

Media Innovation: Technology-Based Infinity Folding Paper on Cell Splitting Materials

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ABSTRACT

Innovation in technology-based learning media is increasingly needed to support an interactive and effective learning process in the digital era. However, in Indonesia, the application of innovative media such as technology-based Infinity Folding Paper is still not common. This media offers a creative and interactive alternative approach to facilitate students' independent learning. This research aims to examine the potential and development of Infinity Folding Paper learning media innovations that are integrated with digital technology. The method used is literature review with data sources from Google Scholar. The results of the study show that this media can help overcome the problem of learning effectiveness, especially in cell division material, through the presentation of visual, interactive, and flexible content. In addition, this innovation is designed to support students in understanding cell division concepts such as mitosis and meiosis independently and deeply. The findings of this research are expected to be the basis for developing technology-based learning media that are relevant, interesting, and in accordance with the needs of 21st century learning.

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Introduction

Generation Z or often known as Gen Z is a demographic group that emerged after Millennials. This generation is often also known as digital natives because its members were born and raised in the era of technological advancement, especially the internet and easily accessible handheld devices (Schroth, 2019). This generation has distinctive characteristics, namely: (1) born between 1995 and 2010, (2) getting to know technology at an early age, (3) integrated with technology at all times, (4) adaptive to digital literacy, (5) have an online identity, (6) prioritizing the use of gadgets, and (7) learning and accessing information online (Szymkowiak et al., 2021). This characteristic certainly changes the way of life or views in various aspects of life, one of which is the educational aspect.

Education also needs to adjust to the progress of the times, especially to attract the attention of Gen Z to learn. The learning process needs to be integrated with digital technology that makes it easier for students to learn independently or collaborate online (Hernandez et al., 2020). Tendency of students to use Gadgets. (There is inconsistency in the use of terms like "Gadgets," which is sometimes capitalized and sometimes not. It's better to choose one style and stick with it.) At any time, it can be used as a direction for the potential development of strategies or learning media. Good learning media can certainly help students to construct abstract concepts into concrete or strengthen existing concepts (Aryani & Nugroho, 2022). Abstract concepts are found in various subject subjects, one of which is Biology. The field of study of Biology has abstract concepts, especially concepts that talk about microscopic organisms or the concept of phenomena and processes that take place in the body. Failure to change abstract concepts into concrete can cause misconceptions or even wrong concepts in students. This misconception can be a threat to the development of students' knowledge until adulthood. One of the concepts of Biology that often has misconceptions in students is the concept of cell division.

The concept of cell division is generally distinguished by mitosis and meiosis. In the mitotic phase of fission, misconceptions are often found in the sequence of the fission phase (Azizah & Susantini, 2020). Misconceptions on the concept of cell division are common as high because students are less interested and are difficult material (Mulya & Zulyusri, 2022). Cell division in genetic material is known to be the material that has the highest level of misconception compared to several other concepts (Wulandari et al., 2021). Students' disinterest in the material can be overcome with the use of good learning media. However, how to develop learning media so that it is interesting but still integrated with technology?

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The development of learning media needs to pay attention to several aspects of both content, goals, and development. In the content aspect, the media developed needs to be directed to the competencies that need to be achieved by students by paying attention to which concepts are the most difficult or misconceptions occur in students. The target of the media, in this case Gen Z, needs to be analyzed, especially what is needed, whether there is a tendency to learn behavior in Gen Z students and other factors. Media development also needs to consider the usability, ease of manufacture or up to the cost factor needed in making it. Related to the identification of these aspects, it was found that the potential for the development of learning media is in the form of technology-based Infinity folding paper on cell division material. (more explanation is needed on how this media can help in learning or address the issues mentioned earlier, such as difficulties in understanding cell division concepts.) Based on the presentation of the problems and potentials that can be developed, this study examines in detail related to the learning media innovations that will be assembled.

Methods

This study uses the literature review method, which involves critically analyzing scholarly works related to a specific topic of interest. The literature reviewed consists of publications from 2010 to 2023, accessible in full-text PDF format through Google Scholar. The selected articles are research journal publications that focus on innovations in learning media. The literature search was conducted using the keywords "infinity folding paper" and "cell division material." The primary objective of this literature review is to explore innovative learning media related to cell division concepts, which will serve as a foundation for further development in this study.

Results and Discussions

Infinity Folding Paper

Origami-based learning has been used for a long time, starting from the kindergarten level. This learning method utilizes origami, the art of folding paper, as a tool for teaching and learning. Origami activities can be applied across various subjects and educational levels. Learning with origami provides a unique experience where students actively participate in shaping or assembling origami (Tanjung & Parsika, 2014). This activity enhances cognitive skills, creativity, and problem-solving abilities in students (Alfikri & Ahsyar, 2017). Origami learning can be applied in various ways, including in Biology education.



Figure 1. Infinity Folding Paper.
Source: OrigamiTree.com

Origami can be used to introduce biological concepts and principles. Biology contains many abstract concepts that can be illustrated through origami. For example, a strand of DNA can be represented using folded paper placed on a background symbolizing the cell nucleus. Additionally, origami can be integrated with pop-up designs to transform abstract objects into concrete representations. Pop-up media in biology education is considered effective for enhancing the learning process (Lestari et al., 2020; Mungallamah & Saifuddin, 2021). This type of media is also easy to create, as it utilizes materials commonly found in daily life (Main, 2020).

Origami-based media can also help explain abstract biological processes, such as infinity folding paper. Infinity folding paper, as a form of origami, can represent cycles or processes that repeat continuously. It is created by connecting origami pieces into a frame that can be unfolded repeatedly, illustrating ongoing biological processes. Since it is made of folded paper, this media can be integrated with digital technology, such as by embedding QR codes that link to relevant websites or applications. Additionally, it can be combined with other origami forms, such as pop-ups, to better represent abstract objects or processes.

While infinity folding paper offers flexibility and advantages, it also has certain limitations. The primary drawback of this media is the limited number of cycles it can represent within a single piece. If a biological concept involves more than four cycles, additional infinity folding papers would be needed to illustrate the remaining sequences. Furthermore, this media is prone to tearing and getting dirty with repeated use. To enhance its durability, selecting sturdier paper and adding protective plastic layers are necessary. The lack of research on the development of infinity

folding paper in scientific forums presents both a challenge and an opportunity for further exploration, particularly in the field of biology education.

Implementation of infinity folding paper with technology

The following is the design result of infinity folding paper integrated with technology.

a. First fold

In the first fold (layout), the name of the process (prophase) is displayed alongside an image illustrating the prophase stage, a QR code linking to a Google Docs file containing DKL (onion root mitosis), and an explanation outlining the essential aspects of the prophase process. This section serves as the initial part that students can interact with. To enhance engagement and understanding, it is recommended to incorporate a pop-up section that visually represents the state of the cell. For example, a pop-up featuring thread-like structures could symbolize condensed chromosomes. Whenever possible, additional interactive elements, such as touchable pop-up media or other tactile features, should be integrated into the layout to support image interpretation and improve conceptual understanding.

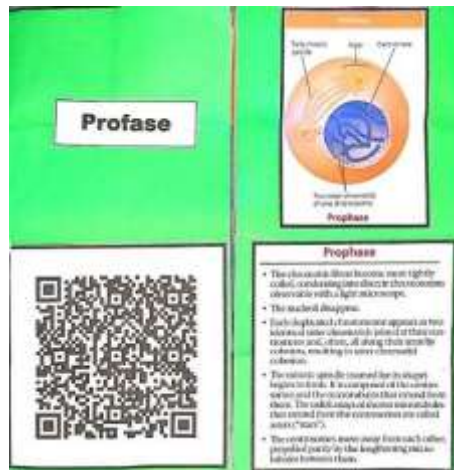


Figure 2. The First Layout of the Prophase Cycle

b. Second fold

The second fold (layout) presents the name of the process (metaphase), an image illustrating the metaphase stage, and a QR code linking to an AR/video that explains the cell division cycle. Additionally, it includes a description outlining the essential aspects of the metaphase process. Similar to the first fold, it is recommended to enhance this section with illustrations, such as pop-up media representing chromosomes aligned along the equatorial plane (center of the cell). Alternatively, static images can be replaced with AR (Augmented Reality) elements that visually demonstrate the metaphase process.



Figure 3. The Second Layout of the Metaphase Cycle

c. Third fold

The third fold (layout) presents the name of the process (anaphase), an image illustrating the anaphase stage, and a QR code linking to MindMeister, which contains a concept map of cell division. Additionally, it includes a description outlining the essential aspects of the anaphase process. For this stage, it is recommended to add a pop-up element that visually represents homologous chromosomes being pulled toward opposite poles. This can be achieved by incorporating an image at the edge of the paper so that when it is opened, it effectively illustrates the movement of chromosomes toward opposite poles.



Figure 4. The Third Layout of the Anaphase Cycle

a. Fourth fold

In this fourth fold (layout) contains the name of the process (telofase), then the image of the telofase process, the QR Code of kahoot! which contains quizzes (for assessment) and explanations in the form of essential content of the telofase process. In this process, it is recommended that the cell part be drawn on folded paper or added with additional folded paper at the end before opening. This can describe cells in the telophase and cytokinesis phases. Pop-up paper can also be added as a filling of cells where chromosomes gradually disappear.



Figure 5. The Layout of the Fourth Telofase Cycle

Cell division is a complex and abstract biological concept. The learning objectives for this topic, based on the 2013 revised curriculum (basic competencies) or the independent curriculum (learning outcomes), are presented in Table 1.

Table 1. Basic Competencies and Indicators of Competency Achievement

It	Basic Competencies (KD)	It	Competency Achievement Indicators (GPA)
3.4	Analyze the process of cell division as the basis for decreasing traits from the parent to the offspring.	3.4.1	Explaining the phases of mitosis cleavage
		3.4.2	Explaining the phases in meiosis division
		3.4.3	Comparing mitosis and meiosis fission
		3.4.5	Identifying the gametogenesis process
		3.4.6	Combining spermatogenesis and oogenesis
		3.4.7	Analyze the process of cell division as the basis for decreasing traits from the parent to the offspring.
		4.4	Presenting the results of cell division observations in animal and plant cells

This learning method can also be integrated with the Independent curriculum. The learning outcomes (independent curriculum) in the material on changes in cell division are explained in the following sections.

At the end of phase F, students have the ability to describe cell structure and bioprocesses that occur in cell division.

The implementation on this media uses a conceptual approach, a model based on ausubel theory, and a practicum method (Widodo, 2021).

Conclusions

The development of interactive learning media using Smart Apps Creator has been shown to enhance students' critical thinking skills. Based on expert assessments, the average validity score was 87%, categorized as very valid. The implementation of this learning method over three sessions resulted in an average score of 91%, interpreted as excellent. The N-gain test showed an average score of 34.93%, indicating a moderate improvement. Additionally, student responses were overwhelmingly positive, with an average satisfaction rate of 81.67%, categorized as very interesting. Hypothesis testing confirmed that the use of interactive learning media developed with Smart Apps Creator significantly improved students' critical thinking skills in the Work and Energy topic for Class X IPA 4 at SMAN 6 Tambun.

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