

Designing Board Game Based Learning Products as A Learning Medium for Light Matter and Optical Devices Physics for Junior High School Children

T G Amran^{1,3}, V Darmaputra^{1,4} and W Kurniawan^{1,5}

¹University of Trisakti, Jl. Kyai Tapa No. 1, Jakarta, Indonesia

²tiena@trisakti.ac.id, ³valendio063001700073@std.trisakti.ac.id, ⁴wawan@trisakti.ac.id

Abstract. The world of education is currently one of the areas that are experiencing the adverse effects of Covid-19 virus. The students' learning outcomes will not be as much as face-to-face learning, because the average student's competence is only met by 50% with the decrease in average grades by 30%. Data obtained from an interview with Math Teacher at SMP Budi Mulia, Central Jakarta represent teachers' complaints. There is a need for additional media development in the form of Board Game Based Learning that can support distance learning during the pandemic for junior high school students. Designing product business models such as Design Thinking, Value Proposition Canvas, Lean Canvas, Business Model Canvas, and Blue Ocean Strategy, validation, and business feasibility calculation with Break Even Point can aid student competence. Design Thinking can help students to comprehend the customer demands. Value Proposition Canvas proposes the design of Board Game Based Learning in Physics of light materials and optic tools help students understand the material, reduce boredom, increase psychomotor use, and Blue Ocean Strategy creates superior product innovations from competitors in terms of single mode, additional formulas, without competitors for science subjects. Thus, new learning system was based on and conformed to the 2013 Secondary curriculum. The Validation Test shows that 78.37% of respondents agreed with the design of the MVP concept, and 82% agreed to furniture products. The business feasibility test declared feasible with the BEP Unit of 44.29 units, and a payback period of 0.12 months.

Keywords: Design Thinking, Model Canvas, Blue Ocean strategy, Board Game, Education

10. Introduction

Starting from March 16, 2020, formal education in schools was transferred to distance learning (DL) which was carried out individually in their respective homes. Academically, there is certainly a decrease in student learning outcomes because no matter how our teachers provide material, of course, the total material is far below the normal situation when those children are learning face-to-face." [1]. The decline in student learning outcomes will not be as good as face-to-face learning, because the average student's competence is only met by 50% which leads to a decrease in the average score by 30%. The data are obtained from an interview with a Mathematics Teacher at Budi Mulia Junior High School, Central Jakarta, who represented the complaints of teachers [2].

Learning media is a tool for teachers in the process of learning activities. Only with the right learning media can students take part in Distance Learning. However, there are still many shortcomings related to learning media, especially Distance Learning. A UNICEF survey in June 2020 stated that 66% of junior high school students in Indonesia feel uncomfortable studying at home. As many as 38% stated that the limitations of existing learning media make it difficult for students to understand the subject matter presented by the teacher. Students' limitations in

understanding the material are also hampered because the 3 aspects of educational evaluation cannot be fulfilled optimally, especially affective and psychomotor. It requires additional learning media that can support 3 aspects of educational evaluation, namely cognitive, affective, and also psychomotor.

Middle school students are early adolescence where they will begin to enter the transition phase from childhood to early adolescence (preteen) at the age of 12-15 years. The learning phase of junior high school students is currently included in the stage of material visualization and also its application in life. Where the introduction phase has been passed in elementary schools and the further material analysis phase will be carried out in high schools [3]. Board games will train children's concentration, memory, and train the creative and critical side of junior high school children.

Students aged 12-15 years are classified as teenagers where most of them prefer to play games instead of studying, referring to research by the University of Michigan, United States which states that 86% of adolescents are addicted to playing online games. This principle is in accordance with the application of gamification or more popular with game-based learning as a new learning medium in Indonesia that utilizes games as a means of absorbing material. According to Nick Pelling Gamification is a learning approach using elements in games or video games with the aim of motivating students in the learning process and maximizing the feeling of enjoyment and engagement of the learning process [4]. Regarding the competitors of the specific board game design, there has not been a circulating board game developed specifically for learning media for junior high school children aged 12-15 years. Most board games on the market are general to all ages. Currently, there is still no board game that is able to specifically related to the material taught in the curriculum of junior high school children. Board games on the market provide more knowledge with themes that are basic knowledge that are not related to the curriculum, such as aquatic games that aim to preserve the sea.

The main problem on which the research is based is the ineffectiveness of distance online learning media currently junior high school students aged 12-15 years. (based on the results of previous studies) This has an impact on reducing the quality of education in Indonesia which is not optimal

The purpose of this study was to design a Board Game-based learning product that will be used as a learning medium for Junior High School children. The research will limit the participants on junior high school students aged 12-15 years with data collection starting from December 2020 to June 2021.

Business is an activity that aims to get a profit for those who run it or who are interested. Business is also related to the business carried out by a corporate institution or organization to produce goods or services [4]. A Business Model is simply described as the rationale for how an organization creates, conveys, and captures a value[5]. Of course, a quality business model will be able to compete with competitors. Board game is a game that is applied in the form of a game board design that is played by two or more people. Generally, components of a board game can use coins, dice, pawns, cards or the like that are used in a certain way, according to the rules of each existing game theme [6].

Learning media is defined as an intermediary, or introductory that builds conditions for students to be able to acquire 19 knowledge, skills or attitudes. Generally, the media used are teachers and textbooks [7]. A good learning medium must be able to communicate the essence of the material from the teacher to the students. The initial stage of Design Thinking is a method of human-focused

approach to innovation drawn from designer tools to integrate human needs, technological possibilities, and requirements for business success [8]. There are 5 stages of design thinking, namely: empathize, define, ideate, prototype, and testing. Value proposition canvas is a tool used to help companies explain or create value for customers regarding the products or services we sell. This is necessary so that the value proposition reaches a fit with customer segments and can help solve problems in that segment [9]. The relationship between value map and customer profile must always match. The FIT in question is appropriate and interrelated with each other. The reason is because both have a relationship of harmony with each other where the customer profile is in the form of observations and questions about the needs, opportunities, and risks of the customer. While the value map is a solution to the statement on the customer profile in the form of an answer.

Lean canvas makes it easy for businesses to be accepted and planned according to market needs. Lean startups focus on problems, solutions, key metrics and competitive advantage. Consists of 9 components, namely: customer segment explaining the target customer, problem 3 problems to be overcome, solution becomes the answer to the problem. Next are: unique value proposition, key metric that is the benchmark of the business, unfair advantage, which is an advantage that only the company has. The last 3 components are: channel, revenue stream, cost structure.

Business Model Canvas is a more complete version of Lean Canvas that explains more details related to the company's business processes, covering customer strategy, products, and also finance by using this business model, we can describe and narrow down several aspects of the business as a whole strategy [10]. This business model canvas consists of nine elements that can support the running of a company's business. There are many components in the BMC. Customer segment (CS), which is to determine the target customer segment of the product or service to be designed. Value proposition (VP), which is the uniqueness of the designed product. Customer relationship (CR), which explains the relationship with the customer. Channel (CH), which is a way to reach customers using media. Revenue stream (RS) is the flow of receiving money that will be received from each customer. Key resources (KR) are the main resources involved and become the most important asset needed in creating a business model, Key activities (KA) are the main business activities Key partners (KP) are partnership keys that describe supplier networks. Cost structure (CR) is a cost structure that describes all costs incurred in a business.

Blue Ocean Strategy is one of the marketing strategies that is widely used today which is the opponent of the Red Ocean Strategy. Blue Ocean Strategy describes an industry that does not exist in the broad market today and without competition such as Red Ocean Strategy [11]. The Blue Ocean Strategy begins by creating an initial strategy canvas, followed by 4 steps working schemes, compiling ERRCs, utility maps, and new schema indexes.

Minimum Viable Product is an advanced stage of design thinking after passing the prototype formulation stage and is ready to enter the test or testing stage. The goal is to get input as well as suggestions and criticisms from early product design adaptors. Generally, MVP will provide the most important features of the product that are the uniqueness of the product.

Business feasibility test uses the method used to consider the feasibility of a business from the financial side. The suitability of the return time of capital with expenses to become a reference for the business can be said to be feasible and can be continued [12]. The calculations carried out are related to finding break event points and payback periods.

The Validation Test is the final stage of a series of business designs where it becomes a method used to prove whether a business model is valid or not [13]. Testing was carried out using many data collection methods, one of which was to use questionnaires to early adaptors to assess pre-

designed MVP performances. It takes 70 percent of the total respondents to declare the product valid and wants to be used by customers. By using the Likert scale as a reference in assessing the response of respondents.

11. Research Methodology

The research methodology describes the stages carried out to obtain and process the data used in the final project research. The research stage is carried out to produce product designs in the form of prototypes which will later be validated. In a research, steps are needed to achieve the research objectives in chapter 1.

The first step is to conduct previous research related to problems in the object of research, namely junior high school learning media, and research subjects, namely the processing of junior high school students aged 12-15 years during the pandemic. It continued with the literature study stage as material for theoretical studies and also use literature studies related to journals that are in line with the research. The main problem was the study is based is the ineffectiveness of distance online learning media currently among junior high school students aged 12-15 years old. This has an impact on reducing the quality of education in Indonesia which is not optimal Therefore, a study was designed that aims to design Board Game-based learning products that can be utilized as learning media for junior high school (SMP) children. Data collection was aimed to obtain information and data related to the research topic. This study used Primary Data and Secondary Data. The primary data used is survey [14] data from the results of 3 questionnaires: empathy map, customer job, Solution Demo validation, and competitor data. The secondary data used was interview with customers and interviews with teacher, junior high school students, and board game designers.

Data processing was conducted by Microsoft word, Microsoft excel, Visio, and Google Forms web site. The data processing process began with the design thinking stage to sharpen and find the main problem to be solved using the empathy method and the classification of the problem becomes more specific. Followed by the preparation of knowing the appropriate customer including the job to be done, customer persona determination, and pain and gain compilation. Followed by the stage of customer needs compilation with the value proposition canvas. The next stage was to develop a prototype framework using lean canvas, Business Model Canvas, and blue ocean strategy to reduce competition. After that, it continued to the test stage with MVP injection that includes specifications and product mechanisms. Continued trial phase and also market acceptance. This strategy can be processed related to the results of product design validation and then tested for business feasibility to find out BEP and profit product design validation to then be tested for business feasibility to find out BEP.

12. Result and Discussion

12.1. EMPHATIZE

The research stage begins with conducting the first design thinking method, namely empathize. Empathize, the stage of studying the problem, recognizing the user and finally to find out what the consumer wants from the problem at hand. Stage of studying related problems: Problems in online learning media for junior high school children aged 12-15 years. Data are taken from the results of interviews with teachers, parents, and also students. In addition, data was also obtained from 31 respondents to the Empathy Map questionnaire.

Table 1. Subjective Problems

The problem of online learning media in junior high school students aged 12-15 years		
Teacher	Student	Parents
Student competence is only fulfilled by 50%	Difficulty understanding the material provided by the teacher	Limitations of parents to accompany children in understanding the material
The average decrease in value is about 30%	Less serious in following learning and tend to play games	Prolonged negative effects of excessive use of gadgets
Untimely task collection	Too many tasks assigned by the teacher	Children tend to be lazy to study
Student activity and interaction rates are only 75%	Lack of focus, lack of interaction and inactivity in learning	Financial limitations that require buying gadgets and internet packages
Technological and network limitations	Students are not enthusiastic and easily get bored	Network/signal limitations due to region

Table 2. Problems in Terms of Learning Media

The problem of online learning media in junior high school students aged 12-15 years		
Media conference (zoom)	Google Class Room	WhatsApp Group
2-way but limited	1-way	2-way but limited
Substitute for face-to-face sessions	Task Collection	Communication media
Signal and network constraints	Frequent system errors related to deadlines	Minimum response from students and teachers
Consumes a lot of quota	Minimal quota	Minimal Quota
Direct online interaction between students and teachers	No Interaction	Minimal interaction

he distribution of the questionnaire to 31 respondents after processing concluded that complaints of problems related to online learning during the pandemic from each subject were as follows:

1. **Teacher or Lecturer** : The learning that is applied today is still not optimal and efficient because it cannot touch the overall aspects of education which has an impact on the difficulty of understanding concepts and materials in students due to lack of supervision and interaction which leads to a decrease in grades. Plus network problems and also minimal technology
2. **Tutor or private teacher** : Lack of practice that makes it difficult for students to understand the material being taught.
3. **Parents** : Network limitations, damage to children's eyes due to excessive use of gadgets, lack of enthusiasm and unfocused while studying, and children prefer to play games
4. **JHS students** : The lack of teacher guidance to students in understanding difficult material, this can occur because the delivery of material from the teacher is too little and difficult for students to understand. Plus the absence of a practicum makes learning boring with so many tasks piling up.
5. **College Students** : Boring learning and also network limitations.
6. **Siblings** : Difficulty understanding of the material and eye damage in a child due to excessive use of gadgets.

The next is grouping the problems per category of respondents is synchronized with the main reference being junior high school students aged 12-15 years as users and early adapters or the main target consumers of the product. Then several contexts of the problem to be solved are obtained:

1. The absence of a practicum that supports psychomotor aspects in junior high school students aged 12-15 years.
2. Difficulty delivering material from the teacher to students which makes it difficult for students to understand the given subject matter. Leads to a decrease in student grades.
3. Limited use of existing learning media due to network constraints and also difficulties in using technology.
4. Today's online learning is boring and non-interactive that leaves students unfocused, inactive, and playing games more often
5. Negative impact on eye health on excessive use of gadgets.

12.2. DEFINE

This Define stage is a continuation of Emphaty Map to find problems that customers want to solve. The data used came from the distribution of Customer Job questionnaires filled out by consumers,

namely junior high school children aged 12-15 years with a total of 44 respondents. In addition, it is also combined with problem data that has been previously concluded at the emphasize stage.

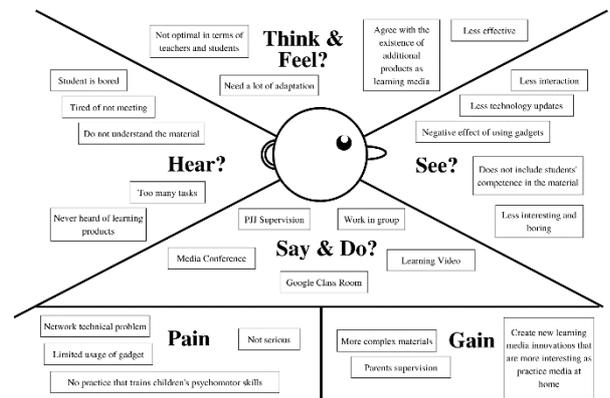
12.2.1. Job to be done

Job to be done will explain the work that consumers want to complete. The main consumers of board game based learning are junior high school children aged 12-15 years. Job to be done filling is also based on the conclusion of problems that have been found at the emphasize stage.

Tabel 3. Job-To-Be-Done

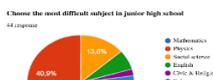
Job To Be Done		
Designing a Board Game based learning physics themed on light and optical tools for junior high school students that fits the curriculum and involves family, teachers, and friends who are able to support aspects of student education.		
Emotional Criteria (personal)	Emotional Criteria (social)	Emotional Criteria (objective)
Learning media in the form of Board Game-based learning made with interesting storylines and able to support psychomotor, affective, and cognitive aspects in students	Learning media in the form of Board Game-based learning that is able to relieve children's boredom, refreshing facilities, and can actively interact between students and family, teachers, and friends	Learning media in the form of Board Game based learning in accordance with the 2013 curriculum of junior high schools for science-physics subjects, in order to help students understand the concept of Light material and Optical Tools

Tabel 4. Emphaty Map



On the objective side, consumers want games that can help provide an understanding of the concept of science-physics subject matter, especially for Light materials and Optical tools. It is hoped that the board game designed will be able to help students who have learning difficulties. As many as 40.9% of respondents chose Science-Physics as the most difficult subject in junior high school.

12.2.2. Emphaty Map



12.2.3.

Figure 2. Questionnaire Data on The Hardest Subjects in Junior High School

As many as 26.8% of respondents chose Light and Optical Tools as the most difficult material in science- physics subjects.

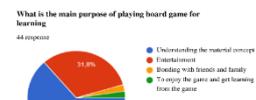


12.2.4.

Figure 3. Questionnaire Data of Most Difficult Subject Science-Physics

As many as 26.8% of respondents chose Light and Optical Tools as the most difficult material in science- physics subjects.

12.2.5.



12.2.6. Figure 4. Questionnaire Data Purpose of Playing Board Game Learning

As many as 63.8% of respondents chose the main purpose of playing board games is to understand the concept of material that is conveyed indirectly through the storyline of the game.

12.2.7. Customer Persona



13. Figure 7. Customer Persona

13.1.1. Pain and Gain

13.1.2. Tabel 4. Pain and Gain

Pain	Gain
Difficult to understand physics subject matter	Supporting student psychomotor
Boring learning	Learn interactive physics
Limitations of signal, technology, and eye health	Co-played board games

14.

14.1. IDEATE

The Ideate stage enters the process of formulating solutions and solving problems that have been further defined at the define stage.

14.1.1. Value Proposition Canvas

The process is carried out by extracting solutions that are in accordance with predetermined pain and gain. Made in the form of a value proposition canvas, which consists of a value proposition and also a customer segment.

The most suitable Customer Persona is the main consumer of the product you want to design later, namely a junior high school student in grade 9 aged 15 years. This persona has portrayed the consumers of this learning media board game. The goal of the persona to be achieved is certainly a game that is able to accommodate learning activities with fun with the family and of course involves the psychometric side of the child. To overcome the obstacles faced by personas, namely the internet network, boring learning, and most importantly difficulty understanding the subject matter. The subject of persona is in accordance with the results of the most choices on the customer segment questionnaire, namely Physics.

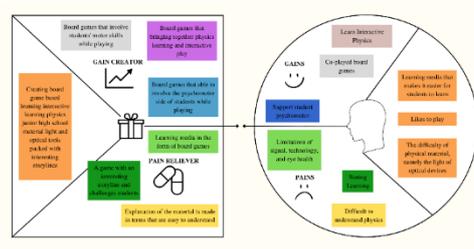


Figure 5. Value Proposition Canvas

Customers want a learning medium during the pandemic that can make it easier for school students to learn physics with light materials and optical devices. Gains from a customer's point of view are learning interactive physics, board games that can be played together, and supporting student psychomorphics..

The thing that doesn't like or the pain is that it is difficult to understand physics material, boring learning, and the limitations of signals, technology, and eye health So it must be answered in a value proposition that is able to create a product in the form of an interactive learning board game learning physics for junior high school light materials and optical tools packed with interesting storylines.

The designed gain creators are to create board games that can be played with family and friends as entertainment, support the psychomotor side, and unite learning activities while playing interactively. Pain Relievers that are designed to overcome pain from customers is to design a learning media in the form of a board game that is able to explain physics material in terms that are easy to understand and create an interesting and interactive storyline

14.2. PROTOTYPE

The fourth stage is compiling a product prototype design by adjusting what has been planned at the idea stage. Starting with making a lean canvas, Business Model Canvas, and blue ocean strategy to the prototype design stage of a minimum viable product.

14.2.1. Business Model Canvas

The Business Model Canvas is structured to make it easier to determine the relationship and business flow from product sales to customers. Broadly speaking, the main consumers of Optical Mirror board game products are junior high school students aged 12-15 years. The main customers who will buy the product come from 2 outlines, namely parents who have junior high school children and also junior high school teachers. Therefore it takes 2 different business models to achieve balance in sales.

The following BMC for the 2 product subjects have been revised after passing the validation stage:

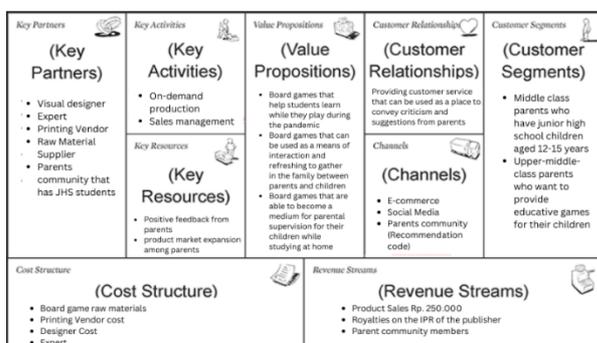


Figure 10. Business Model Canvas for Parents Revision

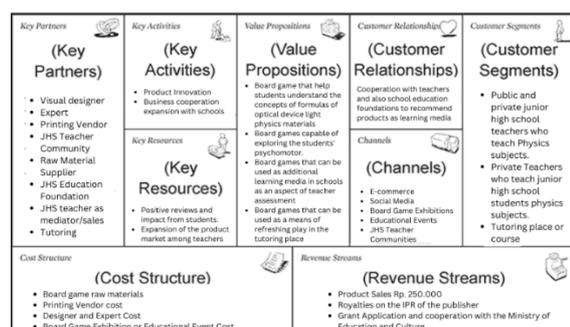


Figure 6. Business Model Canvas for Teacher Revisions

14.2.2. Blue Ocean Strategy

This strategy requires a product design that is unique and also different from others in order to compete comfortably in the market. It starts with benchmarking competitors which is then continued by creating an initial strategy canvas. The next stage is to do a 4-step framework to draw up the final strategy canvas

Table 4. Competitor Analysis

	Optical Mirror	Cashflow 101	Cytosis	Timeline	Mathcat	Periodic
Price	Rp.250.000	Rp.750.000	Rp.620.000	Rp.85.000	Rp.100.000	Rp.580.000
Science	Physic	Economy	Biology	Social History	Mathematic	Chemistry
Advance Level	Hard	Very Hard	Hard	Easy	Very Easy	Intermediate
Design	Attractive	Attractive	Very Attractive	Attractive	Not Attractive	Attractive
Material	Fair	Good	Very Good	Fair	Bad	Very Good
Game Parts	Cards, board, token, pawn, sideplay	Cards, board, token, pawn, property, money, sideplay	Cards, board, token	Cards	Cards	Cards, board, token
Mechanical	Simulation, Dice Rolling, area movement, action point, area control, line drawing	Simulation, Betting, dice rolling, action points, math, loans, bluffing, communication, auction, paper & pencil, take that	Set collection, card drafting, placement, modular board.	Hand management, timeline, memory	Hand management & Math point	Set Collection, action points, grid movement, area control, point to point, worker placement
Age Range	12-15 year	16+ year	15+ year	9+ year	8-11 year	15-18 year
Num. of Player	1-4 persons	2-6 persons	2-5 persons	2-4 persons	2-4 persons	2-5 persons
Game Duration	20-30 mins	150-180 mins	60-90 mins	15-20 mins	10-20 mins	40-60 mins
Game Mode	2	1	1	2	2	1
Rules Book	Comprehensive	Very Comprehensive	Comprehensive	Comprehensive	Sufficient	Comprehensive
Single Mode	Yes	No	No	No	No	No
JHS Curriculum	Yes	No	No	No	No	No
Bonus	Yes	No	No	No	No	No
Similar Competitors	Blue Ocean	Acquire, Stocklab, Monopoly	Peptide, Specific, Aquatico, Bios Genesis	The Festivals, Rising Tide, Bhinneka	Math Rush, Pitagoras, Abanteur	Subatomic, Ion, Compounded

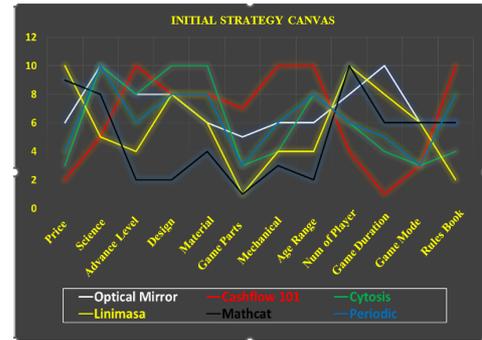


Figure 7. Initial Strategy Canvas

The first stage is by preparing a competitor analysis in the form of Benchmarking Competitor Analysis in accordance with the product developed, namely Optical Mirror. Similar competing products in the form of board gamebased learning are also from abroad and also locally. The list of the competitors are: periodic a game of element, Timeline, MatCat, Cytosis a biology cell, and Cashflow 101. The comparison dimensions used are 12 dimensions, namely price, science, design, advanced level, material, game parts, mechanics, age range, number of players, duration of play, game mode, and rules book. Optical Mirror is represented by white color, it can be seen that the design product is still inferior in some dimensional aspects of competitor products such as in the price, difficulty, design, material, game components, mechanics. Age range, number of players, and rules book.

4-STEP FRAMEWORK STRATEGY	
ELIMINATE	RAISE
No factor is abolished	Material used Boardgame mechanic Boardgame play modes Completeness of game rules book
REDUCE	CREATE
The selling price of the product on the market Boardgame difficulty level	Single Mode Conformity of board games to the junior high school curriculum Additional Bonuses Without competitors of similar subjects

Figure 8. 4-Step Work Strategy

It can be seen from the results of the final / new strategy canvas that it has started to increase from before. Optical Mirror products excel in the fields of science, game duration, rules book, and number of players. Of course, also in terms of creating, namely single mode, curriculum, bonuses, and also without similar competitors. Overall, Optical Mirror products are superior to its competitors.

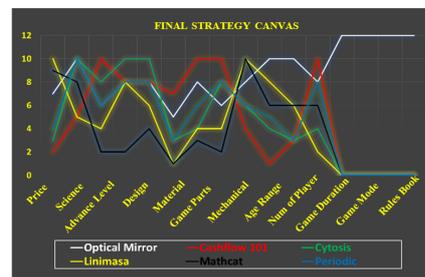


Figure 9. New Strategy Canvas

14.3. TESTING

14.3.1. Minimum Viable Product

In this stage, we discuss the execution of the prototype that has been formulated into the form of a real product design design, namely prototype 1.0 which has been tested on 3 junior high school children for playtest. This MVP represents and provides an overview to the customer of the designed product. The delivery of MVP to customers is summarized in a short video of about 6 minutes that explains the background of board game design, an explanation of the game's objectives and core values, game components, board game design, how and conditions of playing, and is equipped with prototype trial documentation. This video is used as a reference in receiving responses from consumers whether they are interested in using the design product in learning activities which will later pass the validation stage.

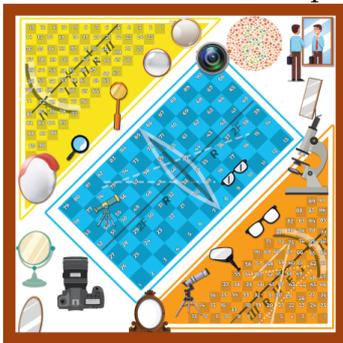


Figure 10. Top View of Product Design Plan



Figure 11. Prototype that has been tested on 3 junior high school children



Figure 12. Game Cards

The game component consists of a game board measuring 31cm x 31 cm x 1 cm. Made of 260 grams of art-cardboard material. It consists of 3 game areas, namely convex mirrors, convex lenses, and concave mirrors. On the side of the game area, it is equipped with images of optical tools such as binoculars, mirrors, telescopes, glasses, lup, and Ishikawa. Each play area is equipped with a 1 x 1 cm tile box which is used as a reference for the path of each player's pieces. The game card is rectangular with 230 grams of art paper material measuring 8 x 5.5 cm. Card games consist of 1 deck cards totaling 48 cards divided into 4 card properties

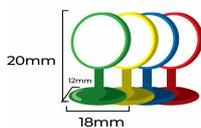


Figure 13. Game pawns



Figure 14. A pair of Dice

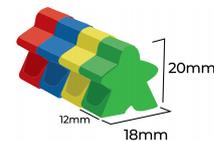


Figure 15. Star Token

Game pieces are made of PLC material with a 3d printing method weighing 6-8 grams, in the form of a concave mirror, which is an optical lup tool. There are 4 pieces with different colors. Game Tokens vary and there are 4 different types. The first token is a star-shaped object token with 3d printing PLC material measuring 2 cm with 6 pieces each in red, yellow, and blue. The second token is a trapezium-shaped object token made of 230 grams of 230-gram cardboard with a trapezium of 6 pieces measuring 3 x 4 cm.



Figure 16. Trapezoidal Token

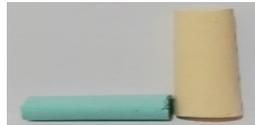


Figure 17. Tube Token



Figure 18. Resource Crystal tokens

The third token is a cylindrical object token made of PLC 3d printing with a length of 3-6 cm in the amount of 6 pieces. The fourth token is a crystal-shaped shadow marker resource token with PLC material with a size of 2-4 mm. There are 4 colors of each token, namely light blue, red pink, yellow, and light green. Each color is 10 tokens for a total of 40 crystals.

It is also equipped with print out formulas related to SMP physics of light matter and Optical devices. To make it easier when playing, do not forget to be given a print out of the manual guide book optical mirror board game based learning.

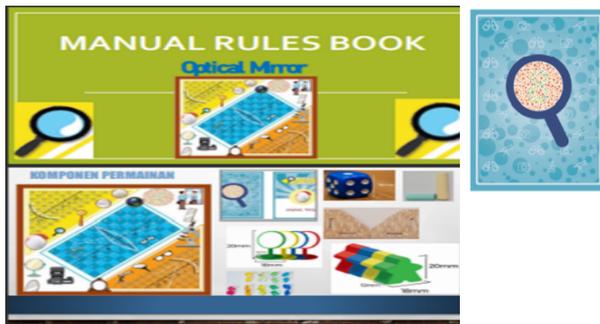


Figure 19. Initial Cover of Manual Guide Book

Table 6. Board Game Dimension

Highlighted Key	Design	Most importance
Features of the board game	Material (cognitive aspects)	
	Psychomotor aspects	
	3 in 1 board game	
	3d printing (pawn, tokens, dice)	
	Formula Notes	
Content Board Game	Light and optical tools Junior High School 2013 Curriculum	Nice to Have
Subject	Science - Physics	Most importance
Storyline	Racing to paint shadows	Nice-to-have
Number of Game Players	2-4 person	Nice To Have
Evaluation of results		Most importance

It requires a dimension of importance in compiling board game products to learn physics.

The mechanics and flow of the board game are explained as follows which are divided into 3 phases:

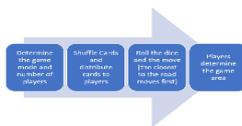


Figure 20. Early Preparatory Phase of the Game



Figure 21. Core phase of the game

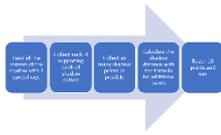


Figure 22. Final phase of the game

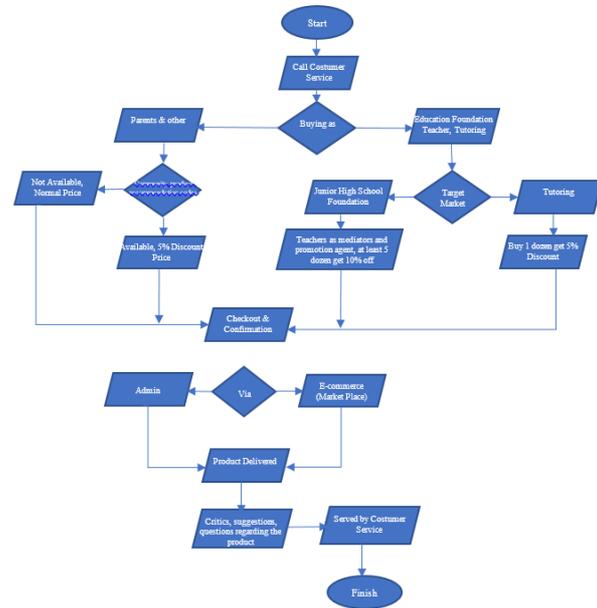


Figure 23. Product Purchase Flow Mechanism

14.3.2. Validity Tes

The validity test is a stage to test the minimum viable product design that has been made whether it has met the needs of consumers. Testing to consumers was carried out through a short 6-minute video that explained the Optical Mirror board game. Direct testing has also been carried out directly on 3 junior high school students related to the main test and also product introduction. This is to get a response from users regarding the prototype 1.0 product design



Figure 24. Prototype 1.0 introduction



Figure 25. Prototype Trials



Figure 26. Shadow Formation Simulation

The validation test with the distribution of questionnaires was carried out using linkert scale intervals to measure the degree of match between respondents arranged in intervals: Strongly agree, agree, neutral, disagree, and strongly disagree with represented scales 1-5. The distribution of questionnaires is carried out during the week to get accurate results and estimate product sales in a day.

Table 7. Questionnaire

No.	Questions	SDA	DS	N	A	SA
1	Can the Optical Mirror Board Game help the understanding of the material and physics formulas of SMP light optical tools?					
2	Can Optical Mirror Board Game support the psychomotor, cognitive, and affective sides of students?					
3	Can Optical Mirror Board Game help students in interactive learning while playing during Distance Learning?					
4	Can Optical Mirror Board Game be played together with friends and family as a medium of interaction?					
5	Can Optical Mirror Board Game relieve boredom during study from home?					
6	Can Optical Mirror Board Game be used as an addition to the middle school physics learning media for DK?					
7	Does the Optical Mirror Board Game conform to the curriculum of Physics SMP 2-13 light matter & optical tools?					
8	Can Optical Mirror Board Game simulate shadow painting clearly and correctly?					
9	Does the Optical Mirror Board Game have a flow/gameplay that is easy to play and understand?					
10	Does the Optical Mirror Board Game have an attractive look?					
11	Does the Optical Mirror Board Game have advanced levels (complex difficulty) when played?					
12	Does the Optical Mirror Board Game have quality materials?					
13	Does the Optical Mirror Board Game have complete and complex game components?					
14	Does the Optical Mirror Board Game have an appropriate duration and number of players?					
15	Does the Optical Mirror Board Game have interesting game modes?					
16	Can the Optical Mirror Board Game compete in the board game based learning industry in Indonesia?					
17	Is the above short video able to explain the Minimum Viable of Optical Mirror Board Game product?					
18	Do you agree to play and recommend to parents to buy Optical Mirror Board Game?					



Figure 26a. Percentage of Willing-to-pay respondents

Questions	5	4	3	2	1	Total	Total/Respondent	Conclusion
1	70	80	21	6	1	178	3.96	Agree
2	65	84	27	4	0	180	4.00	Agree
3	80	60	33	6	0	179	3.98	Agree
4	105	68	12	4	1	190	4.22	Strongly Agree
5	90	56	30	4	1	181	4.02	Strongly Agree
6	80	68	24	6	1	179	3.98	Agree
7	65	76	24	8	1	174	3.87	Agree
8	65	84	18	10	0	177	3.93	Agree
9	40	84	36	6	1	167	3.71	Agree
10	70	88	18	2	2	180	4.00	Agree
11	50	28	57	16	1	152	3.38	Agree
12	70	48	48	6	0	172	3.82	Agree
13	85	60	27	8	0	180	4.00	Agree
14	70	76	27	4	1	178	3.96	Agree
15	50	96	21	2	3	172	3.82	Agree
16	85	40	45	4	1	175	3.89	Agree
17	90	56	33	4	0	183	4.07	Strongly Agree
18	80	56	33	8	0	177	3.93	Agree
Total	Overall Questionnaire Percentage						3.92	Agree
							78.37	

Figure 26b. Percentage of Willing-to-pay respondents

The test was conducted on 45 respondents consisting of 44.4% of grade 9 children, 26.7% of grade 8 children, and 28.9 children in grade 7 of junior high school. The percentage rate received from respondents through the market acceptance questionnaire related to the percentage willing to pay from Optical Mirror products was 82%, with 37 students out of 45 respondents stating that they were willing to play, recommend, and buy Optical Mirror Board Game Base Learning products.

The questionnaire given to 45 respondents with 18 question items was declared valid because the count R of each question item was greater than the Table R for 45 respondents which was 0.294. Therefore, the distribution of questionnaires to 45 respondents with 18 questions was declared valid and accountable for processing the results of the decision. It stated 15 questions were concluded in agreement and 3 questions were said to be very affirmative. Finally, the average of each average weight per line was carried out to the overall average of the questionnaire results and the weight number was 3.92 or 78.37% of respondents agreed with the results of all the questions in the questionnaire. The scale agrees with the design of the Optical Mirror board game prototype which can help understand the 2013 SMP Physics material in relation to light matter and optical devices that are used as additional learning media during PJJ.

14.3.3. Business Feasibility Test

A business feasibility test is required to calculate the finances of a business plan that has been prepared and passed the validation stage. The calculation is divided into two, namely calculating the cost of expenses and business revenue.

Table 9. Direct Material Costs

Direct Material Costs				
No	Item	Unit Cost	Qty	Total Cost
Components and Raw Materials				
1	3D printing pawns	Rp 4,000	3	Rp 12,000
2	Star printing 3D token	Rp 3,300	6	Rp 19,800
3	Tube printing 3D tokens	Rp 3,000	6	Rp 18,000
4	Crystal tokens	Rp 200	40	Rp 8,000
5	Trapezoidal paper tokens	Rp 500	6	Rp 3,000
6	Dices	Rp 1,500	2	Rp 3,000
Total				Rp 63,800
Raw Material Vendors				
1	Print A3 board Art Carton 260	Rp3,000	1	Rp3,000
2	Cards Printing (sets)	Rp2,500	3	Rp7,500
3	Packaging Printing	Rp10,000	1	Rp10,000
3	A3 Board Laminating	Rp2,000	1	Rp2,000
Total				Rp22,500
Grand Total				Rp86,300
Variable cost of unit materials per product is Rp.86.300,00				

Table 10. Direct Labor Costs

Table 13. StartUp Cost

Start Up Cost		
No	Description	Total
1	RnD Cost	Rp 1,145,000
2	Laptop	Rp 3,300,000
3	Administrative ATK Stationery	Rp 55,000
Total		Rp 4,500,000
Start Up Cost Rp.4.500.000,00		

Direct Labor Costs				
No	Item	Unit Cost	Qty	Total Cost
Direct Labor				
1	Production and packing power	Rp3,500,000	1	Rp3,500,000
2	Admin or customer service	Rp3,500,000	1	Rp3,500,000
	Total			Rp7,000,000
	Production Time in 1 month		25	Rp280,000
The cost of direct work per day are Rp.280.000,00 and Rp.7.000.000,00 Per month				

Table 11. Fixed Cost

Fixed Cost		
No	Description	Total
1	Direct labor costs	Rp 7,000,000
2	Electricity and hygiene	Rp 200,000
3	Adhesives, duct tape, packing equipment	Rp 50,000
	Total	Rp 7,250,000
Fixed Cost / month Rp.7.250.000,00		

Table 12. RnD Cost

RnD Cost		
No	Description	Total
1	Designer Services	Rp 450,000
2	Junior High School Physics Teacher consultation services / hours (3)	Rp 600,000
3	Survey costs	Rp 50,000
4	Junior Highschool Physics Book	Rp 45,000
5	Total	Rp 1,145,000
RnD Cost Rp.1.145.000,00		

Table 14. Total Cost

Total Cost		
No	Description	Total
1	Non-fixed cost	Rp 86,300
2	Direct labor costs	Rp 7,000,000
3	Start-up cost	Rp 4,500,000
	Total	Rp 11,586,300
Total Cost Rp.11.586.300,00		

Table 15. Revenue Stream

Revenue In A Month		
No	Description	Total
1	Total Customer/day	6
2	Sales unit	1
3	Product Price	Rp 250,000
4	Sales in 1 day	Rp 1,500,000
5	Total sales in 1 month	150
6	Sales 1 month (25 days)	Rp 37,500,000
7	Publisher sales royalty (4 %)	Rp 1,500,000
	Total	Rp 39,000,000
Revenue/ month Rp.39.000.000,00		

Table 16. Summary

Summary		
No	Description	Total
1	Revenue	Rp 39,000,000
2	Sales	150
3	Fixed Cost	Rp 7,250,000
4	Variable cost x sales	Rp 12,945,000
5	Total cost / month	Rp 20,195,000
6	Profit	Rp 18,805,000
8	Unit Breakeven	44.29
9	IDR Breakeven	Rp 11,072,083
10	Payback period (month)	0.12
Profit / month is Rp.18.805.000,00, with 44.29 BEP Unit within 0.12 month payback period		

The total costs consist of non-fixed or variable costs per product, direct labor costs, and start-up costs. The total costs incurred in the business development of Optical Mirror Board Game Based Learning products are Rp.11,586,300.00. The product revenue design flow was obtained based on the distribution of validity questionnaires that lasted for a week with a total of 45 respondents and a total willing-to-pay of 82% which was 37 units / week. Then it can be concluded that the number of sales in 1 day becomes 6 units / day with a reference of 1 week as much as 6 working days. The product revenue flow is obtained from the estimated sales in a month of 150 units with a budget of 25 working days a month. The total revenue from the sale of 150 units is IDR 37,500,000.00 / month. For the unit price of the product of Rp.250.000,00. The profit in a month obtained from the sale of Optical Mirror Board Game Based Learning products is Rp.18,805,000.00, which is obtained from the results of revenue reduction with fixed costs and variable product costs. The breakeven of product units is at 44.29 units amounting to Rp.11,072,083.00. The payback period of the business is 0.12 months. It can be concluded that business is worth living.

15. Conclusion

The problem statement is formulated into five points, which are: Students have difficulty understanding subjects, Distance Learning Media that causes boredom while studying, limitations in student psychometric aspects, limited networks and technology related to Distance Learning, and negative impacts of eye health due to the use of gadgets. The value proposition of the business

creates a product in the form of an interactive learning board game learning physics for junior high school light materials and optical tools packed with interesting storylines. The designed Gain Creators is to create board games that can be played with family and friends as entertainment, support the psychomotor side, and unite learning activities while playing interactively. Pain Relievers that are designed to overcome pain from customers is to design a learning media in the form of a board game that is able to explain physics material in terms that are easy to understand and create an interesting and interactive storyline. Blue Ocean Strategy produces superior Optical Mirror Products in the fields of science, game duration, rules book, and number of players. Of course, also in terms of Create, namely single mode, curriculum, bonuses, and also without similar competitors. Overall, Optical Mirror products can be said to be superior to its competitors. The validity test with the questionnaire was declared as valid because the results stated that 15 questions were concluded to “agree” and 3 questions were said to “strongly agree”. An average weight of 3.92 or 78.37% of respondents agreed with the results of all questions in the questionnaire. The scales show that they are agree with the design of a prototype of the Optical Mirror board game that can aid the understanding of junior high school physics material according to the 2013 curriculum related to light matter and optical devices that are used in addition to learning media. During the Business Feasibility Test states that the business model is considered feasible with a profit / month of Rp.18,805,000.00, with a BEP of 44.29 units and a payback period of 0.12 months.

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