New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION
Edition 4

Development of Lesson Analysis System for Student-Centered Science Teaching toward International Cooperation

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Abstract
UNESCO's Global Monitoring Report on Education for All (EFA) has shown that undesirable teaching practices, such as chalk-and-talk and teacher-centered pedagogy, persist in Sub-Saharan Africa [1]. The education policy documents from these countries encourage the use of student-centered teaching and learning, especially in science. However, what student-centered teaching and learning actually looks like in the science classroom has not been fully discussed. Thus, it is fundamental to investigate the learning process of children and develop tangible methods that help teachers visualize student-centered teaching. This paper discusses the development of a lesson analysis system to help teachers visualize student-centered teaching in the science classroom. The study focuses on the sub-Saharan African country of Zambia and the local context of the science education program was taken into consideration when developing the lesson analysis system.
The developed lesson analysis system contains two major features: the category system and the coding unit. The category system focuses on students' responses during classroom discourse, reflecting the characteristics of the teaching practices in the region. It has been designed to provide information about whether a segment of teaching and learning activity in a science lesson is student-centered, based on the level of students' engagement from the viewpoint of social constructivism. The unit for coding used in this lesson analysis system is a move, consisting of a set of a teacher's question and a student's response to the question. Analyzing the flow of coded moves is a simple way to visualize the lesson.
The developed lesson analysis system provides a simple tool for teachers to see what is student-centered teaching and learning in the science classrooms.

1. Introduction
UNESCO's Global Monitoring Report on EFA has shown that undesirable teaching practices, such as chalk-and-talk and teacher-centered pedagogy, persist in Sub-Saharan Africa. The education policy documents from these countries often encourage the use of student-centered teaching and learning, especially in science. Recognizing these issues, the Japan International Cooperation Agency (JICA) supports initiatives to improve science lessons by making them more student-centered, as in the case of the Strengthening of Mathematics and Science in Secondary Education (SMASSE) Project in Kenya. Educationists engaged in this project have observed that the local teachers' science lessons with hands-on activities are usually teacher-centered. These observations led them to point out the need for discussion on how student-centered teaching and learning should be conducted in the science classroom. As explained by Baba [2], in order to visualize student-centered lessons, it is necessary to develop model lessons and investigate the learning process of children in the field of international cooperation in education. Considering this idea, investigating the learning process of children, and developing some means to help teachers visualize student-centered teaching is of great importance.
This paper discusses the development of a lesson analysis system to help teachers visualize student-centered teaching in the science classroom. The study focuses on the sub-Saharan African country of Zambia.

2. Methodology

2.1 Consideration of Local Context
In general, the noticeable advantage of a quantitative lesson analysis is that it assures a certain level of reliability. This is because the applied category systems usually consist of low inference items, which do not ask the observers, or raters, for a high level of judgment when coding. On the other hand, a qualitative lesson analysis is often advantageous in terms of content validity while its coding involves a high level of inference. The lesson analysis system developed in this study needed to be sufficiently

reliable to at least be able to use the results for a general comparison in the region. In the meantime, the system also needed to have sufficient validity to provide some level of interpretation of student-centered teaching. This means that the lesson analysis system needed to maintain a balance between the required levels of reliability and validity. In addition, since the lesson analysis system was intended for use in the field of educational development, it needed to be simple enough for application in a field where technological resources are limited. As Lewin [3] pointed out, when it comes to educational development, paying attention to the context of the locality and the country is important. Accordingly, the situation of Zambia's science education has been taken into consideration in the development of the lesson analysis system. Matsubara [4] has shown that basic schools in Zambia's Southern Province struggle to provide the science apparatus and chemicals needed for major chemistry-related experiments described in the grade 8 and 9 textbooks. Considering the local context, it is suggested that educational development in the region could focus on verbal scientific interaction, which does not always require materials. Regarding verbal interaction in the classroom, it is beneficial to pay attention to the classroom structure. As Mehan [5] pointed out, the classroom structure often consists of teacher initiation, student response and teacher evaluation, in that order. For verbal interaction, teacher initiation can be translated as teacher question, which means that teacher question, student response and teacher evaluation can consist of a fixed structure.

2.2 Research Procedure

Pretesting was carried out to determine unique pattern characteristics of verbal interaction of the teaching practices in the region. The pretest involved observing the discourse during 50 science lessons for grades 8 and 9 at basic schools in Southern Province, Zambia and analyzing the transcripts of 12 of the science lessons. The findings of the pretest were used as the basis for developing the lesson analysis system. Using tentative lesson analysis systems, development was implemented through a series of discussions using scores for the analysis results and the respective systems. The discussions consisted of 10 cycles and each cycle was spiraled in order to improve each system by providing a better balance between reliability and validity, as well as to make the system as simple as possible.

3. Development

3.1 Findings from the Pretest and Developing the Lesson Analysis System

The pretest identified the following pattern in the science classroom communication as unique characteristics of the teaching practices in the region.
A distinctive characteristic of the students' responses is that in many cases the responses were given immediately after the teacher asked the question and the responses functioned as agreement with the teacher's opinion or the intention of that particular lesson segment. The following shows examples of typical classroom interaction involving this type of students' response.

Eg. 1
Teacher: Do you understand, this is OK, right?
Students: Yes, sir.

Eg. 2
Teacher: It may take too long for the salt to dissolve, isn't it?
Students: Yes.

The above responses show very little variety, and are often fixed as "yes" and "yes, sir". It is observed that the initiative of the students' responses is led by the teacher or the classroom culture. In other words, students are asked to answer the teacher's question, but they are almost forced to give the reply that the teacher expects. The source of the content of these responses comes from the teacher's remarks and/or questions, rather than the learning content of the lesson, the students' scientific knowledge and thinking. It means that they do not demonstrate the students' scientific knowledge or thinking about the learning content of the lesson. Since the responses do not contain any information, the teacher is provided with almost no information about the students' understanding of the teaching content. It would be difficult for the teacher to monitor the level of students' understanding, which creates a significant barrier to carrying out student-centered teaching. To distinguish this type of response from the others, this study refers to it as the teacher-led response (TLR). It has been assumed that TLR is culturally rooted in the teaching practices of the region and that it contributes to teacher-centered pedagogy in the region. Accordingly, in the development process of the lesson

analysis system, TLR has been taken into consideration in the types of responses. One code is prepared for the Yes/No response of TLR, and another code is prepared for the longer response of TLR.

As discussed above, TLR cannot demonstrate the student's scientific knowledge or thinking while there are responses that do demonstrate their knowledge and thinking. These responses were observed and regarded as evidence of knowledge externalization. When students' scientific knowledge and thinking are externalized, the teacher can monitor how well the students understand the learning content of the lesson segment. In this study, this type of response is referred to as the non-led response (NLR). It has been assumed that NLR plays an important role in student-centered teaching and several codes are prepared for NLR based on the level of students' engagement from the viewpoint of social constructivism.

The lesson analysis system has been designed to determine if a segment of teaching and learning activity in a lesson is student-centered. For instance, responses demonstrating the students' thinking and/or reasoning can be interpreted as more student-centered than responses demonstrating the students' knowledge. The highest category (QP) includes students' responses against other students' remarks.

It should be noted that students' no-response provides important information to consider. When students do not verbally reply to the teacher's question, it can mean that they do not understand the question or simply do not know the answer, but it can also mean that they are processing their thoughts. Thus, it is expected that including the students' "no-response" can enrich the lesson analysis system in terms of considering students' engagement. Accordingly, the aspect of "no-response" was included in the types of responses. As this study focuses on the verbal interaction of teachers and students, cases of no verbal response but only a physical response, such as a student not responding verbally while raising their hand, were treated as no verbal responses and included in the types of no responses.

	Teacher-led response (TLR)	**Non-led response (NLR)**
Initiative of response	Teacher	Student
Source of content of response	Teacher's remarks/question (often based on classroom culture)	Teacher's remarks, learning content of the lesson, student's knowledge, scientific thinking
Monitoring of student's understanding	Difficult	Possible

3.2 Developed Analysis System

The developed lesson analysis system contains two major features: the category system (Table 1) and the coding unit. The category system focuses on students' responses during classroom discourse, reflecting the characteristics of the teaching practices of the region and the level of students' engagement from the viewpoint of social constructivism. The unit for coding used in this lesson analysis system is a move, which is a set of a teacher's question and a student's response to the question. It should be noted that although there are several definitions of move, this research has adopted Fujii's definition [6]. The use of moves allows the analysis to focus on the communication between the teacher and student(s). As discussed above, this study includes students' no-response, and it indicates that handling students' no-response must be carefully considered when defining the move for this lesson analysis system. This lesson analysis system considers it a move when there is no student response to the teacher's question, and it is obvious that the teacher is expecting a response. One important guideline when arranging the moves in this system is that moves consisting of similar questions, or intentions of the teacher classified into one category, should be regarded under one umbrella. This grouping was carried out in order to make the lesson analysis system simpler and more capable of following changes in the intentions of the teacher's questions. These grouped moves are described as intentional moves in the study. Student's coded moves and analyzing the flow of intentional moves in a lesson makes it easy to visualize the lesson.

Table 1: Developed category system

Types of response	Coding categories	Descriptions
No verbal Response	NR 1	No verbal and no physical response
	NR 2	No verbal response but only a physical response
Teacher-led response (TLR)	LU	Response to a teacher's utterance
	L 1	Yes/No response to a teacher's led question
	L 2	Longer response to a teacher's led question
Non-led response (NLR)	UN	Response to a teacher's remarks
	NY/NN	Response showing agreement or disagreement
	DI	Response demonstrating information and/or knowledge
	DR	Response demonstrating reasoning and/or thinking
	QT	Question to the teacher
	QP	Question/response to other pupils

Examples of move

Teacher Question:	Just give me a simple explanation of what you understand about a fuse, what is a fuse?	Move
Student Response:	It is a device.	
Teacher Question:	Just give me a simple explanation of what you understand about a fuse, what a fuse is?	Move
Student Response:	……（NO REPLY）	

4. Application

Figure 1 shows an example of an analyzed science lesson conducted by utilizing the developed system in sub-Saharan African countries. The science lesson used was one of the 12 lessons previously mentioned. Preparing the entire transcript of this 48-minute lesson would normally require a substantial amount of work; however, the developed system only requires a transcript of the moves, greatly reducing the work load. The students' responses in the moves were coded into one of the coding categories, and they were grouped into intentional moves. The number of moves was 80, which were grouped into 28 intentional moves. The intentional moves were then arranged in order of the lesson flow as shown below. For example, the second intentional move consisted of three moves and both the first and the second moves were coded as NR2, while the third move was coded as DI. The analysis suggests that the discussion part of the lesson was interpreted as being more student-centered because the seventh, eighth, ninth and tenth intentional moves contained students' responses with DR, responses demonstrating reasoning and/or thinking. Furthermore, the series of four intentional moves with DRs was evidence that the students were engaged in deep thinking activities in the lesson segment.

Activity	Intentional move	Responder	No response		Teacher-led response(TLR)			Non-led response (NLR)					
			NR1	NR2	UL	L1	L2	UN	NY/NN	DI	DR	QT	QP
Introduction	1(1)	Ss				1							
	2(3)	C,C, s1		1,2						3			
	3(5)	C,s2, s3,Ss		1,3						2,4,5			
	4(1)	Ss				1							
Discussion	5(1)	Ss				1							
	6(1)	S				1							
	7(3)	C,C,s4	1	2							3		
	6(3)	C,C,s1	1,	2							3		
	8(3)	C,s5, s6	1,2								3		
	9(2)	C,s2		1							3		
Demonstration	10(1)	Ss				1							
	11(3)	Ss,Ss,Ss				1,2,3							
	12(1)	Ss				1							
Explanation	11(1)	Ss				1							
	13(1)	Ss				1							
	14(1)	Ss				1							
	15(1)	Ss				1							
	16(2)	Ss/T,Ss				2			1				
	17(1)	Ss/T			1								
	18(1)	Ss			1								
	19(1)	Ss				1							
	20(1)	Ss				1							
Demonstration	10(1)	Ss				1							
	13(1)	Ss				1							
Discussion	21(5)	C,C,s7, s8, s2	1,2,								3,4,5		
	22(5)	C,s9,s9,C,C	1,4,5								2,3		
	23(1)	Ss/T			1								
	24(1)	Ss				1							
Explanation	25(1)	Ss				1							
	26(1)	Ss							1				
	27(1)	Ss				1							
Conclusion	22(9)	C,s9,s9,s9,s9,Ss, s7, s7, Ss	1,6						9	7,8	2,3,4,5		
	23(1)	Ss				1							
Exercise	24(2)	C,s10		1					2				
	25(3)	C,s1,Ss	1						2	3			
	26(3)	C,s11,s11	1							2,3			
	27(6)	s11,C,s2,C,s12, s11	1	2,4						3	5,6		
	28(1)	T/Ss						1					

The flow of intentional moves in a lesson makes it easy to visualize the lesson.

Figure 1: Example of an analyzed science lesson

The developed lesson analysis system can study a segment of teaching and learning in a lesson by categorizing students' responses for better learning. The developed lesson analysis system is expected to work as a simple tool to help teachers realize what student-centered teaching and learning are in the science classroom. In order to apply the developed lesson analysis system to other countries, consideration must be given to the situation of science education in that particular country.

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