model integrated with scientific, creative, and future thinking competencies in the experimental group and comparing it to the control group. The participants involved in this study were 500 students divided into two groups, namely the experimental and control. The experimental group consisted of 250 students with a composition of elementary school (grades 4-6) and junior high school students (grades 9-12). The instrument used to measure the students' thinking skills was a questionnaire that contained three dimensions, namely scientific thinking, creative thinking, and future thinking. Data analysis was then carried out. First, factor analysis was used for the item scale analysis for each competency, the Pearson correlation to investigate the relationships between the competencies, paired sample tests to investigate the pre-test and post-test differences, and repeated tests to determine the results based on all variables. The results show that a multidimensional curriculum is proven to be effective at increasing the high-level thinking skills of elementary and middle school students. The improvement in higher-order thinking skills at the junior high school level is more significant than that of the elementary school students because the development of high-level thinking skills are by then sufficiently trained to think scientifically, creatively, and for the future compared to elementary school students. The dimensions of ability that have the most significant improvement are the ability to think about the future and the dimensions of the ability to think creatively. The strongest correlation between higher-order thinking skills and curriculum dimension elements was found in the correlation between creative thinking (identifying and solving problems). This research has the implication that the multidimensional curriculum in its implementation

* Corresponding author: *Anita Yosepha; anitahandjaya19@upi.edu*

must be accompanied by the use of learning methods that are able to encourage students to think scientifically, creatively, and be able to predict the future.

Keywords: higher order thinking skills; multidimensional curriculum; thinking skills dimensions; innovative strategies and methods

1. Introduction

Today's teachers need to be better able to support students to improve their skills both in general and in particular to meet the demands of the world (Hadianto et al., 2021a; Saido et al., 2018). Schools must prepare their students to answer future challenges. What kind of education is appropriate and the best to answer the challenges of the future? This question is of concern to stakeholders both in government and the school itself. The answer lies in a curriculum design that must be able to equip students to face challenges in the future. There are several abilities that must be possessed by students in the 21st century, namely the ability to think critically and solve problems, the ability to communicate, collaborate, computing and information technology skills, as well as career planning, cross-cultural, creative and innovative (Bovill & Woolmer, 2019; Green, 2018). The integration of critical thinking skills and other abilities is still not enough to create a curriculum that is able to provide excellent abilities. Education must be appropriate to the context both locally and globally. In addition, education must be able to meet specific characteristics according to its culture, demands, and history as well as the demands of the future, such as digital capabilities (Davis et al., 2023; Fensham, 2022).

Improving the students' thinking skills can be done through various methods and strategies. However, it is still rare for curriculum models to be designed that are intended to improve higher-order thinking skills that integrate future thinking skills, individual views, and concepts, as well as global understanding and the ability to predict problems in the future (Manassero-Mas & Vázquez-Alonso, 2022; Whalen & Paez, 2021). This ability is needed by students today. The ability to plan for the future must be given to students. This ability usually depends on the age level of the student. The ability to plan for the future using multiple perspectives requires the ability to analyse problems and solve them. The multidimensional curriculum is used by researchers to better determine its role in improving higher-order thinking skills by focusing on three aspects, namely scientific thinking (scientific questions), creative thinking (creative problem solving), and future thinking (individual and time perspectives) (Hadianto et al., 2022; Sung et al., 2019). The difference between this study and the previous research is intervention design in the form of a multidimensional curriculum and the competencies that it develops. Most of the previous research used interventions that were teaching methods and focused only on higher-order thinking skills (Lu et al., 2021; Miedijensky et al., 2021). This is in contrast to this study where the intervention used was a multidimensional curriculum design and the competencies developed not only focused on higher-order thinking skills but all abilities that belong to higher-order thinking, namely scientific thinking, creative thinking, and predicting the future.

Through this research, the researchers tried to investigate the contribution of a multidimensional curriculum design to the students' higher-order thinking skills, the dimensions of said higher-order thinking skills, and also to see whether there is a connection between the aspects of school level and gender. This research provides knowledge on how to improve the level of thinking skills and future thinking skills through curriculum design. The researchers investigated the results of the intervention in an experimental group that learned certain material using three types of thought processes (scientific, creative, and future thinking) in a multidimensional curriculum. Next, they compared it with the learning outcomes of students who studied using conventional methods who were in the control group. In addition, this study investigated the results of the intervention of learning programs with a multidimensional curriculum design at different school levels and their relationship with the student's gender. The formulation of the research problem is as follows: 1) What is the effect of the multidimensional curriculum program intervention on the students' higher-order thinking skills? and 2) Does the school level and gender of the students have a relationship with higher-order thinking skills when receiving interventions from a multidimensional curriculum?

2. Literature Review

2.1 Curriculum development

The basis for developing this multidimensional curriculum is a constructivist approach which is believed to be able to improve higher-order thinking skills and future thinking skills. The multidimensional curriculum framework is built on a curriculum model made for gifted children. The multidimensional curriculum model is based on an integrated curriculum and parallel curricula and programs to provide future problem-solving skills (Guo et al., 2022; Saido et al., 2018). The integrated curriculum focuses on three aspects, namely content dimensions, issue dimensions, and process and product dimensions. The parallel curriculum focuses on the interdisciplinary curriculum, the involvement of personality aspects, and expert practicum (Cross, 2021; Oberauer et al., 2022). The problem-solving program contains creative problem-solving competencies and abilities that are needed in the future so then students can adapt to the demands of the world. It is not enough for students at school to just learn about the past but they must also be equipped with the ability to understand and predict possible future choices about a problem (Guo et al., 2022; McConnery et al., 2021). Students must be able to actively imagine surviving in an era that is experiencing very rapid changes. If students are equipped with the ability to predict the future, they will use their imagination to see problems within a modern paradigm, as well as to find, analyse, explore and produce new views of a problem that are appropriate to the present (Fensham, 2022). In order for students to have the ability to think in the future, they must be trained in historical views, and equipped with short-term and long-term planning skills. Students should be encouraged to develop their competencies in three aspects, namely product development, concepts, and views.

When designing a multidimensional curriculum, there are three additional dimensions suggested by researchers, namely personal, global, and the time perspective (Carroll & Harris, 2020; Heron & Palfreyman, 2021). Personal perspective reflects personal identity. This dimension encourages personal student involvement, increases self-awareness, fosters interest, and encourages intrinsic motivation. Some questions that reveal the personal dimension include 1) How do you feel about the problem? 2) How did you get involved in the process? and 3) How do you improve your competence so then you can contribute to society. The personal perspective focuses on developing the students' awareness in order for them to be involved in the learning process, to participate in social life, and to be active when predicting future problems (Green, 2022; Hadianto et al., 2021b). The personal perspective aspect in the curriculum dimension is useful for training students to use procedures, and to compare and contrast, when building a global perspective and perspective based on future time. The personal perspective is used as a basis for improving future thinking skills. Next, there is the global perspective dimension. The global perspective views the world as integrated. Events that occur in one country will affect other countries in various aspects. Students need to be given the ability to identify problems or concepts from micro and macro views, to analyse differences and similarities as well as cultural and geographical issues, and other global trends that will definitely affect the conditions of countries worldwide (Barfod & Bentsen, 2018; Carroll & Harris, 2020).

Some of the questions used to reveal the students' global perspectives include 1) What issues are currently emerging in developed countries? and 2) What are the issues that are currently developing globally in each country? The students' awareness of this global perspective will be useful as part of creating a global perspective when the students grow up. The dimension of the time perspective contains the competence to understand developments and changes over time. The time perspective provides competency opportunities to understand problems, to optimise processes and products, and to understand the aspects of the past, present, and future. Questions that reveal the perspective of time include where did it come from, what was it like at first, and what are the current conditions like? What's the future direction? These questions can improve the students' ability to predict and respond to problems or demands in the future using their past knowledge. Through a multi-dimensional curriculum, students are given the tools to analyse and predict various possibilities for the future.

2.2 Development of higher-order thinking skills

The learning methods and strategies used in the implementation of the multidimensional curriculum promote higher-order thinking skills. The levels of cognitive ability drawn from Bloom's taxonomy have been revised into identification, memory, understanding, implementation, analysis, evaluation, and creation. The ability to think at a higher level cognitively is involved in the process of constructing new knowledge (Bovill & Woolmer, 2019; Gore et al., 2018). New knowledge is constructed through processes that promote critical thinking, creative, and problem-solving skills. There are several types of thinking framework that can be used when creating new knowledge including pedagogy or instructional design, productive or philosophical approaches, cognitive structures and development, and comprehensive frameworks (Lu et al., 2021; Miedijensky et al., 2021).

One approach that can be used to improve thinking skills is the infusion approach. This approach uses pedagogy and encourages the ability to think directly so then the students are able to identify patterns, find similarities and differences, guess, give rational reasons, provide different views, solve problems, make decisions, and evaluate the results of their work (Lin & Chuang, 2018). Classical scientific inquiry abilities such as formulating problems, making hypotheses, making experiments, and making conclusions are included in higher-order thinking skills. Cognitive activities that can train higher-order thinking skills include giving arguments, comparing, solving problems, responding to different views, making decisions, and finding implicit assumptions. From previous studies, a relationship was found between knowledge and certain thoughts. This finding confirms that the development of thinking in a particular domain is largely determined by the level of knowledge of said domain. In addition, these findings also confirm that individual creativity is highly dependent on the domain (Elfeky, 2019; Zhang & Chan, 2020). Individual metacognitive abilities use the ability to think critically and creatively simultaneously. Teaching that encourages the students' critical thinking is teaching that contains the teacher's instructions or open-ended teacher questions, as well as providing space for the students to think critically and creatively so then this higher-order thinking activity becomes a routine.

2.3 Increasing higher-order thinking skills through a multidimensional curriculum

Teaching thinking skills is a complex activity because thinking processes can involve inquiry, critical thinking, and creative thinking. Teaching can be done by giving examples of thinking or practicing thinking skills including making concepts, understanding concepts, drawing conclusions, and solving problems (Baghaei et al., 2020; Carroll & Harris, 2020). Teaching thinking processes focuses on three dimensions, namely training scientific thinking skills (inquiry), practicing creative thinking skills (identification and problem solving), and training the ability to think about the future based on personal views (looking at a problem from the perspectives of the past, present, and future). The ability to think about the future is one of the new competencies that must be taught in order to equip students to be ready to face the future and prepare their competencies in order to face future competition (Green, 2022; Nurwanto & Cusack, 2018). The ability to think scientifically is the ability to study scientific concepts, and to explore and test them through scientific experiments. Some of the abilities involved in the scientific thinking process are identifying problems, making hypotheses, making experiments, analysing results, and making conclusions.

Creative thinking teaches students to identify and solve problems. The ability to think creatively is a type of critical thinking skill used in investigating problems. Critical thinking skills are carried out based on objectivity criteria, problem-solving strategies, reflection, and practicing decision-making. Parallel, lateral, divergent, and convergent thinking are the cornerstones of the process of creative thinking and problem-solving (Manassero-Mas & Vázquez-Alonso, 2022; Saido et al., 2018). The ability to solve problems includes the ability to identify problems, determine problems, formulate solutions, evaluate criteria, choose the criteria for solutions, and plan actions. Creativity has various meanings, so the ability to think creatively is represented by the ability to solve problems. The ability to think about the future is a thinking ability that was often used by ancient humans to predict future conditions. With this future thinking ability, individuals can make judgments for the future, assess the significance of an intervention, provide predictions based on existing information, and evaluate their abilities (Hwang et al., 2019; Sung et al., 2019). The ability to predict oneself in the future according to one's abilities is a very important aspect of future thinking skills. The ability to think about the future and make plans appears across all ages of student. This ability gradually develops until the students are 25 years old. By the time the students are grown up, their ability to plan for the future reaches an average of three years into the future (Baghaei et al., 2020; Carroll & Harris, 2020). The utilisation of the recorded past and a global perspective can increase the chances of providing more accurate predictions. Awareness of the ability to predict the future can be increased using several strategies, namely predictions from time to time, designing scenarios for selected events, imagining the future through a global perspective, and providing several solutions to events that occur (Hadianto et al., 2021a; Whalen & Paez, 2021). The four ranges of awareness that are often used to increase the awareness of future predictive abilities are event continuity, correlated events, event duration, and the acceleration or deceleration of events. The five time spans of awareness include the immediate range of 5 years, the short-term range of 6-10 years, the median range of 11-31 years, the long-term range of 31-51 years, and the very long range of 52-100 years.

2.4 Multidimensional curriculum design

The multidimensional curriculum design must consider various aspects including content, thinking strategies, evaluation tools, products, and reflection (McConnery et al., 2021). These aspects focus on three types of thinking skills, namely the ability to think scientifically, to think creatively, and to think for the future. Aspects that need to be considered in a multidimensional curriculum design are how the content of the curriculum must be interdisciplinary and that the concepts must be understood comprehensively. In addition, the thinking process in the curriculum must focus on three types, namely the ability to think scientifically through investigation, the ability to think creatively through identifying and solving problems, and the ability to think about the future which can be used to build new concepts or knowledge (Cross, 2021).

The scientific thinking strategy includes several stages, namely formulating the problem, obtaining information, presenting the results, and drawing conclusions. Creative thinking includes determining the problem, providing solutions, making criteria for selecting solutions, and planning actions from various perspectives. Thinking about the future includes several stages, namely identifying the components, analysing and classifying, comparing, identifying relationships and processes, organising, and making predictions (Green, 2022). The instrument used for improving scientific thinking skills was the TASC (Thinking Actively in a Social Context) Thinking Wheel. The way that this instrument works is to organise individual thoughts by forming a wheel and using inquiry to investigate the problems or concepts. Creative thinking skills are developed by using complex approaches to several types of problem (types 4, 5 and 6), practicing the stages of solving problems, and exploring the perspectives using some of the chosen topics. Future thinking skills can use problem illustrations with mind maps to write future plans. Tools for evaluating the products produced by the students must be discussed with the students and mutually agreed upon. This assessment must include formative and summative evaluations and the assessment must also be carried out using various methods such as self-assessment, and the views of friends and other teachers. The final product of the scientific thinking skills training process should be a small research project.

The final product in the process of improving creative thinking skills can be the formulation of alternative solutions and future action plans. The development of future thinking skills can be oriented towards several products including concept maps, model development, timescales, future plans, and future model designs. The products selected for training future thinking skills must vary including written, spoken, and creative products to acquire new knowledge and new perspectives (Sung et al., 2019; Whalen & Paez, 2021). In addition, there must be time or the opportunity for the students to reflect on the processes they have gone through in relation to metacognition and personal reflection. This can be done by asking specific questions or questions about the different strategies. The design of the multidimensional curriculum components is presented in Table 1.

Table 1. Components of the multidimensional curriculum

Content	Appropriate interdisciplinary content or product orientation		
Thought process	Think scientific (inquiry)	Creative thinking (identify and solve problems)	Future thinking (building and analysing concepts or materials)
Strategy thinking	Formulation of the problem hypothesis Gather information Organising information Presenting graphs	Define the problem Provide solutions Create criteria Identify perspective Choose the best solution Respond to different perspectives	Defining and identifying components Classify and analyse Compare Identify relationships Identify processes Organising sections Prediction development
Tool	Thinking wheel model Inquiry stages	problem type Problem solving stages Thinking topics	Mind map Future scenarios
Assessment instrument	Create criteria for product assessment with the students Use formative and summative assessments Self-assessment, peers, and teachers		
Product	Mini research	Problem solution Action plan	Concept maps Model development Deadline Future models Future scenarios
	Multicategory Written, spoken, and creative		
Reflection	Metacognition/personal reflection on the thought processes General questions on the learning process Question-based thinking strategies		

The teaching strategies that can be used in a multidimensional curriculum design include project-based learning, problem-based learning, and blended learning that combines technology, language skills, and relevant issues (Cheng et al., 2020;

Diamond et al., 2020). The formulation of the subject units in a multidimensional curriculum uses several stages, namely a) introducing the content to students where the mental representation of students must be formed by the teacher through involving the content, process and product components, integrating them with personal, global and time perspectives; b) the teacher must provide alternative choices of content, taking into account suggestions from the students; and c) the learning procedures must be introduced to students and must involve the students actively in deciding something in the learning process (Oberauer et al., 2022; van Leent & Spina, 2022). Teachers in this curriculum are required to have flexible, open, and to use democratic criteria during the learning process. Planning by actively involving the students can increase student motivation and interest. The design of the learning process tools in the multidimensional curriculum uses a constructivist approach and integrates perspectives with innovative learning instruments and strategies. This design process can improve the ability to think scientifically, creatively, and for the future.

3. Methodology

3.1 Participants

This study used an experimental method with a quasi-experimental design to investigate the students' thinking skills as a result of the intervention of a multidimensional curriculum design. There were 500 participants in this study divided into two groups, namely the experimental and control where the groups had the same number of participants who had the same socioeconomic status. The experimental group consisted of 250 students with a composition consisting of elementary (grades 4-6) and middle school (grades 9-12). The control group consisted of 250 students with an equal number of elementary and junior high school students (grades 9-12). The experimental group received the learning program intervention using a multidimensional curriculum, while the control group studied using conventional methods. An explanation of the demographics of the research participants is presented in Table 2.

Table 2. Demographics of the research participants

		Experimental	Control	Total
Grade Level	Elementary	125	125	250
	Secondary	130	120	250
	Total	255	245	500
Gender	Male	120	120	240
	Female	135	125	260
	Total	255	245	500

The selection of the student sample was carried out proportionally according to school level, class and gender. This research was conducted in 8 schools and 15 classes from elementary school to junior high school in West Java, Indonesia. The number of students in one class averaged 30-40. The proportion of gender was 260 female students and 240 male students. The sample in this study represents the culture in the West Java region, namely the Sundanese culture. In one school, about 70% of the students were born in the West Java region, where the Sundanese culture is predominant. In general, the participants involved in this research had academic abilities that were evenly distributed, which means that it can be interpreted that their thinking abilities are not much different.

3.2 Procedure

This research went through several procedures, including the development of an intervention program designed with a multidimensional curriculum in mind. The fields of study that are the focus of the intervention are communication skills, economic capacity and globalisation, culture, understanding of the internal organs, and mathematics. All of these areas are studied at school. Each unit contains 10-15 lessons conducted at secondary school level. All fields of study contain scientific, creative, and future thinking processes. Future thinking competence focuses on the personal and temporal views of a concept. First, all schools integrate these three types of thinking process in their implementation process, namely scientific thinking, creative thinking, and future thinking, specifically thinking scientifically using inquiry, thinking creatively using problem-solving steps and thinking themes, and thinking in the future using mind maps and scenarios or future planning. The control class was taught using the direct or inquiry methods but not too often.

Next, the second stage was piloted. The assessment instruments and indicators were made based on the scale and questionnaire items. The indicators were made based on agreement between the assessor and the teacher who checked the student's answers to the open questionnaire. The scale used was a scale of 1-5 in each category. The agreement used was 90%, so all teachers assessed the results of the questionnaire using these indicators. The third stage was testing the higher-order thinking skills before and after receiving the intervention consisting of a learning program for a multidimensional curriculum. In the pretest session, the students' thinking skills were measured by them answering an open questionnaire individually which took about 30 minutes for the pretest and 45 minutes for the posttest. At the end of the study, the assessment carried out the same procedure again to see the consistency of the higher-order thinking skills.

3.3 Research Instruments

The instrument used to assess higher-order thinking skills was a higher-order thinking questionnaire. The questionnaire consisted of several parts. The first part contained general topics that assessed the students' scientific thinking abilities. The second part assessed the ability to think creatively which provided information on the possibility of life in outer space and its relationship to earth. The third section assessed future thinking skills covering general topics and encouraged the students to provide their personal and timely perspectives. The questionnaire was used in the experimental and control groups before and after the learning program intervention. Instrument validation was carried out by two experts according to their fields using content validity, factor analysis, and varimax rotation. The reliability of the instrument was assessed using the student's responses to the questionnaire with a value of 0.96. The factor analysis assessment obtained three scales according to the focus of thinking competence (scientific, creative, and future). The following are the results of the assessment for each competency. Scientific thinking competence (investigation) consisting of 7 items had a Cronbach's alpha value = 0.90, and a total score of 35. Several of the questionnaire questions assessed scientific thinking skills, namely 'What are the main findings presented in the figure?' This question tests classification and analytical skills, for example.

'What can you conclude from this explanation?' This question tests the ability to draw conclusions. Creative thinking skills test the ability to identify and solve problems, which contained 7 items, with a Cronbach's alpha value = 0.93 and a total score of 35. Some of the questions used in this section of the questionnaire were "Identify the problem that you found in the data? (problem identification ability) and 'Create alternative solutions of at least five alternative solutions to solve the problem you specify!' (ability to provide solutions). The ability to think about the future was divided into two parts, namely personal perspective and time perspective. Personal perspective consisted of 5 items, with a Cronbach's alpha value of 0.86 and a total score of 25. An example of a question in this section is 'Create a paragraph that contains your personal views on the subject matter presented'. This task can be positioned in the first person. The time perspective consisted of 5 items with a Cronbach's alpha value = 0.83 and a total score of 25. An example of a question in this section is 'In your opinion, how is the development of the issue, problem/subject?' (ability to describe processes). The maximum total score possible in the higher-level thinking skills questionnaire is 100. The results of the factor analysis on the questionnaire are presented in Table 3.

Table 3. Results of the factor analysis.

	Scientific thinking	Creative thinking		Future Thinking
Dimensions	Inquiry	Problem-solving	Personal perspective	Time Perspective
Alpha (total 0.95)	.90	.93	.86	+ .83 = .92
Formulate hypotheses	.80			
Information organisation and graphical representation	.79			
Integration	.71			
Classification and analysis	.69			
Define conclusions	.67			
Make a problem statement	.66			
Define the problem		.76		
Create criteria		.72		
Provide solutions		.71		
Identify the problem		.70		
Provide the best solution		.69		
Create an action plan		.52		
Make a different view			.78	

Related to problems			.70	
Have leadership			.60	
Write in first person			.58	
Understand the process				.75
Understand the relationship between processes				.72
Describes three different times				.50
Appropriate content				.43
Variance (in Percentage)	25.35	19.30	13.80	9.43
Average Score	17.82/41	21.90/32	13.10/23	12.50/23
(SD)	(7.89)	(7.10)	(5.50)	(5.31)

3.4 Data analysis

From the results of the trial analysis, the factor analysis of the 500 student responses through the questionnaire resulted in one item being deleted, one repeated, and two integrated. Regarding the questionnaire instrument, it was found that the reliability value of Cronbach's alpha was 0.95 which explained the three dimensions of higher-order thinking skills. The following is an explanation of the results of the analysis of the three dimensions of higher-order thinking competence: a) scientific thinking contained 7 items with a Cronbach's alpha = 0.86, b) creative thinking competence contained 7 items with a Cronbach's alpha = 0.92, and c) future thinking competence contained 8 items with a Cronbach's alpha value = 0.90. The students' thinking ability was calculated using a scale and the items from the factor analysis with a score range of 0 - 5 points. The maximum score of all questionnaire items was 100. The indicators were developed based on the readiness of the assessors and they were processed using the percentage of approved statements multiplied by 100. The reliability of the random sampling had a reliability value of 90%. Pearson's correlation analysis was used to investigate the relationship between the dimensions of thinking process competence. The higher-order thinking ability scores were calculated separately from the general score and the score for each dimension. The difference between the two groups at the pretest and posttest was calculated using the paired sample test. The variable differences by group, school level, gender, pretest-posttest, and the separate dimension scores were calculated using repeated measures analysis.

3.5 Research ethics

All participants involved filled out the consent form in order to take part in the research, thus all participants in this study were involved voluntarily without any coercion. In addition, all participants were anonymous. The research data on the students' higher-order thinking skills in this study was not used for academic purposes in the respective schools but it was used for study purposes.

4. Results

4.1 Higher-order thinking skills in general

To answer the first formulation of the problem, the researcher presents the data on the effect of a learning program intervention using a multidimensional curriculum to increase the use of higher-order thinking skills. Based on the results of the analysis, the intervention program was found to have a significant impact on the high-level thinking skills of the experimental group students. The differences between the two groups were apparent in the pretest and posttest phases. In the pretest phase, in general, the two groups (experimental and control) showed relatively the same thinking skills and did not differ much. Based on the results of the analysis, the mean and standard deviation values were obtained. The experimental group was 22.20 [16.70] and 20.15 [14.45]). Looking at the pretest and posttest phases, significant differences in scores were found in each group. The intervention group obtained the pretest and posttest phase values of (22.20 [16.70] and 63.10 [20.40], MD = -40.80, t = -30.90, p <.001), while the control group obtained mean and standard deviation values in the pretest and posttest of (19.15 [14.45] and 30.80 [16.30], MD = -4.20, t = -6.60, p < .001). The main effect of the multidimensional curriculum intervention was found in the experimental group as having a value of (F[1,195] = 640.50, p <.001, Effect Size = .856). This value indicates that the experimental group experienced a better improvement than the control group in the posttest phases. Based on the results of the multivariate analysis, a significant difference was found between the two groups with scores of (F[1,462] = 857.70, p < .001, ES = .956). This value indicates that the difference in the increase in higher-order thinking skills in the experimental group and the control group is around 45%. The data on the comparison of the scores for the higher-order thinking skills of the experimental and control groups in each phase is presented in Table 4. For clarity, multivariate test analysis was carried out based on gender and school level.

Table 4. Higher-order thinking skills of the two groups in the pretest and posttest phases.

	Pre-test mean (SD)	Post-test mean (SD)	MD	T	F(df = 1,462)	Size effect
Intervention group (n = 199)	22.20 (16.70)	63.10 (20.40)	-40.80	-30.90	857.70	0.956
Control Group (n = 195)	19.15 (14.45)	30.80 (16.30)	-4.20	-6.60		

p < .001.

To answer the second problem formulation, multivariate test analysis was carried out based on the time and sex variables to determine the differences between the two groups. Based on the results of the analysis, the main effect value was obtained based on the gender variable, the F value and the effect size of male students, namely F[1,190] = 310.85, p <.001, ES = .840). This value indicates that the male students in the experimental group had a different average score in each phase. Based on the analysis results, the mean score for the male sex in the posttest phase is greater than in the pretest phase (22.46 [18.89] < 60.90 [21.35]) and the average score of the control group in the posttest phase is greater than the pretest but not too significant for the control group (20.56 [13.50] < 24.10 [15.95]). The main effect value was found for female students (F[1,198] = 489.89, p < .001, ES = .890). In addition, it was found that the intervention group of female students was superior to the control group sequentially in each phase with a score (22.10 [15.78] < 65.30 [16.50) and the control group (17.60 [13.53] < 21.52 [16.60). Another finding was that there was a significant difference in the experimental group between the thinking abilities of the male and female students in the posttest phase with a score of (60.90 [21.35] < 65.30 [15.78], MD = -5.40, F [1.198] = 6.15, p < 0.05, ES = 0.040). From the results of the analysis, it can be concluded that female students have more high-level thinking skills in the experimental group. This is different from the control group which shows the opposite. The results of the data analysis for the experimental and control groups based on phase and sex are presented in Table 5.

Table 5. Higher-order thinking skills of the two groups based on student phase and gender.

	Intervention group			Control group				
	Mean (SD)			Mean (SD)				
	Pre-test	Post-test	MD	Pre-test	Post-test	MD	F (df = 3)	Size effect
Boys (n = 250)	22.46 (18.89)	60.90 (21.35)	-37.67**	20.56 (13.50)	24.10 (15.95)	-5.40**	310.85**	0.840
Girls (n = 250)	22.10 (15.78)	65.30 (15.78)	42.22**	17.60 (13.50)	21.52 (16.60)	-4.70**	489.89**	0.890

__p < .001.

Still answering the second problem formulation, an analysis of higher thinking skills based on school level was carried out. Based on the results of the analysis, a significant difference was found. The data on the average score (standard deviation), F value, and effect size are presented as follows. Differences were found in the experimental and control groups based on elementary and high school levels. From the results of the analysis, it was found that the curriculum had a significant main effect at the elementary school level with a score (F[3,227] = 478.10, p <.001, SE = 0.856). The acquisition of the average score and mean difference in the experimental group's average value in the posttest phase experienced a significant increase with a value of (20.31 [17.90] < 61.70 [20.45], MD = -42.40, p < 0.001), different from the control group. The scores in the control group also showed an increase in the posttest phase but not significantly (16.41 [12.50] < 20.42 [15.85], MD = -4.87, p < 0.001). At the secondary school level, the multidimensional curriculum provided a significant effect size with a score (F[3,230] = 315.25, p <.001, SE = 0.820). In addition, significant mean scores and mean differences were also found in the experimental group in the pretest and posttest phases (32.90 [6.87] < 64.71 [6.20], MD = -35.81, p <.001). The control group also experienced an increase but not as significantly as the experimental group (34.21 [6.4] < 40.21 [6.20], MD = -5.12, p <.001). From the results of the analysis, the higher-order thinking skills of the high school students experienced a more significant increase than that of elementary school students in both the experimental and control groups. In addition, it was also found that the main effect was seen in the elementary school level with grades (MD = -42.40, p <.001) and secondary school grades with grades (MD = -4.12, p <.001), as well as a difference of 4 points between the average scores posttest and pretest (61.70 [20.41] < 65.72 [6.20]). The experimental group of elementary school students in the pretest phase had lower initial abilities than those from the middle school but the increase in the posttest phase was greater. In the posttest phase, the elementary school students had almost the same thinking skills as the high school students. The results of the analysis of the higher-order thinking skills based on school level are presented in Table 6.

Table 6. Results of the analysis of the higher-order thinking skills based on school level.

	Intervention group			Control group				
	Pre-test	Post-test	MD	Pre-test	Post-test	MD	F (df = 3)	Size effect
Elementary (n = 231)	20.31 (17.90)	61.70 (20.45)	-42.40**	16.41 (12.50)	20.42 (15.85)	-4.87**	478.10**	0.856
Secondary (n = 163)	32.90 (6.87)	64.71 (6.20)	-35.80**	34.21 (6.4)	40.21 (6.20)	-5.12**	315.25**	0.820

**p < .001.

Table 7. The relationship between the dimensions of higher-order thinking skills in the dimension curriculum.

	Scientific thinking	Creative thinking	Future thinking
Scientific thinking	_______	.680**	.546**
Creative thinking	_______	_______	.782**

**p < .001.

Based on the results of the correlation test in Table 7, a significant correlation was found between the three dimensions of thinking competence found in the multidimensional curriculum design. The strongest correlation was found in the correlation between creative thinking (identifying and solving problems) and future thinking (personal and time perspectives) with a value of 0.782. This was followed by the second correlation, namely the relationship between scientific thinking (inquiry) and creative thinking (identifying and solving problems) with a value of 0.680, and finally the relationship between scientific thinking (inquiry) and future thinking (personal and time perspective) with a value of 0.546. It can be concluded that the Pearson correlation between the dimensions of thinking competence in the multidimensional curriculum had a significant main effect. From this data, it was interpreted that the ability to think creatively has a stronger relationship with future thinking than scientific thinking.

4.2 Analysis of higher-order thinking skills in each dimension
The researcher conducted a more detailed analysis of each dimension of the multidimensional curriculum to find out more about the role of each dimension in relation to the students' higher-order thinking skills. Based on the results of the analysis, it was found that the main effect of each dimension was as follows. The main effect on scientific thinking ability was ($F[3,412] = 212.785$, $p < .001$, SE = 0.903), creative thinking ability ($F[3,412] = 290.135$, $p < .001$, SE = 0.893), and future thinking ability in general ($F[3.412] = 189.412$, $p < .001$, SE = 0.852), in addition to when it was based on personal perspective ($F[3.412] = 120.754$, $p <.001$, SE = 0.742), and time perspective ($F[3.412] = 189.425$, $p<.001$, SE = 0.825). Each of the dimensions was analysed based on the group variables, school level, and gender, which will be presented in Table 8.

Table 8. Higher-level thinking skills for each dimension of thinking competence

		Intervention group			Control group				
		Pre-test	Post-test	MD	Pre-test	Post-test	MD	F (df = 3)	Size effect
Scientific thinking	Inquiry (30p.)	9.41 (6.70)	17.82 (7.89)	-9.25**	8.65 (5.80)	10.40 (6.50)	-1.70**	180.34**	0.581
Creative thinking	Problem-Solving (30p.)	7.84 (6.21)	26.89 (8.03)	-17.12**	6.70 (5.20)	5.89 (5.24)	-0.26	470.20**	0.784
Future thinking	Personal P. (20p.)	4.92 (5.78)	13.10 (5.52)	-8.25**	3.80 (4.90)	5.32 (5.50)	-1.65**	180.80**	0.668
	Time P. (20p.)	4.25 (5.24)	13.60 (6.32)	-10.42**	2.89 (3.80)	3.56 (5.10)	-0.81 **	270.70**	0.758
	Personal & Time P. (40p.)	7.89 (9.90)	25.50 (8.24)	-17.23**	4.57 (6.18)	6.65 (7.45)	-2.10**	314.61**	0.782

Based on the results of the analysis in Table 8, a significant difference was found in each dimension of the ability to think highly in the experimental group. The increase in higher-order thinking skills in the pretest and posttest experimental groups experienced an increase of 9-15%. Higher-order thinking skills were very low but experienced a significant increase of around 65% in the posttest phase in all dimensions. The dimensions of thinking competence that experienced an increase in the experimental group were mass thinking competence with a value of (7.89 [9.90] < 25.50 [8.24], MD = -17.23, $p <.001$) and creative thinking competence (6.91 [5.24] < 25.90 [7.05], MD = -16.04, $p <.001$). The lowest thinking ability score was for the future thinking ability score in the time perspective in the pretest with a score of (3.20 [4.25]) but this increased in the posttest phase by about 9 points (12.56 [5.21]). The value of future thinking skills from the time perspective in the posttest phase was in the middle category. Furthermore, the ability to think scientifically was found to have the highest value in the pretest phase and showed a significant increase. The increase occurred more in the experimental group than in the control group with the following values: (9.41[6.70] < 17.82 [7.89], MD = -

9.25, p <.001 and 8.65 [5.80] < 10.40 [6.50], MD = -2.70, p < 001). The increase in higher order thinking skills in the control group was very small. There was also a significant difference in higher order thinking skills based on school level, namely creative thinking skills at the elementary school level had a value (F[3,189] = 11.89, p <.001, SE = 0.063), whereas at the secondary school level, it was (6.07 [3.54] < 21.70 [3.70] and 9.41 [4.70] < 21.30 [4.89] However, no significant differences were found in each dimension based on the gender variable.

5. Discussion

This study investigated the role of a multidimensional curriculum design in increasing higher-order thinking skills among both elementary and secondary school students. To investigate the role of the proposed multidimensional curriculum design, a learning intervention program was created for both groups of experimental students, while the learning intervention for the control group used conventional methods. In the integrated experimental group intervention, three dimensions of thinking competence were integrated with the multidimensional curriculum, namely scientific, creative, and future thinking competencies. The research findings show that this multidimensional curriculum design can improve the high-level thinking skills of elementary and secondary school students. This finding is consistent with the theory that thinking competence will be more effective if it is taught in an integrated manner in the curriculum design as well as the teaching process (Hwang et al., 2019; McConnery et al., 2021). Students will indirectly be trained in thinking competence through the processes and products that the curriculum demands. So, the use of an integrated approach, explicit instruments, and the implicit teaching of the thinking competence in the curriculum have been proven to be effective at increasing the students' higher-order thinking skills. The multidimensional curriculum was designed by introducing thinking competency evaluation instruments, selecting appropriate content, promoting collaboration, integrating it with technology, and providing opportunities for the students to provide different perspectives. The design of the multidimensional curriculum component was able to improve the competence of the students' higher-order thinking skills. This research is in accordance with the previous research which has tested a thinking ability improvement program that was proven to be effective at improving the academic abilities of students in their schools. This was in contrast to the students who did not receive the teaching of thinking competency improvement programs with a relatively poor academic achievement (Barfod & Bentsen, 2018; Saido et al., 2018).

Teaching thinking skills is not enough if you only use teaching instruments as it needs to be accompanied by other components. This was done in this study. A multidimensional curriculum designed to improve higher-order thinking skills using various components that are integrated into the curriculum can include thinking topics, thought wheels, problem solving stages, instructions for writing future plans, and other relevant units (Elfeky, 2019; Lin & Chuang, 2018). A multidimensional curriculum that integrates the three dimensions of thinking (scientific, creative, and future thinking) was able to effectively improve higher-order thinking competencies in the experimental group at both the elementary and secondary school levels. The main effect size given by the multidimensional curriculum as a whole is 0.90. From these findings, it can be concluded that students at the primary and secondary school levels have potential in their thinking abilities if they are optimised using appropriate intervention programs (Fang et al., 2021; Lu et al., 2021).

Students at the elementary school level who have low higher-order thinking skills can also improve their thinking skills using a multidimensional curriculum design, meaning that the high-order thinking skills of the elementary school students are almost equal to the students' high-order thinking skills at the middle school level. This improvement can be seen in both the thinking competencies in general, as well as in every dimension of the scientific, creative, and future thinking competencies more generally. Teaching thinking competencies such as scientific thinking competencies (inquiry), creative thinking (problem solving), and future thinking (personal and time perspectives) carried out among early age students (elementary school) will greatly assist the students in getting used to continuing to use high-level thinking skills high in each learning process (Miedijensky et al., 2021; Wijnen et al., 2021).

From the results of the analysis, the increase in the dimensions of the ability to think scientifically increased at least from pretest to posttest among the other thinking competencies. This is inseparable from the complexity of the scientific thinking competencies which require quite long stages of involvement. Scientific thinking competence is an inquiry process that contains quite complex stages including defining problems, formulating hypotheses, planning experiments, analysing results, and drawing conclusions (Bovill & Woolmer, 2019; Gore et al., 2018). The difference in improvement in each significant dimension of thinking in the experimental group is caused by the other additional aspects used by the teachers to increase student motivation, for example, the use of innovative learning strategies, interesting topics, involving students in formulating the assessment criteria and materials, as well as the use of a challenging learning process and encouraging the students' higher-order thinking skills. Furthermore, an increase in the dimensions of creative thinking can be seen in the students' ability to identify and solve problems (Whalen & Paez, 2021; Zhang & Chan, 2020). This increase also occurred for the students who had never been involved in the problem-solving process before in class, such as the elementary school students who rarely used this method.

All students at the primary and secondary school levels are able to demonstrate their ability to identify problems and solve them in various fields of study. Students who have very low high-order thinking skills are able to improve their thinking skills to almost match the thinking abilities of the middle-level students. This finding was quite a surprise to the researchers, as well as providing an illustration that younger students are able to optimise their thinking skills very quickly if given the right intervention (Lin & Chuang, 2018; Lu et al., 2021). Furthermore, future thinking competence also increased but the increase was not too significant in the experimental group when viewed according to each dimension of personal perspective and time perspective. This happens because the competence to think about the future for elementary and middle school students is something new and rarely used either at school or in everyday life.

This is consistent with the theory that future thinking contains higher thinking competencies that require inter-process understanding, meaning that it takes a longer time to master them (Manassero-Mas & Vázquez-Alonso, 2022; Saido et al., 2018). In general, more than 55% of elementary and middle school students were able to use the future thinking ability in the posttest phase. This indicates that students can be taught the ability to think well in the future even though it is difficult unless the right intervention program is used.

6. Conclusion and Implication

The multidimensional curriculum has been proven to be effective at increasing the higher order thinking skills of primary and secondary school students. The improvement is seen in the three abilities that are at the core of higher-order thinking, namely the ability to think scientifically, to think creatively, and to think about the future. From the two school levels, the increase in higher-order thinking skills at the secondary school level was more significant than that of the elementary school students because the development of high-level thinking skills was more sufficiently trained. Furthermore, the effect of the multidimensional curriculum on the higher thinking skills of female students was more significant than that of male students. The strongest correlation between higher-order thinking skills and curriculum dimension elements was found in the correlation between creative thinking (identifying and solving problems) and future thinking (personal and time perspectives), followed by the second correlation, namely the relationship between scientific thinking (inquiry). by thinking creatively (identifying and solving problems), and lastly the relationship between scientific thinking (inquiry) and thinking about the future (personal and time perspectives).

A teaching process that uses a multidimensional curriculum can facilitate the students in acquiring scientific, creative thinking, and future thinking skills in a relatively short time. The multidimensional curriculum in its implementation must be accompanied by the use of learning methods that are able to encourage students to think scientifically, creatively, and be able to predict the future. This research facilitates several implications, namely that a) curriculum designers should pay attention to several aspects, including the design of the inputs, processes, and outputs as part of the curriculum implementation, the teaching of integrated thinking competencies, the training of teachers, and the development of future thinking competencies with a multidimensional curriculum design; b) students who receive the learning program interventions have better opportunities in the future to get a decent life; c) thinking competence must be experienced directly according to the context so then the students can optimally develop their ideas from various perspectives; d) teachers at all school levels must have the capacity to provide a learning process that improves the students' higher-order thinking skills; e) the teaching process must promote future thinking skills so then the students are able to identify the processes involved and relate them, allowing them to provide predictions of a problem in the future.

7. Limitations and Recommendations

This study has several limitations, including the limited sample of students both in terms of number and school level, research data that only relies on quantitative data, no investigation of previously acquired learning experiences, and focusing only on three dimensions of thinking, namely scientific, creative, and future. Based on these limitations, the recommendations for further research are that the samples that must be expanded in terms of both number and school level, for example, up to senior high school and tertiary education levels. The research data can also be better equipped with qualitative data which can be obtained through interviews. Experiential investigations into the previous learning need to be done so then any deficiencies in the teaching process can be corrected, and thinking dimensions can be expanded or added to the thinking dimensions needed at this time. The combination of scientific, creative, and future thinking competencies provides opportunities for researchers to carry out further research on future thinking literacy.

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