Development of Learning Tools for Karyotype Group Types in Class XII High School Genetics Material

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Abstract: The Karyotype Group Learning Tool is a learning tool in the form of a learning guidebook which includes lesson plans. Functions to help students in the learning process by implementing karyotype group type learning strategies. The aim of this research is to produce a valid learning tool for karyotype group types in class XII high school genetics material. This type of research is research and development which uses the ADDIE development model. The research was carried out in August 2023- February 2024 at MAN 2 Makassar City. The research subjects were 1 Class XII Biology teacher and 43 Class XII MIPA MAN 2 Makassar City students. The research instrument is an interview guide sheet and a questionnaire sheet consisting of a student needs analysis questionnaire and a validation questionnaire. The data analysis techniques in this research are qualitative and quantitative analysis. Product validity is assessed by a team of experts/validators. The assessment criteria used to determine the degree of validity of learning tools consist of 3 main aspects, namely: (1) the content appropriateness aspect, (2) the construction appropriateness aspect, and (3) the language appropriateness aspect. The results of the research show that the average assessment results from the two validators for the learning tools as a whole is 97.18% which is in the very valid category, so it can be concluded that the karyotype group type learning tool product in class XII high school genetic material is declared valid and suitable for use. in learning.

Keywords: ADDIE Model, Genetics, Karyotype Group Types, Learning Tools

INTRODUCTION

The teaching and learning process is a crucial aspect that influences the quality of education. Understanding concepts in learning has an important role in the student learning process. Understanding concepts is the foundation for subsequent concept learning. When students have a good understanding of concepts, they are better able to integrate those concepts with previous knowledge and build a deeper understanding. However, students often experience obstacles in understanding learning concepts. Students have difficulty connecting different concepts and understanding their relationships which is caused by various factors (Rohmah *et al*., 2023).

Generally, in genetics material, students often face difficulties in learning concepts related to this material because of its high complexity. Learning genetics at the high school level has an important role in developing students' understanding of basic concepts such as genes, DNA, chromosomes, karyotypes and cell division. Genetics material has its own complexity so that quite a lot of students have difficulty understanding the concept. Students' difficulties in studying genetic material mainly occur in genetic concepts (genes, DNA, and chromosomes), the relationship between genetic material and polypeptides, the principles of heredity, sex

determination, the relationship between cell division and inheritance of traits, and mutations. It was noted that there were several conceptual misunderstandings that commonly occurred in these concepts, such as the concept of chromosomes (20%), genes (15%), DNA (15%), and protein synthesis (10%) (Wulandari *et al*., 2021).

The implementation of the teaching and learning process usually still faces obstacles. The lack of implementation of innovative learning strategies by teachers is one of the factors causing obstacles in students' understanding of concepts. The learning process in class is often faced with students who show learning attitudes and behavior that are indifferent or inactive in participating in learning. As a result, students have difficulty understanding the lesson material presented by the teacher and achieve low learning outcomes. Therefore, a teacher should use learning strategies that can increase student motivation in learning. Implementing appropriate learning strategies will help teachers in the teaching and learning process and is expected to make it easier for students to receive and understand the material being taught. Teachers need to have skills in managing learning activities creatively and innovatively, creating a learning environment that motivates and involves students actively and collaboratively (Sura *et al*., 2020).

The application of learning strategies cannot be separated from learning models, because learning models have a wider scope than learning strategies. If a teacher wants to implement a learning strategy, the learning model used must also be determined. The cooperative learning model is one of the popular and effective learning models for achieving learning goals because students work together in groups to achieve learning goals thereby increasing student collaboration in learning (Kasayanond *et al*., 2019).

There are several cooperative learning strategies that can be utilized to increase the effectiveness of the learning process. In this context, the type of cooperative learning model *Think Pair Share* (TPS) and *The Power of Two* (TPOT) emphasizes cooperation in the form of group pairs that allow the exchange of ideas between members of the pair. These two learning strategies have their respective advantages and disadvantages. The advantage of both types is that pair collaboration allows students to give each other full attention, listen carefully, and share ideas in more depth. The disadvantage of both types is that they tend to focus more on interactions within the couple and often ignore the potential for discussions in large groups. This can limit the variety of perspectives and solutions discussed and there is a tendency for students to choose their group friends because they are used to only working in pairs (Putri, 2020).

This deficiency can be overcome with a karyotype group type learning strategy. It is important to create an inclusive atmosphere in the classroom where all students feel welcome and valued. This strategy allows students to become accustomed to working with a variety of individuals and learn to appreciate diversity in views and ideas. By working in groups consisting of more members, students will have the opportunity to interact with a variety of classmates which contributes to increased tolerance, acceptance of differences, and the ability to work in more heterogeneous groups. This strategy also allows students to exchange ideas with partners and participate in wider large group discussions to form a deeper understanding as well as a simulation of the material (Arsal *et al*., 2023).

Karyotype in genetics learning is a description of the chromosome structure in a cell, including the number and details of the chromosome structure. Chromosomes are arranged in pairs starting with the longest and numbered. Homologous chromosomes are pairs of chromosomes that have the same length, centromere position, and coloring pattern. Homologous chromosome pairs are formed when paternal chromosomes (chromosomes from the father) and maternal chromosomes (chromosomes from the mother) combine through the fertilization process (Arsal, 2018).

The karyotype group type is adapted from the karyotype concept in genetic material. So, this learning strategy is very appropriate to use in learning genetics, especially genetic material and cell division, but it does not rule out the possibility that this learning strategy can also be used in other materials in general. This learning strategy allows students to build a deeper understanding through collaboration and reflection in the context of small groups (pairs) and larger groups and can better understand the material, especially genetic material because this learning strategy also acts as a material simulation.

This learning strategy makes students work in small groups consisting of 2 people who are likened to homologous chromosomes in a karyotype. When students are asked questions or problems related to genetic material, they discuss them with their partners. Next, students in pairs will separate and form two large groups who will discuss each other in more depth. This situation resembles the process of cell division. By implementing this learning strategy, it is hoped that students can increase their understanding of the concepts of genetic material and cell division because they are adapted from the concepts themselves. This is the reason researchers chose genetic material and cell division as a form of material simulation so that learning is more meaningful as if students experienced it directly.

Astuti *et al* (2021), stated that success in learning depends on the suitability of learning tools with the learning model or strategy used and the material taught. According to Sahidu (2019), learning tools include lesson plans, syllabi, LKPD, teaching materials, learning media, and assessment instruments. Good quality learning tools will provide important support for teachers in designing and implementing effective learning.

January *et al* (2023), also argue that learning tools are a means of supporting the implementation of learning strategies. As explained by Lugiati (2020), effective learning strategies require the support of appropriate learning tools so that harmonization between learning strategies and learning tools becomes an important factor in achieving optimal learning goals.

Based on the explanation above, to implement an effective karyotype group type learning strategy, learning tools are needed that are appropriate to the learning strategy and learning materials that will be applied. Learning tools such as the Learning Guidebook which includes a Learning Implementation Plan (RPP) are an important aspect in implementing karyotype group type learning strategies in genetic material. Therefore, researchers are interested in carrying out research with the title "Development of Learning Tools for Karyotype Group Types in Genetic Material for Class XII SMA".

RESEARCH METHODS

This research is a type of research and development (*Research and Development)* which uses the ADDIE development model. The research was carried out in August 2023-February 2024 at MAN 2 Makassar City. The research subjects were 1 Class XII Biology teacher and 43 Class XII MIPA MAN 2 Makassar City students. The research instrument is an interview guide sheet and a questionnaire sheet consisting of a student needs analysis questionnaire and a validation questionnaire. The data analysis techniques in this research are qualitative and quantitative analysis.

The assessment criteria used to determine the degree of validity of learning tools consist of 3 main aspects, namely: (1) the content appropriateness aspect, (2) the construction appropriateness aspect, and (3) the language appropriateness aspect. Product validity is assessed by a team of experts/validators. Expert validity questionnaire answers use a Likert scale. According to Sugiyono (2019), the Likert scale is used to measure the attitudes, opinions and perceptions of a person or group of people about social phenomena. The score categories on the Likert scale can be seen in Table 1.

Table 1. Score Categories on the Likert Scale

No	Information	Code	Score
1.	Strongly agree	SS	4
2.	Agree	S	3
3.	Don't agree	TS	2
4.	Strongly Disagree	STS	1

(Source: Sugiyono, 2019)

The expert validity test can be carried out by comparing the number of scores given by the ΣR validator with the number of ideal scores that have been determined (Sugiyono, 2019). The formula is as follows:

$$P = \frac{\Sigma R}{N} \times 100\%$$

Information:
P = Percentage of score sought ΣR = Score obtained
N = Maximum or ideal number of scores

The validation criteria or levels of achievement used in developing learning tools can be seen in Table 2.

Table 2. Achievement Levels and Qualifications

No	Level Achievement (%)	Information
1.	81 - 100%	Very valid
2.	61 - 80%	Valid
3.	41 - 60%	Fairly valid
4.	21 - 40%	Not valid
5.	<20%	Very invalid

(Source: Arikunto, 2016)

The criteria used to decide on the karyotype group type learning tool in class XII high school genetic material that is produced has an adequate degree of validity,

namely if the achievement level is ≥ 61%. If the learning tool has not reached the criteria ≥ 61% then revisions will be carried out until the desired criteria are obtained.

RESULTS AND DISCUSSION

1. Analysis (*Analysis*)

a. Needs Analysis

Students' needs for the development of Karyotype Group Type Learning Tools in Class XII High School Genetics Material can be seen from the results of interviews with biology subject teachers and the results of distributing questionnaires to class presented in class XII SMA according to the applicable curriculum. The curriculum used is the 2013 Curriculum. Table 3 below is an identification of the results of interviews with class XII biology teachers.

Table 3. Interview Results of Biology Subject Teachers MAN 2 Makassar City

No	Indicator curiculum	Answer
1	Ministry of Health	The school implements the 2013 Curriculum and sets Minimum Completion Criteria (KKM) for class XII of 80.
2	Learning tools	Teachers use the Learning Implementation Plan (RPP), syllabus, printed books from the Erlangga publisher, Student Worksheets (LKPD), assessment instruments, as well as Powerpoint (PPT) learning media and learning videos from YouTube.
3	Learning strategies and methods	Teachers are faced with time constraints, making implementing innovative learning strategies difficult. There is no comprehensive application of simulation methods for genetic material and cell division. Group learning is rarely implemented. If there is, it usually consists of 5-7 people. The determination of group members can be determined by the class leader or teacher. But more often it is students who divide groups. The group learning strategy implemented is not yet fully able to make it easy for students to understand the material.
4	Student activities	Students tend to be active in learning, but can become passive if the material is difficult or in the last hour. Motivation to learn is high, but interest in reading is somewhat lacking, especially if the material is difficult to understand. There is no dominant learning style, students have a variety of learning styles.
5	Genetic material and cell division	Students have difficulty understanding genetic material and cell division because there are many scientific terms that are difficult to remember. The average test score is low

Table 4 below is an identification of the results of the needs analysis questionnaire answers for class XII MIPA students at MAN 2 Makassar City totaling 43 people.

Table 4. Questionnaire Answer Results for Class XII MIPA MAN 2 Makassar City

No	Indicator	Answer
1	Learning strategies and methods	Teachers usually give individual assignments and sometimes groups of 5-7 people. Group learning is considered to help the majority of students understand the material but requires interesting learning variations. Teachers often use the lecture method. The simulation method was applied once during protein

		synthesis material and students were very enthusiastic because it provided a more interactive and enjoyable learning experience.
2	Learning Resources	Printed books are the main learning resource for students and PowerPoint for teachers. The need for additional explanations from teachers or online references to understand complex genetic material and cell division is necessary. Students can take advantage of various additional learning resources such as learning videos, teaching modules, and the internet.
3	Student activities	The majority of students are active in discussions, asking and answering class questions. Student activity tendencies are influenced by interests, level of understanding, and variations in teacher teaching methods. But most students feel that learning still needs to be made more interesting.
4	Genetic material and cell division	The majority of students experience difficulties in studying genetic material and cell division, especially concepts that are complex and require high memorization, as well as many terms that are difficult to understand.
5	Opinions and suggestions	Students support research for the development of learning tools that can help them understand the material better. Students provide suggestions so that the learning tools developed can provide significant benefits for students which will improve the quality of learning

b. Content Analysis

Content analysis was carried out through material review for the development of Karyotype Group Type Learning Tools in Class XII SMA Genetics Material. The material used refers to the applicable curriculum, namely the 2013 curriculum.

Content analysis was carried out by reviewing textbooks, the internet or trusted online sites, survey results, images, and adapted to the 2013 curriculum KI/KD. Analysis of learning content on Genetics material can be seen in Table 5 (Genetic Material) and Table 6 (Division Cell).

Table 5. Content Analysis of Genetic Material Learning for Class XII SMA

KD	Indicator	Teaching Materials
3.3 Analyzing structural relationships and gene function, DNA, chromosome in implementation principle of inheritance nature of creatureslife	3.3.1 Explain the structure and function of genes, DNA, RNA, and chromosomes. 3.3.2 Discuss the relationship between structure and the function of genes, DNA and chromosomes in determine inherited traits. 3.3.3 Identify the stages of protein synthesis in eukaryotic organisms. 3.3.4 Analyze the relationship between protein synthesis and the formation of traits in living things. 3.3.5 Conclude the relationship between gene function and synthesis protein with the	1. Genes, DNA and chromosomes 2. Protein synthesis and the formation of the characteristics of living things.

	principle of inheritance of traits in living beings.	
Formulate process sequence protein synthesis in relation with code delivery genetic (DNA RNA-Protein)	4.3.1 Design a simulation model for the protein synthesis process. 4.3.2 Simulating the protein synthesis process and its related to the transmission of the genetic code. 4.3.3 Discuss the results of any protein synthesis simulations if there are problems in the transcription process, translation or replication 4.3.4 Conclude the relationship between protein synthesis with the formation and inheritance of traits on living beings.	

Table 6. Content Analysis of Class XII High School Cell Division Learning

KD	Indicator	Teaching Materials
3.4 Analyzing process cell division as the basis decline the nature of the parent to his descendants.	3.4.1 Explain the phases of mitosis 3.4.2 Explain the phases of meiotic division 3.4.3 Compare mitosis and meiosis 3.4.4 Identify the gametogenesis process 3.4.5 Compare spermatogenesis and oogenesis 3.4.6 Analyze the cell division process as a basis passing down traits from parent to offspring.	1. Mitotic division 2. Meiotic division 3. Gametogenesis (Spermatogenesis and Oogenesis)
4.4 Presenting observation results cell division in animal and plant cells.	4.4.1 Present data from observations of division animal cells. 4.4.2 Present data from observations of division plant cells.	

c. Instructional Analysis

The development of learning tools that suit students' needs is needed, especially regarding effective learning strategies and methods. The majority of students tend to like simulation methods and group-based learning. Students also prefer learning resources that are easy to understand, interesting and easy to access, such as teaching modules, learning videos and presentations.

The development of learning tools for the karyotype group type is important to achieve learning objectives in the high school curriculum, especially in presenting genetic material and cell division in accordance with the indicators and learning

objectives set. This learning tool is expected to encourage active student participation, help understand complex concepts, and increase enthusiasm in learning.

The resulting learning tools will be the basis for more effective and interesting learning strategies according to students' needs in understanding genetics and cell division. This learning tool is expected to be able to integrate karyotype group type learning strategies, materials and learning objectives well.

d. Content Analysis

Content analysis is carried out to adjust and find out the content of the material that will be included in the learning tool. Content analysis takes the form of material structure which can be seen in Figures 1 and 2 below.

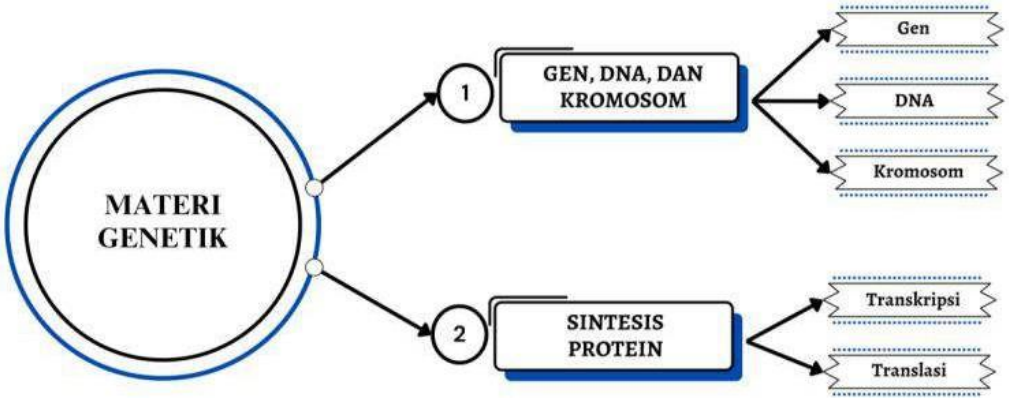


Figure 1. Structural Analysis of Genetic Material for Class XII SMA

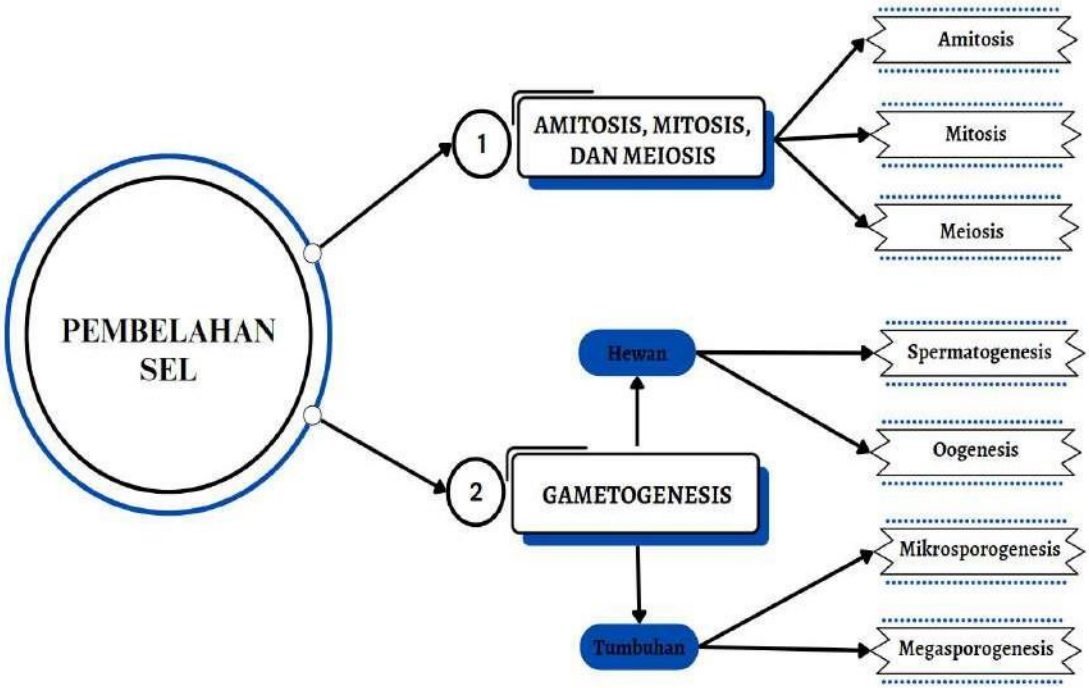


Figure 2. Analysis of the Structure of Cell Division for Class XII SMA

2. Design (*Design*)

a. Design Storyboard

The initial stage taken is designing *storyboard* which displays the composition of the contents of the learning tools can be seen in the following table.

Table 7. *Storyboard* Karyotype Group Type Learning Tool

Component	Sub Component
Cover	1. Author Name 2. Illustration Image 3. Title 4. City and Year
Foreword	Contents of the Foreword
List of contents	Complete the Table of Contents
Chapter I Delimiter	1. Illustration Image 2. Chapter Name 3. Sub Chapter Name
Chapter I Introduction	1. Background 2. Purpose and Benefits of the Guide 3. Instructions for Use Guide
Delimiter Chapter II	1. Illustration Image 2. Chapter Name 3. Basic Competency Number and Title (KD) 4. Sub Chapter Name
Chapter II Genetic Material	1. Learning Steps 2. Material 3. Evaluation Questions 4. Learning Implementation Plan (RPP)
Delimiter Chapter III	1. Illustration Image 2. Chapter Name 3. Basic Competency Number and Title (KD) 4. Sub Chapter Name
Chapter III Cell Division	1. Learning Steps 2. Material 3. Evaluation Questions
Delimiter Chapter IV	1. Learning Implementation Plan (RPP) 2. Illustration Image 3. Chapter Name 4. Sub Chapter Name
Chapter IV Conclusion	1. Conclusion 2. Suggestion
Bibliography	Fill in the bibliography
Author Biography	Contents of Author Biography

The learning tool designed contains 2 biology materials in the odd semester of class XII, namely genetics (KD 3.3 and 4.3) and cell division (KD 3.4 and 4.4). After creating *storyboard*, the researcher then designed a display design for the contents of the learning device. The design is designed and prepared based on development plans and research needs.

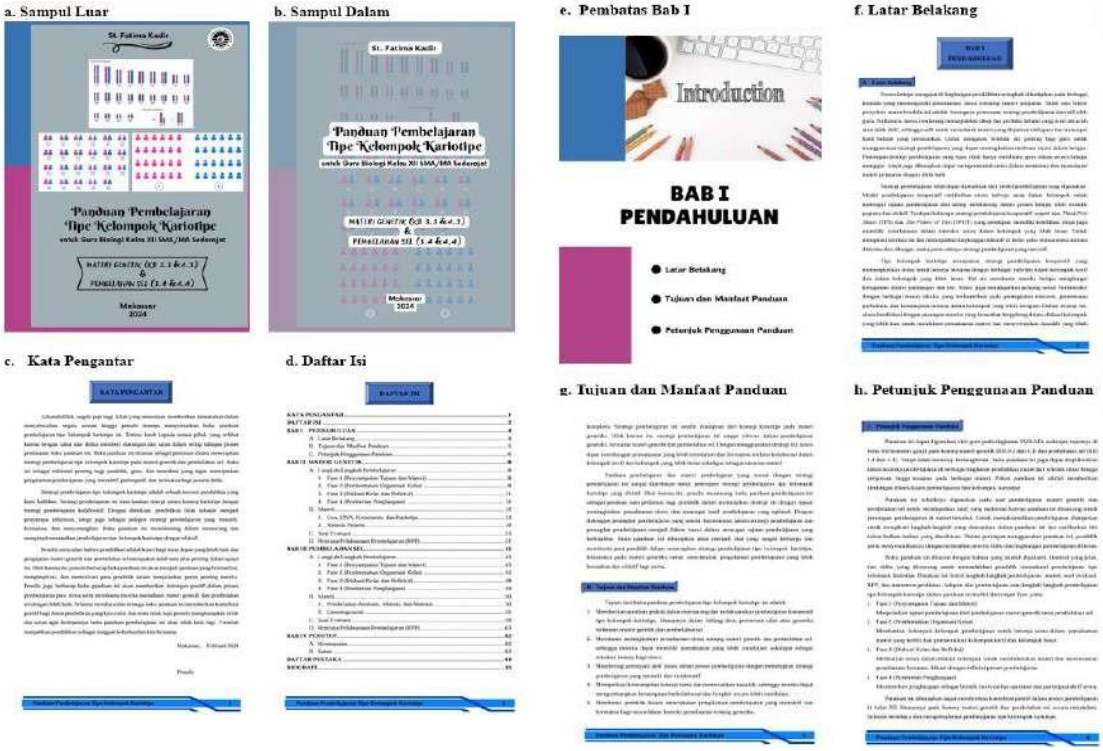
b. Design Layout

Design *Layout* is the stage where the researcher arranges the layout of the learning device as well as elements related to the content of the learning device. The designed layout displays image and text elements to be more communicative and varied, making it easier for readers to understand the information presented. Researchers in preparing the layout design for the learning tools used Microsoft Word to prepare the content and the Canva application to design the cover and several parts of the learning tools. After completing the design, it is then converted into a Portable Document Format (PDF) file which is then printed.

3. Development (Development)

a. Product Development

The development stage is carried out after the product design design process is complete. This stage aims to implement the design plans that have been made into a product which is then validated and revised by expert validators to obtain results in the form of learning tools that are valid so that they are suitable for use as learning resources. The development of learning tools is carried out based on the results of the analysis and design that have been depicted through storyboards. The learning tool uses A4 paper with margins of 3, 3, 2, 3 (cm). Learning device products can be seen in Figure 3 below.



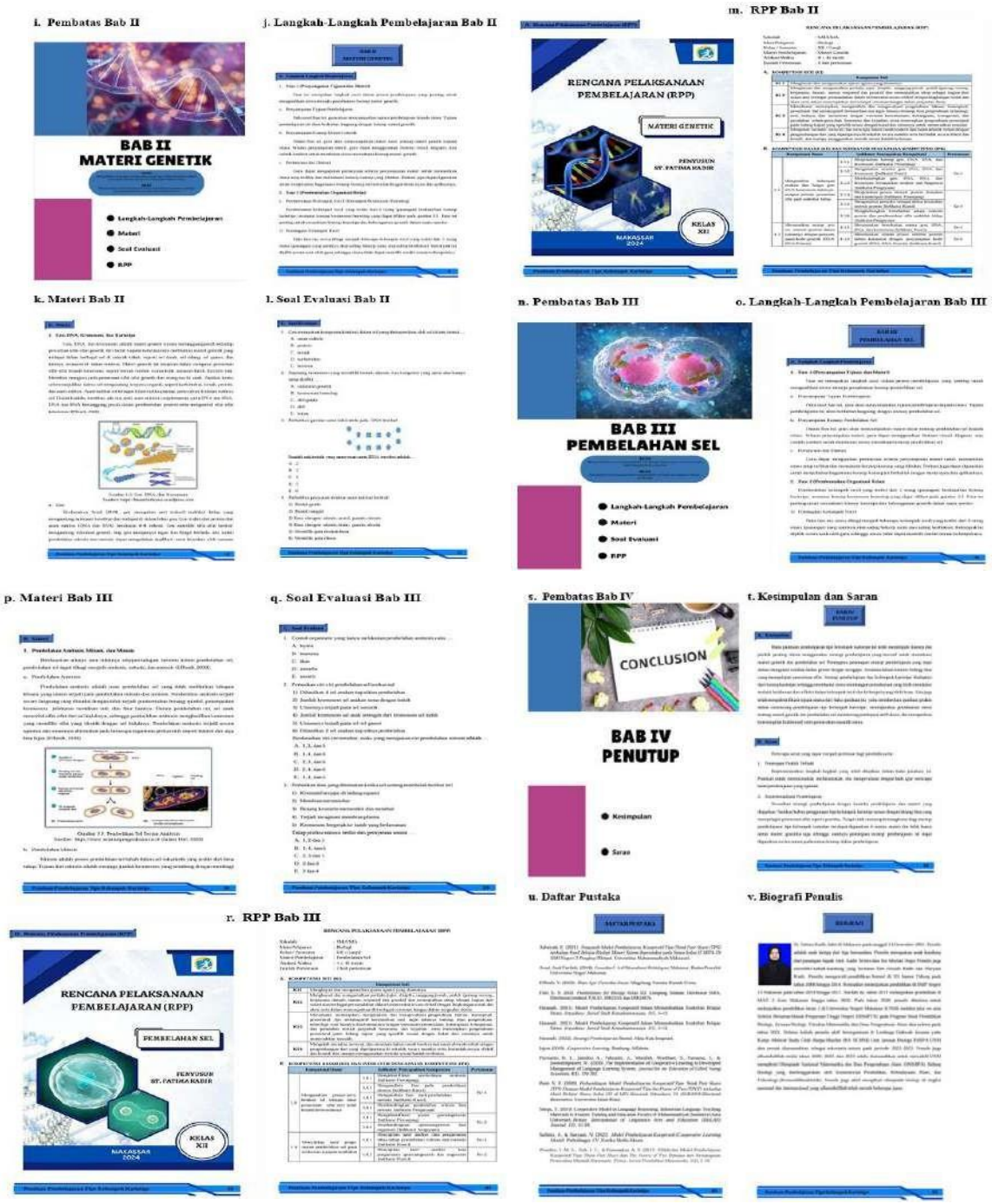


Figure 3. Learning Tool for Karyotype Group Types in Genetic Material Class XII SMA

b. Product Validation

The product that has been created will then be assessed by a validator to obtain validation data as a reference that the product developed has met valid criteria and is suitable for use in school learning. Obtained several suggestions from validators to improve the product being developed. Next, the learning device product assessment was carried out by the validator, which can be seen in Table 8 and Table 9 below.

Table 8. Validation Results of Learning Guidebook

No.	Aspect	Maximum Score	Shoes Validator 1	Shoes Validator 2	Average Score
1.	Content/Content	36	35	35	35
2.	Construction	40	37	39	38
3.	Language	32	30	31	30,5
	Total Shoes	108	102	105	103,5
	Percentage	100%	94,44%	97,22%	95,83%
	Category	Very Valid	Very Valid	Very Valid	Very Valid

Table 9. Results of Validation of Learning Implementation Plans (RPP)

No.	Aspect	Maximum Score	Shoes Validator 1	Shoes Validator 2	Average Score
1.	Content/Content	96	93	96	94,5
2.	Construction	68	67	66	66,5
3.	Language	12	11	12	11,5
	Total Shoes	176	171	174	172,5
	Percentage	100%	97,16%	98,86%	98,01%
	Category	Very Valid	Very Valid	Very Valid	Very Valid

The average assessment results from the two validators in Table 8 are 95.83% for the learning guidebook and in Table 9 it is 98.01% for the RPP which is in the interval 80% < P ≤ 100%, namely in the very valid category, so the product declared valid and suitable for use in learning.

Table 10. Learning Device Validation Results

No	Product	Validator		Average
		1	2	
1	Study Guide	102	105	103,5
2	Learning Implementation Plan (RPP)	171	174	172,5
	Amount	273	279	276
	Percentage (%)	96,13%	98,24%	97,18%
	Category	Very Valid	Very Valid	Very Valid

The average assessment results from the two validators based on Table 10 for the overall learning device is 97.18% which is in the interval 80% < P ≤ 100%, namely in the very valid category, so the product is declared valid and suitable for use in learning.

The karyotype group type learning tool developed in this research refers to the Research and Development (R&D) development model, namely the ADDIE model which consists of five main stages, namely the analysis stage (*analysis*), design stage (*design*), development stage (*deve-lopment*), implementation stage (*implemen-tation*), and evaluation stage (*evaluation*). The implementation and evaluation stages of this research were not carried out because this research only reached the valid stage. After going through several stages, valid learning tools are produced. Based on the results of the needs analysis that has previously been carried out, it shows that the use of learning tools that implement karyotype group type learning strategies in genetic material for class Success in the learning process is the fulfillment of students' needs.

If students' needs are met through effective and efficient learning, then it is likely that the quality of the learning process in the future will increase (Deviyanti and Suci, 2020).

The analysis stage consists of the analysis stage of needs analysis, goal analysis, instructional analysis, and content analysis. The results of the needs analysis at MAN 2 Makassar City through interviews with class XII Biology teachers and 43 class positive by students because it provides a more interactive and enjoyable learning experience. In addition, group learning is sometimes carried out by teachers and is considered to help students understand the material. This shows that there is a need to further integrate active and interactive learning strategies, such as group learning and the application of simulation methods in teaching genetic material and cell division.

In addition, from learning resources, although printed books are the main learning source for students, there is a need for additional explanations from teachers or online references to understand complex genetic material and cell division. This emphasizes the importance of developing learning tools that do not only rely on printed books, but also provide additional learning resources, such as learning videos and teaching modules, which can help students understand the material better. Regarding genetic material and cell division, the majority of students experience difficulties in learning this material, especially concepts that are complex and require high memorization. Group learning is considered to help the majority of students understand the material. Therefore, the development of karyotype group type learning tools can be an effective solution to overcome difficulties in understanding this material. By utilizing group- based learning that integrates karyotype concepts, students can more easily understand genetic material and cell division through discussion, collaboration and joint problem solving.

The results of this needs analysis are in line with research by Arsal *et al*. (2023) that several problems were found in genetics learning. Genetic material is considered difficult because there are many confusing terms and requires deep conceptual understanding. Students' cognitive abilities are also not optimal, especially in understanding scientific terms used in genetics. In addition, the learning methods and strategies used have not been able to overcome all learning problems, such as disinterest in courses and difficulty understanding the material. As a solution, the development of a cooperative-karyotyping learning strategy is proposed. This strategy involves dividing groups based on groupings on chromosomes, allowing each participant to have a role in the group and making it easier to understand scientific terms. Apart from that, this strategy can also be a simulation of learning material, allows identification and analysis of inheritance traits in living things, and is suitable for complex material such as genetics.

The results of the objective analysis show that the learning objectives have been clearly described in accordance with the basic competencies and indicators determined which can be seen in Table 3 (Genetic Material) and Table 4 (Cell Division). From an instructional analysis perspective, it appears that effective learning methods have been considered. Simulation methods and group-based learning strategies are very necessary because they are considered effective in understanding genetic material and cell division. In addition, students prefer learning resources that are easy to understand, interesting and easy to access such as teaching modules,

learning videos and presentations. This indicates that the use of diverse and interesting learning resources will increase students' interest and understanding of the material. Content analysis provides an overview of the structure of genetic material and cell division that will be contained in the learning tool. A clear material structure helps in preparing learning content that is structured and easy for students to understand. The structure of the material can be seen in Figure 1 (Genetic Material) and Figure 2 (Cell Division).

The design stage begins with designing the learning device by selecting and determining the required device specifications, in this case the required hardware and some software that supports development. The design stage used in developing this learning tool was using Microsoft Word and Canva applications. The researcher used Microsoft Word to prepare the content and the Canva application to design the cover and several parts of the learning tool. The Canva application was chosen because it can produce higher quality graphic designs and is equipped with various interesting and complete features, making it easier for researchers to design more creative designs. After completing the design, it is then converted into a Portable Document Format (PDF) file which is then printed.

The development stage carried out is developing learning tools that have been previously designed and adapted to the analysis stage that has been carried out and testing the validity of the product being developed. The learning tools that have been developed have undergone several revisions from the validators. These revisions include adding a campus logo, deleting the word "book", correcting the title, and providing specific information about Basic Learning Competencies (KD) and the book's target audience. The reason for this revision is to clarify the identity of the institution, avoid confusion regarding the type of material provided, and the objectives of the learning tools.

Apart from that, the inner cover of the learning tool was also adjusted to the outer cover, by changing the white background to a more transparent illustration of the karyotype group type learning strategy. This is done to create visual consistency between the outside and inside of the learning tool, as well as to provide a clearer visual picture of the content of the learning tool. Furthermore, revisions were made to the order, writing and addition of sub-chapters in Chapters II and III. The reason behind this revision is to improve the structure and cohesion of the learning material, making it easier for users to understand and follow. Chapter dividers are also added to each chapter, accompanied by appropriate illustrative images and sub-chapter title information. This aims to make it easier for readers to understand the contents of each chapter. Chapter II which was previously entitled "Theoretical Foundations" was changed to "Genetic Material" and Chapter III was also changed to "Cell Division" to clarify the focus of learning on this topic.

Evaluation questions are added to Sub-Chapter II Genetic Material and Chapter III Cell Division, equipped with an answer key. RPPs have also been added to the two sub- chapters, complete with assessment instruments for attitudes, skills and knowledge. An introductory sentence before attaching a video link for learning karyotype group types is included, by changing the background from blue to white. The goal is to provide clearer context for the learning video that will be presented and improve visual consistency with other parts of the learning tool. Finally, a complete

author biography was added to provide information about the author's background and credibility to learning tool users. This revision aims to improve learning tools so that they comply with established criteria.

The product validation sheet will be assessed by expert validators. This validation is carried out to assess whether the product being developed is valid and suitable for use in the learning process (Sugiyono, 2019). The validation sheet consists of 3 aspects, namely content, construction and language aspects. The average assessment results from the two validators for the product in Table 4.7 were 95.83% for the learning guidebook and in Table 4.8 it was 98.01% for the RPP. The average assessment results from the two validators for the overall learning tools in Table 4.9 is 97.18%. The conclusion obtained is that the product validation results are in the interval $80\% < P \leq 100\%$, namely in the very valid category, so the product is declared valid and suitable for use in learning.

CONCLUSION

Based on the results of the research and development carried out, it can be concluded that the average results of the two validators' assessments of the learning tools as a whole are 97.18% which is in the interval $80\% < P \leq 100\%$, namely in the very valid category, so it can be concluded that the product The karyotype group type learning tool in class XII high school genetics material was declared valid and suitable for use in learning. It is hoped that this learning tool that applies the karyotype group type learning strategy can be used as a guide for biology teachers in class XII high school genetics material. However, it does not rule out the possibility that the application of this learning strategy can be applied to material other than genetics. Further development to the stage of testing the practicality and effectiveness of karyotype group type learning tools in class XII high school genetics material is highly expected.

SUGGESTION

Based on the research results, the researchers suggest that learning tools using the karyotype group type learning strategy be used as a guide for biology teachers in teaching genetics material for class XII high school, although this strategy also has the potential to be applied to other materials outside of genetics or at other levels. In addition, further development to the stage of testing the practicality and effectiveness of this learning tool on genetic material is highly expected to ensure its benefits in the learning process.

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