



The Scientific Approach of The Indonesian 2013 Curriculum: A Comparison with Other Active Learning Strategies in Mathematics

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Abstract: The Indonesian 2013 curriculum is an improvement on the previous curriculum, namely the Education Unit Level Curriculum (KTSP). The implementation of the 2013 curriculum strongly emphasizes a Scientific Approach with student-centred learning to prepare Indonesian citizens to have the ability to live as individuals and citizens who are productive, creative, and innovative. The Scientific Approach is a learning process designed so that students actively construct concepts and principles through the stages of observing, asking, exploring, associating, and communicating. The purpose of this study is to compare the principles of the Scientific Approach of the 2013 curriculum with four different active learning strategies, namely Discovery Learning (DL); Inquiry-Based Learning (IBL); Problem-Based Learning (PBL) and Realistic Mathematics Education (RME). The result of this study is the recommendation of a dynamic modification of the Scientific Approach in the 2013 curriculum.

Keywords: *Scientific Approach; Discovery Learning; Inquiry-Based Learning; Problem-Based Learning; Realistic Mathematics Education.*

Introduction

The Indonesian 2013 Curriculum was introduced as an improvement to the previous Indonesian curriculum. In the 2013 Curriculum, the government sought to encourage changes in mindset, teaching culture and ability in carrying out the teaching and learning process. In implementing the 2013 Curriculum, teachers are expected to professionally design effective and meaningful learning by organizing activities and choosing the right approach by determining and using procedures that improve student outcomes (Mulyasa, 2014). Furthermore, in 2018, through the Ministry of Education and Culture, the government of Indonesia revised the 2013 National Curriculum to include skills for 21st-century learning skills by adopting the Partnership for 21st Century

Skills framework. The skills are creativity, innovation, critical thinking, problem-solving, collaboration and communication (Ministry of Education and Culture, 2018).

According to the Permendikbud¹ No. 65 of 2013 on the standard processes of teaching and learning, implementation of the 2013 Curriculum should use the Scientific Approach as the main pedagogical strategy for all subjects, including mathematics. The Scientific Approach to teaching has similarities with the scientific method used in scientific research (see, for example, Tang et al., 2010 and Edmund, 1994). In this article, the phrase “the Scientific Approach” is

¹ Permendikbud: Regulation of The Minister of Education and Culture of The Republic of Indonesia

used to refer to the pedagogical strategy set out in the 2013 Curriculum. In the 2018 revision of the 2013 Curriculum, it was acknowledged that the five stages in the Scientific Approach may be modified by incorporating elements of other active learning strategies. The Scientific Approach set out in the 2013 Curriculum is a learning process that encourages students to participate in meaningful learning through five steps: 1) observing, 2) asking, 3) exploring, 4) associating, and 5) communicating. The learning process is directed at developing three areas: attitudes, knowledge, and skills (Ministry of Education and Culture, 2013).

A key characteristic of the intended implementation of the 2013 Curriculum is that the learning process should undergo very fundamental changes, with the emphasis being on active learning. Active learning refers to anything that all students in a class session are required to perform, in addition to watching, listening, and taking notes (Felder & Brent, 2009). Active learning is a crucial element in the learning process, and most learning models view interaction (active

Research Question and Methodology

This study should be viewed as a theoretical one which is a precursor to a second (empirical) study which is currently underway. The empirical study will gather data from a classroom implementation of the modified Scientific Approach set out in this paper. This paper seeks to address the following research questions:

1. How does the Scientific Approach to learning and teaching mathematics, as set out in the 2013 Indonesian Curriculum documents from the Ministry of Education and Culture, relates to four established mathematics active learning strategies,

learning) as an essential component (Fayombo, 2012). The implementation of the five stages of the Scientific Approach in mathematics education is related to many established active learning teaching approaches, such as Discovery Learning (Sabina, 2019), Inquiry-Based Learning (Aulia et al., 2018; Dimas Anjar Sasmita et al., 2018), Problem-Based Learning (Dimas Anjar Sasmita et al., 2018; Rahayu et al., 2018) and Realistic Mathematics Education (Wibowo, 2017). One of the key principles of teaching using the Scientific Approach is to use active learning strategies to integrate students into the thinking process by using scientifically tested methods. In this paper, a comparison is made between the Scientific Approach and each of these active learning approaches. The focus of this study is to explore if elements of these four established active learning strategies (Discovery Learning, Inquiry-Based Learning, Problem-Based Learning and Realistic Mathematics Education) can be incorporated within the design of the five stages of the Scientific Approach (observing, asking, exploring, associating, and communicating) to potentially make it more effective.

namely Discovery Learning, Inquiry-based Learning, Problem-based Learning and Realistic Mathematics Education?

2. How could the Scientific Approach be beneficially modified by incorporating elements from any of these other strategies?

This study is a literature-based comparative review of four strategies and the Scientific Approach set out in the 2013 Indonesian Curriculum. As suggested in (Webster & Watson, 2002), a structured approach was used to identify relevant literature and source material for the review. To accomplish this, a set of procedures were followed. First, journal books, book chapters,

articles, Indonesian curriculum documents and other academic papers were consulted. Secondly, three academic research databases, Scopus, ICI world of journal and Google Scholar, were used with key word “2013 Curriculum” and the four strategies (“Discovery Learning,” “Inquiry-Based Learning,” “Problem-Based Learning,” and “Realistic Mathematics Education”) were used. Third, to locate research conducted in Indonesia, the same databases and keywords were used, along with the addition of the keyword “Indonesia.”

This study begins by comparing the Scientific Approach with each of the other strategies in turn. The key steps of each pedagogy are identified, and a mapping of each pedagogy and the Scientific Approach is developed. An analysis of the mappings and the similarities and differences of each pedagogy and the Scientific Approach allows potential modifications to be identified. This allows for the development of a theoretical framework for the implementation of a modified (dynamic) Scientific Approach. The underpinning literature that supports this framework came from Pedaste et al. (2015), Graham et al., (2006) and Skemp (1976). The value of these modifications can be seen from the way they incorporate some of the proven strengths of the other strategies into the Scientific Approach.

The Scientific Approach of the 2013 Indonesian Curriculum

Since the independence of the Republic of Indonesia, declared in 1945, the history of the development of the

educational curriculum in Indonesia has gone through 9 stages. These took place in 1947 (Curriculum 1947), 1964 (The Study Plans for Elementary School Curriculum), 1968 (Curriculum 1968), 1975 (Curriculum 1975), 1984 (Curriculum 1984), 1994 (Curriculum 1994), 2004 (Competency Based Curriculum), 2006 (Education unit level curriculum) and the latest curriculum in 2013 (Widiyatmoko & Shimizu, 2018).

The Indonesian government implemented the 2013 Curriculum in the national education system to address internal and external challenges. Internally, Indonesia needed to prepare its citizens for the workplace by equipping them with essential skills and competencies. However, Indonesia also needed to respond to the external challenges of globalization involving the economy, environmental issues, rapidly technological advances, and international education development (Haryani et al., 2019). Furthermore, one of the reasons for the need to transform the Indonesian curriculum was the low results in international assessments that measures the quality of students’ learning, namely TIMSS² and PISA³ (Ministry of Education and Culture, 2014). In the most recent iteration of PISA in 2018, the average position of Indonesian students in mathematics was 72nd out of 78 countries studied (OECD, 2019).

Permendikbud No 22 in 2016 (about the standard process of primary and secondary education) has indicated the need for a learning process that uses the principles of a Scientific Approach. Applying the

² TIMSS: Trends in International Mathematics and Science Study

³ PISA: Program for International Student Assessment

Scientific Approach in the learning process is one of the characteristics and strengths of the 2013 Curriculum (Ministry of Education and Culture, 2016). Scientific approaches are intended to enable students to know, understand and practice what is being studied scientifically. Therefore, in the learning

process, it is intended that students learn from various sources through observing, asking, exploring, associating, and communicating (Ministry of Education and Culture, 2013). A short description of each of these five activities can be found in Table 1.

Table 1

The Scientific Approach as set out in the 2013 Curriculum document (Ministry of Education and Culture, 2013)

Activity	Description
Observing	The students are required to carry out observation in identifying or finding problems through research by reading books, interviewing people, or using the internet. The competencies that will be developed through the Observing activity are curiosity, carefulness, ability to communicate and ability to seek information.
Asking	The students formulate questions about the information that they lack from what they observe or questions to gain additional information about what they were observing, then the students construct a hypothesis. Through this activity, the competencies that will develop are creativity, curiosity, the ability to formulate questions, critical thinking skills, and developing the character of a lifelong learner.
Exploring	The students test the hypothesis by doing an experiment, reading various sources, observing objects, observing events, and interviewing people. The competencies that will develop from this activity are carefulness, honesty, politeness, respect for other people's opinions, ability to communicate and the ability to gather information in various ways and become a lifelong learner.
Associating	The students analyse data and construct meaning in various ways through this learning experience. It is intended that students will develop discipline, carefulness, hard work and the ability to apply a procedure in thinking deductively and inductively to a conclusion.
Communicating	The students make a conclusion based on the results of the analysis and communicate the result by an oral presentation or in written form. From this activity, students can develop their competencies in terms of thinking systematically, honesty, tolerance in expressing an opinion and having the ability to speak correctly and properly.

Table 1 gives brief descriptions of each of the five steps of the Scientific Approach. A more detailed description of these five steps can be found in (Nugraha & Suherdi, 2017). Applying the Scientific Approach provides students with more opportunities to build independent learning and optimize their potential intelligence. Students should build their attitude, knowledge, and skills in the learning process,

while teachers provide students with reinforcement and enrichment in the lesson.

The scientific approach is a pedagogic strategy that uses steps similar to those used by scientists in building knowledge through research. This learning model improves scientific thinking skills and develops a "sense of inquiry" and students' creative thinking

abilities (DeVito, 1989). Furthermore, one of the key principles of teaching with the Scientific Approach is to use active learning strategies that integrate students in the thinking process and use scientifically tested approaches like inquiry-based learning, discovery-based learning, project-based learning, and Realistic Mathematics Education (Ministry of Education and Culture, 2016). Comparisons of the Scientific Approach with each of these active learning approaches are given below.

Active Learning Strategies

Discovery Learning

Discovery learning is a way to encourage students to interact with the environment by exploring and manipulating objects and inspiring them to think, ask questions, hypothesize, speculate and cooperate with others to develop the confidence to use their minds to solve problem (Brown & Campione, 1994). Discovery learning is a process that encourages students to assimilate a concept by observing, grouping, hypothesizing, explaining, measuring, and concluding (Klahr & Nigam, 2004). There are six steps in discovery learning: 1) giving stimulus; 2) identifying problems; 3) collecting data; 4) processing data; 5) verifying; and 6) making a conclusion (In'am & Hajar, 2017). Table 2 shows how the six steps of discovery learning relate to the five activities in the Scientific Approach.

Discovery learning, where the learner can interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments, is very similar to the principles of the Scientific Approach. The similarity is

not only in terms of the actions that it is intended students should undertake but also in terms of how these actions are conceptualised into different phases. There are some small but important differences. For example, in the Scientific Approach, the Exploring phase covers both collecting and processing data, whilst in Discovery Learning, these are presented as two separate phases, and the phase boundaries are slightly different, resulting in six activities in Discovery Learning but only five in the Scientific Approach. Furthermore, in Discovery Learning, the initial problems come from the teacher; however, in Scientific Approach, the students are more to the fore in finding the problem to be studied.

Inquiry-Based Learning

The inquiry-based learning approach focuses on organizing learning activities based on creating cognitive conflict scenarios or discovery problems which bring various opportunities for students to develop the capability of using critical thinking while working on the task and constructing problem-solving solutions (Wu & Lin, 2016). Inquiry-based learning provides an educational strategy to encourage students to follow methods and practices similar to the professional scientist in order to construct their knowledge (Keselman, 2003). As such, it should align closely to the Scientific Approach. According to Pedaste et al. (2015), inquiry-based learning includes five general phases: 1) Orientation; 2) Conceptualization; 3) Investigation; 4) Conclusion; 5) and Discussion. Table 3 summarises how the steps of inquiry-based learning relate to those of the Scientific Approach.

Table 2

A comparison of Discovery Learning and the Scientific Approach

No	Discovery Learning	Scientific Approach
1.	Giving Stimulus In this stage, the teacher gives stimulus that may be in the form of reading a passage or pictures or situations in line with the learning materials that will be discussed.	Observing
2.	Identifying problems In this stage, the students are required to find any problems they face related to the learning material; the students are given experiences of asking questions, finding information, and formulating problems.	Asking
3.	Collecting data At this stage, the students are given some experiences of looking for and collecting data/information that may be used to find solutions to problems they identified. Data collection may include doing experiments. Then use various problem-solving approaches; if one alternative fails, they try another.	Exploring
4.	Processing Data The activity of processing data will train the students to attempt and apply their conceptual knowledge competence to real life. This activity trains them to test the hypothesis using the data collected.	Exploring, Associating
5.	Verifying This stage leads the students to verify the truth of the results of processing data through various activities, among others asking questions of classmates, discussing, or looking for relevant sources either from books or other media, and associating them so that a conclusion may be made.	Associating, Communicating
6.	Making conclusions In this phase, the students focus on generalizing their conclusion into a similar event or problem so that this activity may also train their metacognitive knowledge.	Associating, Communicating

Table 3 may give the impression that inquiry-based learning is a linear process, starting with activity one and working through to activity five. However, this is not the case. Pedaste et al. (2015) have presented inquiry-based learning as a dynamic, iterative process, as shown in Figure 1.

As can be seen in Figure 1, there are two important differences between inquiry-based learning and the Scientific Approach. Firstly, inquiry-based learning is intended to be an iterative process. Having reached

the Conclusion then it is helpful to go back to the investigation phase and undertake further experimentation to validate the conclusion; also, it might sometimes be beneficial to go back earlier to the conceptualization phase and review the hypotheses that have been generated and tested (this is like the standard mathematical modelling cycle, (Blum & Leiß, 2007)). Secondly, the discussion activity takes place in parallel with each of the other activities and is not left to a single communication phase at the end of the process.

Table 3

A comparison of Inquiry-Based Learning and the Scientific Approach

No	Inquiry-Based Learning	Scientific Approach
1.	Orientation The orientation focuses on stimulating interest and curiosity about the problem at hand. This stage is similar to observing in the Scientific Approach, leading students to observe and identify or find the problems.	Observing
2.	Conceptualization The conceptualization is a process of understanding a concept or concepts belonging to the stated problem. It is divided into two sub-phases, Questioning and Hypothesis Generation.	Asking
3.	Investigation The investigation is the phase where curiosity is turned into action to respond to the stated research questions or hypotheses. The sub-phases of Investigation are Exploration, Experimentation, and Data Interpretation.	Exploring, Associating
4.	Conclusion This phase is the process of analysing the data and comparing inferences made based on data with hypotheses or research questions.	Associating, Communicating
5.	Discussion The discussion contains the sub-phases of Communication and Reflection. Both Communication and Reflection can be seen as ongoing processes that help students receive feedback about their learning process by sharing their domain-related outcomes and process-related ideas with others.	Communicating, Associating

Problem-Based Learning

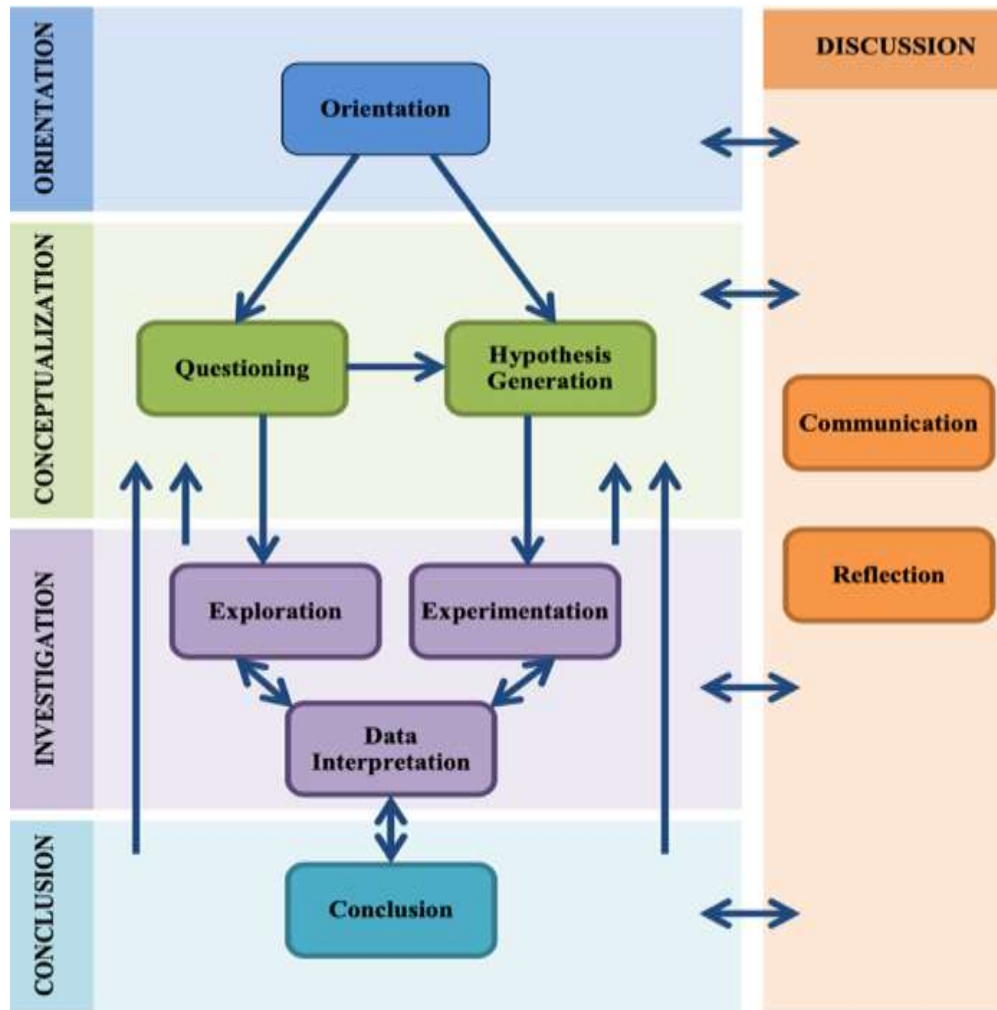
Problem-Based Learning (PBL) was originally developed in medical education at university and has since been extended to many disciplines and educational levels from middle school to professional education (Hmelo-Silver, 2004). Problem-based learning education strategy is characterized by using a real problem as a motivation for student learning, to acquire basic knowledge related to that problem and acquire problem-solving skills (Abdalla & Gaffar, 2011).

According to Gorghiu et al. (2015), the PBL model is based on the elaboration of a scenario which includes

seven steps, these are: 1) Clarifying Unfamiliar Terms; 2) Defining the Problem; 3) Brainstorming; 4) Analysing the problem; 5) Formulating Learning Goals; 6) Self-studying; 7) Reporting. Furthermore, a key feature of PBL requires that students work in small groups to achieve their learning objectives (Lambros, 2004). The group work in the project gives students the opportunity to learn to take criticism and revision, share resources, and think more deeply about what they learned. Table 4 shows the relationship between the elements of PBL and the Scientific Approach.

Figure 1

The framework of Inquiry-Based Learning (Pedaste et al., 2015)



Although, as shown in Table 4, there is a mapping between the activities in PBL and the Scientific Approach, there are some very clear differences in approach. In the problem-based learning approach, the starting point is a quite well-defined problem which is solved by identification of learning needs,

self-study and applying the new knowledge (Abdalla & Gaffar, 2011). An important point here is that the learners are directed to the problem and its specification, whereas in the Scientific Approach (and inquiry-based) there is more freedom to define the problem to be investigated.

Table 4

A comparison of Problem-Based Learning and the Scientific Approach

No	Problem-Based Learning	Scientific Approach
1.	Clarifying Unfamiliar Terms In this stage, students' activity gathers necessary information; they learn new concepts, principles, and skills about the proposed topic by asking for an explanation of words or concepts that are not understood.	Asking
2.	Defining the Problem In this phase, the group members list what they already know about the scenario and list in what area they lack information and identify the problems.	Observing, Asking
3.	Brainstorming In this activity, group members focus on collecting the ideas and potential explanations regarding problem statements.	Asking, Exploring
4.	Analysing the problem This phase focuses on explanations and hypotheses of the group members, which are discussed in-depth and systematically analysed.	Exploring, Associating, Asking
5.	Formulating Learning Goals In this phase, the group reaches a consensus about the learning objectives based on contradictions, obscurities, and ambiguities from the problem analysis by listing possible actions and solutions to the problem, formulation, and testing of potential hypotheses.	Associating
6.	Self-studying In this activity, students undertake independent study; they read literature, look for additional sources, and prepare answers that can answer the questions in the learning goals.	Exploring
7.	Reporting In this phase, the group disseminates the results of their independent study, the students try to synthesize what they have found in different sources, identify learning resources, and then share the obtained results with the others.	Communicating

Furthermore, in the problem-based learning approach, students always work in collaborative groups (Hmelo-Silver, 2004). Students work in groups not just to identify what they need to learn in order to solve the problem, they work in groups throughout the whole process (except for the self-study activity). However, the Scientific Approach, as set out in the 2013 curriculum document, does not state specifically that students must work in a group at certain points (or indeed at any point) in the process. It appears that it is envisaged that students can work individually or in

groups at the teacher's direction. Although the final stage of PBL is reporting, and this mirrors the final stage of the Scientific Approach (communicating), the fact that, in PBL, students are working in groups means that communicating is taking place at all stages of the process (which is similar to inquiry-based learning, as discussed above). In the Scientific Approach, the Asking phase is seen as a distinct activity. However, in PBL, the activities that take place in Asking are distributed amongst four different phases (clarifying, defining, brainstorming, and

analyzing). This suggests that the flow of activities in PBL is somewhat different from that in the Scientific Approach.

Realistic Mathematics Education

Realistic Mathematics Education has its roots in Hans Freudenthal's interpretation of mathematics as a human activity (Barnes, 2005). The purpose of Realistic Mathematics Education (RME) is to enable

students to visualise mathematical processes by careful use of context and model-building, which is always present and accessible to the student (Tong et al., 2022). According to Sumirattana et al. (2017), the Realistic Mathematics Education approach consists of five stages; 1) Posing real-life problems; 2) Solving problems individually or in a group; 3) Presenting and discussing; 4) Developing formal mathematics and 5) Applying knowledge.

Table 5

A comparison of Realistic Mathematics Education and the Scientific Approach

No	Realistic Mathematics Education	Scientific Approach
1.	Posing real-life problems This step focuses on posing real-life problems connected and related to mathematical topics to review existing knowledge, which is necessary to learn new knowledge.	Observing, Asking
2.	Solving problems individually or in groups This step focuses on collecting problem-related data and assessing problem situations to plan a solution and create a meaningful self-developed model or method for students to solve a problem individually or collectively.	Exploring, Associating
3.	Presenting and Discussing This step focuses on presenting and discussing how to solve the problems and the solutions that lead to the examination of various problem-solving methods.	Associating, Communicating
4.	Developing formal mathematics This step focuses on solving other similar problems and discussing problem-solving methods, which would lead to the formulation of solution-finding procedures.	Exploring, Associating
5.	Applying knowledge This step focuses on applying the developed mathematical conceptual and procedural knowledge to solve various problems in real-life situations.	Associating

The mathematical processes in RME are divided into two: vertical and horizontal mathematics. Horizontal mathematics is the activity of formalizing from the contextual problems to the mathematical world (mathematical modelling) and interpreting the solution of the mathematical problem into the context of the original real-world problem. Vertical mathematics is progressing from a formalized mathematical statement

of the problem to a solution of the mathematical problem by using a variety of mathematical methods and a variety of principles or rules that exist in mathematics (Barnes, 2005).

Of the four mathematics active learning strategies considered here, RME is the one which is most different from the Scientific Approach (and indeed

from the other three approaches). Whilst the other approaches may start from a real-world problem, they do not have to; inspirational abstract problems can also be used as starting points for learning. The Scientific Approach does not explicitly have the “horizontal” element described above as a feature of RME (although it may, on occasions, incorporate this). Likewise, the Scientific Approach may, sometimes, develop formal mathematics (in the exploring and associating phases), but it is not an essential activity in the way that it is within RME. Furthermore, in RME, the communication activity (called Presenting and Discussing) does not come at the end, rather, it comes mid-way through the five steps. In RME, the discussion is seen very clearly as a way of helping students construct and refine their learning, whereas in the Scientific Approach its role appears to be more about reporting what has been learnt.

Findings, Analysis and Proposal

This paper set out to address the two research questions listed above. We are now in a position to answer these questions. The first research question focuses on the relationship between the Scientific Approach of the 2013 Curriculum and four established active learning strategies in mathematics education. Tables 2 to 5 show mappings between the stages of each of these four approaches and the five stages of the Scientific Approach set out in the 2013 Curriculum. The similarities and differences are explored in the following paragraphs.

The steps in the Scientific Approach of the 2013 Curriculum (observing, asking, exploring, associating, and communicating) are an adaptation of the steps in scientific research. The

application of a Scientific Approach to learning focuses not only on how to develop the competence of students in making observations or experiments but also on how to develop knowledge and thinking skills (Muhammad & Nurdyansyah, 2015). From the comparison of the Scientific Approach with some active learning strategies given above, we can see that the Scientific Approach in the 2013 curriculum correlates very well with discovery learning and IBL. It has some key differences when compared with PBL and even more differences when compared to RME, although it clearly shares some underlying principles with these two strategies. The steps in the Scientific Approach constitute an active learning methodology. As seen above, the steps of the Scientific Approach have much in common with those of these other active learning strategies. However, they also have differences so that every approach has different characteristics and uniqueness.

The second research question addressed the possibility of improving the Scientific Approach of the 2013 Curriculum by including elements of these four established strategies. A key principle of teaching using the Scientific Approach is to use active learning strategies to integrate students into the thinking process. Peremendikbud No. 22 (2016) specifically promotes the use of established pedagogical methods to encourage the ability of students to solve contextual problems. We present below a modified version of the Scientific Approach, which incorporates strengths of some of the four active learning strategies considered above. This provides an answer to research question

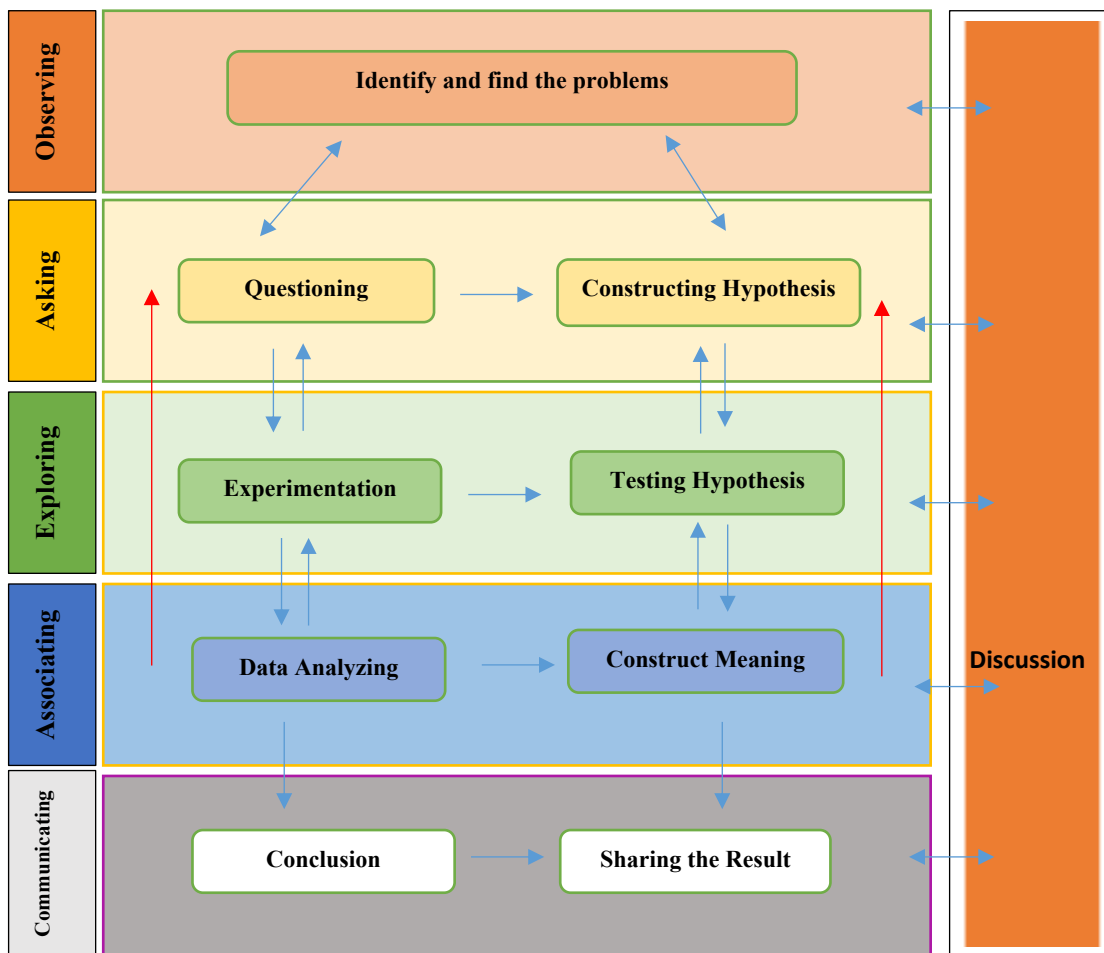
two, exemplifying how the Scientific Approach can be beneficially modified.

There are two areas where it appears that other active learning strategies are stronger than the Scientific Approach set out in Table 1. Firstly, there is the role played by communication (as shown in the Problem-Based Learning and the Inquiry-Based Learning phases) and secondly, there are the benefits that can be gained by treating the pedagogical approach as iterative rather than linear (as shown for Inquiry-based

learning in Figure 1). Consideration of these strengths leads to a proposed enhancement of the Scientific Approach from the 2013 Curriculum, turning it into a more dynamic and less rigid pedagogy, shown in Figure 2. This enhancement preserves all the essential elements (the five phases) of the Scientific Approach but utilizes them in a dynamic and iterative fashion instead of being static and linear; it also explicitly places the discussion activity as something that permeates all other activities rather than being a separate activity taking place at the end.

Figure 2

Diagrammatic representation of a dynamic implementation of the Scientific Approach.



Based on the diagram above, in the stage of Observing, the students are required to identify the problem by Observing (such as, interviewing people, reading a book, or using the internet). In Asking, students focus on formulating the problems, identifying any information that is lacking, taking into account what they found from the Observing stage. Then they construct a hypothesis, but if they need to look back to find more information, they can go back to the observation stage. In the Exploring stage, the student will be doing experiments in various ways and then testing the hypothesis.

Furthermore, in the Associating stage, students will analyze data and construct meaning in various ways. If the data analysis is successful, they could continue to the next stage (Communication), but if the data analysis was not as successful as planned, students can go back to the Asking phase to re-state a question or hypothesis and then do further experimentation, testing hypotheses, data analyzing and constructing meaning. After constructing meaning, students will make a conclusion based on the result of the analysis and communicate the result to others in oral or written form. Furthermore, at every stage, from Observing to Communicating, the process of the discussion is possible, even desirable. Discussion can help students receive feedback about their learning process by sharing with others, and therefore the possibility (rather than a requirement) of discussion is included in each phase. The use of group work can promote discussion and, furthermore, help students to develop their social skills, but this is seen as something to be used at the teacher's discretion rather than imposed a priori (as in PBL). Furthermore, this supports a dynamic implementation of the Scientific Approach

supported by the framework of Graham et al. (2006), Pedaste et al. (2015) and Skemp (1976).

Final Considerations

This study adds to the literature by comparing the Scientific Approach set out in the 2013 Curriculum and the elements of four established active learning strategies (Discovery Learning, Inquiry-Based Learning, Problem-Based Learning and Realistic Mathematics Education) that can be incorporated within the design of the five stages of the Scientific Approach (observing, asking, exploring, associating, and communicating). Based on the result, the researchers have developed a recommendation diagram to enhance the Scientific Approach based on elements from other active learning strategies. This enhancement preserves all the essential elements (the five phases) of the Scientific Approach whilst capturing the strengths of other strategies not present in the original formulation of the Scientific Approach in the 2013 Curriculum. The value of these modifications can be seen in how they incorporate some of the known strengths of the other strategies. This modification can be used to improve the teacher's understanding of the 2013 Curriculum through teacher training to ensure they are capable of carrying out the national program. This is necessary to improve the quality of education in Indonesia. An empirical study on the implementation of the enhanced Scientific Approach pedagogy described in this paper is currently being conducted. This is a control/intervention study on teaching geometry; within the intervention, teachers give lesson plans structured according to the modified Scientific Approach outlined above. The findings of this study will be reported in a subsequent paper.

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