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Research Article

The learning continuum of living reproduction: Generating a curriculum grid based on students' cognitive levels

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ABSTRACT

One of the overlapping curriculum designs indicates the mismatch of teaching materials with the cognitive level process and student development, impacting the unstructured qualification of mastery of the material. On the other hand, the breadth and depth of teaching materials in the curriculum must be following students' mental development and level of cognitive processes. This study aims to collect the opinions of science teachers in junior high schools and biology teachers in high schools about the learning continuum design on reproducing living things. The method used is a survey. The study population is a hypothetical population with a convenience sample. The sample involved in this study were 111 teachers in Bantul Regency and Yogyakarta City. The data collection method used a questionnaire distributed through four subject teachers' conference (MGMP). The data obtained were analyzed using descriptive analysis. The results showed several sub-aspects of reproduction of living things that cannot be taught in elementary schools. The material for propagating fungi, protists, bacteria, and viruses starts in grade VII with a cognitive level of C1 (remembering), after previously students received material about types of animals and plants in grade VI (elementary school). Furthermore, the material on reproductive anatomy and physiology can only be given to class IX with cognitive level C2 (understanding) and continued in class X and XI with cognitive level C4 (analyzing). Especially for reproductive anatomy and physiology, fungi were introduced to class VII with C1 level cognitive processes (remembering). This teacher opinion generates a learning continuum grid that can help policymakers improve educational curriculum.

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INTRODUCTION

The quality of education is greatly influenced by the curriculum (Kranthi & College, 2010; Steiner, Magee, & Jensen, 2019). A set of planned objectives, content, materials, and learning strategies are documented in curriculum documents as guidelines for implementing learning (Ministry of National Education, 2016; Steiner et al., 2019). The presentation of the curriculum's scope of teaching materials is based on the level of cognitive processes and mental development of students. The learning continuum makes classroom learning more meaningful and useful (Kusumadewi, Subali, & Paidi, 2019). Besides, the learning continuum can help teachers identify student weaknesses in learning.

Nevertheless, teaching material has not been presented based on students' level of cognitive processing and mental development. It is evidenced by the many essential competencies found in overlapping teaching materials (Situmorang, 2016). Based on the analysis of Permendiknas Number 37 of 2018, the competence and scope of biology teaching materials in elementary school and junior high school have not been arranged sequentially from each level (Ministry of National Education, 2018). In the 2013 curriculum, the competency levels are also found that have not been regulated in stages (Ministry of National Education, 2016). Even though the characteristics, breadth, and depth of the material must be following the students' needs and development at the educational level. The incompatibility of teaching materials with the cognitive level processes and student development causes the qualification of material mastery in Indonesia to be unstructured. Besides, the scientific concepts that students accept are not sustainable at every level of education (Situmorang, 2016). Biology teaching materials that jump up and down make students burden heavier to receiving learning material. On the other hand, students' understanding of the teaching material is a measure of learning success (Dowd, Thompson, Schiff, & Reynolds, 2018; Kiliç & Sağlam, 2014; Olympiou & Zacharia, 2012).

At the beginning of the learning process, the students' treatment must be based on their cognitive development (Kuhn, 2011; Suryawati & Osman, 2018; Sutarto, 2017). The different characteristics of cognitive development at each stage are the main reasons learning is more likely to succeed (Dowd et al., 2018). As we age, a person's nervous system becomes more complicated. It causes a person's learning process to follow specific patterns and development stages according to their age. Furthermore, the nervous system of students develops more complicated with age. It causes the student learning process to follow specific patterns and stages of development according to their age. In other words, students cannot learn something that is beyond their cognitive abilities (Köseoğlu, 2015; Suryawati & Osman, 2018). Cognitive processes consist of six levels: remembering, understanding, applying, analyzing, evaluating, and creating (Anderson et al., 2001). The most crucial thing in this taxonomy is a hierarchy starting from the lowest learning objectives to the highest level. The highest level cannot be reached without reaching the previous cognitive level (Barrouillet, 2015; Carey, Zaitchik, & Bascandziev, 2015; Siegler, 2016).

The cognitive abilities of first-grade students of primary school age are still at the memory stage (C1), and the initial level of understanding (C2) is still limited, even though the students have entered the concrete operational stage (Astuti & Subali, 2017; Liu, He, & Li, 2015). This second-grade student of SD has entered the level of complete understanding (C2) and the application level (C3), which is getting better. The cognitive processes of application (C3) and analysis (C4) are already owned by ten-year-old or fourth-grade elementary school students. Students can analyze and dare to make mistakes for scientific reasons at this age, even though they are still simple (Bujuri, 2018). Students under the age of eleven can think logically and systematically based on empirical (real) objects captured by the senses

In contrast to students aged eleven to twelve years and over, students can think of hypotheses that might occur and something abstract. This phase is known as the formal operational phase, which is the last phase in cognitive development, according to Piaget (Bujuri, 2018). Students have used hypothesis-deductive thinking at this stage, namely developing hypotheses and systematically developing strategic steps in solving a problem (Im, Hokanson, & Johnson, 2015; Thompson, 2011). Grades V and VI begin to enter the realm of evaluation (C5) and creation (C6), even though the ability to assess and create is still effortless compared to the abilities of students currently in high school.

If the process of curriculum refinement is continuous without paying attention to the level of cognitive processes and mental development of students, then the success of students in learning will be very doubtful (Alhassora, Abu, & Abdullah, 2017; Stupple et al., 2017). Several studies have shown that applying the integrated science curriculum at the secondary level is not as expected, and its application in tertiary institutions has not succeeded in achieving learning objectives (Nampota, 2008; Sun, Wang, Xie, & Boon, 2014). Failure to implement this is due to teachers' competence, but many possibilities are caused by the existing curriculum structure not structured according to a learning continuum. For this reason, it is necessary to refer to a functional learning continuum as a learning guide (Subali, Kumaidi, & Aminah, 2018).

The formulation of the teaching material assessment grid needs to be asked about the teacher's opinion. It is because teachers have empirical experience directly with students in the class. Curriculum development by paying attention to material content at every level of education can make the learning process more effective (Subali et al., 2018). In several recent studies, teachers were asked for their personal opinion on the continuum of learning specific pedagogical materials for biology targeted at each level of education (Andriani & Subali, 2017; Astuti & Subali, 2017; Juniati & Subali, 2017; Kusumadewi et al., 2019).

However, there has been no research on the continuum of learning pedagogic material in living things' reproductive aspects. Therefore, the teaching material grid's arrangement for the aspects of reproduction of living things based on the level of cognitive processing is significant for the development of a better curriculum. The purpose of this study was to ask for the science teachers opinion in junior high schools and biology teachers in high schools regarding the division of biology teaching materials based on cognitive process levels.

METHOD

This survey research included all Junior High School (JHS) science and Senior High School (SHS) biology teachers in the Yogyakarta Special Region Province. Furthermore, the research samples were science teachers of JHS and SHS in Bantul Regency and City of Yogyakarta. This study involved 111 teachers consisting of 68 JHS teachers and 43 SHS teachers as respondents. In more detail, the number of respondents will be presented in Figure 1.

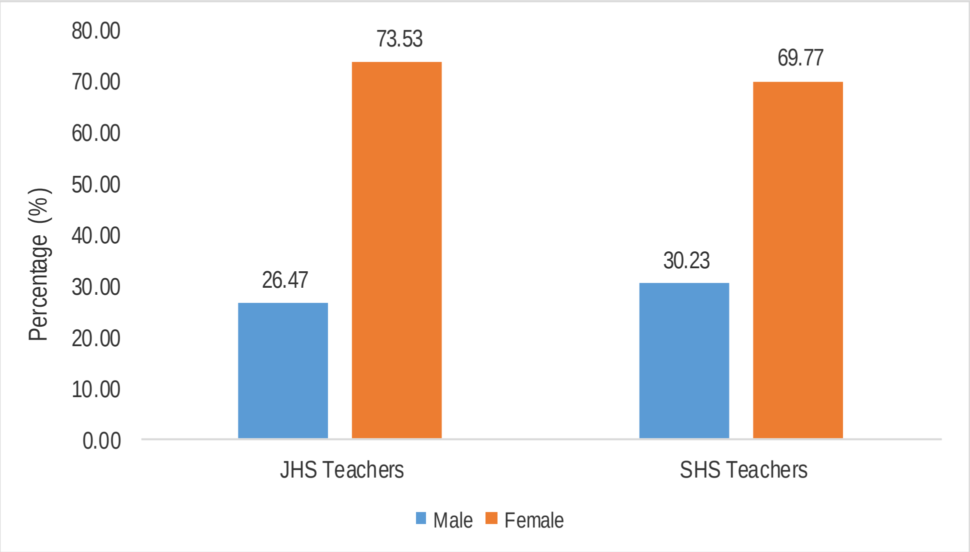

Figure 1. The percentage of respondents based on gender

The instrument used was a questionnaire with a confirmatory assessment model based on the level of cognitive processes concerning the characteristics of the content's biological aspects, especially in the reproduction of living things. There were five sub-aspects of living things reproduction, namely: 1) types of reproduction of living things, 2) human reproduction, 3) animal reproduction, 4) plant reproduction, and 5) fungal reproduction.

The level of cognitive processes used consists of six levels, namely, remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6) (Anderson et al., 2001). The instrument consists of five material sub-aspects with 18 statement items that biology education experts have validated, both construct and content. Data collection was carried out by distributing questionnaires through the Subject Teacher Conference (*Musyawarah Guru Mata Pelajaran*/MGMP) in Bantul Regency and Yogyakarta City. In each area, researchers used two MGMP (consisting of JHS and SHS). The number of MGMPs used in this study were four MGMPs The data analysis technique used is the descriptive analysis technique by describing the data that has been collected with actual results without any manipulation. The aim is to gather practitioners' opinions about ranking teaching materials based on the level of cognitive processes according to biological aspects' characteristics targeted at students in primary to secondary education levels. There is no assessment of the opinion given by the teachers. All opinions will be recapitulated, and opinion models are searched and then compiled as a teaching material grid.

RESULTS AND DISCUSSION

In this study, the five sub-aspects of living things reproduction are divided into several study topics for more detail. The percentage of opinions of junior high school science teachers and high school biology teachers on the aspects of reproduction of living things is presented in Table 1.

Table 1. Respondents' opinions regarding aspects of reproduction of living things taught in schools

Aspects of living things reproduction	Opinions of JHS science teachers and SHS biology teachers (N[a] = 111)					
	ES[b]		*JHS*[c]		*SHS*[d]	
	%	Class/LCP[e]	%	Class/LCP[e]	%	Class/LCP[e]
Sub-aspect 1: Types of reproduction						
a. Types of animal reproduction	15%	VI/C1[f]	69%	IX/C2[g]	45%	X/C4[h]
b. Types of plant reproduction	15%	VI/C1	60%	IX/C2	59%	X/C4
c. Types of fungi reproduction	-	-	54%	VII/C1	68%	X/C2
d. Types of protists reproduction	-	-	49%	VII/C1	71%	X/C2
e. Types of reproduction bakteria	-	-	39%	VII/C1	72%	X/C2
f. Types of virus reproduction	-	-	45%	VII/C1	70%	X/C2
Sub-aspect 2: Human reproduction						
a. Morphology of human reproduction	10%	VI/C1	62%	IX/C2	72%	XI/C4
b. Anatomy of human reproduction	-	-	64%	IX/C2	69%	XI/C4
c. Physiology of human reproduction	-	-	58%	IX/C2	68%	XI/C4
Sub-aspect 3: Animal reproduction						
a. Morphology of animal reproduction	7%	VI/C1	60%	IX/C2	70%	X/C4
b. Anatomy of animal reproduction	-	-	51%	IX/C2	69%	X/C4
c. Physiology of animal reproduction	-	-	55%	IX/C2	68%	X/C4
Sub-aspect 4: Plant reproduction						
a. Morphology of plant reproduction	15%	VI/C1	59%	IX/C2	72%	X/C4
b. Anatomy of plant reproduction	-	-	60%	IX/C2	65%	X/C4
c. Physiology of plant reproduction	-	-	53%	IX/C2	67%	X/C4
Sub-aspect 5: Fungi reproduction						
a. Morphology of fungi reproduction	-	-	46%	VII/C1	75%	X/C4
b. Anatomy of fungi reproduction	-	-	41%	VII/C1	77%	X/C4
c. Physiology of plant reproduction	-	-	41%	VII/C1	79%	X/C4

Descriptions: (a) total respondents, (b) Elementary School, (c) Junior High School, (d) Senior High School, (e) Level of cognitive processes, (f) remembering (C1), (g) understanding (C2), (h) analyzing (C4)

Table 1 explains four types of reproduction that are not taught at the elementary school level, namely the types of reproduction of fungi, protists, bacteria, and viruses. Furthermore, the types of animals and plants taught in grade VI with cognitive memory processing levels (C1) were 15%. At the JHS level, a different portion of the reproductive type is taught. Material on the types of fungi, protists, bacteria, and viruses was introduced to class VII with a cognitive process at the memory level (C1) while discussing types of reproduction of plants and animals it was taught in grade IX at the cognitive process level. Comprehension (C2), having previously been taught in elementary schools. At the high school level, the sub-types of reproduction aspects of living things are taught again in class X with cognitive processing level (C2) and analyzing (C4). The sub-aspects of human reproduction, animal reproduction, and plant reproduction are only part of the morphology taught in elementary school grade VI with cognitive processes at the memory level (C1).

The percentage is also not very high. The new anatomy and physiology section will be taught in grade IX at the cognitive process understanding level (C2). Furthermore, at the high school level, human reproductive anatomy and physiology will be provided in class XI with cognitive process-level analysis (C4), and the anatomy and physiology section for animals and plants will be taught in class X with cognitive material at the analysis process level (C4). Meanwhile, the sub-aspects of mushroom reproduction are not taught at all in elementary schools. They will only be taught in class VII with a cognitive process of understanding level (C1), then further studied in class X with the level of cognitive processing that increases to understanding (C2). Several factors cause teaching materials that are not taught in elementary schools. The difficulty, complexity, and abstractness are the main reasons this discussion cannot be given to students. Even though students who are eleven or twelve years of age and over can already think of something that is somewhat abstract, the level of difficulty and complexity is quite complicated, making it difficult for students to accept discussions. For example, mushroom reproduction's sub-aspects cannot be taught at the elementary school level because the subject matter is quite tricky, and learning material cannot be captured by the senses (Holyoak & Morrison, 2012).

Based on Table 2, the percentage value at each level of education shows the number of material coverage students deserves. Besides, there is also an increase in the level of cognitive processing at each level of education. It shows differences in the depth of the material in each subject at each level of education. Such teacher opinion makes teaching materials arranged in such a way as to form a learning continuum. Each competency or concept in teaching materials is arranged from easy to complicated and straightforward to complex according to students' development (Prihatin, Kumaidi, & Mundilarto, 2016; Subali, 2009). The presentation of the learning continuum data for the reproductive aspects of living things based on science teachers' opinions in JHS and biology teachers in SHS is described in Table 2.

Table 2. Learning continuum framework of living things reproduction aspects

Aspects of living things reproduction	Opinions of JHS science teachers and SHS biology teachers (*N*[a] = 111)					
	ES[b]				*ES*[b]	
	Class	*LCP*[e]	*Class*	*LCP*[e]	*Class*	*LCP*[e]
Sub-aspect 1: Types of reproduction						
a. Types of animal reproduction	VI	C1[f]	IX	C2[g]	X	C4[h]
b. Types of plant reproduction	VI	C1	IX	C2	X	C4
c. Types of fungi reproduction	-	-	VII	C1	X	C2
d. Types of protists reproduction	-	-	VII	C1	X	C2
e. Types of reproduction bakteria	-	-	VII	C1	X	C2
f. Types of virus reproduction	-	-	VII	C1	X	C2
Sub-aspect 2: Human reproduction						
a. Morphology of human reproduction	VI	C1	IX	C2	XI	C4
b. Anatomy of human reproduction	-	-	IX	C2	XI	C4
c. Physiology of human reproduction	-	-	IX	C2	XI	C4
Sub-aspect 3: Animal reproduction						
a. Morphology of animal reproduction	VI	C1	IX	C2	X	C4
b. Anatomy of animal reproduction	-	-	IX	C2	X	C4
c. Physiology of animal reproduction	-	-	IX	C2	X	C4
Sub-aspect 4: Plant reproduction						
a. Morphology of plant reproduction	VI	C1	IX	C2	X	C4
b. Anatomy of plant reproduction	-	-		C2	X	C4
c. Physiology of plant reproduction	-	-	IX	C2	X	C4
Sub-aspect 5: Fungi reproduction						
a. Morphology of fungi reproduction	-	-	VII	C1	X	C4
b. Anatomy of fungi reproduction	-	-	VII	C1	X	C4
c. Physiology of plant reproduction	-	-	VII	C1	X	C4

Descriptions: (a) total respondents, (b) Elementary School, (c) Junior High School, (d) Senior High School, (e) Level of cognitive processes, (f) remembering (C1), (g) understanding (C2), (h) analyzing (C4)

Table 2 shows a learning continuum framework from the aspect of reproduction of living things according to junior high school science teachers and high school biology teachers. The sequence of concepts arranged from simple to complex will help students build their knowledge quickly. Those concepts would make students learning run more logically and easier to understand. Thus, the students have sufficient basic knowledge before they learn the more difficult concepts as in the sub-aspects of human reproductive morphology, when elementary school students are only taught to remember (C1) in grade VI (ES) when in junior high school, students will relearn material but with a higher cognitive level (C2) in grade IX. Furthermore, students will deepen the topic in class XI with the level of analysis (C4). Learning like this makes students remember the material obtained and increase their knowledge more broadly and gradually.

Andriani and Subali (2017) state that most science teachers in SMP and Biology in SMA argue that the conceptual arrangement and level of competence in the curriculum are not arranged from simple to complex. Therefore, it is hoped that the teacher can pay attention to student development stages to find out all their needs. The learning continuum can help teachers identify students' abilities in understanding material appropriate to their mental development and age. The existence of a teaching material grid following the learning continuum can contribute to the point of view of policymakers that curriculum development must be tailored to students' needs, abilities, and competencies (Akar, 2014). After all, the curriculum is the heart of a school (Agustin & Puro, 2016). It acts as a powerful tool to increase student knowledge (Harrell, 2010).

CONCLUSION

The study results concluded that the sub-aspects of reproduction of living things were taught in stages according to the students' ability to receive the material. The existence of stages and sequences in tiered learning at each school level allows teaching materials to be well and wholly accepted by students. The absence of overlapping concepts makes students able to build their knowledge healthier and more comfortable to remember. The teacher's opinion that gave birth to the learning continuum grid is expected to help the government make future policies for better education.

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