RANGE : Jurnal Pendidikan Matematika
e-ISSN :2685-2373

Volume 6, Nomor 1, Juli 2024, pp. 49-58

Designing Student Worksheets (LKM) Based on the Rigorous Teaching and Learning (RTL) Model

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Received: December 11th, 2023. Accepted: March 30th, 2024. Published: July 30th, 2024.

ABSTRACT

This research aims to design Student Worksheets (LKM) for the Discrete Mathematics course, where the LKM design is structured so that the LKM can be used in the Rigorous Teaching and Learning (RTL) learning model. The results of the lecturers' reflections found that the main problem lies in the content of the material in textbooks which is not interesting, students are often unable to understand the textbooks they own, especially in solving the questions given. This has implications for 1) lack of motivation to learn, 2) lack of understanding of the material, 3) fear of expressing opinions, and 4) lectures are less effective and less enjoyable. Therefore, teaching materials need to be packaged appropriately according to the substance and conditions of students in LKM. The research design used in this research is Thiagarajan's 4-D development model. This model is a system of educational development approaches that are carried out in 4 sessions, namely Define or Introduction where in this session preliminary analysis, student analysis, and needs analysis are carried out, Design or Planning where in this session what is done is format selection, initial design and design preparation, Develop or Development where in this session validation and limited trials are carried out, as well as Disseminate or Disseminate where in this session the LKM is given to the teaching lecturers. This research produces an LKM that is used in Discrete Mathematics courses.

Keywords: student worksheet, discrete mathematics, rigorous teaching and learning

How to Cite: Mirza, A., Pasaribu, R. L. & Simarmata, J. E. (2024). Designing Student Worksheets (LKM) Based on the Rigorous Teaching and Learning (RTL) Model. *Range: Jurnal Pendidikan Matematika*, 6 (1), 49-58.

Introduction

Learning mathematics is one of the most important lessons at every level of education (Pono & Lutfi, 2012; Wanti, 2017) . With mathematics, someone will be able to think more critically, and creatively, be able to solve problems, and think logically (Purwanto et al., 2019) . Therefore, it is very important to provide an interesting and enjoyable learning experience so that students can receive mathematics learning well. To provide interesting learning, we need a way to improve the quality of learning (Febriani, 2016), namely by determining the right way of learning for these students. With the demands of the 21st century, with the main aim being to build individual learning abilities and support their development to become lifelong, active, and independent learners, students are expected to be more active in the ongoing learning process (Etistika Yuni Wijaya et al., 2016; Mellick, 2018).

According to Syah (Rusno, 2011) some factors influence student activity in learning, namely internal and external factors, where internal factors are factors that originate from the students themselves

which include 1) Physiological factors which include physical health, 2) psychological factors which include: attention, talent, interest, motivation, maturity, and readiness. (Rusno, 2011) found that the internal factors mentioned by Syah were the dominant factors influencing students' activeness in the learning process. To create activity in students, it is very necessary to apply active learning strategies that lead to managing learning individually or in groups and placing students as subjects who must plan, explore, interpret, and evaluate their learning results. Teachers as facilitators must always be ready to serve students' learning needs (Andrias, 2011). Teachers are required to be able to create active and enjoyable learning situations so that they can support the optimal absorption of material by students (Febriani, 2016).

Activeness in the learning process is a very important internal affective domain. Educational experts and researchers have emphasized that activity can support successful learning. (Ibrahim, 2021) in a study revealed empirical findings that student activity in the active learning process is very effective in increasing student learning success. According to (Pratiwi, 2017) there is a positive and significant influence of student activity on learning outcomes. Utomo and Ruijter (Febriani, 2016) also stated that "Learning actively in varied ways while paying attention to the structure will be understood better and will be remembered longer." These findings reinforce the importance of the active aspect in participating in learning. Efforts to increase student activity require practicing educational innovations that can make students more active when exploring education, one of which is the educational model used (Ibrahim, 2021; Rustini, 2021).

One learning model that requires student activity is Rigorous Teaching and Learning (RTL). According to Rhodes (Hamid, 2016) Hamid emphasized that there are 3 characteristics of students who participate in rigorous learning, namely: 1) they display a set of attitudes that include task intensity, orderly arrival, and prolonged attention. 2) emotionally, they display excitement, interest in learning, and a sense of belonging, 3) they display cognitive engagement by taking on academic challenges, a positive self-concept, and a willingness to continue learning. RTL has core components that will increase the effectiveness of teachers in advancing student learning. If this component is applied in the lecture process, it is assumed that students will achieve great learning outcomes according to the expected educational focus. According to (Rustianingsih & Manoy, 2013) RTL meets the effective criteria for increasing student activity and results in positive student responses.

Active and fun learning is learning that can be enjoyed by each student so that each individual can devote their attention to the learning process (Indartiwi et al., 2020). Meanwhile, study and learning activities will be disliked if students are in an atmosphere of pressure, threat, fear, feeling, lack of enthusiasm, feelings of boredom, laziness, and monotonous learning (Febriani, 2016). This problem also

arises in learning Discrete courses, especially in the Mathematics Education Study Program at Tanjungpura University. From observations of the lecture process, aspects of student activity in attending lectures need serious attention.

Based on the results of reflection on the Discrete lectures carried out, the main problem lies in the content of the material in the textbook, which is not exciting and makes students bored (inactive), especially when it is only packaged with lecture methods and assignments as has been the case so far. Through interviews conducted with several students who took Discrete courses, it was found that students were often unable to understand the textbooks they had, especially in solving the questions given; of the 28 students in 1 class, data was obtained that only around 22% passed. This has implications for 1) lack of motivation to learn, 2) lack of understanding of the material, 3) fear of expressing opinions, and 4) lectures could be more effective and enjoyable. Therefore, teaching materials must be packaged well with suitable substances, considering the conditions of students equipped with LKM.

According to (Febriani, 2016) there are at least three scientific arguments that confirm the effectiveness of using LKM to increase student activity. First, is the part of the teaching materials that will provide stimulus to students to make them more active. Second, worksheets are used as a learning resource by students. Third, worksheets can also be a means used by students to convey information that cannot be conveyed orally (see Ministry of Education 2006 (Khikmiyah & Midjan, 2017; Ratnasari, 2019)).

Based on the things that have been explained, it is important to design an attractive LKM to be used in the Discrete mathematics learning process based on the RTL learning model in the mathematics education study program of the Faculty of Teacher Training and Education (FKIP) Tanjungpura University (Untan) Pontianak. Specifically, the research question asked in this study is how to design LKM based on the RTL learning model.

This research was carried out to produce an LKM based on the RTL learning model and through this research, it is hoped that it can produce a product in the form of an LKM with preparation based on the RTL learning model which will then be applied in subsequent research. Furthermore, the findings of this research can be published in accredited journals and become study material and input for developing the RTL learning model to support the formation of student activity in the lecture process.

Methods

This model is a system of educational development approaches that are implemented through four sessions, namely Define, Design, Develop, and Disseminate below we describe the stages used in this research based on the 4-D model (Anugraheni, 2018; Hasbi et al., 2021; Prayogo & Suwono, 2021).

This research was conducted from May to November 2023 in the mathematics education study program at FKIP Tanjungpura University, even the semester of the 2023/2024 academic year in the Discrete Mathematics course.

Table 1. *Stages of LKM Development*

No	Development Stage	Stage Description		
1	Define	Preliminary analysis at this stage is carried out by analyzing the curriculum, as well as the learning objectives, and what students' needs for LKM.	Student analysis at this stage will explore information about the student's initial abilities regarding the material	Material analysis at this stage explores the concept of the material being taught and how it is related
2	Design	Format selection at this stage will be the format used to design the LKM	The initial design at this stage will be a draft LKM with its components	In the design preparation at this stage, each component of the LKM will be explained
3	Develop	Expert validation is carried out by submitting a complete LKM draft to be validated internally by experts.	Trial, the LKM that has been validated and revised is then carried out in a limited trial	
4	Desseminate	Valid LKM are distributed to lecturers who teach Mathematics Diskrit		

In this research, the criteria for the validity of the LKM are suitability of the LKM to the learning objectives, material taught, student needs, and readability of the language in the LKM.

Results and Discussion

Define

preliminary analysis

At this preliminary stage, curriculum analysis is carried out on Discrete Mathematics material. This course studies Power Sequences and Series, Mc Laurin Expansion/Taylor series, Generating Functions, Generating Functions for combinations, Generating Functions for permutations, Introduction to Graph Theory which includes definitions/terminology, isomorphism and sub-graphs, graph connectivity, trees, planarity, and graph coloring. In Discrete Mathematics, you are required to have general skills, namely, students will have logical, critical, systematic, and innovative thinking and apply it to discrete mathematics.

Discrete Mathematics courses also require special skills, namely mastering mathematical theoretical concepts, especially geometry, mathematical logic, algebra, analysis, mathematical modeling, and

calculus which supports mathematics learning in primary and secondary education as well as further studies.

Meanwhile, the learning outcomes for the Discrete Mathematics course are that students can master and apply the concept of generating functions to solve problems of selecting, selecting, and distributing objects involving combination and permutation cases and students can master and explain the basic terminology in graph theory, and use it in solving problems.

Student Analysis

Active and fun learning is learning that can be enjoyed by each student so that each individual can devote their attention to the learning process (Indartiwi et al., 2020). Meanwhile, learning becomes unpleasant if students are in a depressed atmosphere, feeling threatened, scared, helpless, unenthusiastic, lazy, bored, and in a monotonous (Febriani, 2016). This problem also arises in learning Discrete courses, especially in the Mathematics Education Study Program at Tanjungpura University. From observations of the lecture process, aspects of student activity in attending lectures need serious attention.

Based on the results of reflection on the Discrete lectures carried out, the main problem lies in the content of the material in the textbook which is not interesting and makes students bored or inactive especially when it is only packaged with lecture methods and assignments as has been the case so far. Through interviews conducted with several students taking Discrete courses, it was found that students were often unable to understand the textbooks they had, especially in solving the questions given. This has implications for 1) lack of motivation to learn, 2) lack of understanding of the material, 3) fear of expressing opinions, and 4) lectures are less effective and less enjoyable. Therefore, teaching materials need to be packaged appropriately according to the substance and conditions of students in the form of Student Worksheets (LKM).

Material Analysis

Course learning outcomes in the Discrete Mathematics course means that students can hold and apply the concept of generating functions to solve problems of selecting, selecting, and distributing objects involving combination and permutation cases and students can master and explain basic terminology in graph theory, and use it in solving problems. However, in this research, students will be able to hold and apply the concept of generating functions to solve problems of selecting, selecting, and distributing objects involving combination and permutation cases. So the material that will be included in this LKM is: Power sequences and series, Mc Laurin expansion and Taylor series, ordinary generating functions and exponential generating functions, generating functions for combinations, and generating functions for permutations.

Design

The LKM format used in this research refers to research conducted by (Hamid, 2016).

Lecture Unit
Meeting 1 to 3

Faculty :
Study Program :
Course :
Course Code :
Time Allocation :

Learning Outcomes :
Indicator:
Matterial:
Learning Methods:
Langkah-langkah Pembelajaran:

A. Learning Steps :
B. Core Learning Activities :
   1. Communicate explicitly and with clarity
   2. Involve students in learning
   3. Question, probe, and facilitate discussion
   4. Provide feedback to students
   5. Use various grouping structures
C. Final Learning Activities:
D. Final Test:
E. Learning Auds and Resources

1. Aids
2. Resources:

HOME WORK

Kelompok:
Nama:

1. ..... NIM: .....

2. ..... NIM: .....

3. ..... NIM: .....

4. ..... NIM: .....

5. ..... NIM: .....

6. ..... NIM: .....

LKM

(Meeting -01)

Faculty	***: KIP***
Study Programs	***: Mathematics Education***
Courses	***: Discrete mathematics***
Material	***: Generating function***
Sub Material	***: Barisan & Deret Kuasa, Ekspansi Deret Taylor/Mc Laurin.***
Time	***: 3 x 50 menute***
Semester	***: V/odd***

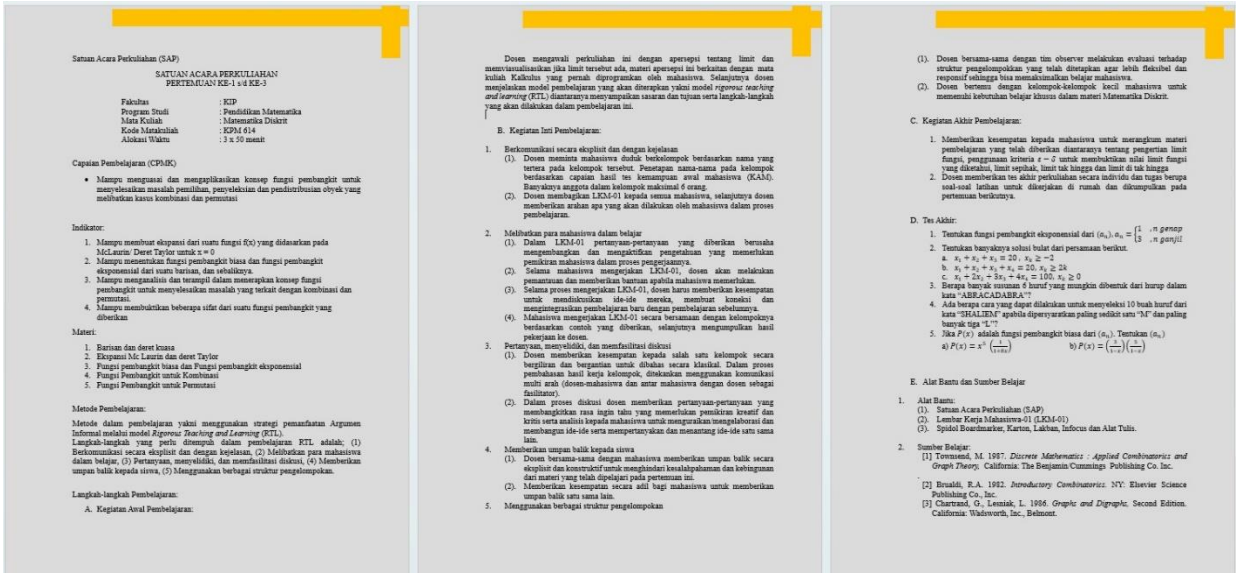
Instructions:

- Student worksheets are a medium for discussion within a group or between groups
- Fill in and complete the statement and answer the questions in the space provided on the LKM
- Each group is required to fill in and complete the answers to 2 (two) LKMs and then one LKM is submitted to the lecturer concerned and the other one becomes group documentation
- If you feel it is necessary, you are allowed to ask and clarify questions from the lecturer

Material

Initial Planning

After the format is determined, the LKM is designed



Satuan Acara Perkuliahan (SAP)

SATUAN ACARA PERKULIAHAN
PERTEMUAN KE-1 s/d KE-3

Fakultas : KIP
Program Studi : Pendidikan Matematika
Mata Kuliah : Matematika Diskrit
Kode Matakuliah : KPM 614
Alokasi Waktu : 3 x 50 menit

Capaian Pembelajaran (CPMK)

- Mampu menguasai dan mengaplikasikan konsep fungsi pembangkit untuk menyelesaikan masalah pemilihan, penyeleksian dan pendistribusian obyek yang melibatkan kasus kombinasi dan permutasi

Indikator:

1. Mampu membuat ekspansi dari suatu fungsi f(x) yang didasarkan pada McLaurin/ Deret Taylor untuk x = 0
2. Mampu menentukan fungsi pembangkit biasa dan fungsi pembangkit eksponensial dari suatu barisan, dan sebaliknya.
3. Mampu menganalisis dan terampil dalam menerapkan konsep fungsi pembangkit untuk menyelesaikan masalah yang terkait dengan kombinasi dan permutasi.
4. Mampu membuktikan beberapa sifat dari suatu fungsi pembangkit yang diberikan

Materi:

1. Barisan dan deret kuasa
2. Ekspansi Mc Laurin dan deret Taylor
3. Fungsi pembangkit biasa dan Fungsi pembangkit eksponensial
4. Fungsi Pembangkit untuk Kombinasi
5. Fungsi Pembangkit untuk Permutasi

Metode Pembelajaran:

Metode dalam pembelajaran yakni menggunakan strategi pemanfaatan Argumen Informal melalui model *Rigorous Teaching and Learning* (RTL).
Langkah-langkah yang perlu ditempuh dalam pembelajaran RTL adalah; (1) Berkomunikasi secara eksplisit dan dengan kejelasan, (2) Melibatkan para mahasiswa dalam belajar, (3) Pertanyaan, menyelidiki, dan memfasilitasi diskusi, (4) Memberikan umpan balik kepada siswa, (5) Menggunakan berbagai struktur pengelompokan.

Langkah-langkah Pembelajaran:

A. Kegiatan Awal Pembelajaran:

Dosen mengawali perkuliahan ini dengan apersepsi tentang limit dan memvisualisasikan jika limit tersebut ada, materi apersepsi ini berkaitan dengan mata kuliah Kalkulus yang pernah diprogramkan oleh mahasiswa. Selanjutnya dosen menjelaskan model pembelajaran yang akan diterapkan yakni model *rigorous teaching and learning* (RTL) diantaranya menyampaikan sasaran dan tujuan serta langkah-langkah yang akan dilakukan dalam pembelajaran ini.

B. Kegiatan Inti Pembelajaran:

1. Berkomunikasi secara eksplisit dan dengan kejelasan
   (1). Dosen meminta mahasiswa duduk berkelompok berdasarkan nama yang tertera pada kelompok tersebut. Penetapan nama-nama pada kelompok berdasarkan capaian hasil tes kemampuan awal mahasiswa (KAM). Banyaknya anggota dalam kelompok maksimal 6 orang.
   (2). Dosen membagikan LKM-01 kepada semua mahasiswa, selanjutnya dosen memberikan arahan apa yang akan dilakukan oleh mahasiswa dalam proses pembelajaran.
2. Melibatkan para mahasiswa dalam belajar
   (1). Dalam LKM-01 pertanyaan-pertanyaan yang diberikan berusaha mengembangkan dan mengaktifkan pengetahuan yang memerlukan pemikiran mahasiswa dalam proses pengerjaannya.
   (2). Selama mahasiswa mengerjakan LKM-01, dosen akan melakukan pemantauan dan memberikan bantuan apabila mahasiswa memerlukan.
   (3). Selama proses mengerjakan LKM-01, dosen harus memberikan kesempatan untuk mendiskusikan ide-ide mereka, membuat koneksi dan mengintegrasikan pembelajaran baru dengan pembelajaran sebelumnya.
   (4). Mahasiswa mengerjakan LKM-01 secara bersamaan dengan kelompoknya berdasarkan contoh yang diberikan, selanjutnya mengumpulkan hasil pekerjaan ke dosen.
3. Pertanyaan, menyelidiki, dan memfasilitasi diskusi
   (1). Dosen memberikan kesempatan kepada salah satu kelompok secara bergiliran dan bergantian untuk dibahas secara klasikal. Dalam proses pembahasan hasil kerja kelompok, ditekankan menggunakan komunikasi multi arah (dosen-mahasiswa dan antar mahasiswa dengan dosen sebagai fasilitator).
   (2). Dalam proses diskusi dosen memberikan pertanyaan-pertanyaan yang membangkitkan rasa ingin tahu yang memerlukan pemikiran kreatif dan kritis serta analitis kepada mahasiswa untuk mengurutkan mengelaborasi dan membangun ide-ide serta mempertanyakan dan menantang ide-ide satu sama lain.
4. Memberikan umpan balik kepada siswa
   (1). Dosen bersama-sama dengan mahasiswa memberikan umpan balik secara eksplisit dan konstruktif untuk menghindari kesalahpahaman dan kebingungan dari materi yang telah dipelajari pada pertemuan ini.
   (2). Memberikan kesempatan secara adil bagi mahasiswa untuk memberikan umpan balik satu sama lain.
5. Menggunakan berbagai struktur pengelompokan

(1). Dosen bersama-sama dengan tim observer melakukan evaluasi terhadap struktur pengelompokkan yang telah ditetapkan agar lebih fleksibel dan responsif sehingga bisa memaksimalkan belajar mahasiswa.
(2). Dosen bertemu dengan kelompok-kelompok kecil mahasiswa untuk memenuhi keburuhan belajar khusus dalam materi Matematika Diskrit.

C. Kegiatan Akhir Pembelajaran:

1. Memberikan kesempatan kepada mahasiswa untuk merangkum materi pembelajaran yang telah diberikan diantaranya tentang pengertian limit fungsi, penggunaan kriteria $x = 0$ untuk membuktikan nilai limit fungsi yang diketahui, limit sepihak, limit tak hingga dan limit di tak hingga
2. Dosen memberikan tes akhir perkuliahan secara individu dan tugas berupa soal-soal latihan untuk dikerjakan di rumah dan dikumpulkan pada pertemuan berikutnya.

D. Tes Akhir:

1. Tentukan fungsi pembangkit eksponsial dari $(a_n), a_n = \begin{cases} 1 & ,n \text{ genap} \\ 3 & ,n \text{ ganjil} \end{cases}$
2. Tentukan banyaknya solusi bulat dari persamaan berikut.
   a. $x_1 + x_2 + x_3 = 20$, $x_k \geq -2$
   b. $x_1 + x_2 + x_3 + x_4 = 20$, $x_k \geq 2k$
   c. $x_1 + 2x_2 + 3x_3 + 4x_4 = 100$, $x_k \geq 0$
3. Berapa banyak susunan 6 huruf yang mungkin dibentuk dari hurup dalam kata "ABRACADABRA"?
4. Ada berapa cara yang dapat dilakukan untuk menyeleksi 10 buah huruf dari kata "SHALIEM" apabila dipersyaratkan paling sedikit satu "M" dan paling banyak tiga "L"?
5. *Jika* $P(x)$ adalah fungsi pembangkit biasa dari (a_n). Tentukan (a_n)
   a) $P(x) = x^5 \left(\frac{1}{1-x}\right)$ b) $P(x) = \left(\frac{1}{1-x}\right)\left(\frac{1}{1-x}\right)$

E. Alat Bantu dan Sumber Belajar

1. Alat Bantu:
   (1). Satuan Acara Perkuliahan (SAP)
   (2). Lembar Kerja Mahasiswa-01 (LKM-01)
   (3). Spidol Boardmarker, Karton, Lakban, Infocus dan Alat Tulis.
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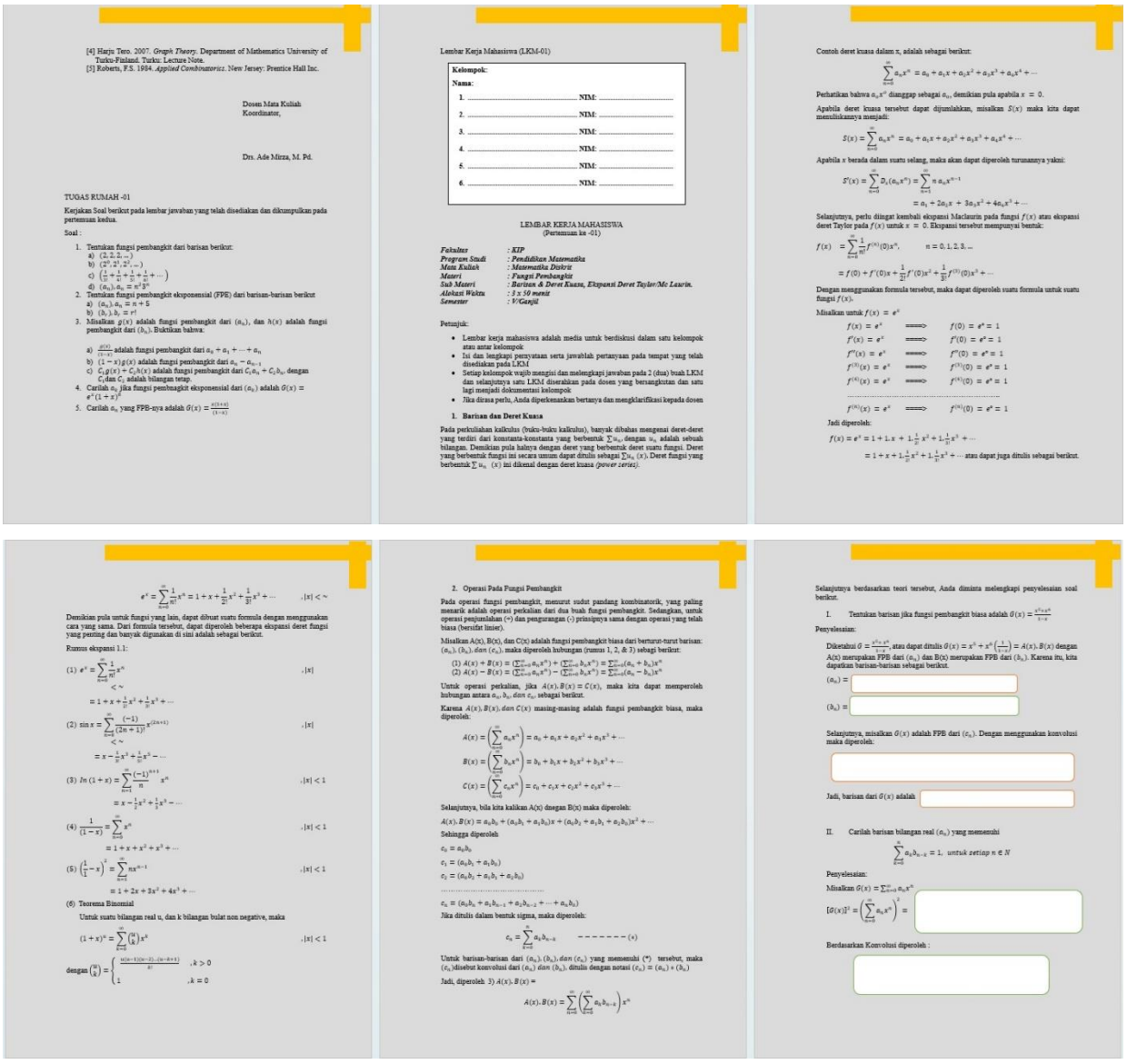

***Figure 1**. LKM that has been designed*

Develop

The LKM that has been designed has been validated by three Mathematics Education Study Program lecturers who are experts in their field. This LKM is validated from the content, namely the suitability of the LKM to the learning objectives, learning materials, and readability of the language in the LKM. From the three validators, revisions were obtained in the material, formula writing, and readability. After the revisions were carried out, the LKM was declared valid because it was in accordance with the learning objectives, material, and readability and was suitable for limited testing. After being declared

valid, the LKM was tested limited to 42 Mathematics students taking discrete mathematics courses consisting of 2 classes.

Desseminate

LKM that has been declared valid is then given to every lecturer who teaches Discrete Mathematics courses.

Conclusion

The LKM designed in research uses the strategy of utilizing Informal Arguments through the Rigorous Teaching and Learning (RTL) model. The RTL steps used are; (1) Communicate explicitly and with clarity, (2) Engage students in learning, (3) Question, probe, and facilitate discussion, (4) Provide feedback to students, (5) Use a variety of grouping structures. However, the preparation of this LKM has shortcomings, the LKM was tested on students who had taken the Discrete Mathematics course in the previous semester, so it was indicated that the students had forgotten the material studied in this course. Furthermore, you can develop Discrete Mathematics LKM to be used more effectively and efficiently by students.

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