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The development of a cognitive conflict-based ecosystem hypercontent ebook for biology learning in senior high schools

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Abstract

Today's students tend to prefer autonomous learning, practical learning experiences, and visual forms of communication such as images, icons, and symbols rather than text. Therefore, learning resources should accommodate these learning preferences. This study aimed to develop a cognitive conflict-based ecosystem hyper-content e-book that is valid and suitable for use in high school biology learning. The e-book features cognitive conflict-based activities embedded in each topic, brief information corners, and self-review sections at the end of each chapter, distinguishing it from existing e-book products. The research subjects included material, media, and language experts, as well as teachers and students. Data were collected using observation sheets, interview guides, and questionnaires. Expert validation results indicated that the e-book was highly suitable for learning implementation. Student responses during the trial showed that the e-book was easy to use, provided comprehensive material coverage, was engaging, and was beneficial for learning. Teachers also evaluated the e-book positively and considered it suitable for classroom use. Based on these findings, it can be concluded that the cognitive conflict-based hyper-content e-book is valid and suitable for use in high school biology learning. Further large-scale studies are needed to empirically examine its effectiveness, particularly in teaching ecosystem concepts.

Abstrak. *Siswa masa kini cenderung lebih menyukai pembelajaran mandiri, pengalaman belajar praktis, dan bentuk komunikasi visual seperti gambar, ikon, dan simbol daripada teks. Oleh karena itu, sumber belajar harus mengakomodasi preferensi belajar ini. Penelitian ini bertujuan mengembangkan ebook hiperkonten ekosistem berbasis konflik kognitif yang valid dan layak digunakan dalam pembelajaran biologi di SMA. E-book ini menampilkan aktivitas berbasis konflik kognitif yang tertanam di setiap topik, sudut informasi singkat, dan bagian tinjauan mandiri di akhir setiap bab, yang membedakannya dari produk e-book yang sudah ada. Subjek penelitian meliputi ahli materi, media, dan bahasa,serta guru, dan siswa. Data dikumpulkan menggunakan lembar observasi, panduan wawancara, dan angket. Hasil validasi ahli menunjukan bahwa e-book layak digunakan dalam pembelajaran. Tanggapan siswa selama uji coba menunjukkan bahwa e-book mudah digunakan, memberikan cakupan materi yang komprehensif, menarik, dan bermanfaat untuk pembelajaran. Guru juga memberikan respon yang sama bahwa ebook sangat layak digunakan dalam pembelajaran. Berdasarkan data yang diperoleh, dapat disimpulkan bahwa ebook hiperkonten berbasis konflik kognitif ini valid dan layak digunakan dalam pembelajaran biologi di SMA. Perlu dilakukan uji coba skala besar untuk membuktikan secara empiris efektivitas produk dalam pembelajaran biologi kususnya materi ekosistem.*

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A. Introduction

Biology is one of the subjects studied at secondary school level (Nurdin et al., 2025; Ristanto et al., 2018) Biology learning is considered difficult learning for students. This difficulty is due to the very broad range of materials and interrelated concepts (Chrzanowski et al., 2018). Ecosystem is one of the basic topics in biology learning which discusses the interaction of living organisms and their physical environment (Yu et al., 2021).

This material is considered difficult and there are many misconceptions. Many studies reveal misconceptions about ecosystem material, including (Hanifah, Hernawati, et al., 2022; Nurfadilah & Rochintaniawati, 2021; Nurhidayah et al., 2020; Pebrianto et al., 2021; Putri, S. & Rusyati, 2021) Students' perceptions of learning and misconceptions that occur certainly have an impact on the effectiveness of learning. Effective learning needs to be continuously pursued.

Effective learning cannot be separated from the support of the availability of learning resources. Paradigm changes in learning and developments in technology used in learning also have an impact on the use of learning resources Learning resources are starting to transform from traditional resources to digital resources. Electronic learning resources are an option that can be used in 21st-century learning (Dias & Victor, 2017). There are many forms of digital learning resources, such as electronic books and electronic modules.

E-books have the advantage of being able to present some material using interactive learning media because e-books can be enriched with pictures, animations, and interactive assignments, so they can be used as educational games (Wojdon, 2016). Another advantage of electronic books is that they can be accessed via electronic devices: computers, laptops, tablets, and Android-based mobile phones such as smartphones. This ease of access is the main advantage of e-books. Furthermore, being enriched with multimedia not only enhances the ebook with additional information but also ensures it remains portable and convenient to carry.

There are many studies related to the development of learning resources in the form of e-books, including the development of hypercontent modules coupled with the power of audio and visual media, called screencasts (Johan et al., 2022). The developed e-books are interactive (D. Septiana et al., 2015; Sung et al., 2022; Tampubolon et al., 2022). The basis for ebook development is also diverse, such as socio-scientific issue-based, multiple intelligence-based, and multi-representation based (Khasanah et al., 2023; Rasmawan, 2020; Septiana et al., 2015)

There has been much research on the effects of e-books, including the effect of e-books on learning outcomes in mathematics (Awaludin et al., 2020; Wijaya et al., 2022), chemistry (Rasmawan, 2020)biology (R. Septiana et al., 2023). The use of e-books also has an impact on student performance in learning (Sung et al., 2022; Tsai & Lin, 2022)

The product being developed is a cognitive conflict-based hypercontent E-book. Hypercontent comes from the concept of hypertext, by changing delivery patterns that tend to be linear to be more dynamic (Johan et al., 2022). Hypercontent is a combination of hypertext, hyperlinks, and hypermedia to enrich material content. Another meaning of hypercontent is linked in a virtual world, which is combining two dimensions such as the virtual world with the real world, while using cloud computing patterns such as Google Drive or data centers which can be accessed using QR-Code either online or offline (Amin et al., 2020). Cognitive conflict is a condition of conflict that occurs in the cognitive structure. This conflict will occur during the learning process because students who are learning already have an understanding of a concept (pre-concept) (Lee & Kwon, 2003)

This cognitive conflict-based hyper-content e-book was developed with the characteristics of presenting cognitive conflict in each material description. E-books are enriched with connectivity patterns with multiple content in the form of text, audio, and video. The e-book is also provided with a quick info corner in addition to interesting information related to the material being discussed. Cognitive conflict is presented in the form of provoking questions, presentation of examples and non-examples, and case analysis. This detailed material description, coupled with the presentation of cognitive conflicts, enables students to rectify misconceptions by replacing them with accurate concepts. This process leads to a reduction in misunderstandings and promotes a deeper understanding of the concepts. Each chapter concludes with a comprehensive review of the material, empowering students to assess their learning outcomes independently. The presence of cognitive conflict presentations, brief information corners, and independent reviews at the end of each chapter differentiates this product from existing ebook products. The characteristics of ebooks that integrate technology can meet the learning demands of today's generation of students, make learning easier, and enrich the variety of learning resources that can be used so that optimization of biology learning processes and outcomes can be achieved.

B. Material and method

The research uses research and development methods with the Hannafin and Peck model with steps that can be described as Figure 1.

Need assessment phase

Needs assessment is carried out through discussions with biology teachers regarding learning resource needs. In this discussion, conditions regarding the availability of learning resources, the need for learning resources, and the potential for developing learning resources in the form of hypercontent ebooks were also explored. Apart from that, analysis was also carried out on research results in the field of learning resource development.

Design phase

The design phase begins with creating a storyboard (Devi & Sudarma, 2023). Storyboards were developed into product drafts using Adobe InDesign and Canva.pro applications. The Canva and Adobe applications are used because they are available online and provide various editing tools to create various visual designs (Ilyas et al., 2023; Mulyadi et al., 2020; Traboco et al., 2022). The design result document is in pdf format, converted into flipbook form using the corporate flip pdf application.

Development/implement phase

In the development or implementation phase, it involves material experts, media experts, and linguists while in the implementation stage, it involves teachers and students. One-to-one evaluation with experts and students is conducted through interviews and discussions (Tessmer, 2005). The experts involved were 2 experts for each aspect (material, media, language). Material experts were lecturers in Biology with expertise in ecology, more than 10 years of teaching and research experience, and a record of scientific publications relevant to ecological studies. Media experts were academics with expertise in the development of learning media and more than five years of experience in the design, development, and evaluation of educational media. Linguistic experts were academics with expertise in linguistics and more than five years of experience in evaluating language use in instructional materials and learning media. Validators were selected based on the relevance of their expertise, professional experience, and academic track records to the aspects being evaluated.

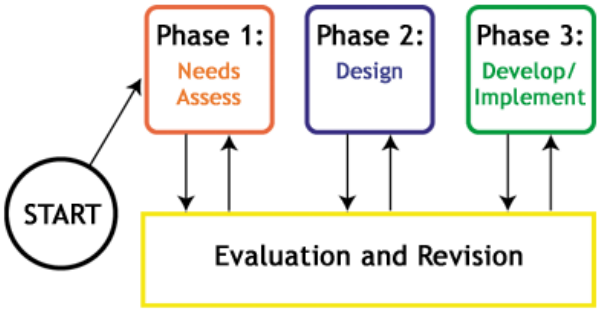

Figure 1 Hannafin and Peck's model (Bradbury et al., 2018)

Table 1 Guidelines for interpreting product eligibility

Percentage Interval	Category
80% ≤ x ≤ 100%	Very feasible
60% ≤ x < 80%	Eligible
40% ≤ x < 60%	Fair enough
20% ≤ x < 40%	Not feasible
0% ≤ x < 20%	Not very feasible

After the product has been revised, the product is sent back to the expert validator to be given a quantitative assessment. The instrument used is a questionnaire with a rating range of 1-4. Furthermore, the score given is changed in the form of a percentage. Percentage data is converted into qualitative data with product feasibility interpretation guidelines (Riduwan & Akdon, 2007) as shown in Table 1.

At the product implementation stage in learning, students and teachers are asked to provide feedback on the product being developed. The product implementation stage was carried out at one of the high schools in Jakarta. The students involved are grade 10 students who are studying biology on Ecosystem material. One of the grade 10 classes was randomly selected and 36 students served as product test subjects. The biology teacher involved is a biology teacher who teaches in the class and has more than 10 years of teaching experience.

The instrument used for student responses is a questionnaire with a rating scale of 1-4. Aspects that students respond to the product include ease of use,

material coverage, motivation in learning, and usefulness of the product in learning. The assessment scores given by students are converted into percentage scores and the eligibility criteria refer to Table 1. For teacher responses, open questions are used (Branch, 2009), so that teachers can openly respond to the product. Aspects that teachers respond to include: ease of use, coverage of material, and usefulness in learning (Tessmer, 2005).

C. Results and discussion

The results obtained in this study can be described as follows:

Need assessment

Based on the study conducted, it was found that the potential for developing digital learning resources is very high. This potential is based on the opportunities for product use by students, related to the condition of the supporting devices for the use of the product developed. The current condition is that students generally already have mobile devices that can be used for the learning process using digital learning resources. Research (Arthur-Nyarko et al., 2020) states that more than 50% of students (212, 69.3%) are ready to use digital content. 105 (34.3%) students have access to a laptop, 34 (11.1%) have access to a tablet or iPad while the least (n = 26, 8.5%) reported having access to a desktop computer. Some students (n = 31, 10.1%), however, did not have access to any of the devices. Research (Suryanda et al., 2023)showed that almost 100% of learners already had a personal smartphone, laptop, or tablet. About 52% of learners use smartphones, laptops, or tablets for 6-12 hours per day to study (92.9%), play (96.9%), search for information (92.1%) and communicate (89%). Based on this, the development of technology-based learning resources needs to be done and the potential for use is quite high.

The use of ebooks in learning also has a positive impact on the learning process and outcomes (Kusumatuty et al., 2018; Tampubolon et al., 2022; Wijaya et al., 2022). The use of ebooks has an impact on increasing knowledge and knowledge retention (Radović et al., 2020). The use of ebooks impacts academic achievement as well (Lim et al., 2020). Based on the analysis of various studies, it can be seen that the development of digital learning materials is very useful in learning. The results of discussions with the biology teacher also stated that learning resources were urgently needed and technology-based ones would be preferred and would make it easier for students to learn.

Design

The design phase begins with creating a storyboard. Storyboards are very important in the design phase because the storyboard functions to translate scenario content or a brief description (Hanafri et al., 2018). Storyboards can be image-based which will be a valuable aid to designers. Storyboard developed into product design. A snapshot of the storyboard and product design can be seen in the Figure 2.

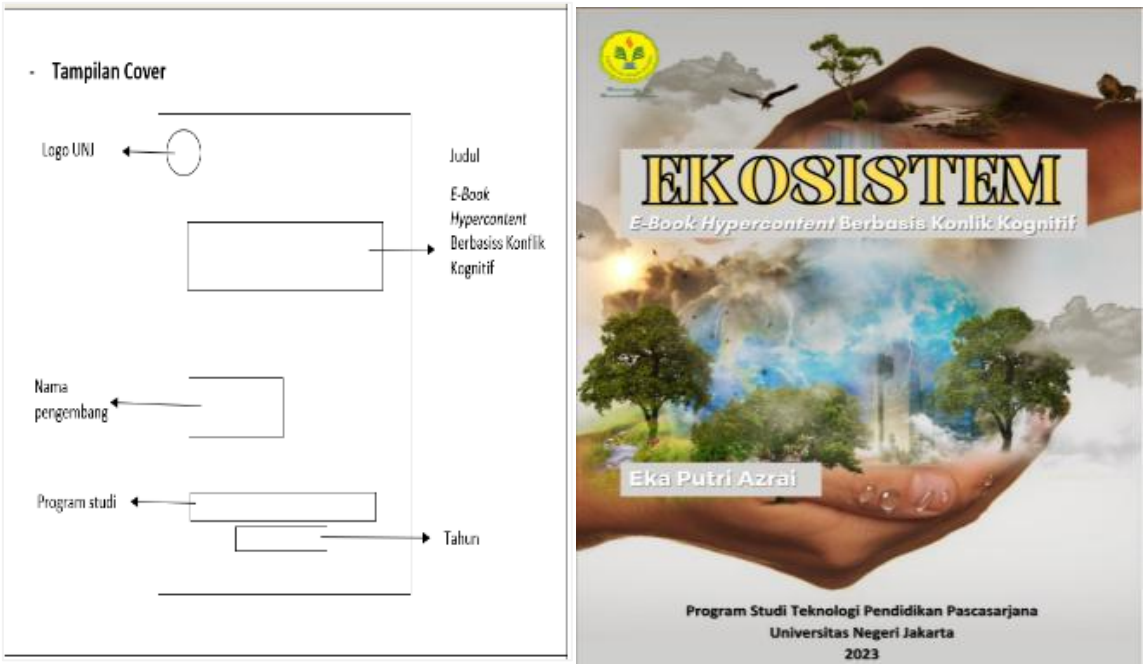

Figure 2 Storyboard snippet (left) and design results (right) (in Indonesian)

Development/implementation

At the development stage, the product design in the form of a flipbook is then validated by experts covering material, media and language aspects. Material aspect testing is intended to find out whether the concept conveyed in the product is correct and if there are no

conceptual errors. The media test is intended to find out whether the product complies with media graphic standards and the language aspect test is intended to determine the suitability of the language used with standard Indonesian language rules. The results of input from experts are used as a basis for product improvement. Table 2 is a summary of the results of input from experts.

One-to-one interviews with students obtained input about the need for additional page numbers in the ebook and some videos could not be played (page 8). Based on input from experts, revisions were made to the product. Figure 3 and Figure 4 are snapshot of the product description before and after the revision.

Based on the input from the material experts, the video needs to be replaced to explain the concept of ecosystem and ecology and check the video on page 8 so it can be played. Revisions were made for typos, punctuation, and grammatical errors. The product is now equipped with page numbering and a table of contents.

After the product was revised, the experts were asked to provide a quantitative assessment of the product before it was tested for use by students in learning. The results of the quantitative assessment given by material experts to the product can be seen in Figure 5.

Table 2 The expert suggestions

Expert		Notes/Suggestions
Media	1)	The cover page of Ebook hypercontent writing is white on a light gray background so there is no contrast, and it is less legible. Including the author's name
	2)	Maybe it should be written on the cover, who is this book intended for?
	3)	Pay attention to the legibility of each illustration, you can increase the size.
	4)	It is necessary to pay attention to the contrast of the background and the object, in order to improve readability
	5)	The font type in the material description is replaced with MS Gothic/San Serif
Material	1)	The video about the concept of ecosystem and ecology is not quite right. Replaced the video.
	2)	Video on page 8 cannot be played
	3)	Should be equipped with page numbering and a table of contents
	4)	The video that is inserted should not be in the form of an explanation, but rather an example of processes that occur in nature, completed by narration/voice explanation
	5)	Check for missing text and typing errors
Languages	1)	Some sentences are not standard, so they need to be corrected
	2)	There are some grammar and punctuation that need to be fixed
	3)	Some words do not use standard words

Figure 3 The cover before (left) and after revision (right) (in Indonesian)

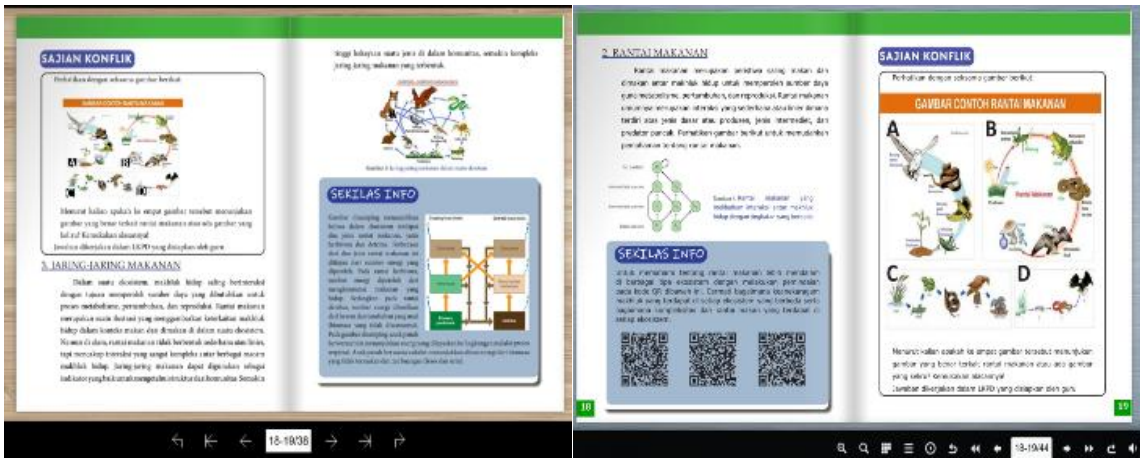

Figure 4 Illustration/images before (left) and after revision (right) (in Indonesian)

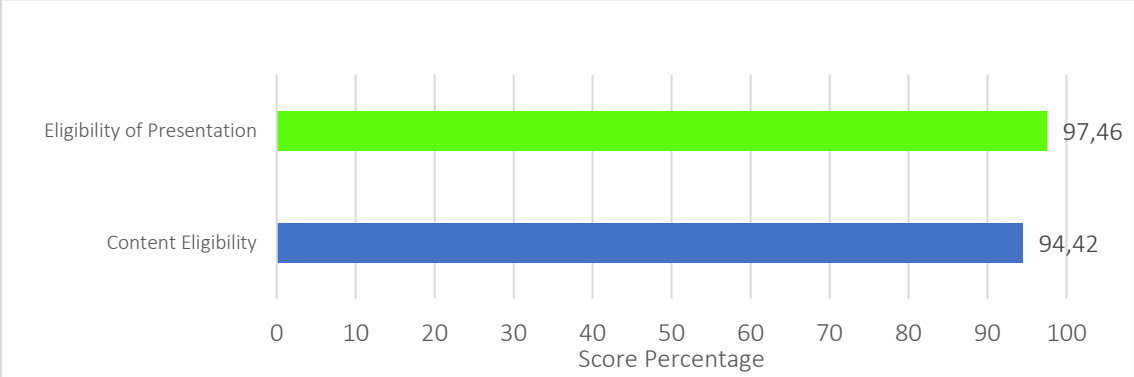

Figure 5. The percentage of material expert assessment to the product

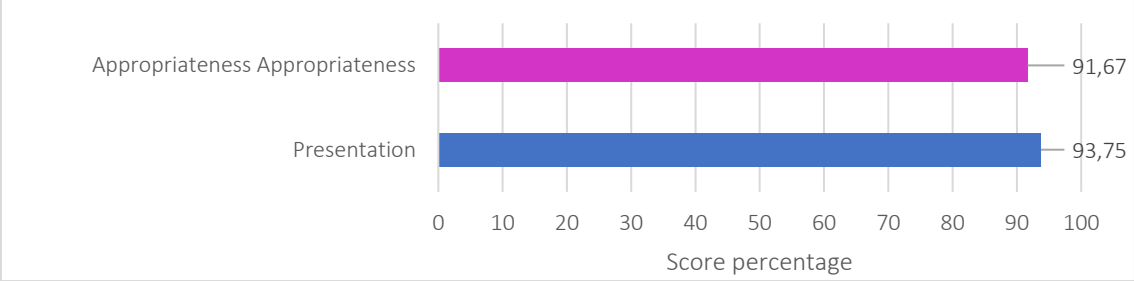

Figure 6 The percentage of product feasibility assessment by media experts

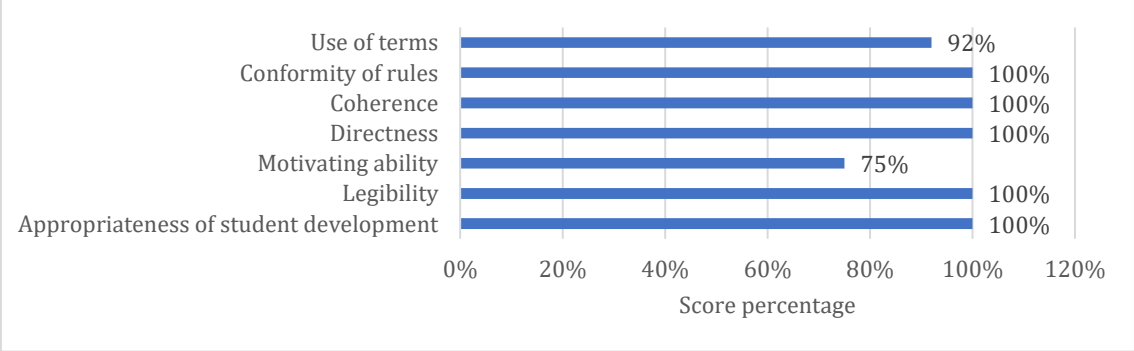

Figure 7 Product assessment from the language aspects

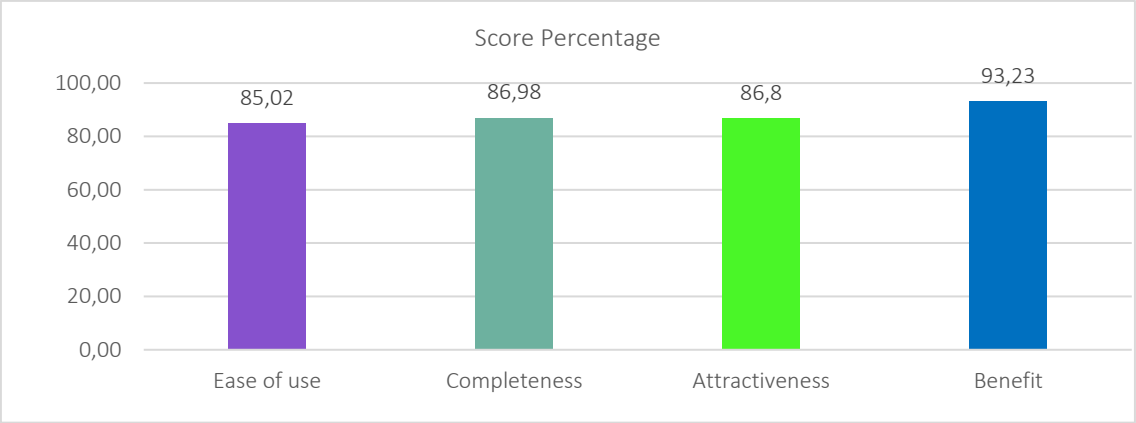

Figure 8 The Percentage of students' response to the product

Two aspects assessed by material experts include the presentation feasibility and content feasibility, each of which was rated 97.46% and 94.42%. Referring to Table 1, the product can be stated in a very feasible category from a material aspect. The evaluation given by media experts to the product can be seen in Figure 6. Media experts give a score of 91.67% for the feasibility aspect and a score of 93.75% for the presentation aspect. Based on the assessment given by media experts, the product is in a very decent category.

Linguists provide an assessment of the product covering aspects of the use of terms, conformity with language rules, coherence, straightforwardness, ability to motivate, readability, and suitability for student development. The ability to motivate is given the lowest score compared to the other aspects but is still in the proper category. For other aspects, linguist experts provide ratings in the range of very feasible categories. The average score for all language aspects is in the very decent category. An overview of the assessment given by linguists can be seen in Figure 7.

The assessment from experts for all aspects is on average above 90%, indicating that the product is highly suitable for further use in learning. After the product is declared feasible by experts, it is then implemented in the learning process. Student responses to products based on 4 aspects (ease of use, completeness of content, attractiveness, and usefulness) can be seen in Figure 8.

Overall, it can be seen that the responses given by students are in a very decent range of assessments. This means that the product is very easy to use, very complete, very attractive, and very useful for learning. The highest assessment given by students was on the product usefulness aspect, which is 93.23%. Overall, the average assessment given by students was 88% for the four aspects responded to. Teachers gave the same response to the product. According to the teacher, the material coverage is very appropriate to the learning needs of class X SMA students and the language used is appropriate. All learning activities provided in the learning resources are highly accessible, fostering student engagement and facilitating comprehension. Overall, teachers think that the product is very suitable for use in biology learning.

The assessment given by students is certainly inseparable from the characteristics of the product which is equipped with a clear usage guide at the beginning. The existence of instructions for use will make it easier for students, including when studying independently. In accordance with opinion (Lestari et al., 2022),every command and description of the instructions presented are helpful to the user. Complete instructions and study guides help to make it easier for students to use the product when studying independently. Products in the form of hypercontent ebooks are also effective to be used as independent study materials (Amin et al., 2020; Sun & Pan, 2021)

The description of the material is accompanied by case examples, various media, and additional information at a glance to broaden students' horizons and the existence of a review of material at the end of each chapter makes this material considered by students to be very complete. The completeness of the contents of the e-book is one of the requirements as a good learning resource. Components in e-books include text content, images, graphics, etc., and supporting components in the form of online teaching materials that can be accessed by users in the form of videos, animations, audio, images, text, and others, as well as connecting channel components between the main content and the supporting content using several QR Core features, Augmented Reality and hyperlinks (Surahman et al., 2021). These components are fulfilled by the product being developed.

E-books are provided by connecting channels to make students connected with other learning resources. Connectivity in this ebook uses hyperlinks and QR codes so that the learning becomes more modern, easy, and interesting (Azrai et al., 2023). This will help students to be connected to the learning community according to the theory of learning connectivity (Siemens, 2005). The concept of connectivism describes the relationship between human learning and access to knowledge made

possible by today's technological environment (Corbett & Spinello, 2020). Connectivism explains that learning occurs in a digital environment where students form networks with fellow students and with digital resources (Boyraz & Ocak, 2021). Hypercontent allows learning resources to be rich in material but does not create additional pages that might make students feel burdened by having to read a book with a large number of pages.

The product is equipped with a variety of multimedia, in the form of images, audio, and video. This variety of multimedia makes learning resources not monotonous, so it will increase student motivation in learning. Reader motivation can arise because of the attractiveness of the topic title, the use of language that is easy to understand, the availability of images, summaries, main ideas, and additional references that are not available in textbooks such as online site links and YouTube links (Sun & Pan, 2021; Surahman et al., 2021). Motivation will have an impact on the acquisition of learning outcomes (Jeno et al., 2023).

Another characteristic of the product is that it is equipped with a discussion forum and material review. The discussion forum in the e-book will also allow students to discuss with their study groups. Involving students actively and socially in learning plays an important role in mastering biological concepts (Bizimana et al., 2022) Discussion forums stimulate students to collaborate and respect each other so that social skills are also honed. Following the social constructivism learning theory, students will construct their understanding through social interaction. Material reviews provide opportunities for students to measure their understanding of the material being studied.

This hypercontent ebook product, serving as digital learning material, is accessible to students through various mobile devices, including smartphones, tablets, phablets, iPads, and more, not restricted solely to laptops or PCs. Leveraging these devices enables students to tailor their learning experience, seamlessly transitioning between formal and informal contexts or personal and social settings (Dias & Victor, 2017). This is very in line with the learning characteristics of generation Z students who prefer freedom in learning.

The next characteristic that differentiates the product from other ebooks is the presence of conflict. The purpose of this conflict presentation is to streamline the implementation of cognitive conflict strategies for teachers in the learning process. Cognitive conflict arises when mental equilibrium is disrupted by experiences or encounters with anomalous data that do not align with existing interpretations (Madu & Orji, 2015), therefore, teachers need to disturb students' mental equilibrium.

D. Conclusion

The development of this cognitive conflict-based ecosystem hypercontent ebook goes through the stages of needs assessment, design, development, evaluation and revision. During the needs assessment stage, an analysis is conducted to gauge the level of necessity and the potential for product development. Subsequently, at the design stage, a storyboard is crafted, and during the development stage, product development ensues based on the storyboard. Evaluation and revision take place at each stage. Products that have been developed are validated by material experts, language experts and media experts. Material experts validate products based on aspects of concept accuracy and ensure that there are no erroneous concepts in the material description. Media experts validate products in graphic aspects and linguist experts validate the suitability of the language used with standard Indonesian language rules. affirming the product's high suitability for integration into biology learning, particularly regarding ecosystem materials. Product trials in learning are obtained based on student responses as product users. Student responses included ease of use; completeness of material; product attractiveness and usefulness. With an average score of 88% from students, it can be confidently asserted that the product excels across all dimensions. The teacher also gave the same response that the product was very suitable for use in Biology learning. Based on expert validation and responses from students and teachers, the cognitive conflict-based ecosystem hypercontent ebook was found to be highly suitable to use as a learning resource for ecosystem topics in high school biology. Beyond its demonstrated feasibility, the ebook shows considerable potential to support the digital transformation of biology learning. By integrating cognitive conflict strategies with hypercontent technology, the ebook promotes active knowledge construction, self-directed learning, and access to diverse learning resources. These features make it a valuable digital learning resource for enhancing students' conceptual understanding and digital literacy in technology-enhanced biology learning environments. Future research should investigate the effectiveness of the ebook in improving learning processes and student learning outcomes through broader implementation and experimental studies.

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