

# artikel 2015

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**Submission date:** 23-Jan-2020 12:02PM (UTC+0700)

**Submission ID:** 1245266670

**File name:** EMENTATION\_AT\_FOURTH\_GRADE\_OF\_ELEMENTARY\_SCHOOLS\_IN\_MAGETAN.docx (38.73K)

**Word count:** 4047

**Character count:** 23218

## ANALYSIS OF 2013 CURRICULUM IMPLEMENTATION AT FOURTH GRADE OF ELEMENTARY SCHOOLS IN MAGETAN

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### Abstract

The curriculum in Indonesia has been amended several times, most recently in 2013. One of the regencies used for testing it is Magetan involving 11 elementary schools. The purpose of this research is to describe curriculum 2013 implementation for fourth grade in Magetan. This research used a phenomenological approach to qualitative research. The Subjects used were fourth grade teachers at the elementary schools that use the 2013 curriculum. The objective of the current research is to explore the learning, the learning process, and evaluation instruments developed by the teacher. The data collection technique included documentation, observation and interviews. Researchers acted as the main instrument in data collection and combined with field notes and check lists using instrument. The results show that: (1) the curriculum 2013 for fourth grade in Magetan was not fully implemented in terms of lesson plan development, learning implementation, and evaluation due to the mindset of the teachers being not completely changed and the less involvement of school community; and (2) the scientific approach to teaching and learning was not fully implemented, which requires students to perform inquiry based process throughout and a careful planning by the teacher.

**Keywords:** implementation, curriculum 2013, fourth grade, Magetan

### Introduction

Curriculum is a guidance to implement education in field. Mulyasa (2006: iii) states that curriculum is dynamic and flexible, so curriculum must change and be developed to improve the quality of education. Curriculum in Indonesia has been changed several times, and the newest is 2013 curriculum. The principal of 2013 curriculum is using scientific approach and integrated learning both for lower grade and higher grade. The implementation of integrated learning in lower grade has been done earlier, while for higher grade is in the plan. One of regencies that will implement is Magetan regency that involves eleven elementary schools. Thus, it needs rigorous research into the implementation of 2013 curriculum in Magetan especially for fourth grade students.

<sup>4</sup> The aim of this research is to describe the implementation of 2013 curriculum in fourth grade of all elementary school in Magetan viewed from the development of lesson plan, the implementation of learning process, and the evaluation of learning done by teachers, and to describe the problems in the field related to the implementation of 2013 curriculum in Magetan.

### Literature review

The content of curriculum is material of subject as a lesson plan, and experience of learning (Hamalik, 1994: 18). Hidayat says that curriculum is a written text used by teacher in implementing learning to students. In sum, the meaning of curriculum is a written plan arranged to run the process of learning. This definition matches with that defined in the constitution of the National Education System 2003 article number 20, which states that curriculum is package of plan and rule about purpose, content, material, and step of how to apply it as guidance in conducting learning activities to achieve education aim. Recently, the 2013 curriculum becomes a trending topic for education practitioners. However, most of them still feel confused in the implementation stages of 2013 curriculum.

The 2013 curriculum is developed based on education theory of standard-based education and curriculum theory of competency-based curriculum. The standard-based education is about the national standard as minimum quality of citizen, including content standard, teacher standard, facilities standard, management standard, financial standard, and education assessment standard. Competency-based curriculum is designed to give learning experience to the students in developing their ability in attitude, knowledge, skill, and action.

The 2013 curriculum focuses on (1) learning done by teacher (taught curriculum) developed in learning activities in school, class, and societies; and (2) direct learning experience of students adjusted with background, characteristic, and prior knowledge of students. Direct learning experience of students is the outcome of student learning, while the entire result of student learning becomes the outcome of curriculum.

The aim of 2013 curriculum is to prepare Indonesian human resources to become a productive, creative, innovative, and affective person and to contribute to the society, country, and the world. To reach that aim, the structure of 2013 curriculum is arranged as core competence, subject, and basic competence. For higher grade, especially for fourth grade students, the structure of 2013 curriculum is arranged as follows:

#### *Main competence in fourth grade of elementary school*

The main competence of fourth grade of elementary schools includes: (1) to accept, to conduct, and to respect to the religion they believe; (2) to show honest, discipline, responsible, sympathetic, respectful, and confident attitudes when they interact with family, friends, teachers, and their neighbors; (3) to understand about factual knowledge by observing and questioning based on curiosity about themselves, the creatures and their activities, and things that they found at house, school, and play ground; and (4) to produce factual knowledge in clear language, systematic and logic, esthetic, healthy, and reflective as a child who has good behavior. The subject and time allotment of main competence in the fourth grade of elementary schools are depicted in Table 1.

Table 1  
Subject in 2013 Curriculum

No	Subject	Time Allotment per week					
		I	II	III	IV	V	VI
	Group A						
1.	Islamic Studies and behavior class	4	4	4	4	4	4
2.	Civics	5	5	6	5	5	5
3.	Indonesian language	8	9	10	7	7	7



No	Subject	Time Allotment per week					
		I	II	III	IV	V	VI
4.	Mathematics	5	6	6	6	6	6
5.	Science	-	-	-	3	3	3
6.	Social Studies	-	-	-	3	3	3
<b>Group B</b>							
1.	Culture and art	4	4	4	5	5	5
2.	Sport	4	4	4	4	4	4
<b>Total of Time Allotment per week</b>		<b>30</b>	<b>32</b>	<b>34</b>	<b>36</b>	<b>36</b>	<b>36</b>

Source: The Regulation of the Minister of Education and Culture Number 67 year 2010.

### *Basic competency in 2013 curriculum*

The basic competency in the 2013 curriculum is an explanation of main competency (KI). The regulation of the Minister of Education and Culture (Permendikbud) No 67 year 2010 states that Basic Competency (KD) is arranged to reach core competency (KI). The arrangement of basic competency is focused on students' characteristics, prior knowledge, and characteristic of subject. The KDs are integrated into themes and are divided into four groups, they are:

- Group 1 is a spiritual attitude basic competency to explain KI 1
- Group 2 is a social attitude basic competency to explain KI 2
- Group 3 is a group of knowledge basic competency to explain KI 3
- Group 4 is a skill group basic competency to explain KI 4

According to the Ministry of Education and Culture (MoEC) (2013) the scopes of curriculum implementation include changing mindset, skill and competency of teacher, and leadership and school culture. Three of those aspects are needed to implement the new curriculum. Teachers as implementers of curriculum in the classroom are key aspect in running curriculum. Assessment aspect in the implementation of learning by teacher consists of lesson plan, implementation of learning, and development of evaluation tools.

### **Method**

The approach of this research is phenomenology, which is qualitative in nature. The subject of this research was the teachers of fourth grade in 11 elementary schools which conduct a tryout of the 2013 curriculum. The objects of the current research were learning media developed by teachers, process of learning, and evaluation instrument. Data collection technique included the documentation of learning media, observation to the learning process, and interviews to investigate the problems related to the implementation of 2013 curriculum in field. In this research, researchers took role as the main instrument in data collection and helped by additional instrument such as field notes and check lists.

### **Results**

The data in this research are: 1) data about the implementation of learning in 2013 curriculum viewed from lesson plan, teaching and learning process, and evaluation; 2) data about problems in 2013 curriculum viewed from teachers and principals. Explanation of research result as below:

### *Implementation of 2013 curriculum in Magetan Regency*

#### a. Aspect of lesson plan

The more detail of result of lesson plan aspect is depicted in Table 2. According to Table 2, lesson plan that has been developed by teacher was suitable with 2013 curriculum and logically systematic. It is to note that lesson plan was developed by KKG team and adjusted by each teacher according to their needs. Based on using sentences to explain learning steps, teacher has used effective sentences. On the contrary, in content only one lesson plan that had learning with focus on student-centered.

Table 2  
Results of Lesson Plan

Subject	Aspect		
	Format	Language	Content
S1	Well-developed with requirements, the systematic format has followed logical principles	Effective sentences, understandable, no double interpretation	Complete, detail learning activities, conduct scientific approach phase, students centered
S2	Well-developed with requirements, the systematic format has followed logical principles	Effective sentences, understandable, no double interpretation	Incomplete (no evaluation sheet), detail learning activities, teacher centered.
S3	Has Well-developed with requirements, the systematic format has followed logical principles	Effective sentences, understandable, no double interpretation	Incomplete (no material, worksheet, and evaluation tool), detail learning activities, conduct scientific but students were not active; development of spiritual and social did not appear.
S4	Well-developed with requirements, the systematic format has followed logical principles	Effective sentences, understandable, no double interpretation	Incomplete (no material, worksheet, evaluation tool), had detail learning activities, conducted scientific approach but students were not active; development of spiritual and social did not appear.
S5	Well-developed with requirements, the systematic format has followed logical principles	Effective sentences, understandable, no double interpretation	Incomplete (no material and worksheet), activities were not detail, scientific approach did

Subject	Aspect		
	Format	Language	Content
			not appear
<b>S6</b>	Well-developed with requirements, the systematic format has followed logical principles	Effective sentences, understandable, no double interpretation	Incomplete, did scientific approach but still teacher centered.
<b>S7</b>	Well-developed with requirements, the systematic format has followed logical principles	Effective sentences, understandable, no double interpretation	Incomplete (no material, worksheet, and evaluation tool) didn't do scientific phase, teacher-centered
<b>Conclusion</b>	Suitable	Suitable	Only one complete lesson plan, effective sentences, only one showing students active (S1)

b. Aspect of learning process

According to Table 3, in apperception phase, most of the teachers did not construct student's knowledge. They just focused on reminding students about previous assignments or showing themes. In addition, the group discussion did not run effectively because most of groups only focused on doing the tasks and not finding the concepts (teacher still delivered concepts directly without conducting inquiry phase). Despite the fact that some teachers gave conclusion and feedback, some did not. Most of the teachers still had problem in time management (see Table 3 for more detail result).

Table 3  
Results of Learning Process

Subject	Aspect			
	Introduction	Main activities	Closing	Time management
<b>S1</b>	Conditioning, apperception did not relate with themes, teacher directly explained about theme that will be learned	Group answered and presented their assignments, discussion ran well, but not all students were active, scientific approach appeared but wasn't maximum.	Feedback did not apply	Fit with planning
<b>S2</b>	Conditioning, presence, apperception, reminding about assignment of last material	Gave cases, answered questions, classical learning, teacher centered, scientific	Evaluation and feedback	Wasn't completed
<b>S3</b>	Conditioning, apperception, just	Students read, observed, discussed, teacher	Conclusion, feedback	Less fit with planning

Subject	Aspect			
	Introduction	Main activities	Closing	Time management
	reminded students, no brainstorming of student ideas	stimulated by asking questions classically, teacher centered, group didn't do their job well, no interaction among students in solving problems, observing was not inquiry	didn't run well	
S4	Apperception about heroes and was related with students daily life	Read texts, groups answered the questions; teacher surrounded the class and gave guidance to groups having difficulties, ran scientific approach well; students presented results of discussion by reading	Concluded the material, but there was no feedback	Fit with planning
S5	Apperception related with material (national education day, Ki Hajar Dewantara)	Students were asked to open book, teacher checked student reading by asking some questions related to text, teacher gave questions sheet individually, classical learning, students did the assignments individually	Concluded, submitted the assignments.	Fit with planning
S6	Apperception was just to remind students, but it didn't stimulate students in main learning	Students read, observed, discussed, teachers stimulated by giving questions classically, teacher centered, group didn't do their job well, no interaction among students in solving the problems, observing was not inquiry	Didn't give conclusion and feedback	Less fit with planning
S7	Apperception by singing Indonesia Raya	Practiced to follow direction in doing something, students did their tasks in group but didn't discuss, process in finding concept and steps in making something were kind of scientific, but no follow up	Concluded and gave information about a thing in material	Fot with planning
Conclusion	In average, apperception	Group work was less effective	Some teachers gave	Time management

Subject	Aspect			
	Introduction	Main activities	Closing	Time management
	didn't reflect the construction of knowledge		conclusion and feedback, but some of them didn't	was difficult for some teachers

c. Aspect of learning evaluation

Evaluation used by teacher was also developed by KKG team, so there were not differences in evaluation among seven objects of observation. They used effective sentences and the format of the sentences from KI 1 to KI 4, and so was the content. However, the evaluation instrument has not been written in detail in each KI particularly for the spiritual and social aspects. Table 4 summarizes the result of learning evaluation.

Table 4  
Results of Learning Evaluation

Subject	Aspect		
	Format	Language	Content
<b>S1</b>	Separated KI 1-4, then calculated average achievement in percentage after describing it qualitatively.	Used effective language	Included KI 1-4
<b>S2</b>	Separated KI 1-4, then calculated average achievement in percentage after describing it qualitatively.	Used effective language	Included KI 1-4
<b>S3</b>	Separated KI 1-4, then calculated average achievement in percentage after describing it qualitatively.	Used effective language	Included KI 1-4
<b>S4</b>	Separated KI 1-4, then calculated average achievement in percentage after describing it qualitatively.	Used effective language	Included KI 1-4
<b>S5</b>	Separated KI 1-4, then calculated average achievement in percentage after describing it qualitatively.	Used effective language	Included KI 1-4
<b>S6</b>	Separated KI 1-4, then calculated average achievement in percentage after describing it qualitatively.	Used effective language	Included KI 1-4
<b>S7</b>	Separated KI 1-4, then calculated average achievement in percentage after describing it qualitatively.	Used effective language	Included KI 1-4
<b>Conclusion</b>	Same because developed by KKG (Teacher Working Group) team	Suitable	Suitable

*Problems in implementing 2013 curriculum in Magetan Regency.*

The main problem of conducting 2013 curriculum was evaluation technique. Teacher must observe students intensively in fact some schools have a large number of students. It was not possible for teachers to observe students one by one at home. Implicitly, the most



difficult aspect was assessment for KI 1 and KI 2 about the spiritual and social aspects. In the learning process, teachers had difficulties in guiding students to find concept because students did not use to following scientific approach which requires inquiry with specific steps. The more detail of problems in the implementation 2013 curriculum in Magetan regency is depicted in Table 5.

Table 5  
Problem in Implementing 2013 Curriculum

Subject	Aspect		
	Lesson Plan Development	Learning Implementation	Evaluation
<b>I1</b>	Lesson plan developed by KKG team consisted of 11 try-out schools, which then adjusted by teacher based on school condition. Thus, in the process of lesson plan development, teacher didn't have problems	In explaining the material, teacher didn't find difficulties. Teachers assumed that materials in 2013 curriculum are not complete, so they added materials by giving additional time. To reach cognitive score was easier because the material content of 2013 curriculum was less than that in the previous curriculum.	Teacher got difficulties in doing assessment because they must check students one by one
<b>I2</b>	Lesson plan developed by KKG team consisted of 11 try-out schools, which then adjusted by teacher based on school condition. Thus, in the process of lesson plan development, teacher didn't have problems	In explaining material, teacher got difficulties in guiding students to find new concept because the time was not enough	Teacher got difficulties in doing assessment because they must check students one by one
<b>I3</b>	Lesson plan developed by KKG team consisted of 11 try-out schools, which then adjusted by teacher based on school condition. Thus, in the process of lesson plan development, teacher didn't have problems	In explaining the material , teacher didn't get difficulties	Teacher got difficulties in doing assessment because they must check students one by one
<b>I4</b>	Lesson plan developed by KKG team consisted of 11 try-out schools, which then adjusted by teacher based on school condition. Thus, in the process of lesson plan development, teacher didn't have problems	In explaining material, teacher got difficulties in making students understand the concept or finding concept by scientific approach phase. The development and abilities differed from one student to the other, so teacher had to	Teacher got difficulties in doing assessment because they must check students one by one

Subject	Aspect		
	Lesson Plan Development	Learning Implementation	Evaluation
		explain the material further to the students who had lower ability and it needed additional time	
<b>I5</b>	Lesson plan developed by KKG team consisted of 11 try-out schools, which then adjusted by teacher based on school condition. Thus, in the process of lesson plan development, teacher didn't have problems	In explaining material teacher didn't get difficulties, but they were confused when they got other jobs besides teaching. It happened because class teacher is only one in each class, so they couldn't reach material targeted if they often left class (e.g., workshop, etc.)	Teacher got difficulties in doing assessment because they must check students one by one. The number of students in this school is huge (25 students)
<b>I6</b>	Lesson plan developed by KKG team consisted of 11 try-out schools, which then adjusted by teacher based on school condition. Thus, in the process of lesson plan development, teacher didn't have problems	In explaining material, teacher got difficulties in making students understand the concept or finding concept by scientific approach phase. The development and abilities differed from one student to the other so teacher had to explain the material further to the students who had lower ability and it needed additional time	Teacher got difficulties in doing assessment because they must check students one by one
<b>I7</b>	Lesson plan developed by KKG team consisted of 11 try-out schools, which then adjusted by teacher based on school condition. Thus, in the process of lesson plan development, teacher didn't have problems	In explaining material stage, teacher had difficulties in making group work run well, because many students couldn't work cooperatively. To reach higher score, students felt easier because material content in 2013 curriculum was less than that in the previous curriculum	Teacher got difficulties in doing assessment because they must check students one by one
<b>Conclusion</b>	Teacher didn't have difficulties because lesson plan was developed by KKG team	The majority of students had difficulties in finding concept because they were used to accepting concept. Scientific phase was not fully done, time managements is important	Teacher got difficulties in doing assessment because they must check students one by one.

## **Discussion**

### ***Implementation of 2013 curriculum in Magetan Regency***

#### **a. Aspect of lesson plan**

The format of lesson plan developed by teacher was in line with 2013 curriculum and fulfilled the systematic logical requirements. To note the lesson plan was developed by KKG team. Teachers wrote lesson plan using effective sentence. However, only one lesson plan that showed learning activities which indicated student-centered approach. Thus, the implementation of 2013 curriculum was successful. The 2013 curriculum that focuses on scientific approach leads students to master concept then results in the skill development.

#### **b. Aspect of learning process**

In the apperception aspect, most of teachers just reminded the students of the previous assignments or showed the themes, and discussion did not run effectively. Almost in all of group discussions, the students just did it and completed the task. Teachers did not guide students to find concept, but gave conclusion and feedback. Their time management was not effective. Then, discussion process was not maximized; even some teachers still used classical learning processes that to a large extent lessen the student exploration of material. Teacher just focused on material in cognitive aspect. This all suggested that teacher did not understand the development of student thinking which is required in 2013 curriculum. Teacher reasoned that if students just get little material, they will face difficulties when they follow Olympiad, etc. The orientation of 2013 curriculum in elementary school is character building not cognitive aspect, but the majority of teachers are not aware of it.

#### **c. Aspect of learning evaluation**

Same as the lesson plan, evaluation used by teacher was also developed by KKG team, so there were no differences of evaluation among seven objects of observation. They used effective sentences and the format of the sentences including KI 1 to KI 4, so was the content, but instrument has not been written in detail in each KI especially the spiritual and social aspects. Actually, this problem can be solved by teacher's creativity; for example by using a communication book between teacher and parents, or by creating special portfolio for each student.

### ***Problems in implementing 2013 curriculum in Magetan Regency.***

The main problem of implementing 2013 curriculum was evaluation technique. Teacher must observe students intensively in fact some schools have a large number of students. It was not possible for teachers to observe the students one by one at home. Implicitly, the most difficult aspect was assessment for KI 1 and KI 2 about the spiritual and social aspects. In the learning process, teachers had difficulties in guiding students to find concept because students were not used to following scientific approach that needs inquiry with specific steps. The problems about time and additional task can be solved by a good team teaching. The alternatives of assessment technique can be done by teacher by modifying them to suit school condition and environment.

## **Conclusion**

1. The 2013 curriculum for fourth grade in Magetan elementary schools was not fully implemented in terms of learning plan development, learning implementation, and

- evaluation. This happened because the mindset of the teacher has not completely changed and the school community has not been involved in this case
2. The main obstacle in learning is the partial implementation of scientific approach that requires students to use inquiry-based process throughout and needs serious planning by the teacher.

### Reference

- Arikunto, S. 2012. *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta.
- Gafur, A. 2007. *Bahan Diklat Profesi Guru Sertifikasi Guru Rayon II DIY Jateng. Buku B 2.4. Pengembangan Rencana Pelaksanaan Pembelajaran (RPP)*. Yogyakarta: LPMP.
- Griffin, P., dan Nix, P. 1991. *Educational Assessment and Reporting*. Sydney: Harcourt Brace Javanovich Publisher.
- Gunawan, I. 2011. Evaluasi Program Pembelajaran. *Jurnal Pendidikan*, 17(1): 52 – 70.
- Hamalik, O. 2001. *Perencanaan Pengajaran Berdasarkan Pendekatan Sistem*. Bandung: Bumi Aksara.
- Hamalik, O. 2005. *Kurikulum dan Pembelajaran*. Jakarta: Bumi Aksara.
- Hidayat, S. 2013. *Pengembangan Kurikulum Baru*. Bandung: Rosda.
- Kirkpatrick, D. L. 1998. *Evaluating Training Programs: The Four Levels*. San Francisco: Berrett-Koehler Publisher, Inc.
- Madaus, G. F., Scriven, M. S., dan Stufflebeam, D. L. 1993. *Evaluation Models, Viewpoints on Educational and Human Services Evaluation*. Boston: Kluwer-Nijhoff Publishing.
- Majid, A. 2008. *Perencanaan Pembelajaran Mengembangkan Standar Kompetensi Guru*. Bandung: Rosda.
- Mardapi, D. 2000. *Evaluasi Pendidikan*. Makalah disajikan dalam Konvensi Pendidikan Nasional, Universitas Negeri Jakarta, Jakarta, 19-23 September.
- Molcong, L. J. 2012. *Metodologi Penelitian Kualitatif*. Bandung: Rosdakarya.
- Oliva, P. F. 2009. *Developing the Curriculum*. New York: Pearson Education, Inc.
- Oriondo, L. L., dan Antonio, E. M. D. 1998. *Evaluating Educational Outcomes (Test, Measurement, and Evaluation)*. Florentino St: Rex Printing Company.
- Peraturan Pemerintah Republik Indonesia Nomor 32 Tahun 2013 tentang Perubahan Atas Peraturan Pemerintah Nomor 19 Tahun 2005 tentang Standar Nasional Pendidikan* (Online). (<http://kemdikbud.go.id>, diakses 12 September 2013).
- Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 67 Tahun 2013 tentang Kerangka Dasar dan Struktur Kurikulum Sekolah Dasar/Madrasah Ibtidaiyah* (Online). (<http://kemdikbud.go.id>, diakses 12 September 2013).
- Sa'ud, S. 2008. *Inovasi Pendidikan*. Bandung: Alfabeta.
- Soetopo, H. 2007. Evaluasi Program Supervisi Pendidikan. Dalam Imron, A., Burhanuddin, dan Maisyaroh (Eds.), *Supervisi Pendidikan dan Pengajaran: Konsep, Pendekatan, dan Penerapan Pembinaan Profesional* (hlm. 136-149). Malang: Fakultas Ilmu Pendidikan Universitas Negeri Malang.

Stark, J. S., dan Thomas, A. 1994. *Assessment and Program Evaluation*. Needham Heights: Simon & Schuster Custom Publishing.

Sudjana, N., dan Ibrahim. 2004. *Penelitian dan Penilaian Pendidikan*. Bandung: Sinar Baru Algesindo.

*Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional*. 2006. Bandung: Fokus Media





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