Universitas Muhammadiyah Malang, East Java, Indonesia

JPBI (Jurnal Pendidikan Biologi Indonesia)

p-ISSN 2442-3750, e-ISSN 2537-6204 // Vol. 7 No. 1 March 2021, pp. 53-62

Research Article

Teachers' opinion about learning continuum in evolution based on the material complexity level

Hani' Faridah [a,1*], Bambang Subali [b,2]

[a] Magister of Biology Education Department, Faculty of Mathematics and Sciences, State University of Yogyakarta, Jl. Colombo No.1 Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia

[b] Biology Education Department, Faculty of Mathematics and Sciences, Yogyakarta State University, Jl. Colombo No.1 Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia

[1] hani.faridah331@gmail.com *; [2] bambangsubali@uny.ac.id

* Corresponding author

ARTICLE INFO

Article history
Received: 15 September 2020
Revised: 16 March 2021
Accepted: 21 March 2021
Published: 31 March 2021

Keywords
Evolution
Learning continuum
Material complexity level
Teachers' opinion

ABSTRACT

Evolution is one of biology topics which covers a wide range of material taught across education levels. Unfortunately, the material has not been arranged according to its complexity level and students' development. This study aimed to collect teachers' opinions about the learning continuum of evolution material based on its complexity level. This descriptive research was conducted in Bantul and Yogyakarta Cities by distributing questionnaires. As many as 68 junior high school (JHS) teachers and 43 senior high schools (SHS) teachers were selected through convenience sampling. The data gained was analyzed using descriptive statistics to determine the mode of practitioner opinion. The results showed that the JHS teachers thought that evolutionary material had a complexity level of 3 (quite complex) to level 5 (very complicated) that could be taught in class VII & IX as well as at higher level (XII SHS). Furthermore, the SHS teachers argued that the evolution material from level 3 (quite complex) to level 4 (complex) could be taught in XII class. Further research needs to be carried out using more complete instruments with more detailed indicators

How to cite: Faridah, H. & Subali, B. (2021). Teachers' opinion about learning continuum in evolution based on the material complexity level. *JPBI (Jurnal Pendidikan Biologi Indonesia), 7*(1), 53-62. doi: https://doi.org/10.22219/jpbi.v7i1.13680

INTRODUCTION

The implementation of learning in schools has been guided by the curriculum, which is an essential factor in achieving learning objectives (Darling-Hammond & John Bransford, 2005; McNeill et al., 2012). According to (Andriani & Subali, 2017) the curriculum structure is prepared based on national education standards to determine the aspects studied and the competencies to be achieved in an educational program. However, several studies indicate that curriculum development has not considered the continuum of learning, thus making learning materials between levels of education ineffective (Juniati & Subali, 2017; Kusumadewi et al., 2019; Lemos & Veríssimo, 2014; Pramesti & Subali, 2017). In fact, (Subali et al., 2018) stated that curriculum development carried out by paying attention to learning content at each level of education will make learning more effective. In other words, curriculum development requires standards that pay attention to the essence of the learning continuum so that the curriculum can meet students' needs at every level of education (Suyanto, 2018).

Continuum learning is one way of teaching material, including science, which has a wide variety of materials, making it easier for students to master the concept. The learning continuum is a logical and systematic sequence that shows the vertical connection of material from an aspect of science in learning (Prihatni et al., 2016). Competencies regulated in the curriculum also need to pay attention to the levels that students must achieve gradually, so that curriculum developers must consider the suitability of the teaching materials used with student development at each level of education (Juniati & Subali, 2017). Besides, the learning continuum arranged from simple to more complex can represent an overview of student development's developmental stages at each level of education (Situmorang, 2016).

Students at each level of education have different ages and levels of cognitive development. Therefore the teaching materials provided must be adapted to their development. Awwad (2013); Kose and Arslan (2017) stated that cognitive development is one of the natural developments of the individual, which determines the thinking skills of students in the learning process. Furthermore, this can help students build an understanding concept from the superficial to the complex level and make problem hypotheses (Agustina & Ahmad, 2020; Bujuri, 2018; Ibda, 2015; Nurhadi, 2020). In other words, each stage in cognitive development provides a basis for achievement at the next stage (Simatwa, 2010). As part of the sciences, biology has been taught from elementary school, junior high school, to high school. Studies such as diversity of living things, the morphology of living things, anatomy of living things, biological resources, genetics, evolution, ecology are the fields of biological studies taught at the three levels of education (Andriani & Subali, 2017; Pramesti & Subali, 2017).

(Priyayi et al., 2018) One of the problems in learning biology is that some material is considered difficult for students to learn. It is consistent with related with (Suryanda et al., 2020), which stated that 72.5% SHS teachers argued that Biology material is challenging to learn because it has many fields of study, so it needs to be taught gradually through the learning continuum starting from the elementary school level. One of the biological studies that have a broad material scope is evolution. Evolution refers to changes in organisms' structure that occur gradually to achieve functional conformity with their environment. This study is an essential material that can answer various phenomena in nature (Helmi et al., 2019; Taufik, 2019).

Furthermore, the material for the study of evolution is unique, quite complex, and continues to develop along with advances in science and technology so that a deeper and more complete understanding is needed (Sidiq, 2016). According to (Situmorang, 2016), a properly developed learning continuum can make it easier for teachers to be efficiently involved in learning activities. It is possible because, with detailed teaching material indicators, the teacher will present the material to students in a comprehensive and orderly manner. Therefore, the aspect of evolution is considered essential to be carefully organized into a proper learning continuum.

Previous research related to the learning continuum has dissected various studies such as physiology (Hadi & Subali, 2017), ecology (Mendala et al., 2019), reproduction (Trilipi & Subali, 2020), to biological resources (Kusumawati et al., 2019). Furthermore, this study involved experts and teachers as respondents based on implementing the curriculum they had carried out had not yet seen how their perspective was on the learning continuum in specific fields of study (Kusumawati et al., 2019; Mendala et al., 2019). This study aims to develop a learning continuum on evolutionary material based on the level of complexity of the material perceived by the teacher. This study's results are expected to be one of the considerations in curriculum development, especially on evolutionary material.

METHOD

This survey research was conducted by distributing questionnaires to respondents. The instrument was developed from previous research instruments through Focus Group Discussion (FGD), which involved Biology education experts. The evolutionary material assessed in the instrument corresponds to the evolution sub-material taught in schools, and among these materials, there are several other related sub-materials. The number of evolution material matter indicators entered into the instrument consisted of 68 items, consisting of material related to the theory of evolution and all things related to evolution. Respondents were asked to fill in their opinion about the complexity of these indicators (between levels 1-5) and which class the material should be taught. This research was conducted from May until August 2020. The questionnaire was then distributed to respondents via a Google form.

The study population was determined by following the population hypothesis rules, and the sample members were selected by convenience sampling (Edgar & Manz, 2017). The members of this sample represent a hypothetical population that has the appropriate characteristics. This study's population was all science and biology teachers in Yogyakarta and Bantul Cities, while the research sample was 68 junior high school science teachers and 43 SHS biology teachers, so the number of respondents was 111 teachers. Respondents' demographics are presented in Table 1.

Table 1. Demographic data of the participating teachers

Group of respondents	Based on the region		Total
	Yogyakarta n (%)	*Bantul regency n (%)*	
JHS Teachers	29 (43)	39 (57)	68
SHS Teachers	34 (78)	9 (22)	43

After the research data was collected, a recapitulation and data analysis was carried out. The research data analysis was conducted using descriptive statistics. Data processing is carried out to find the largest frequency distribution (mode) of all data that has been collected from teacher respondents. From the resulting mode, the Evolution aspect of the learning continuum is then arranged as teaching material based on the level of complexity of primary and secondary education according to the teacher's opinion. The higher the mode score, the higher the level of understanding between practitioners.

The limitations of this study are that the research is limited to only assessing the level of complexity of the material, the biological aspects that are assessed are only related to aspects of evolution, and the research respondents are limited to only involving JHS science teachers and SHS biology teachers. Data analysis used descriptive analysis techniques that have no significant value so that generalized conclusions cannot be made.

RESULTS AND DISCUSSION

The evolutionary material analyzed in the study consisted of evolutionary sub-material taught at the JHS and SHS levels. In this case, the evolutionary sub-material (especially at the JHS level) does not stand as a separate material but is related to other fields of biological studies. The evolutionary sub-material in this research includes environmental adaptation, natural selection, theory of evolution, kinds of evolution, evolutionary mechanisms, speciation, evolutionary clues, evolution in living things, and the theory of evolutionary tendencies. Table 2 explicitly describes the teacher's opinion on the environmental adaptation sub-material.

Table 2. Modes of teacher's opinions in complexity level of environmental adaptation

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
a.	Human Adaptation				
	1) Human physiological adaptations	IX / 3 [i]	44	XII / 4 [j]	24
	2) Human behavior adaption	IX / 3 [i]	42	XII / 4 [j]	24
b.	Animal Adaptation			XII / 4 [j]	
	1) Animal morphology adaptations	IX / 3 [i]	36	XII / 4 [j]	23
	2) Animal physiological adaptations	IX / 3 [i]	30	XII / 4 [j]	25
	3) Animal behavior adaptations	IX / 3 [i]	39	XII / 4 [j]	23
c.	Plant Adaptation	IX / 3 [i]		XII / 4 [j]	
	1) Plant morphology adaptations	IX / 3 [i]	39	XII / 3 [i]	23
	2) Plant physiological adaptations	IX / 3 [i]	42	XII / 4 [j]	24
	3) Plant behavior adaptations	IX / 3 [i]	42	XII / 3 [i]	23

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Table 2 shows that there were differences of opinion between JHS and SHS teachers. The SHS teacher argues that adaptation sub-material can be taught at the JHS level because grade IX students are also taught about adaptation. However, it is not specific about evolution but is part of the ecology material in basic competency (*Kompetensi Dasar*/KD 2.1) related to identifying the survival of living things through adaptation, natural selection, and breeding. Thus, the teacher argues that the adaptation sub-material can be taught at the JHS level and then developed and deepened when learning at the SHS level with a higher complexity level. The level of understanding between groups of practitioners is quite high based on the resulting mode values, which leads to the quite complex level in JHS and level 4 and some at level 3 (plant morphology adaptations and plant behavior adaptations) in SHS.

JHS and SHS teachers' opinions on the natural selection sub-material showed similar results (Table 3). The SHS teacher believes that natural selection can begin to be taught at the JHS level. Factors that influence natural selection such as symbiosis, competition, natural disasters, and population density can be taught in grade VII, while for other factors such as predation, sexual selection, food availability, human behavior, and habitat availability and the impact of natural selection is taught in grade IX. All respondents believe that the factors and impacts of natural selection are classified as quite complex and following the level of cognitive development of JHS students. Natural selection sub-material in JHS is taught in basic competencies (KD 3.7 and 4.7) regarding the analysis and presentation of the analysis results of the interaction of living things with the environment and

population dynamics. On the other hand, according to the SHS teacher, natural selection materials that are more specific to evolution can be taught in class XII SHS. Perceptions between groups of practitioners are also relatively high based on the obtained mode scores.

Table 3. Modes of teacher's opinions in complexity level of natural selection

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
a.	Factors influencing natural selection				
	1) Predation	IX / 3 [i]	43	XII / 4 [j]	21
	2) Symbiosis parasitism	VII / 3 [i]	43	XII / 3 [i]	21
	3) Competition	VII / 3 [i]	43	XII / 3 [i]	22
	4) Sexual selection	IX / 3 [i]	43	XII / 4 [j]	26
	5) Natural disasters	VII / 3 [i]	40	XII / 4 [j]	21
	6) Availability of food	IX / 3 [i]	42	XII / 4 [j]	21
	7) Population density	VII / 3 [i]	43	XII / 4 [j]	25
	8) Human behavior	IX / 3 [i]	40	XII / 4 [j]	23
	9) Habitat availability	IX / 3 [i]	42	XII / 4 [j]	23
b.	Impact of Natural Selection				
	1) The formation of new species	IX / 3 [i]	43	XII / 4 [j]	25
	2) Extinction of organisms	IX / 3 [i]	40	XII / 4 [j]	25

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Table 4. Mode of teacher's opinion in complexity level of theory of evolution

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
a.	The theory of the formation of the earth	VII / 3 [i]	40	XII / 4 [j]	24
b.	Theory regarding the origin of life				
	1) Abiogenesis theory	XII / 4 [j]	43	XII / 4 [j]	25
	2) Biogenesis theory	XII / 4 [j]	40	XII / 4 [j]	24
	3) Modern biological theory	XII / 4 [j]	40	XII / 4 [j]	26
c.	Theory of the origin of another life				
	1) Typical creation theory	XII / 4 [j]	40	XII / 4 [j]	28
	2) Cataclism theory	XII / 4 [j]	37	XII / 4 [j]	27
	3) Cosmozoan theory	XII / 4 [j]	36	XII / 4 [j]	27
	4) Biochemical evolutionary theory	XII / 4 [j]	38	XII / 4 [j]	24

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Different results are shown in Table 4. JHS and SHS teachers' opinion regarding the theory of evolution states that, except the theory of earth formation, can be taught at the SHS level (class XII). The theory of evolution, classified as complex (level 4) and more suitable for students with more robust cognitive maturity levels. The teacher opinion mode shows that the level of perception among practitioners is relatively high. It shows that the level of perception among practitioners is relatively the same. Furthermore, the JHS and SHS teachers also agree that some experts classify the theory of evolution and kinds of evolution as complex (level 4), so it is more appropriate to teach it in class XII. Table 5 shows that teachers' had a same perceptions.

Sometimes, the pros and cons of the material taught in evolution provide a pretty complicated discourse for students (Afidah, 2017; Helmi et al., 2019). Mattsson and Mutvei (2015) confirm that the theory of evolution is rarely well understood by students. The religious beliefs and mechanistic views that science must use to present accurate predictions make the theory of evolution sometimes challenging to accept. However, evolution is still an essential part of biological science for students to learn in school despite the pros and cons. Saputra (2017) states that most Biology teacher candidates consider evolutionary material to be taught because it reveals essential phenomena such as the formation of the earth and the evolution of living things from the past to the present. One of the efforts that can be made to understand evolutionary material correctly and adequately is to develop a learning continuum with evolutionary aspects appropriate for each level of education.

Table 6 shows the difference of opinion between the JHS and SHS teacher groups on the evolution mechanism sub-material. However, the mode scores indicate that teachers agree that studies related to migration, gene recombination, mutations, gene flow, non-random mating, and genetics drift are more appropriate when taught in grade XII. The mode score in Table 7 shows that the teachers' perceptions are relatively the same in this regard. On the other hand, the matter's complexity in this sub-material is classified as varied from quite complex (level 3), such as natural selection and migration, to very complicated (level 5), such as gene recombination. Therefore, both JHS and SHS teachers agree that this sub-material tends to be more

appropriately taught in SHS XII, except natural selection material, which can be relatively taught starting at the junior high school level.

Table 5. Mode of teacher's opinion in complexity level of theory of evolution and kinds of evolution

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
Theory of evolution					
1)	According to Aristoteles	XII / 4[j]	42	XII / 4[j]	24
2)	According to Anaximander	XII / 4[j]	40	XII / 4[j]	23
3)	According to Empedoclas	XII / 4[j]	42	XII / 4[j]	23
4)	According to Erasmus Darwin	XII / 4[j]	43	XII / 4[j]	22
5)	According to Count De Buffon	XII / 4[j]	43	XII / 4[j]	22
6)	According to Sir Charles Lyell	XII / 4[j]	42	XII / 4[j]	25
7)	According to Lamarck	XII / 4[j]	40	XII / 4[j]	22
8)	According to Charles Robert Darwin	XII / 4[j]	42	XII / 4[j]	23
Kinds of evolution					
Based on the direction	a) Progressive evolution	XII / 4[j]	41	XII / 4[j]	26
	b) Regressive evolution	XII / 4[j]	39	XII / 4[j]	27
Based on the scale of change	a) Microevolution	XII / 4[j]	39	XII / 4[j]	29
	b) Macroevolution	XII / 4[j]	44	XII / 4[j]	27
Based on the final results	a) Divergent evolution	XII / 4[j]	44	XII / 4[j]	26
	b) Convergent evolution	XII / 4[j]	40	XII / 4[j]	29

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Table 6. Mode of teacher's opinion in complexity level of evolutionary mechanism

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
1.	Natural selection	IX / 3[i] & 4[j]	29	XII / 4[j]	28
2.	Migration	XII / 3[i]	38	XII / 4[j]	23
3.	Gene recombination	XII / 5[k]	39	XII / 4[j]	24
4.	Mutation	XII / 4[j]	38	XII / 4[j]	28
5.	Gene flow	XII / 4[j]	41	XII / 4[j]	26
6.	Marriage is not random	XII / 4[j]	37	XII / 4[j]	28
7.	Genetic drift	XII / 5[k]	38	XII / 4[j]	27

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Similar results are shown in the sub-material speciation (Table 7) and evolutionary clues (Table 8). The JHS and SHS teachers agreed that the two sub-materials were more appropriate when taught to XII grade students. These results explain that the speciation sub-material consisting of domestication studies, polyploidy, and isolation mechanisms has a level 4 material complexity—likewise, the evolutionary clues sub-material. The five studies of evolutionary clues such as anatomical comparisons (analogy and homology), embryological comparisons, physiological comparisons, evolutionary evidence, and paleontological clues are also classified as complex (level 4).

Table 7. Mode of teacher's opinion in complexity level of speciation

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
1.	Domestication	XII / 4[j]	39	XII / 4[j]	28
2.	Polyploid	XII / 4[j]	39	XII / 4[j]	28
3.	Isolation mechanism	XII / 4[j]	38	XII / 4[j]	29

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

One of the essential studies in other evolutionary material is the evolution of living things that study human evolution, such as studies of ancient humans (*Pithecanthropus erectus*) and modern humans (*Homo erectus*). The JHS and SHS teachers agreed that the study was classified as complex (level 4) and very appropriate if it was taught to students with a more mature cognitive level, such as class XII (Table 9). Similar opinions are expressed in the study of animal evolution and plant evolution. Interestingly, respondents judge that fungal evolution has a higher material complexity (level 5) than animal evolution and human evolution.

Table 8. Mode of teacher's opinion in complexity level of evolutionary clues

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
1.	Comparative anatomy				
	a) Analogy	XII / 4[j]	40	XII / 4[j]	27
	b) Homology	XII / 4[j]	38	XII / 4[j]	23
2.	Comparative embryology	XII / 4[j]	39	XII / 4[j]	27
3.	Comparative physiology	XII / 4[j]	40	XII / 4[j]	29
4.	Instructions of the remaining tools	XII / 4[j]	37	XII / 4[j]	22
5.	Paleontology clues	XII / 4[j]	40	XII / 4[j]	25

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Table 9. Mode of teacher's opinion in complexity level of evolution in living things

No	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
1)	Human evolution				
	Early humans-Modern humans	XII / 4[j]	38	XII / 4[j]	28
2)	Animal (Animalia) evolution				
	a. Short-necked giraffes to long necks (Lamarck's Theory)	XII / 4[j]	37	XII / 4[j]	24
	b. Variation of finches due to differences in adaptation and natural selection (Darwin's theory)	XII / 4[j]	38	XII / 4[j]	27
	c. The formation of insect mutants due to changes in genes	XII / 4[j]	38	XII / 4[j]	29
3)	Plant evolution				
	The existence of watermelon plants without seeds is due to changes in genes in the form of polyploidy formation	XII / 4[j]	39	XII / 4[j]	28
4)	Fungal-viruses evolution				
	The formation of mutant species that are resistant to something, for example, environmental conditions due to gene changes	XII / 5[k]	39	XII / 4[j]	28

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Table 10. Mode of teacher's opinion in complexity level of the theory of evolutionary tendencies

No.	Evolution sub-material	Mode of teacher's opinion			
		JHS[a] Teachers (N[c]=68)		SHS[b] Teachers (N[c]=43)	
		Cls[d]/ CL[e]	Mo[f]	Cls[d]/ CL[e]	Mo[f]
1)	Synthesis evolution theory	XII / 4[j] & 5[k]	30	XII / 4[j]	26
2)	Theory is in crisis	XII / 5[k]	37	XII / 4[j]	27
3)	Harun Yahya theory	XII / 4[j]	38	XII / 4[j]	25
4)	Implications in society	XII / 5[k]	36	XII / 4[j]	23

Note= JHS[a]: Junior High School; SHS[b]: Junior High School; N[c]: total number; Cls[d]: Class; CL[e]: Complexity Level, Mo[f]: Mode; 1[g]: very simple; 2[h]: simple; 3[i]: quite complex; 4[j]: complex; 5[k]: very complicated.

Table 10 shows the opinions of JHS and SHS teachers on evolutionary tendencies. Both JHS and SHS teachers agreed that this sub-material should be taught in class XII SHS. However, JHS teachers assess that this sub-material has a level of complexity to very complicated. The level of perception among practitioners is relatively high based on the mode of the data collected. It is indicated that the development of information technology which is increasingly advanced, can lead to better understanding.

Moreover, students can access more valuable and relevant sources of information related to evolutionary studies. Furthermore, JHS and SHS teachers argued that this material was suitable for learning in class XII. One of the things that are taken into account is that SHS students have more developed cognitive abilities because, in general, they have entered the formal operational stage, so they are expected to be able to understand the material that is considered complex.

The learning continuum grid on evolutionary material (Table 11) illustrates that this material can be taught at the JHS level and deepened at the SHS level with a higher complexity level. These results indicate that the evolutionary aspect can be taught starting at the JHS level and continuing at the SHS level. If the sub-material taught at a lower level is taught again at a higher level, the material must be taught with a higher level of complexity. On the other hand, based on age maturity, JHS and SHS students are classified as formal operational stages, but SHS students are more developed so they can think more complexly (Barrouillet, 2015; Ibda, 2015). Other characteristics, SHS students are more able to think abstractly, have more intellectual abilities, are more developed, and integrate the problems they face with the theories and concepts they already have (Asih, 2018). In other words, SHS students are considered to be better able to understand more complex material. Previously taught, more straightforward material can become initial knowledge so that it is easier to understand for later,

more complex material. For example, in adaptation material, more straightforward material can be used to understand adaptation and simple examples that can be found nearby. It will be more complex when distinguishing various types of adaptations and examples, then further explaining how adaptation can be a contributing factor—the occurrence of evolution.

Table 11. Learning continuum of evolution aspects for elementary to secondary education grades

No	Evolution sub-material	Education grades					
		ES[a]		JHS[b]		SHS[c]	
		CL[d]	Cls[e]	CL[d]	Cls[e]	CL[d]	Cls[e]
1.	Adaptation (Environmental Adaptation)						
	a. Human physiological adaptations & human behavior adaptations	-	-	3[h]	IX	4[i]	XII
	b. Animal morphology adaptations, animal physiological apt adaptations ations, & animal behavior adaptions	-	-	3[h]	IX	4[i]	XII
	c. Plant morphology adaptations, plant physiological adaptations, & plant behavior adaptions	-	-	3[h]	IX	4[i]	XII
2	Natural Selection						
	a. Factors influencing natural selection	-	-	3[h]	VII & IX	4[i]	XII
	b. Impact of natural selection	-	-	3[h]	IX	4[i]	XII
3	Theory of Evolution						
	a. The theory of the formation of the earth	-	-	3[h]	VII	4[i]	XII
	b. Theory regarding the origin of life	-	-	-	-	4[i]	XII
	c. Theory of the origin of another life	-	-	-	-	4[i]	XII
	d. The theory of evolution according to several figures	-	-	-	-	4[i]	XII
4	Kinds of evolution						
	a. Based on the direction	-	-	-	-	4[i]	XII
	b. Based on the scale of change	-	-	-	-	4[i]	XII
	c. Based on the final results	-	-	-	-	4[i]	XII
5.	Evolutionary mechanism	-	-	3[h] - 4[i]	IX	4[i] - 5[j]	XII
6.	Speciation	-	-	-	-	4[i]	XII
7.	Evolutionary clues	-	-	-	-	4[i]	XII
8.	Evolution in Living Things						
	a. Human evolution	-	-	-	-	4[i]	XII
	b. Animal evolution (animalia)	-	-	-	-	4[i]	XII
	c. Plant evolution	-	-	-	-	4[i]	XII
	d. Fungal-viruses evolution	-	-	-	-	4[i]	XII
9.	The Theory of Evolutionary Tendencies	-	-	-	-	4[i] - 5[j]	XII

Note= ES[a]: Elementary School; JHS[b]: Junior High School; SHS[c]: Junior High School; CL[d]: Complexity Level; Cls[e]: Class; 1[f]: very simple; 2[g]: simple; 3[h]: quite complex; 4[i]: complex; 5[j]: very complicated.

In curriculum development, the arrangement of the material must be able to show the relationship between the material being studied and the material needed for learning at a higher level of education, and it is better if the primary material has been taught at the previous level so that students can more easily understand the concept of the material being studied. The material taught at a lower level of education does not have to be re-taught at the next level of education so that there is no overlapping of the material being studied (Suyanto, 2018). Therefore, at every level of education, the aspects that need to be taught must be adjusted to the needs that still pay attention to the suitability of the level of complexity of the material with students' development and ability to accept and understand. JHS teachers in this context argue that some evolutionary sub-material can be taught at the JHS level as initial knowledge so that it is easier to learn more complex evolutionary materials taught at the SHS level.

A material that is taught repeatedly shows that the arrangement of the material follows the spiral curriculum rules. More specifically, this material will be repeated, expanded, and deepened at a higher level. In the spiral curriculum, the same sub-aspects can be taught at various levels of education from primary to tertiary education but still pay attention to students' cognitive development (Nurhadi, 2020). The spiral curriculum preparation considers the most straightforward material arrangement to the more complex material (Nurjan, 2016) involving structured information so that complex ideas from a superficial level first (Liu, 2016). In the context of evolutionary material, the results of the learning continuum study show that evolutionary material has been introduced to students starting from JHS and continued at the SHS level, so it can be said to follow the spiral curriculum rules because there is a material that is repeated and deepened at a higher level.

In comparison, at a higher level, higher can be said to follow the spiral curriculum rules. The current implementation in schools is based on the 2013 curriculum, and evolution material is taught in class XII SHS semester II, namely KD 3.9 and KD 4.9. (Hanurani, 2019) shows that the genetics and evolution scores tend to decline even though in 2019, there has been a slight increase. However, the scores still tend to be lower when

compared to other Biology sub-material. The most significant decline in the evolutionary aspect's value occurred in 2016-2017, reaching -10.53. The research analysis results stated that one of the reasons for the not too high value of the evolutionary aspect was the sub-material, which was quite tricky for students to understand.

The preparation of teaching materials must be done with due observance of the teacher's opinion. It is related to the learning trajectory. The learning trajectory hypothesis serves as a kind of roadmap to make it easier for teachers to identify learning objectives, interpret student thoughts and provide appropriate instructions (Sztajn et al., 2012), one of which is related to determining suitable material to be taught to students. Teachers are considered capable of understanding students' learning abilities and needs. Mapping teacher opinions shows that evolutionary sub-material cannot be taught to students at the Elementary School (ES) level because the characteristics of the material are considered quite complex for children's ES, which is still in the concrete operational stage (Hikmawati, 2018; Juwantara, 2019; Mauliya, 2019). Candramila et al (2016); Çimer (2012) stated that one of the leading causes of student difficulties in studying biology (including evolution) is that the topic involves many abstract concepts and contains many Latin terms, so it is pretty challenging to learn. Thus, evolutionary learning's success needs to be well and thoroughly designed (Jirana & Amin, 2016). According to the teachers, most aspects of evolution must be taught at the SHS level because students have entered a formal operational stage that tends to understand abstract concepts and has approached maximum intellectual efficiency (Carey et al., 2015; Simatwa, 2010). Therefore, SHS students are considered capable of learning complex materials.

The preparation of the scope, breadth, and depth of evolutionary material is also considered appropriate according to student development so that the scientific concepts taught are in line with the knowledge obtained by students at every level of education (Hadi & Subali, 2017; Situmorang, 2016). However, the success of such evolutionary learning would not be possible if curriculum development did not involve teachers. Teachers have an important role because they are directly involved in the learning process, observe how students develop and abilities, and experience problems that often make learning less effective. In conclusion, the teacher's opinion about the learning continuum can be crucial in curriculum development. Curriculum development, preparation of the learning continuum, and preparation of appropriate teaching materials are intended to make learning effective to achieve all the learning objectives that have been set so that education in Indonesia can be optimally improved.

CONCLUSION

The results of the study concluded that the evolutionary sub-material has a level of complexity from level 3 (quite complex) to level 5 (very complicated) and is more appropriate when taught at the SHS level. However, some sub-material can be taught at the JHS level with material coverage that is following student development. This research is preliminary, so further research is needed to produce a learning continuum that is appropriate and can be used as material for curriculum development. Furthermore, this study recommends using a broader and more complex instrument with more detailed indicators for a deeper analysis.

REFERENCES

Afidah, M. (2017). Identifikasi pola miskonsepsi mahasiswa pada konsep mekanisme evolusi menggunakan Certainty Of Response Index (CRI). *Bio-Lectura: Jurnal Pendidikan Biologi*, *4*(2), 129–140. https://doi.org/10.31849/bl.v4i2.394

Agustina, A., & Ahmad, M. Y. (2020). A study on students' cognitive development in answering english task. *Al-Hikmah: Jurnal Agama Dan Ilmu Pengetahuan*, *17*(1), 11–28. https://doi.org/10.25299/al-hikmah:jaip.2020.vol17(1).3888

Andriani, A. E., & Subali, B. (2017). Teachers' opinion about learning continuum based on student's level of competence and specific pedagogical material in classification topics. *AIP Conference Proceedings*, *1868*. https://doi.org/10.1063/1.4995211

Asih, T. (2018). Perkembangan tingkat kognitif peserta didik di Kota Metro. *Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi*, *2*(1), 9–17. https://doi.org/10.32502/dikbio.v2i1.909

Awwad, A. A. A. (2013). Piaget's theory of learning. *Interdisciplinary Journal of Contemporary Research In Business*, *4*(9), 106–129. https://journal-archieves27.webs.com/106-129.pdf

Barrouillet, P. (2015). Theories of cognitive development: From Piaget to today. *Developmental Review*, *38*, 1–12. https://doi.org/10.1016/j.dr.2015.07.004

Bujuri, D. A. (2018). Analisis perkembangan kognitif anak usia dasar dan implikasinya dalam kegiatan belajar mengajar. *LITERASI (Jurnal Ilmu Pendidikan)*, *9*(1), 37. https://doi.org/10.21927/literasi.2018.9(1).37-50

Candramila, W., Adrianto, O. M., & Ariyati, E. (2016). Pemahaman konsep evolusi di Perguruan Tinggi. *Seminar Nasional Pendidikan dan Saintek 2016*, *May 2016*, 878–886. https://publikasiilmiah.ums.ac.id/handle

/11617/8026
Carey, S., Zaitchik, D., & Bascandziev, I. (2015). Theories of development: In dialog with Jean Piaget. *Developmental Review*, *38*, 36–54. https://doi.org/10.1016/j.dr.2015.07.003
Çimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews*, *7*(3), 61–71. https://doi.org/10.5897/ERR11.205
Darling-Hammond, L., & John Bransford. (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. Jossey-Bass. https://doi.org/10.5860/choice.43-1083
Edgar, T. W., & Manz, D. O. (2017). Exploratory Study. In *Research Methods for Cyber Security* (pp. 95–130). https://doi.org/10.1016/b978-0-12-805349-2.00004-2
Hadi, R. F., & Subali, B. (2017). The learning continuum based on student's level of competence and specific pedagogical learning material on physiological aspects from teachers's opinions. *AIP Conference Proceedings*, *1868*. https://doi.org/10.1063/1.4995216
Hanurani, H. (2019). Gambaran umum penguasaan materi ujian nasional tingkat SMA/MA mata pelajaran Biologi. *JPPS (Jurnal Penelitian Pendidikan Sains)*, *9*(1), 1735–1739. https://journal.unesa.ac.id/index.php/jpps/article/view/5448
Helmi, T., Rustaman, N., Tapilouw, F., & Hidayat, T. (2019). Perspektif ilmiah dan keyakinan terhadap evolusi mahasiswa biologi di universitas berbasis agama. *Jurnal Sosial Humaniora*, *10*(2), 83. https://doi.org/10.30997/jsh.v10i2.1874
Hikmawati, N. (2018). Analisa kesiapan kognitif siswa SD/MI. *Kariman*, *6*(1), 109–128. http://download.garuda.ristekdikti.go.id/article.php?article=528577&val=10827&title=analisa kesiapan kognitif siswa sdmi.
Ibda, F. (2015). Perkembangan kognitif: Teori Jean Piaget. *Intelektualita*, *3*(1), 242904. https://www.jurnal.ar-raniry.ac.id/index.php/intel/article/view/197
Jirana, J., & Amin, M. (2016). Persepsi dosen dan mahasiswa terhadap buku ajar dan metode pembelajaran yang digunakan dalam membelajarkan calon guru biologi. *Prosiding Seminar Nasional II 2016, Kerjasama Prodi Pendidikan Biologi FKIP Dengan Pusat Studi Lingkungan Dan Kependudukan (PSLK) Universitas Muhammadiyah Malang*, *1*, 1019–1028. https://www.researchgate.net/publication/319945026
Juniati, E., & Subali, B. (2017). Teacher's opinion about learning continuum of genetics based on student's level of competence. *AIP Conference Proceedings*, *100002*. https://doi.org/10.1063/1.4995212
Juwantara, R. A. (2019). Analisis teori perkembangan kognitif Piaget pada tahap anak usia operasional konkret 7-12 tahun dalam pembelajaran Matematika. *Al-Adzka: Jurnal Ilmiah Pendidikan Guru Madrasah Ibtidaiyah*, *9*(1), 27. https://doi.org/10.18592/aladzkapgmi.v9i1.3011
Kose, U., & Arslan, A. (2017). Realizing an optimization approach inspired from Piaget's theory on cognitive development. *Broad Research in Artificial Intelligence and Neuroscience*, *6*(1–4), 15–22. https://arxiv.org/ftp/arxiv/papers/1704/1704.05904.pdf
Kusumadewi, M. ., Subali, B., & Paidi. (2019). Developing a learning continuum of biological resources management aspect from elementary school to senior high school based on the experts' opinions. *Journal of Physics: Conference Series.*, *1397*. https://doi.org/10.1088/1742-6596/1397/1/012052
Kusumawati, M. U., Subali, B., & Paidi. (2019). Developing a learning continuum of biological resources management aspect from Elementary School to Senior High School based on the experts' opinions. *Journal of Physics: Conference Series*, *1397*(1). https://doi.org/10.1088/1742-6596/1397/1/012052
Lemos, M. S., & Veríssimo, L. (2014). The relationships between intrinsic motivation, extrinsic motivation, and achievement, along elementary school. *Procedia - Social and Behavioral Sciences*, *112*, 930–938. https://doi.org/10.1016/j.sbspro.2014.01.1251
Liu, Z. (2016). Inspirations of relevance and spiral curriculum theory for EGP teaching. *IOSR Journal of Research & Method in Education*, *6*(5), 62–65. https://doi.org/10.9790/7388-0605046265
Mattsson, J.-E., & Mutvei, A. (2015). How to Teach Evolution. *Procedia - Social and Behavioral Sciences*, *167*, 170–177. https://doi.org/10.1016/j.sbspro.2014.12.658
Mauliya, A. (2019). Perkembangan Kognitif pada Peserta Didik SMP (Sekolah Menengah Pertama) Menurut Jean Piaget. *ScienceEdu*, *II*(2), 86. https://doi.org/10.19184/se.v2i2.15059
McNeill, M., Gosper, M., & Xu, J. (2012). Assessment choices to target higher order learning outcomes: The power of academic empowerment. *Research in Learning Technology*, *20*(3), 283–296. https://doi.org/10.3402/rlt.v20i0.17595
Mendala, Subali, B., & Paidi. (2019). Developing a learning continuum on ecological aspect from elementary to senior high school based on the opinions of biology education experts. *Journal of Physics: Conference Series*, *1397*(1). https://doi.org/10.1088/1742-6596/1397/1/012053
Nurhadi. (2020). Teori kognitivisme serta aplikasinya dalam pembelajaran. *Jurnal Edisi*, *2*(1), 77–95. https://doi.org/10.36088/edisi.v2i1.786

Nurjan, S. (2016). *Psikologi belajar*. Wade Group. http://eprints.umpo.ac.id/4909/1/Buku Psikologi Belajar.pdf

Pramesti, I. C., & Subali, B. (2017). The learning continuum of ecology based on teachers' opinion about student's level of competence and specific pedagogical learning material. *AIP Conference Proceedings*, *1868*. https://doi.org/10.1063/1.4995213

Prihatni, Y., Kumaidi, K., & Mundilarto, M. (2016). Pengembangan instrumen diagnostik kognitif pada mata pelajaran IPA di SMP. *Jurnal Penelitian Dan Evaluasi Pendidikan*, *20*(1), 111–125. https://doi.org/10.21831/pep.v20i1.7524

Priyayi, D. F., Keliat, N. R., & Hastuti, S. P. (2018). Masalah dalam pembelajaran menurut perspektif guru biologi sekolah menengah Atas (SMA) di Salatiga dan Kabupaten Semarang. *Jurnal Penelitian Pendidikan Biologi*, *2*(2), 85–92. https://doi.org/10.32502/dikbio.v2i2.1243

Saputra, A. (2017). Persepsi mahasiswa calon guru biologi tentang pembelajaran materi evolusi di SMA: Studi kasus mahasiswa Pendidikan Biologi FKIP Universitas Sebelas Maret Surakarta. *Bioeducation Journal*, *1*(1), 1–9. http://ejournal.unp.ac.id/index.php/bioeducation/article/view/7085

Sidiq, Y. (2016). Evolusi dalam kehidupan sehari-hari: Sudut pandang mahasiswa terhadap evolusi. *Proceeding Biology Education ConferenceProceeding Biology Education Conference*, *13*(1), 583–586. https://jurnal.uns.ac.id/prosbi/article/view/5840

Simatwa, E. M. W. (2010). Piaget's theory of intellectual development and its implication for instructional management at presecondary school level. *Educational Research and Reviews*, *5*(7), 366–371. https://eric.ed.gov/?id=EJ898837

Situmorang, R. P. (2016). Analisis learning continuum tingkat SD sampai SMP pada tema sistem pencernaan manusia. *Scholaria: Jurnal Pendidikan dan Kebudayaan*, *6*(2), 1. https://doi.org/10.24246/j.scholaria.2016.v6.i2.p1-13

Subali, B., Kumaidi, K., & Aminah, N. S. (2018). Developing a scientific learning continuum of natural science subjects at grades 1 - 4. *Journal of Turkish Science Education*, *15*(2), 66–81. https://doi.org/10.12973/tused.10231a

Suryanda, A., Azrai, E. P., & Julita, A. (2020). Analisis kebutuhan pengembangan buku saku biologi berbasis mind map (Biomap). *Jurnal Pendidikan Matematika dan IPA*, *11*(1), 86–98. https://doi.org/10.26418/jpmipa.v11i1.31861

Suyanto, S. (2018). The implementation of the scientific approach through 5MS of the revised curriculum 2013 in Indonesia. *Cakrawala Pendidikan*, *37*(1), 1689–1699. https://doi.org/10.21831/cp.v37i1.18719

Sztajn, P., Confrey, J., Wilson, P. H., & Edgington, C. (2012). Learning trajectory based instruction toward a theory of teaching. *Educational Researcher*, *41*(5), 147–156. https://doi.org/10.3102/0013189X12442801

Taufik, L. M. (2019). Teori evolusi Darwin: Dulu, kini dan nanti. *Jurnal Filsafat Indonesia*, *2*(3), 98–102. https://doi.org/10.23887/jfi.v2i3.22150

Trilipi, D., & Subali, B. (2020). The learning continuum of living reproduction: Generating a curriculum grid based on students' cognitive levels. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(3), 389–396. https://doi.org/10.22219/jpbi.v6i3.13660