

THE PROPERNESS OF MUTATION TEXTBOOK USING METACOGNITIVE AND MIND MAP STRATEGY FOR SENIOR HIGH SCHOOL GRADE XII

Rita Puspa Lestari

Biology Department, Faculty of Mathematics and Natural Sciences
Universitas Negeri Surabaya, Indonesia
email: ritalestari@mhs.unesa.ac.id

Endang Susantini

Biology Department, Faculty of Mathematics and Natural Sciences
Universitas Negeri Surabaya, Indonesia
email: endangsusantini@unesa.ac.id

Abstract

Mutation is an abstract and difficult topic of biology. It needs metacognitive strategy integrated with mind map technique to facilitate learners to understand the concept. This research aimed to produce a valid and practical mutation textbook using metacognitive and mind map strategy for senior high school grade XII. This research adopted ADDIE development model, consisted of Analysis, Design, Development, Implementation, and Evaluation. The textbook was validated by three validators, namely: an education professional, an expert on mutation material, and a biology teacher. The limited trial was conducted on 15 students at SMA Dharma Wanita 4 Taman, Sidoarjo. Data were collected through validation activity, readability test, and questionnaires. Data were analyzed by qualitative descriptive technique. The results indicated that the textbook was stated as valid with a score of 3.82 and practical based on the readability level of 10 (appropriate for senior high school readers) and a very positive response by 96.14%. Based on the data, the mutation textbook using metacognitive and mind map strategy for senior high school grade XII was stated as valid and practical.

Keywords: properness, textbook, metacognitive, mind map, mutation.

INTRODUCTION

Qualified textbook strongly supports the quality of learning in schools (Susantini 2010; Barroh *et al.*, 2012; Wati *et al.*, 2015) because learners tend to use a textbook as first learning resource before and after learning process (Prastowo, 2013; Rahmawati, 2015). Studying biology textbook requires metacognitive skills to understand the readings in the textbook. Metacognitive skills are needed in particular on learning biological concepts that are abstract, such as the concept of genetic mutations (Susantini, 2009a; Susantini, 2009b).

Metacognition is one's awareness of his cognitive abilities, cognitive tasks, and strategies to solve the cognitive tasks (Flavell, 2004; Gorrel *et al.*, 2009). The most suitable technique for applying metacognitive strategies is mind map (Schunemann *et al.*, 2013; Wu and Chen, 2018). Mind map is a representation of human mind which is vast and complex (Buzan, 2011). The brain makes information network that connects an information with other information. The brain is not designed to receive information in linear text as were done by most people by writing texts from top to bottom (Margulies and Valenza, 2008). Researches by Sperry

(1968), Ornstein (1977), and Zaidel (1983) suggested that mind map involving words, numbers, sequences, lines, colors, symbols and images will satisfy the brain because it works similarly as a human brain.

Metacognitive strategies that are integrated with mind mapping technique is very appropriate to be applied in textbook of mutation. Teachers should give a task of creating mind map in order to initiate students to find keywords while reading the textbook material, then students connect all these keywords in the form of a centralized scheme. This was supported by results of research on the use of mind mapping on learning the nervous system (abstract concept) which were declared eligible and got positive responses from students (Romdhani *et al.*, 2013).

Based on these descriptions, this research aimed to develop a valid and practical textbook of mutation material using metacognitive and mind map strategy for senior high school grade XII.

METHOD

This research adopted ADDIE model of development (Analyze, Design, Develop, Implement,

and Evaluate) proposed by Reiser and Mollenda (Reiser and Dempsey, 2012). The research was conducted at Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya and SMA Dharma Wanita 4 Taman, Sidoarjo. The object of this research was the valid and practical textbook of mutation material using metacognitive and mind map strategy for senior high school grade XII.

At analysis stage, the researcher analyzed the curriculum, students, concept material and tasks. Results of the analysis phase was formulation of learning objectives to be used as reference while writing textbook. At design stage, the researcher designed the textbook. At development stage, the researcher produced a textbook that is ready to be validated and tested practicality of the textbook. At implementation stage, the researcher obtained score of validation, readability level and response percentage. At evaluation stage, all the data were analyzed qualitatively and descriptively.

The validity of the textbook included the feasibility of content, linguistic, and appearance in accordance with National Education Standards Board (BSNP) instruments (2014). The validity of the textbook was evaluated by three validators, namely: an education professional, an expert on mutation material, and a biology teacher. Validity score was on the scale of 1-4 based on modified Likert Scale (1932). The textbook was considered as valid if it had earned an average score of > 2.00 .

The practicality of textbook was evaluated through readability test using Fry Graph (1997) and questionnaires. Readability test was done by taking 15 samples of text containing 100 words chosen by the students, then counted the number of syllables (multiplied by 0.6) and the amount of sentence. The intersection of both determined the level of readability. In addition, the questionnaires were given to 15 students of SMA Dharma Wanita 4 Taman grade XII. The textbook was considered practical if it had earned an

appropriate level of readability (level 9-12) and got a positive response $\geq 70\%$. Data were analyzed qualitatively and descriptively.

RESULTS

Basic competence of mutation is KD 3.8 Analyzing mutation phenomena in living organisms. Attempt to achieve these competencies was done by developing a textbook using metacognitive strategies and integrated with mind mapping technique.

The textbook that had been developed has three stages of metacognitive: *Before You Read*, *Read to Learn*, and *After You Learn*. *Before You Read* helps students get ready to learn by connecting the material with preliminary knowledge, providing questions, then students will find the answer by reading the textbook (**Figure 1a**). At this stage, the students are also asked to create a mind map that represents their prior knowledge before reading the book.

Read to Learn gives students the detail concept of mutation. At this stage, students are asked to create a conceptual framework in their brain about the readings (**Figure 1b**). Title of sub-chapter in this book is a question which the answer can be sought by reading the paragraphs below. Then, there is feature named *Reading Check* which gives questions to be answered after the students understand the paragraph above (**Figure 1b**). In addition, *Mengingat Kembali* (Remembering) will help students to remember previous concepts which were needed to understand the whole concept of mutation (**Figure 1c**).

After You Learn asks students to make *Kamus Mini* (Mini Dictionary) by writing the definition of each term given (**Figure 1d**). Then they will be asked to make a *Mind Map* based on their conceptual framework prepared while learning concept in the book. Mind map (**Figure 1e**). created at *After You Learn* stage and *Before You Read* stage will be compared to the *Refleksi* (Reflection) feature (**Figure 1f**).

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BEFORE YOU READ

[PRA-TEST] Sekarang kamu akan mempelajari mutasi. Sebelum kamu mulai mempelajari materi ini, ada baiknya kamu menjawab beberapa pertanyaan di bawah. Kamu hanya perlu menjawabnya berdasarkan pengetahuanmu sampai saat ini.

1. Apa yang dimaksud dengan mutasi?
2. Jelaskan dimana tepatnya mutasi terjadi?
3. Bagaimana mutasi dapat mempengaruhi aktivitas sel?
4. Apakah peristiwa mutasi dapat bermanfaat? Jelaskan secara singkat!
5. Apa perbedaan mutasi somatik dan mutasi germlinal?

Jawab:

Setelah kamu menjawab pertanyaan-pertanyaan di atas, buatlah *mind map* yang dapat mewakili pengetahuanmu mengenai mutasi!

a

Mutasi | 3

READ TO LEARN

[STUDY COACH] Buku ini memuat berbagai macam informasi yang dapat memperluas wawasan kamu mengenai fenomena-fenomena di kehidupan. Buku ini unik, karena judul pada setiap sub-materi adalah sebuah pertanyaan. Hal yang perlu kamu lakukan adalah bacalah materi yang disajikan untuk memperoleh jawabannya. Kemudian, coba lakukan latihan jawaban menggunakan *spiral* berwarna atau stikdo.

[MIND MAP] Di akhir setiap bagian buku, kamu diminta untuk membuat *mind map* berdasarkan materi yang telah kamu baca. Jadi, ketika kamu membuka materi di dalam buku ini, kamu wajib memahami konsep yang diberikan, kemudian membuat anggotanya sebagai sebuah *mind map* di rumah.

1.1. Apa yang dimaksud dengan mutasi?

Apakah kamu masih ingat dengan konsep DNA di bab sebelumnya? Pada organisme, DNA adalah materi genetik yang terdapat dalam inti sel. DNA terlibat dalam berbagai aktivitas sel, yaitu replikasi DNA dan sintesis protein. Pada proses replikasi DNA dapat melakukannya dengan sangat kritis. Namun tidak hal yang menakutkan apabila terjadi kesalahan, mengingat proses tersebut terjadi jutaan kali. Kesalahan dalam proses replikasi DNA dalam suatu sel dapat berdampak pada perubahan informasi genetik dari dapat diturunkan pada generasi sel selanjutnya, peristiwa ini disebut sebagai **mutasi**. Mutasi dapat disebabkan oleh berbagai hal yang disebut **mutagen**, penyebab-penyebab mutasi dapat kamu pelajari nanti pada bagian 4. Sedangkan hasil mutasi disebut sebagai **mutan**.

Reading Check 1.1
Bulatkan secara singkat perbedaan istilah mutasi, mutan, dan mutagen!

Setelah kamu mempelajari lebih lanjut bagaimana peristiwa mutasi dapat mempengaruhi kelangsungan suatu organisme, kamu wajib mengingat kembali struktur DNA. Gambar 1.1, mekanisme replikasi DNA. Gambar 1.2, dan sintesis protein tahap transkripsi. Gambar 1.3 dan translasi. Gambar 1.4.

b

3 | Buku Ajar Kelas III Semester Genap

MENINGAT KEMBALI

1. Tahap kedua sintesis protein adalah translasi, yaitu hasil transkripsi di sel sel terlihat ke ribosom dan diterjemahkan di sitosol. Ditunjukkan dengan *top to bottom* menunjukkan arah aliran informasi ke ribosom.
2. Ribosa (R) merupakan molekul asam amino-metabolisme primer yang. Ribosa yang merupakan asam amino-metabolisme sekunder dengan rangka ribosa yang stabil.
3. Ribosa yang telah bergabung dengan asam amino membentuk kompleks dengan dengan ribosa yang stabil.
4. Setelah terbentuk dalam eritrosit, mRNA melakukan diri dari asam amino yang dikemasnya. mRNA ini yang membawa asam amino ke arah ribosom dengan bantuan ribosa yang melakukan sintesis yang sama.
5. Ribosa asam amino-metabolisme sekunder primer memiliki struktur yang sama dengan ribosa, sehingga ketika asam amino telah terikat pada ribosa, akan terikat pada ribosa yang stabil.

Gambar 1.8 Sintesis protein tahap translasi terjadi di ribosom (sitoplasma), menghasilkan rantai asam amino (*protein*) dan mRNA.
Sumber: Biologi (Sugianto, 2010).

c

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AFTER YOU LEARN

[APRESIASI] Setelah kamu membaca bagian 1.1. Penilaian apakah kamu merasa telah belajar dan mendapatkan pengetahuan baru? Kamu hebat karena telah selesai membaca bagian ini.

[KAMUS MINI] Hal yang perlu kamu lakukan selanjutnya adalah membuat pegangan dari istilah-istilah dalam Kamus Mini. Lembaran istilah di ruang yang telah disediakan.

[MIND MAP] Di akhir bagian ini, jangan lupa untuk membuat *Mind Map* sebagai rangkai di tempat yang telah disediakan.

Kamus Mini
Tuliskan pengertian dari istilah-istilah berikut!

a. Mutasi	
b. Mutan	
c. Mutagen	
d. Mutasi somatik	
e. Mutasi germlinal	
f. Mutasi gen	
g. Mutasi kromosom	

d

Figure 1. Book features: (a) *Before You Read*; (b) *Read to Learn* and *Reading Check*; (c) *Mengingat Kembali* (Remembering) ; (d) *After You Learn* and *Kamus Mini* (Mini Dictionary)

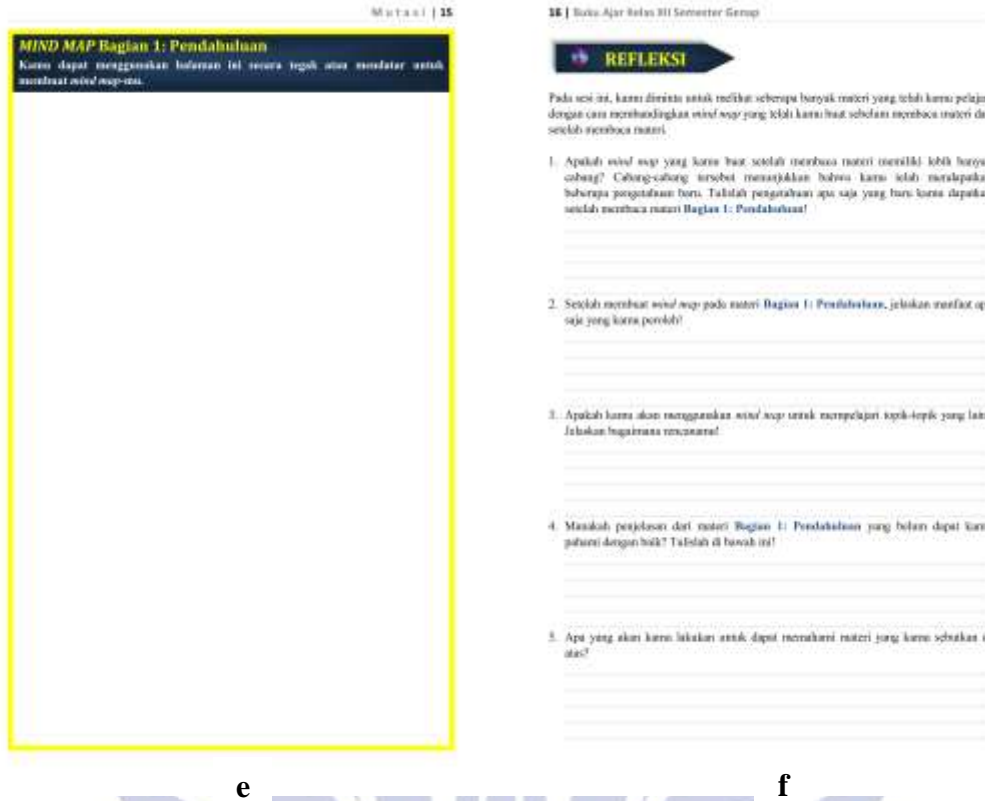


Figure 1. Book features: (e) *Mind Map* ; (f) *Refleksi* (Reflection)

Textbook that has been developed has four sections of material, named Section 1: Introduction, Section 2: Gene Mutation, Section 3: Chromosome Mutation, and Section 4: Causes of Mutation. Each section has the same metacognitive stage repeatedly, so that the three stages of metacognitive contained in each sections of material.

1. Textbook Validity

The validity of the textbook included the feasibility of content, appearance, and linguistic. Content validity gained a score of 3.83; appearance validity gained a score of 3.93; linguistic validity gained a score of 3.70. The average validity is 3.82 (Table 1).

Table 1. Validity Score of Textbook

Aspects	Score	Category
Content		
Conformity of material with learning outcomes	4.00	Valid
Conformity of material with scientific facts	3.67	Valid
Material profundity	3.33	Valid
Material recency	4.00	Valid
References are reliable	4.00	Valid
Examples can be found in real life	3.33	Valid
Before You Read, Read to Learn, After You Learn	4.00	Valid
Study Coach	3.67	Valid
Reading Check	4.00	Valid
Mind Map	4.00	Valid
Refleksi (Reflection)	4.00	Valid
Time allocation	4.00	Valid
Component Validity	3.83	Valid
Appearance		
The material is presented in order of learning outcomes	4.00	Valid
The concept is presented from simple to complex	4.00	Valid

Aspects	Score	Category
Material coherence	4.00	Valid
Illustrations (figures and tables) help readers to understand	4.00	Valid
The size and type of font make easy to read	4.00	Valid
Every section begins with motivation	3.33	Valid
Introduction: preface, table of content, instruction	4.00	Valid
Content: summary, exercise	4.00	Valid
Closing: key answer, glosary, index, references	4.00	Valid
Component Validity	3.93	Valid
Linguistic		
Language is appropriate to the age level	3.67	Valid
Explanation supports the flow of thought	4.00	Valid
The use of communicative sentences	3.00	Valid
Information can be understood	4.00	Valid
Instructions can be understood	4.00	Valid
Terms are contained in KBBI (Indonesian Dictionary)	3.67	Valid
The use of foreign terms	3.67	Valid
Terms consistency	4.00	Valid
Language is motivational	3.33	Valid
Component Validity	3.70	Valid
Average Validity	3.82	Valid

Textbook validity gained score of 3.82, so it can be stated that the textbook is valid.

2. Textbook Practicality

Textbook practicality was obtained from readability test and questionnaire. Readability test was done by counting the number of sentences and syllables

contained in 100 words text. The average number of sentences in the textbook was 7.2 and the average number of syllables (multiplied by 0.6) was 160 (Table 2).

Table 2. Number of Sentences and Syllables in The Textbook

Text Samples	Number of Sentences	Number of Syllables (multiplied by 0.6)
Sample 1	7.0	156
Sample 2	7.5	156
Sample 3	8.0	164
Sample 4	6.4	144
Sample 5	6.4	166
Sample 6	8.9	171
Sample 7	7.2	178
Sample 8	6.7	175
Sample 9	5.3	160
Sample 10	5.8	151
Sample 11	7.2	150
Sample 12	8.0	151
Sample 13	6.3	142
Sample 14	8.8	166
Sample 15	8,5	170
Average	7.2	160

Based on the number of sentences and syllables, the textbook readability level was 10, which is appropriate for high school readers (Figure 2).

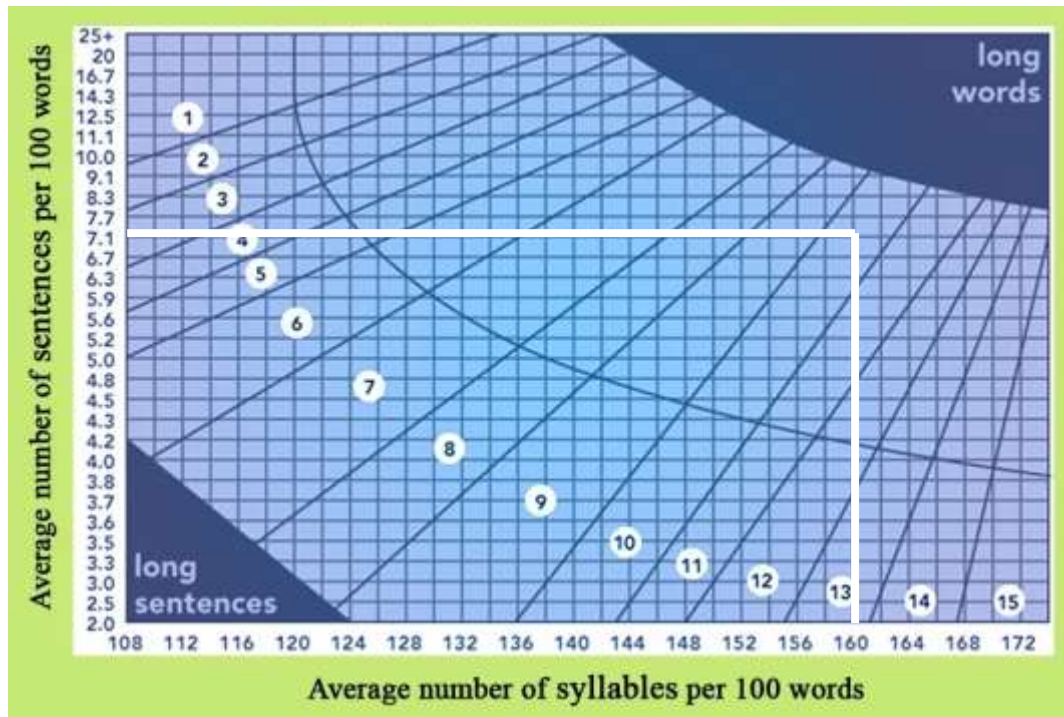


Figure 2. Readability Level of Textbook using Fry Graph

Based on the questionnaire, textbook got a very positive response by 96.14%. Here is the response of textbook on content, appearance, and linguistic aspect given by students, shown in **Table 3**.

Table 3. Questionnaire Result

Aspects	Percentage	Category
Content	96.67%	Very Positive
Appearance	96.19%	Very Positive
Linguistic	95.56%	Very Positive
Response	96.14%	Very Positive

Based on the data, textbook got a very positive response and appropriate level of readability. Hence, it can be stated that textbook is practical.

DISCUSSION

The textbook obtained average validity score of 3.82. The readability level was 10 which is appropriate for high school readers. The textbook got a very positive response by 96.14%. Based on that, the textbook on mutation material using metacognitive strategy integrated with mind mapping technique was stated as valid and practical.

Mutation is a hereditary change in genetic information, both at the level of cells and organisms (Pierce, 2010). Studying mutation requires prior knowledge of genetic substances, mechanisms of cell division, and heredity. Learners who want to learn mutation concept through the textbook require prior knowledge of all the three. Therefore, the developed textbook provides a feature named *Mengingat Kembali* (Remembering) in Part 1: Introduction. Such feature

helps learners to remember previous concepts which are needed to understand the whole concept of mutation.

The textbook provides four sections of material which are adjusted based on the complexity and coherence. The sections are: (1) *Section 1: Introduction*, (2) *Section 2: Gene Mutation*, (3) *Section 3: Chromosome Mutation*, and (4) *Section 4: Causes of Mutation*. Section 1 presents basic concept of mutation, such as definitions, mechanisms, advantages, and mutation category. This section is very important to establish the concept of mutation and provide motivation so that learners want to learn more. Next is *Section 2: Gene Mutation* and *Section 3: Chromosome Mutation* which provide the concept of the types, mechanisms and phenomena of mutation in genes and chromosomes. This section build better concept than

previous section, because learners are introduced to the real phenomena of mutations. The last is Section 4: Causes of Mutations presents knowledge about things that can initiate mutations in the organism. Based on this knowledge, learners will know how to prevent the occurrence of mutations that adversely affect life.

The textbook was developed using stages of metacognitive strategies promoted by Flavell in 1970, namely planning, monitoring, and evaluation (Flavell, 2004). Metacognitive strategies applied in textbook are Planning as *Before You Read*, Monitoring as *Read to Learn*, and Evaluation as *After You Learn*. Monitoring comes with feature of *Reading Check* and Evaluation equipped with *Mind Map*. These features are a form of integration between the use of metacognitive skills and mind map in the textbook. All aspect of metacognition obtained perfect score from three validators and gained a very positive response by 100%. Perfect score of validity on the aspects of metacognitive and mind map indicated that the textbook integrated metacognitive skills and mind map technique properly. This is consistent with the statement of Gorrel *et al.* (2009) who gave a recommendation of collaborating metacognitive strategy with mind map technique.

The main role of using metacognitive strategy is students will become independent learners (self-regulated learners). If someone is able to learn independently, the ability to manage to learn will also be developed (Eggen and Kauchak, 2012; Bienvenida, 2014). During the limited trial, students were asked to read the textbook and do the instructions independently. Both of that can be done correctly and in sequence according to the instructions in the textbook. This activity indicated that learners had implemented metacognitive strategy and mind map technique to understand the concept of mutations.

Based on the questionnaire, students gave a very positive response to the use of mind map. According to the students' comment, the easiest way to summarize and make notes is to use mind map, as was stated by Margulies and Valenza (2008). They said that making notes using linear sentences was similar to copying books. Learners meet difficulties to find the main concept when they make notes using linear sentence (Parikh, 2015). Making mind map requires concentration to find keywords on the readings (Zampetakis and Tsironis, 2007). The keywords will trigger the students to open related information in the brain. This is consistent with the statement of Buzan (2011) that the mind map is a representation of human mind that is vast and complex.

Highest validity score was on the appearance, gained a score of 3.93. Eight out of nine aspects got a perfect score from three validators. The textbook presents the material from simple into complex, and there is a relationship between the sub-material with subsequent sub-material. The textbook presents all material systematically, hence learners can use the textbook for learning activities in accordance with the definition of a textbook by Suhardjono (2012).

Illustration, font size, and font type got a perfect score from three validators. According to Baron *et al.* (2016) textbook material should be presented properly, hence it can deliver the information. The appropriate font size and type should make reader easy to read. Textbook must be accompanied by pictures, illustrations, and examples in accordance with the material (BSNP, 2014). The textbook material contains more about mechanisms of mutation, so the illustrations presented in the textbook should be able to represent the mechanism of mutation properly. Learners should be helped with the illustrations (Baron *et al.*, 2016).

Aspect "every section begins with motivation" obtained score of 3 from two validators. Motivation is given before the reading to raise students' willingness to read. Generating motivation with a brief explanation will invite curiosity. The explanation must contain information that can be found in everyday life learners (BSNP, 2014). Information contained in developed textbook includes mutations in the healthy human body, differences in genes and chromosomes, Down's syndrome, and spread of cancer in the world. This information could attract the attention of students to learn more about mutation.

The second highest score of validity was on content, gained score of 3.83. Material profundity obtained score of 3 (good) from two validators. The textbook was judged to have material that is wider and deeper than a textbook in general. The material presented in the textbooks was not fragmented, so that learners fully understand the material being taught. Material profundity of the textbook had been responded positively and negatively by learners, it was known based on the comments on the questionnaire. Some students wrote it as strength, while few others wrote it as weakness. According to Suhardjono (2012), a textbook has to provide whole content and concept to be mastered by the learners. This statement underlies the developed textbook contains a full and complete explanation of a concept. Hence, the developed textbook considered to have a material that is wider and deeper but still reasonable.

Lowest validity score was on the linguistic component, gained a score of 3.70. Item "The use of communicative sentences" got score of 3.00 from three validators. The textbook use communicative sentences to give learners a good reading experience as if speaking to them, hence the material can be delivered easily (BSNP, 2014). The textbook mostly explain about mutation mechanisms which are procedural, hence not all of the content can be delivered using communicative sentences.

Fry graph uses level 9-12 as an appropriate level for high school readers. Readability test of the developed textbook showed the level of 10, hence it could be considered as an easy level to high school readers. This was supported by the aspect "language is appropriate to the age level " which get a positive response by 86.67%, means that only 2 out of 15 students answered "no" to that statement. According to the students' comment, the complaint about the linguistic is the using of scientific terms considered to be complicated and hard to remember, not about the complexity of the sentence. Answer "yes" was given by 13 of 15 students, so language in the book could still be considered to be easy to understand.

CONCLUSION

The results indicate that the textbook was stated as valid with a score of 3.82 and practical based on the readability level of 10 (appropriate for senior high school readers) and a very positive response by 96.14%. Based on the data, the mutation textbook using metacognitive and mind map strategy for senior high school grade XII was stated as valid and practical.

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