Commercialization of an Academic Outcome: a Case Study of U.CUBE

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Commercialization of an Academic Outcome:

a Case Study of U.CUBE

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Executive Summary

U.CUBE is an educational toy in the form of a cube that puts a ball at the entrance of the block and sets the maze to pull the ball out of the exit on the opposite side. U.CUB is a rare case of successful start-up and entry into the market after the concept was developed in the undergraduate industrial design curriculum. This paper deals with the characteristics of the design process of U.CUBE's success stories and the factors that made it possible to commercialize U.CUBE in educational environments. The characteristics of U.CUBE's design process are explained in detail as it is by comparing the process of U.CUBE development with existing design processes. The success factors of U.CUBE were derived by analyzing the system and characteristics of the existing curriculum specialized for start-up. This paper is intended to provide guidelines for junior design students to develop and commercialize their designs during the degree program. Also, design educators wanted to serve as reference materials when introducing curriculum aimed at starting and commercializing design.

First, the product development process of U.CUBE can be divided into three stages: 'concept design', 'detailed design and test' and 'design for mold and production'. The concept design phase can be further subdivided into three phases: idea generation phase, idea development phase, and idea verification phase. The detailed design and test phases can be subdivided into detailed design stages that take into account initial detailed design, detailed design for usability improvement, and manufacturing. Finally, the design stages for mold and production can be divided into preparation stages, five mold modifications, and the injection process to set final production quality limits.

This U.CUBE development process is conducted by the students of industrial design during the degree program, and they have similarities and differences with the existing product development and design process. In terms of the overall product development stage and the tasks performed, they are similar to Ulrich's proposed process, but due to the nature of the start-up company with a small workforce, it was not possible to conduct several tasks simultaneously. Compared to the Lean Startup Process, we pursued an improvement process that quickly and effectively reflected user feedback through rapid prototyping and testing, but the cost of prototyping was not high enough. Instead, various methods that can be effectively used in the design development process such as experts or exhibitions were used as verification means. In the detailed design and test phase, the method introduced in Ullman's The Mechanical Design Process was used like Parametric Design. Although the Double Diamond Design Process was used to derive the initial idea of U.CUBE, there was little practical use in the later stages. This is because of the abstraction of this process, it is difficult to utilize at the stage of detailed design work such as improvement of usability or functionality.

In each development stage of U.CUBE, it was necessary to verify and complete the necessary items for commercialization such as design aesthetics, product performance, usability, merchandise, and marketability. To this end, we listen to opinions on technology and marketability from patent attorneys, feedback from IR pitching, awards from the Reddot Design Award and SPARK Design Award, selected as excellent design and global living products, school graduation exhibitions and Design Korea 2018, Design Korea 2019, Seoul We used verification methods such as user observation and survey at design festival. It was

possible to try these methods because they made the best use of the conditions given during the degree course at the Graduate School of Design-Engineering Convergence.

By analyzing the existing curriculum specializing in entrepreneurship and comparing it with the case of U.CUBE, the success factors of U.CUBE's commercialization were found. Among the typical start-up curriculum, MIT's design X was abroad, and in Korea, KAIST's K-school entrepreneurship master's course. First, we analyzed and categorized the specialized entrepreneurship systems provided by the two curricula and the characteristics of these curricula. Based on this, we compared and analyzed how similar things occurred in the development process of U.CUBE. In addition, we analyzed the specifics that appeared only in the development process of U.CUBE. As a result, the success factors of the commercialization of U.CUBE were human factors such as the will of students, the guidance of professors with practical experience, and the use of appropriate external experts. It is essential to say that the equipment and facilities for this were important, and the educational factors were the integration and fusion of the integrated courses and the single courses.

In this paper, we describe the process and the success factors of commercialization from U.CUBE's concept design process to commercialization development and market entry during the master's degree. You can do it. First, by showing how the commercial development process of U.CUBE differs from the general product design and product development process, it can be a guide for future juniors who want to commercialize design during the degree course. After reading this paper, juniors will find that the design process and methods they learn in school may not be the right answer, and they will find that the practice requires the integration of a wide variety of methods. Above all, you will understand not only the theory but the challenge, and within that challenge, your expertise expands. Second, the case of U.CUBE, which has been successfully commercialized in the degree course, will be a good reference material for future design educators to improve the design curriculum aimed at entrepreneurship and commercialization. U.CUBE is a rare case of success in an educational environment that is not specialized in entrepreneurship and commercial development. Therefore, the success factors of U.CUBE's commercialization revealed in this paper can provide a hint about what can be improved in our education to design educational programs that can commercialize the design in the degree program.

Finally, I hope that the development examples of U.CUBE introduced in this paper will be introduced to many juniors and professors so that designers can actively explore ways to develop their products and commercialize them with broader expertise and entrepreneurship.

Keywords:

Product Design, Product Development, Design Commercialization, Design Entrepreneurship, Product Development Process, Industrial Design Education, Entrepreneurship Support Education

Contents

Tables

Figures

1
Background & Objectives

1

Background & Objectives

Issues of Current Industrial Design Education

Industrial design is dealing with the knowledge and ability needed to successfully handle the ‘fuzzy front end’ as the first stage of product development (Wormald, 2011). Therefore, students in the field of industrial design generally find issues with design according to the design process, the first stage of product development, repetitively identifying the solutions, and learning how to configure them in visual concepts. Seeing as how such educational procedures enhance the ability to plan products or services, it positively influences on society. However, most of the ideas suggested in the education course at a school tend to be left with visualized concepts without being developed in a commercialized state. Therefore, they are ending up not directly influencing on the society.

Such phenomena can be explained in two aspects. First, commercialized development requires not only industrial design that deals with fuzzy front end but also the collaboration and specialty in engineering design and other various fields to realize concept design (Kim & Lee, 2010). Therefore, it is difficult to commercialize the development only with knowledge learned in industrial design. Secondly, college education provided on the basis of the semester or academic year based on subjects is practically difficult to support commercialized development that tends to require a long time. In spite of them, if there are opportunities for students to experience the entire processes of product development in design education procedures related to industrial design and product development, they will be able to build a wide range of professional knowledge and experience. If commercialized items are produced in the market through the aforementioned procedures, it might be possible to maximize the social contribution of design through education. Especially, if there are many such cases, it will be available to reduce the gap between research and practice as a long-time issue and to contribute design manpower equipped with practical expertise.

This thesis is intended to introduce a commercialized procedure for the concept design of U.CUBE in the master’s program as suggested in the education course and discuss the factors that made them feasible.

U.CUBE Overview

As shown in Figure. 1, U.CUBE is an educational toy where 26 three-dimensional individual blocks rotate in a similar manner with Rubik's cube hat users insert beads to the entrance of middle blocks and take them out in the opposite side to assemble dynamic maze (see idspace-co.com, U.CUBE, 2019). Unlike previous cubes to be assembled with side colors rapidly by memorizing the formula, there is no solution for U.CUBE that users are able to create their own ways to play. In addition, as blocks are rotated using gravity to move beads to the exit, delicate control is required that this is a design to help develop minute muscle adjusting ability and rehabilitate upper limbs.

The first conceptual design of U.CUBE (left on Figure. 1) has been suggested as an outcome of the final project of 3D CAD opened in the industrial design track in 2016. This conceptual design was awarded in the Red Dot Design Award (Red Dot Singapore Pte Ltd., 2017) in 2017 and also with grand prize in Spark Design Award (Spark Design Awards, 2017). Afterwards, it proceeded with commercialized development of it that ended up being awarded the grand prize in Design United Venture Business Foundation School led by the Ministry of Trade, Industry, and Energy in 2017 to secure the business foundation supportive fund (Heo, 2017). Since 2018, I have started attending a master's program at Design-Engineering Graduate School to start commercialized development actively with a theme of it for graduation assignment for a master's degree. During this period, I have developed molding in joint-foundation with my advisor, and the conceptual model for commercialization (right on Figure. 1) has been selected as the final list of Asia Design Prize. Trial manufactured good was selected as good design as well as global luxury daily good in the Ministry of Trade, Industry, and Energy that ended up being actively commercialized.

220 trial manufactured goods have been sold in August 2019. As of December, it is scheduled with mass production and official sales in the market after the fifth modification of the moldings.

Figure 1. Conceptual Design of U.CUBE (left) and Commercialized Design (Right) and Award History (below)

Research Objectives

This thesis is intended to accomplish the following two goals by sharing my personal experience and what I have learned with readers through the procedures for successfully commercializing the conceptual design of U.CUBE developed in the academic curriculum of industrial design by selecting it for the research assignment of master's degree

- Goal 1: Provide a guide to junior students who intend to follow a similar journey with me by showing how different the commercialized development procedure is with U.CUBE from regular product design & development process

- Goal 2: Share success factors and lessons for commercialization I have experienced and make them use as references for improving design education courses for educators in the future.

2
Literature Review related to Product Development

- 2.1. Literature related to Product Design & Development Process
- 2.2. Literature related to Business Foundation Education Course

2

Literature Review

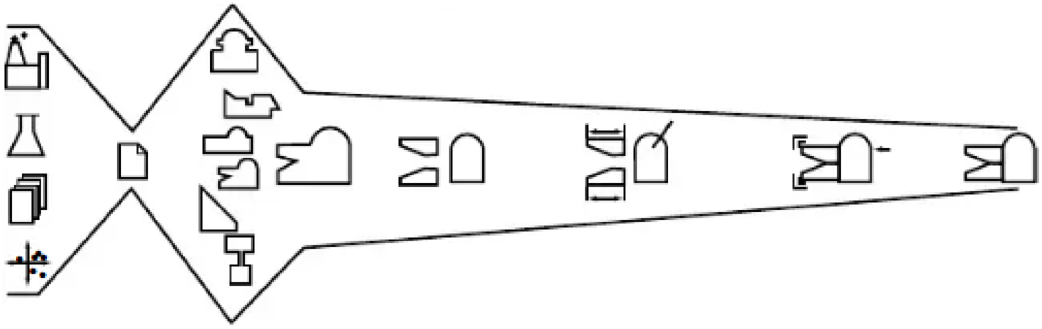
This thesis deals with success factors and implications for the commercialized development courses in the degree course exploring literature in the field of 1) product design and development process and 2) education system for supporting students with commercialized procedures.

Literature related to Product Design & Development Process

First of all, it is intended to discuss literature related to the product design and development process related to this thesis. According to product design & development processes that are well-known among designers, there are process models for overall managing the product development and process models emphasizing the strategies or methods in the stage of design or development even though it is a model about the product development process.

Ulrich & Eppinger's Product Design & Development Process Model is the representative example of a process model for overall managing product development. Ulrich (2003) product development process is stated mostly with a series of stages and works for how company plans for one particular product, deals with design and development procedures and sells it in the market. As shown in Figure. 2, this model consists of six phases of planning, concept development, system-level design, detail design, testing and refinement, and production ramp-up. In the planning phase, it starts with identifying the opportunity of developing products based on company strategies and includes the establishment of goals about technological development and preoccupation with the market. In the concept design phase, the concept for developing the product is determined by identifying the needs of the targeted market.

In the system-level design phase, the architecture of the product is defined as to which physical components are in charge of functional elements of a product. In the detail design phase, shape, texture, and allowance are clearly defined in all the parts along with processing plans. At the same time, pre-productions in many versions are manufactured and evaluated in the testing & refinement phase. In the production ramp-up phase, goods are created in the intended production system identifying whether there are defects existing in this procedure. Hereupon, Ulrich process well explains the duties and expertise needed for overall development procedures of products including the tasks performed by the group in each stage for product development and which expertise and experts are needed for product development. Therefore, Ulrich model is appropriate to be applied to companies well-organized with specialized product development teams such as marketing experts, industrial designers, and production engineers but inappropriate to be applied to venture companies newly established by students like me.



	Planning	Concept Development	System-Level Design	Detail Design	Testing and Refinement	Production Ramp-Up
Marketing	• Articulate market opportunity. • Define market segments.	• Collect customer needs. • Identify lead users. • Identify competitive products.	• Develop plan for product options and extended product family.	• Develop marketing plan.	• Develop promotion and launch materials. • Facilitate field testing.	• Place early production with key customers.
Design	• Consider product platform and architecture. • Assess new technologies.	• Investigate feasibility of product concepts. • Develop industrial design concepts. • Build and test experimental prototypes.	• Develop product architecture. • Define major sub-systems and interfaces. • Refine industrial design. • Preliminary component engineering.	• Define part geometry. • Choose materials. • Assign tolerances. • Complete industrial design control documentation.	• Test overall performance, reliability, and durability. • Obtain regulatory approvals. • Assess environmental impact. • Implement design changes.	• Evaluate early production output.
Manufacturing	• Identify production constraints. • Set supply chain strategy.	• Estimate manufacturing cost. • Assess production feasibility.	• Identify suppliers for key components. • Perform make-buy analysis. • Define final assembly scheme.	• Define piece-part production processes. • Design tooling. • Define quality assurance processes. • Begin procurement of long-lead tooling.	• Facilitate supplier ramp-up. • Refine fabrication and assembly processes. • Train workforce. • Refine quality assurance processes.	• Begin full operation of production system.
Other Functions	• Research: Demonstrate available technologies. • Finance: Provide planning goals. • General Management: Allocate project resources.	• Finance: Facilitate economic analysis. • Legal: Investigate patent issues.	• Finance: Facilitate make-buy analysis. • Service: Identify service issues.		• Sales: Develop sales plan.	• General Management: Conduct postproject review.

Figure 2. Ulrich Product Development Process (Ulrich, K. T. (2003))

Another example of the process model overall managing the product development, the mechanical design process by Ullman (1992) is comprised of six phases of product discovery, project planning, product definition, conceptual design, product development, and product support. (See Figure. 3). In the product discovery phase, it is to select a project among product-related ideas from technology push, market pull, and product change. Project planning is a phase to plan for how to assign resources, manpower, and equipment of the company. Product definition is a phase to solve design problems while understanding requirements from purchasers, setting specifications, and solving design problems. Conceptual design is a stage to suggest various concepts and evaluate them and determine the concept. Product development is a phase to make products and evaluate them from the perspective of performance, robustness, cost, and production. Product support is a phase to deal with works after publishing a product including the registration of patent and documentation of courses for changing products.

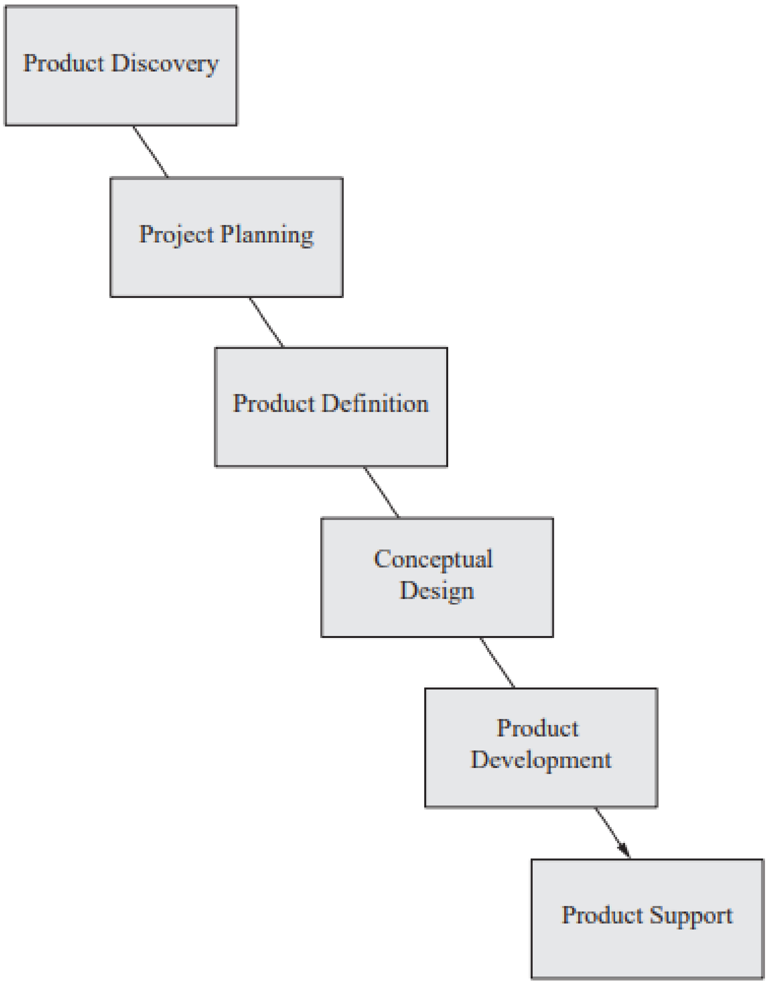


Figure 3. Ullman's The mechanical design process (Ullman, D. G. (1992))

This process deals with overall product design work but more focuses on the product design and development procedures from the perspective of engineering over the design in industrial design such as user-perspective design or aesthetic design. Therefore, it has an advantage for determining specifications of engineering design. In addition, the system has already been established for product development procedures in the same manner with the Ulrich model. Therefore, it is appropriate with product development procedures for large companies to communicate the work in documents as there are specialized departments.

Characteristics of Ulrich (2003) and Ulman's (1992) model can be greatly helpful for newly founded companies without prior experience to identify the tasks needed for product development as they show tasks to be performed in the product development procedures in detail. In other words, these models can be helpful for appropriately identifying what is expected to happen in detailed designing procedures and when manufacturing and modifying the prototypes depending on the circumstances.

Among processes related to product development, the Lean Startup process and Double Diamond model are the representative processes emphasizing the strategies or models in the stage of design or development. The Lean Startup process is introduced to be appropriate for startup companies. This process is used for business founders to rapidly verify the hypotheses on the items, connect them to the business, and efficiently develop products. Lean Startup method creates minimum viable products to verify the concept and avoid wrong assumptions in the market by frequently meeting with customers (Eisenmann, Ries, & Dillard, 2012). This is similar to the practice-based method in the development process used when coding a program, Agile Model (Zhang & Patel, 2010). Agile Model creates a complete product by repetitively finalizing and evaluating the functions instead of manufacturing and assessing completed development models as shown in Figure. 5. Balaji, Murugaiyan, and Management (2012) insisted that Agile Process was advantageous as it made it feasible to flexibly cope with circumstances in the market by iteration process over the Waterfall process (Figure. 4) that proceeded the procedures in stepwise manner. Therefore, using rapid, instantaneous, and repetitive characteristics of the Lean Startup and Agile Process is expected for newly founded companies with insufficient time and period for development to verify and develop items faster than before.

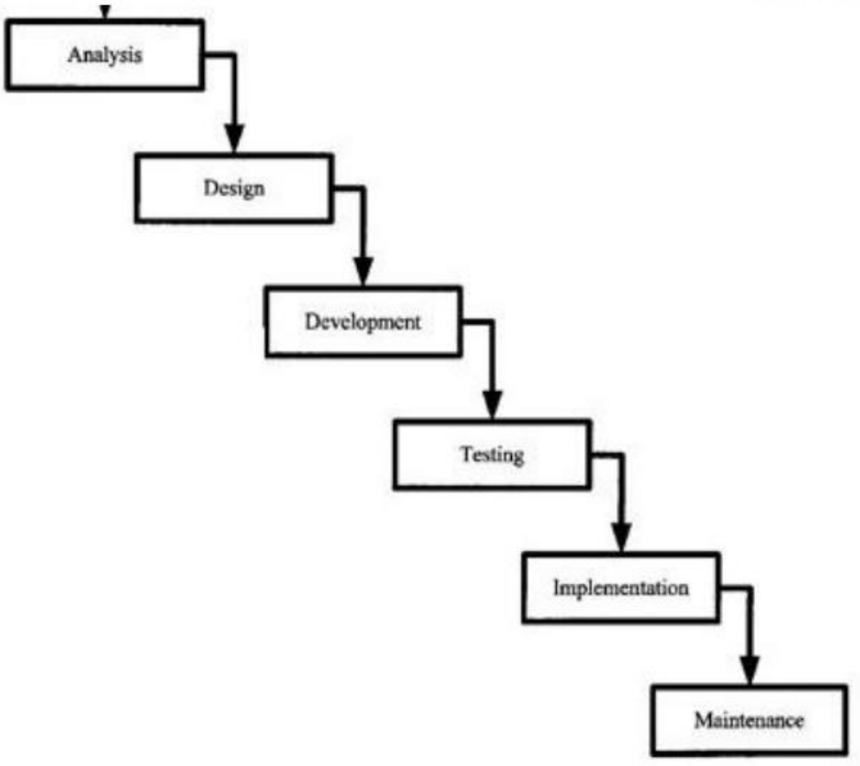


Figure 4. Waterfall model (Balaji, Murugaiyan, & Management(2012))

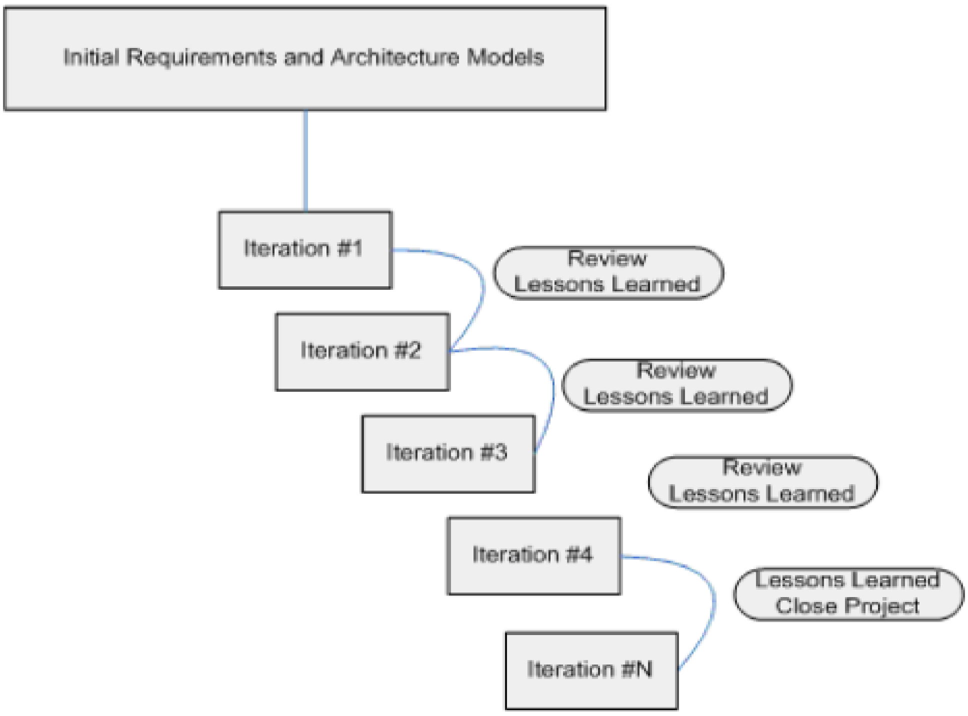


Figure 5. Agile model (Balaji, Murugaiyan, & Management(2012))

On the other hand, rapid prototypes shall be frequently made to often meet with customers to verify market assumptions rapidly as required by Lean Startup. Therefore, it is expected to be difficult to apply instantaneous manufacturing and application like software development due to the issues of cost and time when manufacturing physical products.

On the other hand, it is intended to discuss the Double Diamond process frequently covered in the educational course of industrial design. As shown in Figure. 6, this process is comprised of four phases of discover, define, develop, and deliver, and it is repeated to come up with and converge issues or ideas. In the first discover phase, it starts from an issue in the beginning and leads to identify the needs and issues of people through the market research and user research. In the define phase, it is to identify issues to focus on for solving, while defining the problems and resolving them. In the develop phase, it is to seek for possible solutions. In the deliver phase, it is to come up with a complete and final solution (Design Council, 2015).

This process is useful to conveniently identify general characteristics in the design problem-solving, but is very abstract and generally explained. In addition, since it is not well-defined as to how the process can be used for specific task units in product design and development, it is difficult to apply the process on the entire process of product development. When the business founding team develops products and applies this concept, it is judged to use the process as a strategic approach for developing a good concept through the convergence and divergence. On the other hand, it is difficult to apply the process in details after the stage of detailed design. For example, issues for determining the size and structure of certain parts in the detailed design phase can be solved through scientific methods such as optimal design through the repetitive size adjustment and experiment.

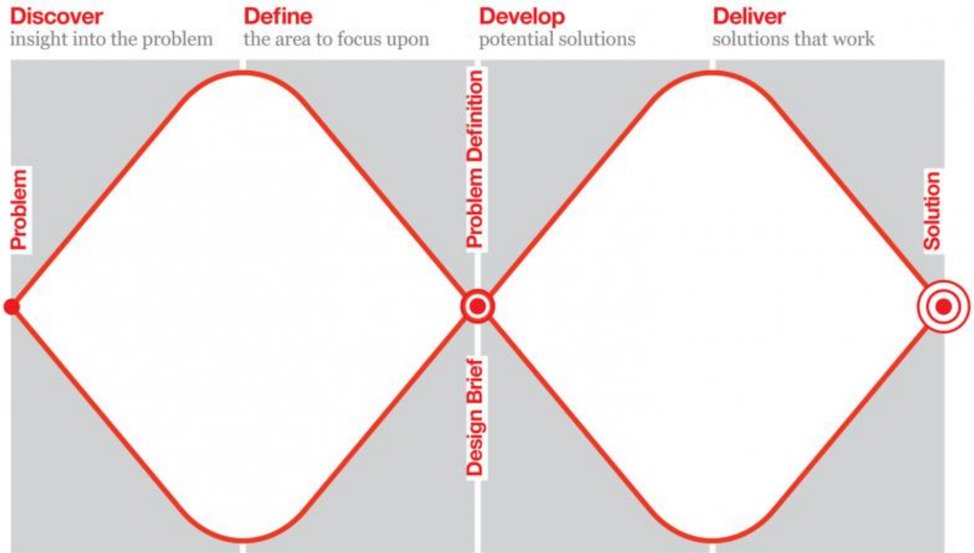


Figure 6. Diamond Process (Pista. (2017, June 15))

These are good models focusing on the design process from each perspective. However, it might be difficult to apply them if a student decides to proceed commercialization of them in the degree course. However, it would be helpful to use the characteristics of each process properly according to the necessity. For example, tasks required to go through mass production from the concept in regard to the product development have been well stated in Ulrich and Ulman's process. Therefore, it would be available to identify the required tasks in the Ulrich and Ulman process. In addition, the business founding team needs to proceed with development rapidly with insufficient funds and manpower. Under these circumstances, it seems to be feasible to suggest an appropriate process for the business founding team if applying how to strategically use the Lean Startup process, Aglie process, or Double Diamond process.

There is no expert team when developing products in the degree course. At the same time, there are not enough funds available. Therefore, it is not possible to classify tasks, and students are required to come up with the best outcome with the minimum fund. In this thesis, it is intended to indicate characteristics of the process for product development by the specific conditions in degree course through the case of development for U.CUBE.

Literature related to Business Foundation Education Course

Secondly, it is to discuss education courses for supporting students to successfully found a business in the design commercializing course. MIT design program is a representative example in foreign countries. MIT's designX is an undergraduate program of Architecture and Planning that is intended to promote entrepreneurship as well as design innovation while providing a systematic education program for promoting new business venture designed to solve issues faced by cities and human environments in the future (MITdesignX, 2019). MIT's designX supports for interdisciplinary teams to rapidly proceed with innovative development and launch them in the market by judging how the venture can successfully exist in the borderline of design, business, science, and technology. There are four major areas of support as follows.

First, there are two subjects related to venture design. There is boot camp with six credits offered in the fall semester and accelerator program offered in the spring semester for four months when team and idea are developed in a startup in the spring semester. In these two venture design subjects, design thinking methodology is used for entrepreneurs to test ventures and suggest how to exit them. Secondly, they fund $15,000 as an interest-free subsidiary to each team for their projects providing a place for work or help them find space at Cambridge, Boston, or New York. Third, more than 25 experts or business leaders with enriched experience for leading ventures mentor the team created in MIT's designX including technology, law, finance, operation issues, or general business strategies, and teams can be connected to a wide range of network or community. Fourth, the business founding team is required to continuously prototype while researching for the market to fulfill the needs of customers, users, or interested parties. MIT's designX helps such test procedures while connecting the pilot opportunities in all over the world. With the support of MIT's designX program, 34 business founding teams have been created for three years from 2017 to 2019.

On the other hand, as for programs created for students to found their businesses in the education course in Korea, there is a foundation integrated master's program at K-School in KAIST. K-School is jointly operated by nineteen departments including physics, chemistry, or mechanics that students are required to complete 33 credits such as entrepreneurship, leadership, ethics and safety, and leadership as prerequisites including 12 credits in each major department. There are fourteen subjects offered in K-School. Among them, there are two practical courses; Advanced Integrated Capstone Design and Business foundation Practice, and each of the subjects is offered in one semester, respectively (K-School, 2016).

The business foundation among students has become a global trend, and a business foundation education program for students has emerged to make such cases in Korea. However, when compared with cases in foreign countries, it seems that there is an issue of a business foundation education program for students in Korea. Business foundation is mostly a practice, but business foundation education for students in Korea focus more on theoretical learning without much of supportive policies for practical aid in business foundation. However, this thesis is intended to identify stages from product conceptual design to commercialization in U.CUBE.

3
U.CUBE Development Process

- 3.1. Concept Design
  - 3.1.1. Idea Conception Phase
  - 3.1.2. Idea Planning Phase
  - 3.1.3. Idea Verification Phase

- 3.2. Detail Design & Test
  - 3.2.1. Initial Detail Design
  - 3.2.2. Detail Design for Improvement of Usability
  - 3.2.3. Detail Design Considering Assembly and Manufacturing

- 3.3. Design for Molding and Production

- 3.4. Product and Market Verification

3

U.CUBE Development Process

The development process of U.CUBE can be divided into concept design, detail design and test, and mold and production process development according to characteristics of the behaviors. These phases are comprised of sub-stages. In this chapter, it is intended to introduce a development course in each phase in detail.

First, it is intended to explain the concept design phase in section 3.1. The concept design phase is classified into idea conception stage, idea planning stage, and idea verification stage. In this phase, the concept of U.CUBE has been derived and confirmed.

In section 3.2, the detail design & test phase is explained. This phase is divided into three stages; initial detailed design, design for the improvement of usability, and design in consideration of assembly and manufacturing. This thesis has dealt with how seven main design items were materialized and developed.

Section 3.3 explained how trial manufactured goods were tested while developing the molds in the phase of molding and production process development and also how U.CUBE was applied with the process of ready-to-mass production. This phase can be divided into six stages as the 1st, 2nd, 3rd, 4th, and 5th mold modification and injection from the preparation of trial injection. This dissertation is intended to explain how interested parties participating in the development in each of the detailed phases influenced each other and how U.CUBE was mass-produced.

Lastly, section 3.4 is intended to explain the verification of product design and the market. This section is intended to explain inquiries and challenges related to the marketability in each stage while going through the concept design, detailed design & test, and mold and production process development and how such issues have been resolved.

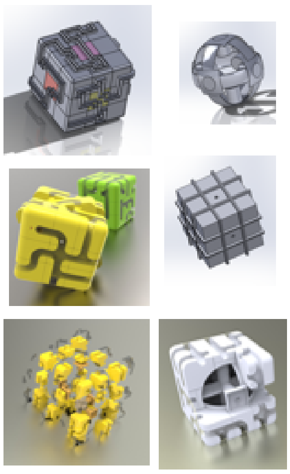
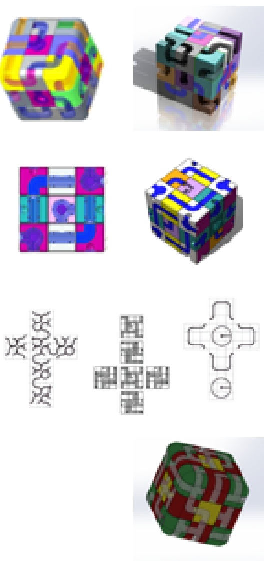
Hereupon, it is expected to identify the success factors of commercialization and also how procedures of commercializing design outcomes in the degree course are different from the previous product development process by figuring out the U.CUBE development procedures in each stage and experiences in each stage. Write down the summary of this chapter within 100-150 words.

3.1 Concept Design

The concept design phase of U.CUBE consists of idea conception stage, idea planning stage, and idea verification stage in detail (See Table 1). In idea conception stage, various idea conception methods were applied to define the formative and functional concept in the first a maze type cube that was combined with maze with cube form. In the idea planning stage, concept was materialized based on the predefined forms and functions exploring the effectiveness of the forms or patterns of routes (maze) and reviewing the possibility of materializing the design. Lastly, design award, IR pitching, patent attorney assessment, value of U.CUBE design from exhibition, market acceptability, technology, and unique value have been verified in the idea verification stage.

This concept design phase proceeded in the undergraduate program. The idea conception phase was made in the fall semester, 2016, with the prerequisite in the industrial design department, IID232 3D CAD. Concept about the form and function of 'Maze Cube,' the initial idea of U.CUBE submitted as the final project in this subject has been developed. Afterward, I have explored the form, structure, and maze pattern of 'Maze Cube' during winter break in 2016 and summer break in 2017 and materialized the concept. The design concept was firstly verified by submitting the results of the final project in IID232 3D CAD subject to Reddot Design Award and Spark Design Award by modifying the results. In results, I was awarded from two of the award ceremonies that outstanding feature of design for Maze Cube was internationally well-recognized. Afterward, technology, market feasibility, and realizability have been confirmed through the meeting with a patent attorney, professional designer from outside, a presentation from participation in the business foundation competition, and demonstration in the exhibition. In this section, it is intended to state the characteristics of behaviors and outcomes in each of the detailed phases.

Table 1. Concept Design Stage

	Idea Conception Phase	Idea Planning Phase	Idea Verification Phase
Tasks	• Incremental development ① Searching idea seed - Finding pain point in daily life - Investigating the working principle of existing product ② Applying the Idea verification method in the constraints situation which is applying existing working principle - Need-Seed Matrix - TRIZ Map - High Tough Matrix - My way(Modified TRIZ) ③ Idea generation through the visualizing tool • Idea generation through exploration - Trying to use 3D CAD tool	• Concept materialization - Forms and patterns of the routes - Principle of the routes(Open circuit, closed circuit) - Width of the routes - The value of R for the overall Edge - Location of entrance/exit • Test - Mechanical design consultation - Path redesign through Cube well-known student	• Submitting design award • Understanding the functionality, rationality, market potential through the design exhibition • Patent attorney assessment • Commerciality checking through IR pitching competition
Works			
Characteristics and Results	• Basic Idea decision about product • Understanding the structural principle • Concept which working with no consideration about connection structure • Ratio are not fitted between each design factors	• Consideration amusement through User feedback • Correction of detail design • Design development which consider connection(screw, pin) and manufacturing cost based on design technology consultation	• After verification among 2 items, Adopt 1 item and develop • Understanding the product development direction and critical problems - Size decision keeping the overall design R value. - Understanding Ball dropping phenomenon between the blocks
Final Results	• 3D CAD modeling files and initial rendering files	• 3D CAD modeling files which consider more detail factors	• Working prototype through 3D printing • High quality image

3.1.1 Idea Conception Phase

The idea conception phase is a course to derive the first design. U.CUBE concept has been derived from the subject titled IID232 3D CAD. Major contents are summarized in the first column of Table 1. In this class, students learn how to configure the internal structure, operating principles, design-oriented appearance, and engineering structure while utilizing 3D CAD on the design process and disassembling existing products (Kim, 2014). In the final project, students were required to design new items. U.CUBE was made according to the operating principles of Rubik's Cube. In order to come up with an idea, various methods such as the Seed-Need matrix[1], Triz, and High-touch matrix were used. In addition, many of the functions of 3D CAD were used to come up with an idea-generating and combining diverse modeling images to produce a concrete idea of the cube. (See Figure. 7). As a result, as shown in the Figure. 8, a very basic idea was derived from the product in the final project. There was a fundamental understanding of the structural principles. However, specific internal design elements such as combined structures were not defined in this phase. At the same time, the design was not fully finalized due to unbalanced form-related factors.

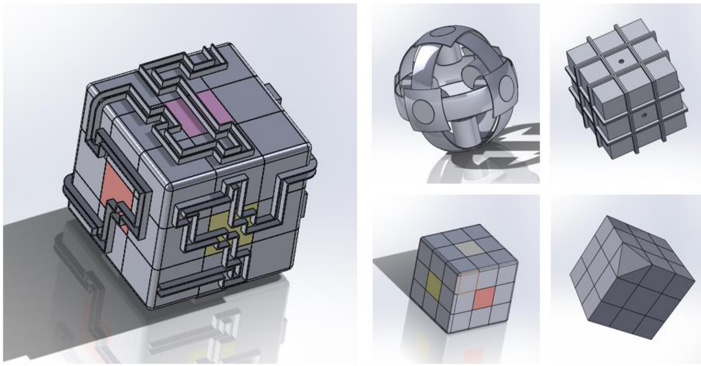


Figure 7. Example of generating and combining the form with 3D CAD in the idea

Figure 8. The first U.CUBE idea in the idea conception phase

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[1] Seed-Need Matrix: Method of coming up with solution or idea for design with the need for an issue to be solved or users' desire from technology or operating principles as a seed, method learned from IID315Design Methodology (class by Professor KwanMyung Kim)

3.1.2 Idea Planning Phase

The idea planning phase is a course to materialize the concept. The main contents are summarized in the mid-column of Table 1. In this phase, the size of U.CUBE, the shape of corners, length and pattern of maze, width, and location of entrance and exit have been explored. In this course, we have defined the size of the cube with a side to be 75-90mm in consideration of existing cube, size of users' hands, and appropriate size of a ball. Ball size has been determined to have a diameter of 9mm when the team evaluated the appropriate size for playing after purchasing balls in the market. Depending on the size of a cube, types with or without circular shape on the corner have been designed creating prototypes to judge whether the length and size of a ball were appropriate to realize the mechanical design. As a result, it has been decided that the length of a side was set to be 90mm. Corner has decided to have a radius of 12mm according to the results of slightly changing the sizes to determine how original conceptual design was to be maintained and visually balanced without infringing the maze on the design.

In addition, as shown in three examples of development in Figure. 9, various patterns and shapes that a maze could possibly have in a cube have been explored while coming up with a new idea on a maze through user workshop. User workshop has conducted an experiment on middle school student users cutting and attaching each size of a regular cube from various maze shapes we designed and assembling regular cube in a minute. From this experiment, it was intended to have feedback from users as to whether mazes we have explored stimulated interest and were too easy or difficult. In this course, users were directed to provide feedback while creating a route that they believed was more interesting to make. (See Figure. 10). With this user workshop, our design team ended up knowing how entrance and exit needed to be located in the middle while removing patterns that were created with routes too easily and coming up with more thoroughly completed maze pattern design including ideas such as trap route.

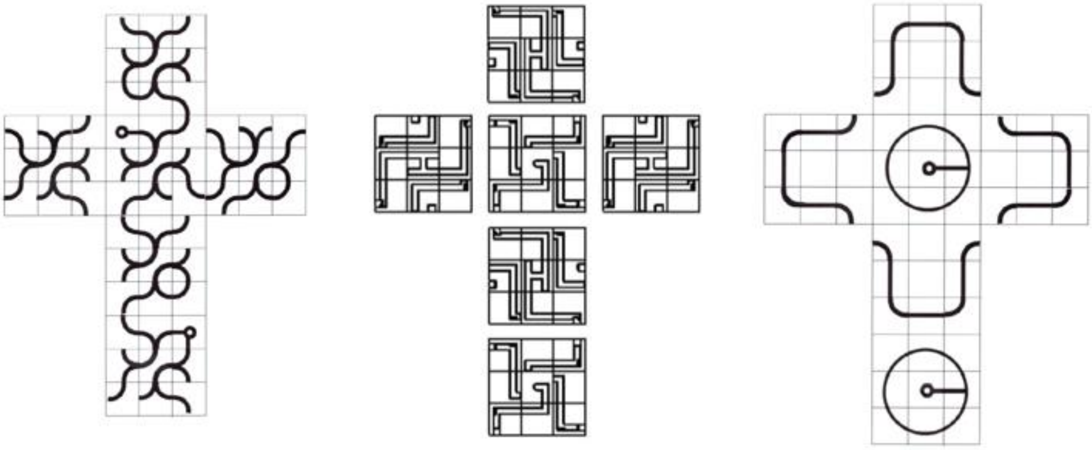


Figure 9. Exploration of design for patterns to possibly be obtained in maze route shape

Figure 10. Maze pattern design workshop on users

As a result of this stage, as shown in the 3D CAD modeling image in Figure. 11, the initial concept of maze-shaped cube where beads moved was maintained while deriving many of the proposals for design in terms of entire shape, maze pattern, or maze route shape. While proceeding this stage, the size of the cube and circular shape were determined to some degree. However, we have explored both the circular shape and right angular shape on the corner of a cube with the possibility of commercialization. At this time, 3D modeling was made by considering the combined structure in detail as shown in the example from Figure. 12. For example, the left side in Figure. 12 shows the shape of a cube, while the right one shows how the block is combined with screw and spring, and the maze window is combined with a block in the form of a pin.

Figure 11. Exploration of design on the maze and entire shape in the idea planning phase

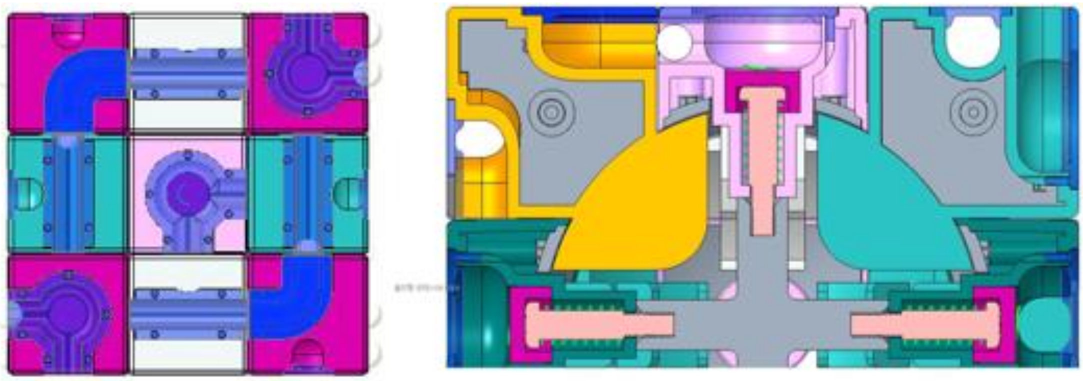


Figure 12. Example of design in the combined structure performed in the idea planning phase

3.1.3 Idea Verification Phase

The idea verification phase is a stage for external evaluation and verification of U.CUBE concept idea. The main contents are summarized in the right column of Table. 1. Conceptual design of U.CUBE in the beginning after idea conception stage was improved with visual completion during winter break and was applied to Spark Award and Red Dot Design Award and awarded with grand prize and winner prize to be well-recognized with uniqueness of design and aestheticism.

What was considered in regard to commercialization when applying for design award was that it might be impossible to acquire patents due to failure in securing the new features when applying for patents if U.CUBE concept was published after receiving design award and 'publicly known to be invented.' In order to avoid this issue, we have applied for a patent immediately after releasing it to the design award. As a result, we were acknowledged with outstanding technology and marketability from a patent attorney as shown in Table. 2 with a score of 43 in technology and 41 in marketability (total 84 scores). For a reference, UNIST is equipped with a system to support patent application by dividing the grades into A with a score of 90 or above, B with the score of 80s and C with the score of 70s as a result of the evaluation.

Table 2. Evaluation of patent attorney for U.CUBE concept

Right/Technology (T)	Completion of technology (T1)	10(Total: 10)
	Features of technology (T2)	9(Total: 10)
	Appropriateness of technology trend(T3)	8(Total: 10)
	Location of lifespan of technology (T4)	8(Total: 10)
	Intensity of rights (T5)	9(Total: 10)
	Subtotal	44(Total: 50)
Marketability (M)	Possibility of commercialization (M1)	9(Total: 10)
	Industrial ripple effect (M2)	8(Total: 10)
	Possibility of growth in the market (M3)	9(Total: 10)
	Possibility of technology demand (M4)	8(Total: 10)
	Convenience of market advancement (M5)	9(Total: 10)
	Subtotal	43(Total: 50)
Total	**87(Total: 100)**	

Two proposals were made on the design after going through the idea conception phase. These two proposals for design were the one with circular corner shape that the maze was much connected as shown in the Figure. 13 and the proposal with angular shape with holes towards outside where maze was disconnected. In the idea verification phase, it was intended to determine one of these two proposals as the final proposal for conceptual design to be more superior in overall conditions. For this, a working prototype manufactured with 3D printer and high-quality rendering images generated in the use of 3D CAD were used as a means for evaluation. Evaluation was conducted by the design team through internal discussion while considering the opinions of research lab members and others. Hereupon, the proposal with a circular shape on the corner has been decided as the final proposal for the development.

Furthermore, these two proposals were demonstrated in the IR pitching competition and exhibitions for two times to verify the potential marketability, commercial value, purpose-appropriateness of conceptual design, and functionality on the idea.

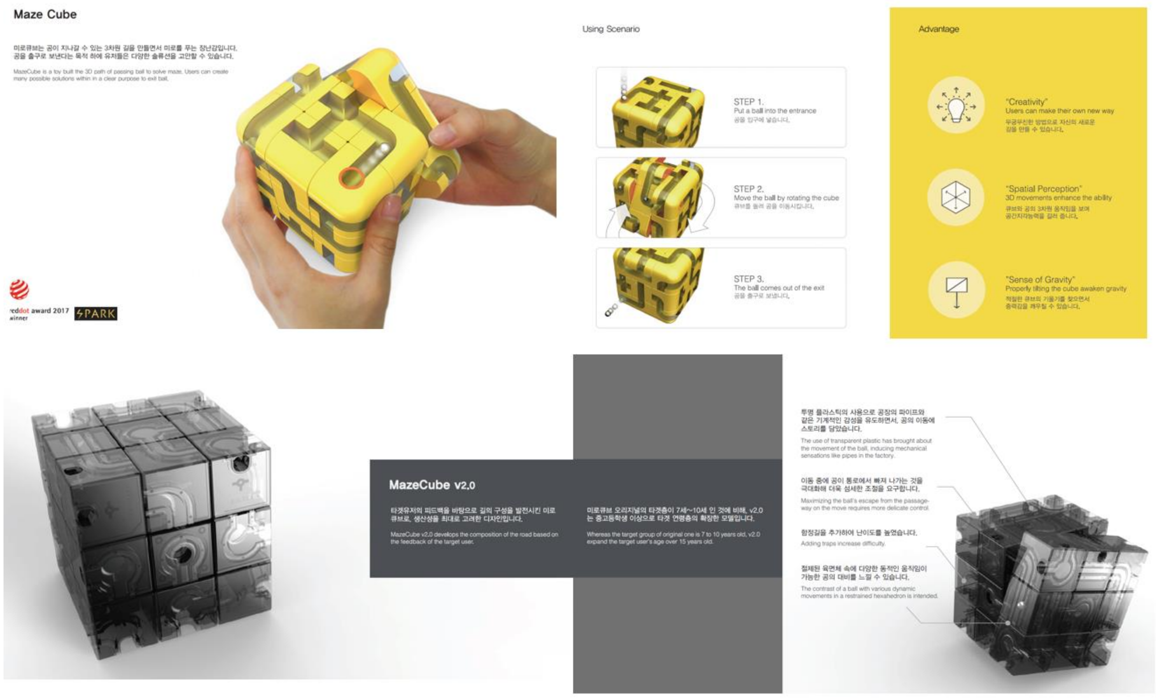


Figure 13. Two proposals for design developed in the idea conception phase

The demonstration of the first exhibition was conducted at the student graduation ceremony held from December 11 to 15, 2017 (Unistnews, 2017). More than 300 people including UNIST students, staff, press media in or out of school, and elementary school students invited by our design team participated in this exhibition. As shown in Figure. 14, we had audiences touch and experience working prototype on two proposals of design manufactured by 3D printing. We have observed this procedure collecting opinions of experienced people to secure more objective grounds for determining the final proposal with a circular shape on the corners. In addition, press media in or outside the school have collected news and presented the Maze Cube in this exhibition.

Figure 14. Experience and evaluation of two proposals of design by users in the undergraduate graduation exhibition

The second exhibition was held at the design venture final presentation competition held from December 19 to 20, 2017. More than 200 people including many of the experts related to the business foundation and participating teams in the business foundation competition participated in this exhibition. We have displayed a working prototype on two proposals of design we have developed and had audiences freely use them. We have observed this procedure by collecting feedback from audiences not only to proceed with objective evaluation but also to find issues to improve.

IR Pitching Competition (Heo, 2017) was held with the exhibition in the final presentation competition of design integrated venture business foundation. Total of ten teams presented in this exhibition that experts in the business foundation and product development including VC participated as a panel member to assess the superiority of business foundation items. Our business foundation team presenting Maze Cube was awarded the grand prize (Fig. 15) and was verified with the superiority of our design and marketability.

Figure 15. Outstanding performance in final evaluation meeting and IR pitching competition in design integrated venture business foundation school

3.2 Detail Design & Test

The detail design & test phase is divided into three sub-stages depending on the causes of design modification. First of all, the initial detailed design is a stage for developing design items of mechanical designers based on the review and instructions of the design team. Afterward, the stage of improvement for usability is when the design team proceeds user tests and reflects on the test results of users. Lastly, the design in consideration of assembly and manufacturing is when the design team reflects feedback from molding companies and injection companies while supplementing the design in the direction for making assembly and manufacturing convenient and improving the quality of products.

U.CUBE has been changed and developed with six design items as shown in the Figure. 16 after going through the detail design & test phase. First of all, central screw parts are where block is inserted to the center of a rube that screws and springs are needed as sub-parts, and also where the detailed design for a cube is changed depending on the specifications of screw and spring. Secondly, rotating parts are related to the design of internal structure influencing on the rotation of each block along the center of the axis. Thirdly, the circular area of the rotating border is related to the design of external circular areas to overcome non-conforming rotation incurring from the interference between blocks when they rotate. Fourth, entrance and exit areas are items for the design determining the shape and size of entrance and exit. Fifth, the magnetic area is an item for design to overcome an issue where usability is degraded due to the immediate exit of beads when beads leave from and arrive at the entrance and exit area. Lastly, the window combined area is related to design for how windows are combined stably without changing the initial design on the block (See Figure. 16).

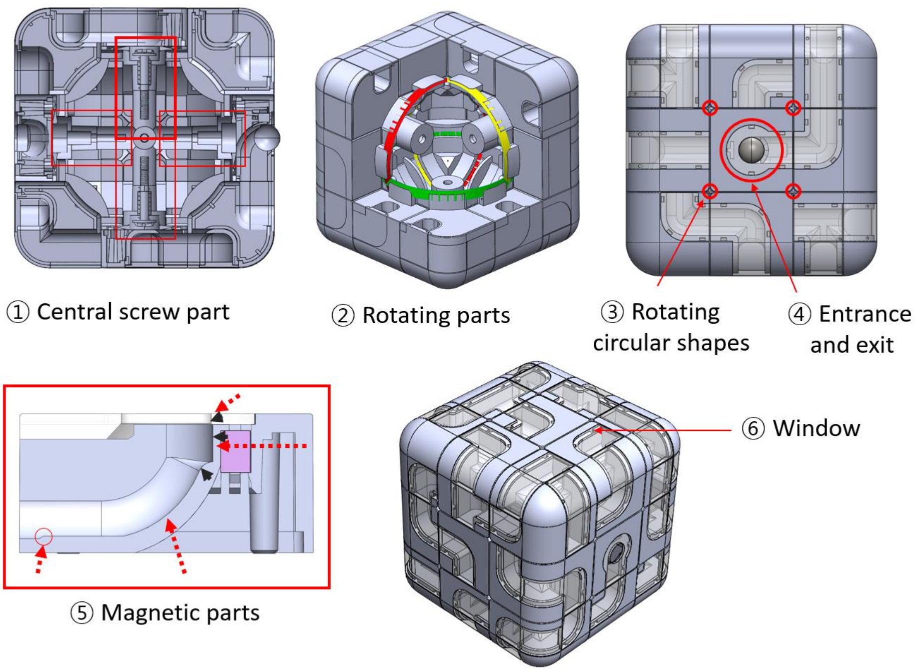


Figure 16. Representative design items

After going through the initial detailed design, design for the improvement of usability, and design in consideration of assembly and manufacturing for each design item, final confirmation has been granted with modification from multiple iterations as shown in the Figure. 17. The period of modification and the frequency of modification were different in each item through the significant review and evaluation procedure. For example, four times of design for screw parts have been completed in the phase for improvement of usability. As for rotating parts, molds were made producing trial manufactured goods with materials to be used for commercialized products that final design was confirmed.

With the detail design & test phase, U.CUBE concept design has been defined to be producible. In this chapter, it is intended to briefly deal with how each of the design items has been modified, changed, and developed to a product.

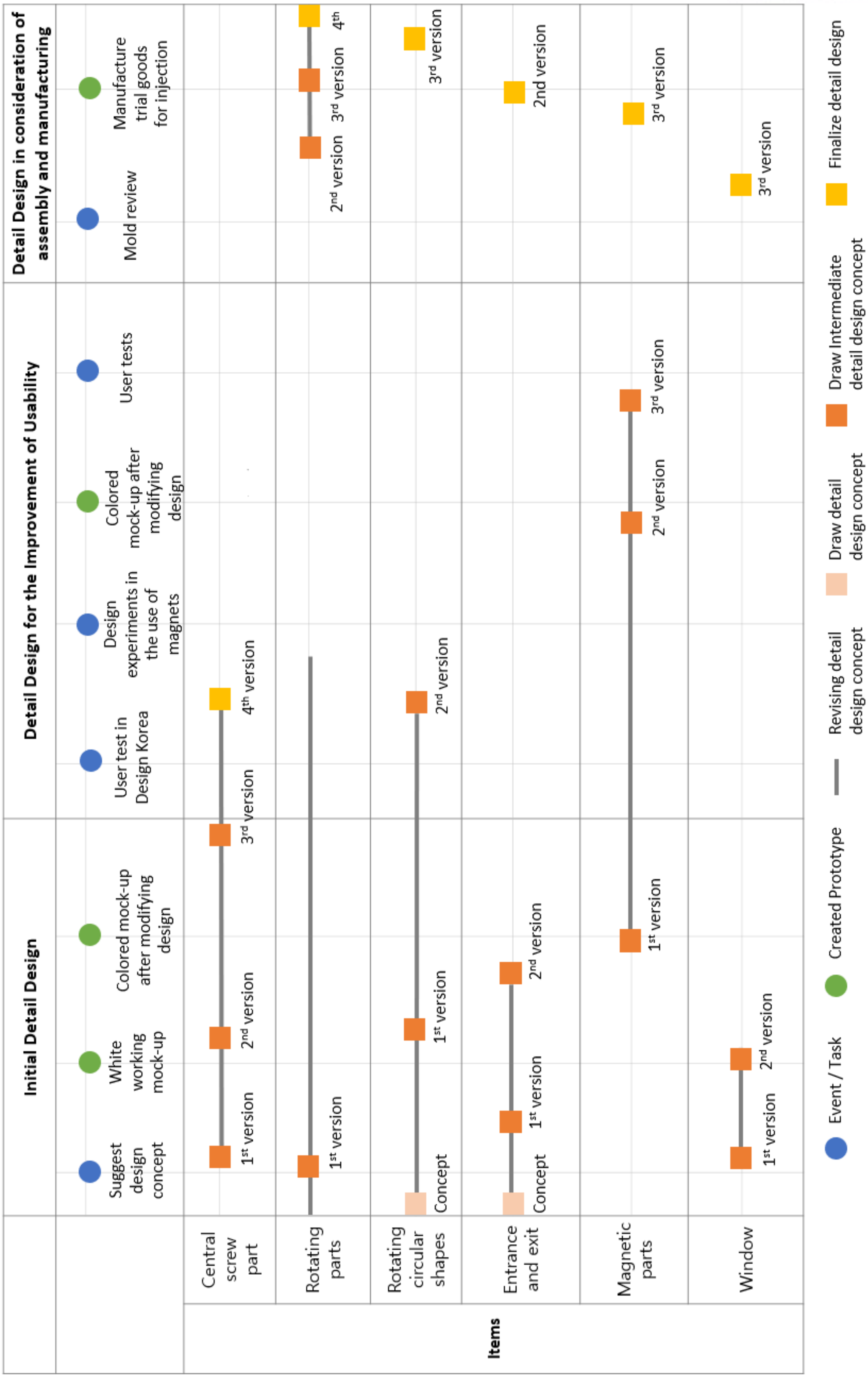


Figure 17. Detail Design & Test procedures

3.2.1 Initial Detail Design

In the initial detailed design phase, the design team and designers from outside communicate with each other while modifying and supplementing the design files. We were in need of a method to rapidly and effectively perform the design as a strategy for successfully proceeding the commercialization with limited time and manpower. For this, we have defined the design concept while providing detailed modeling files generated in the design phase to designers from outside to instruct the direction of design. Designers from outside have reflected the design concepts we provided based on detailed modeling files, while we have identified whether there was any issue by reviewing the design files generated by designers. For the review of design, CAD tool was used on detailed design modeling files to identify the measure, structure, and interference. At the same time, reassembly and simulation functions of parts were used to see if there was any issue on usability when assembling or producing items. Such confirmed files were manufactured in working prototypes in the use of a 3D printer or CNC and actually used to test the usability and functions while identifying the issues to improve.

We have reflected modifications for design in this phase manufacturing total of four high-fidelity working prototypes. From them, it was feasible to confirm the rotation and issues of ball movement that were not verifiable only with modeling in the past. Figure. 18 is the first prototype among manufactured high- fidelity working prototypes focusing on the design in the rotating parts and confirming whether there was a lock-in block when rotating or whether it stably rotated.

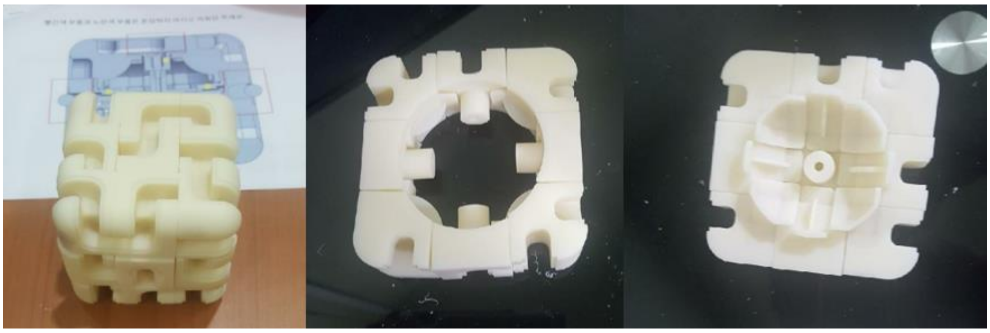
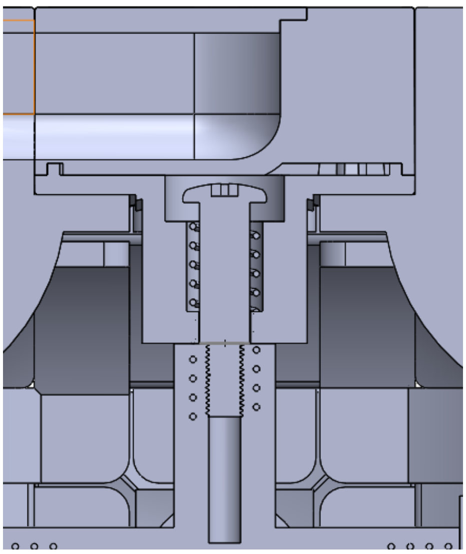


Figure 18. high-fidelity working prototype

In order to effectively manage the design review and modification procedures for multiple times, we have recorded request for modification on the PPT files recorded with dates and provided them to designers from outside. Designers from outside have provided solutions on PPT files. Until the detailed design of U.CUBE was completed, total 29 PPT files were exchanged for the design modification, and there were more than 100 cases for design modifications shared with designers from outside. These design issues could be grouped into six categories. In this thesis, it is intended to explain how design for entrance and exit of central screw parts occurring in the initial detailed design phase has been modified and developed in examples.

The entire size of U.CUBE is 90*90*90mm that is about 1.8 times higher than the Rubik's Cube in the size of 50*50*50mm. Therefore, the internal core of the cube connected to individual blocks tends to become bigger. This means that a part connecting two parts shall be bigger in an appropriate ratio in order to secure structural stability. At the same time, using existing tapping screws in the appropriate length and diameter of Ø3, it has been designed to connect two parts while manufacturing working prototypes and testing them. As a result, there was an issue that spring was stuck in screw thread while the cube block rotated. In order to solve this issue, the size was modified while changing the form so that the screw thread was not stuck in the space where spring was located. Repeating this procedure multiple times, the working prototypes have been manufactured and tested and modified with the design for at least five times until usability and performance were satisfied.

As a result, specifications of the final tapping screw equipped with the current size and form were confirmed. Since it was not possible to find tapping screws with confirmed specifications, we needed to newly develop them in the mold developing phase. The left image in the Figure. 19 indicates an enlarged image of the cross-section where tapping screw is located, and the right image shows the form and size of the finally developed tapping screw. The length without screw thread at where spring is supposed to be compressed is 12mm, and the length of the area with screw thread is 10mm. The size and pitch of screw thread were determined according to three types of standard tapping screws, and the diameter of the screw was 3Ø, and circular and wide screw head was chosen. Based on the advice from the experts in the company specialized in making screws, we have decided to process trivalent white plating to prevent harmful substances in the tapping screws to prevent them as they could be inserted to a product used by children while manufacturing them without thermal processing as the plastic was used.



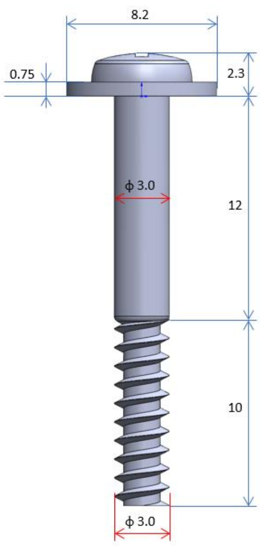


Figure 19. Location (left) and specifications (right) of finally determined tapping screws on the central screw

Then, it is the entrance or exit. Design in consideration of combined structure in the idea conception stage is how one block is configured in the entrance or exit as shown in the Figure. 20 (left), and the block was directly combined with internal cores with screw. However, this design had a screw head seen from outside. Therefore, the modified design concept was suggested as the right image of Figure. 20 (right) in consideration of aestheticism in the idea verification stage. This is a method to divide the block into two (up and down) parts for screw not to be screened from outside.

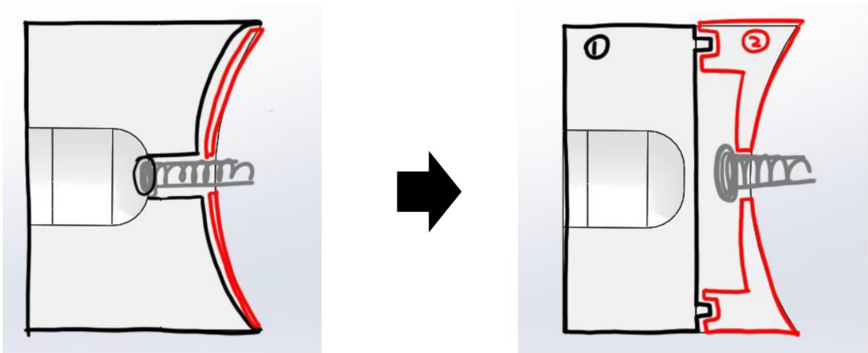


Figure 20. Initial designs (left) and modified design (right) of entrance and exit

In the initial design, the ring part was used for entrance and exit as shown in the Figure. 21 (left). However, single-window part was used instead of individual ring parts as shown in the image of Figure. 21 (right) for the convenience of part management in the second design modified proposal, while applying different printing colors to classify entrance and exit.

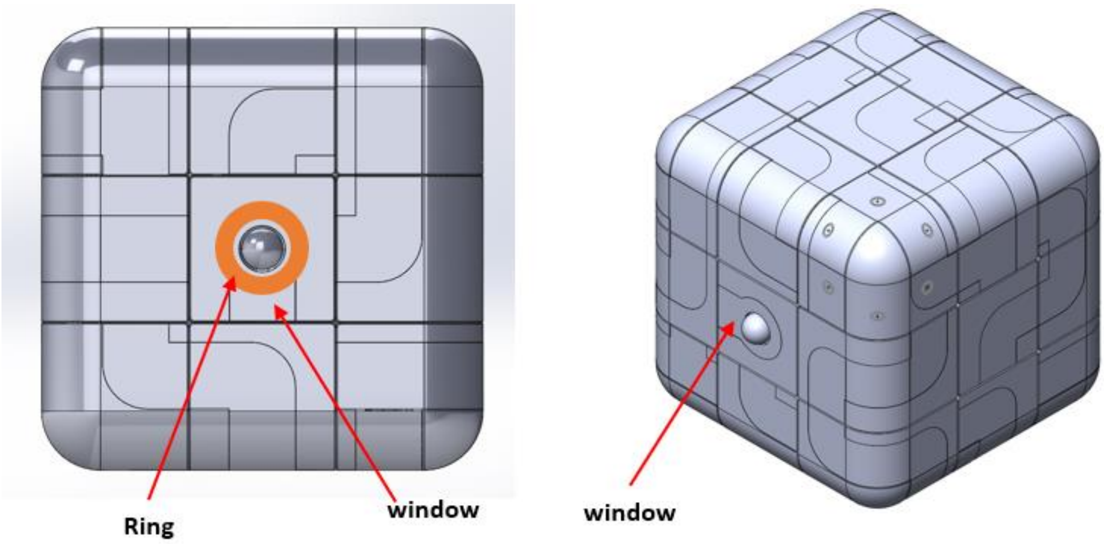


Figure 21. Changes in ring parts in entrance and exit – Initial design (left) and modified design (right)

Overall, finally, determined design specifications in the initial detailed design phase can be summarized as follows. Tapping screw - 3Ø pan head without trivalent white plating thermal process for the plastic; entire cube size – 90*90*90mm; diameter of cube corner – 12mm; width of route where beads move along – 9.6mm; rotating corner circular shape – 1mm; window combination method – adhesive processing. The shape of U.CUBE finished with the initial detailed design has been more specifically developed in consideration of functional or manufacturing aspects over the shape in the previous conceptual design phase (See Figure. 22).

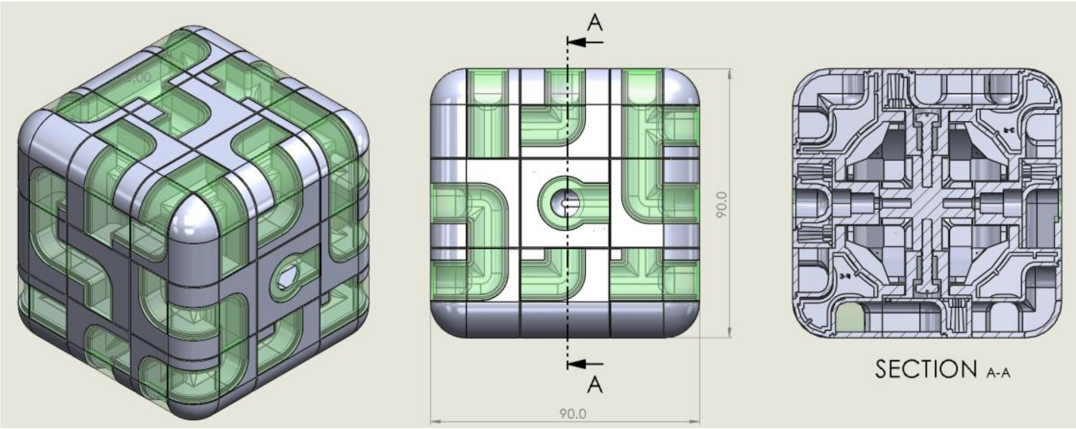


Figure 22. U.CUBE shape determined in the initial detailed design stage

3.2.2 Detail Design for the Improvement of Usability

In this stage, results in the initial detailed design were reflected to manufacture working prototype, while proceeding function and usability test with manufactured working prototype. At the same time, the design was modified to solve found issues. In this stage, it was repeated to manufacture working prototypes, test, and modify the design.

We have manufactured working prototypes to test design completeness, function, and usability of U.CUBE design displaying them at the booth of Design Korea 2018, observing/investigating how visitors played with working prototypes, and proceeding survey on their play experience. In this chapter, it is intended to explain how we identified issues related to usability and how identified issues were resolved by reflecting on the design.

Exhibition at the booth of Design Korea 2018 was held at Ilsan Kintex from October 31 to November 5, 2018. Five types of engineering samples (manufactured by regular mechanical processing method as a working prototype equipped with function and external design) manufactured based on initial detailed design with individual booths for displaying U.CUBE were shown in this exhibition. As shown in the image of Figure. 23, survey was conducted after people in various age groups and genders visited the booth and freely used U.CUBE. Questions in the survey included overall satisfaction of U.CUBE, completeness of design, preferred color and style, willingness for the purchase, affordable price range, targets to present U.CUBE, and improvement and additional opinions.

Figure 23. User test at Design Korea 2018

There were total of 78 participants in the survey in the age group from the 10s to 50s. According to their distribution, there were 44 participants in their 20s as the highest proportion of 56.4% from the entire participants followed by 11 participants in their 30s (14.1%), 10 teenage participants (12.8%), 4 participants in their 40s (5.1%), and 2 participants, respectively, in their 50s and less than 10s (2.5%)

(Table 3). According to the gender distribution, there were 35 male participants and 36 female participants. There were six cases not indicated with the gender.

Table 3. Age and gender distribution of participants

	Men	Women	Not specified	Total	%
10s or below	2	0	-	2	2.5%
Teenagers	5	5	-	10	12.8%
20s	19	24	1	44	56.4%
30s	8	2	1	11	14.1%
40s	-	4	-	4	5.1%
50s	1	1	-	2	2.5%
Not indicated	-	-	6	6	7.7%
Total	35	36	6	**78**	**100%**

In this chapter, it is intended to state the results of analyzing collected data from improvement and additional opinions among inquiries on the survey, and results from other items are to be discussed in Chapter 3.4 Product and Market Verification.

According to the analysis of collected responses from improvement and additional opinions, there were sixteen questions about rotation and durability as the highest frequency. Other than them, there were five opinions about how heavy it was, four opinions about how fast beads were moving and lost, and three opinions about how big they were.

Among them, weight was an issue to be naturally resolved in the mold developing phase. The working prototypes used in this user test was manufactured with CNC that was not reflected as designed due to the complicatedness of internal shape but filled with all the internal space of blocks as shown in the Figure. 24. However, overall weight tends to be lighter by about 70% as external thickness is to be left as designed while making inside as an empty space when developing injection molds.

Figure 24. Internal shape of working prototype used in Design Korea 2018 User Test

Since the issue of durability was from how the cube was not sufficiently tightened from the problem of processing method, I believed that it would be naturally resolved in the mass production phase.

The issue of poor rotation might be from several reasons. These include the abrasion on the surface of a block, poor design in the rotating parts, and blocks stuck with each other when rotating.

As for the abrasion on the surface, it specifically means abrasion occurring when surfaces of a cube contact with each other when cube rotates. As for the working prototypes we manufactured, the surface was spray-colored that the abrasion coefficient became higher for making rotation poor. Therefore, it was an issue to be naturally resolved if using injection plastic with a lower abrasion coefficient without spray coloring in the mass production phase. Design in the rotating parts did not have any problematic issue when simulating with the rotation of a block in modeling data as shown in the Figure. 25.

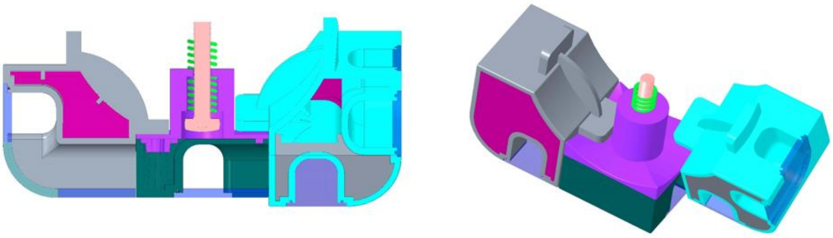


Figure 25. Review of simulation in rotating parts

Representative modification in design was made to make corner as circular shape where blocks met with each other. Initial design had the right angular shape around this place. If blocks rotate, nine blocks located on one surface rotate at the same time. At this time, rotating blocks slowly contacted non-rotating blocks to stop blocks from rotating in the end. Therefore, it is possible to avoid having blocks stop rotating by contacting each other if changing the corner of a block in a circular shape. With such judgment, we have changed it to a circular shape with a radius of 2mm from existing angular shape as shown in the prototype image in the Figure. 26. According to the results of the test on usability with the prototype (right side in Figure. 26) manufactured based on the design modified after Design Korea 2018, it was confirmed to be much improved with a rotation function.

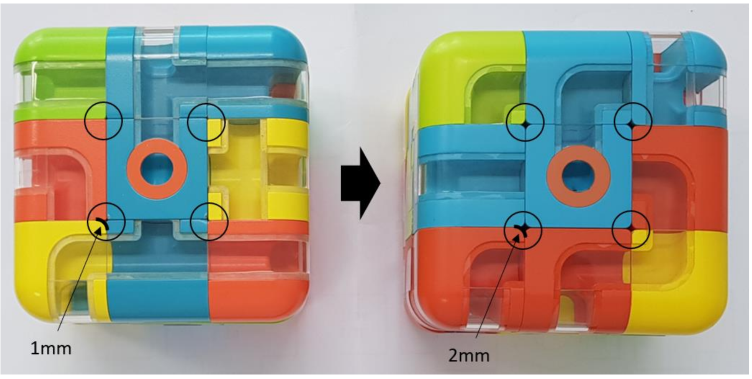


Figure 26. Modification of corner to a circular shape with radius of 2mm for the improvement of rotation function

Then, the issue on the usability that was importantly observed was how beads rapidly fell off to the floor from the exit. Because of this issue, users needed to stop playing to pick beads up or ended up losing them. We thought it was a critical usability problem for not being able to commercialize U.CUBE without solving this issue (Yang, Jeon, Tufail, & Kim, 2019). In order to resolve this issue, we came up with five ideas through the sketching procedures as shown in the right image in the Figure. 27.

(1)Using a rubber cap: We can stop the running ball and pull out it by closing and opening a rubber cap.
(2)Rotating cover: We can change the hole size with a rotating cover.
(3)Sliding cover: We can change the hole size with a sliding cover.
(4)Using a device like a magnet at hidden place near the holes to make the ball stopover
(5)Digging a spot in the path to keep the ball static

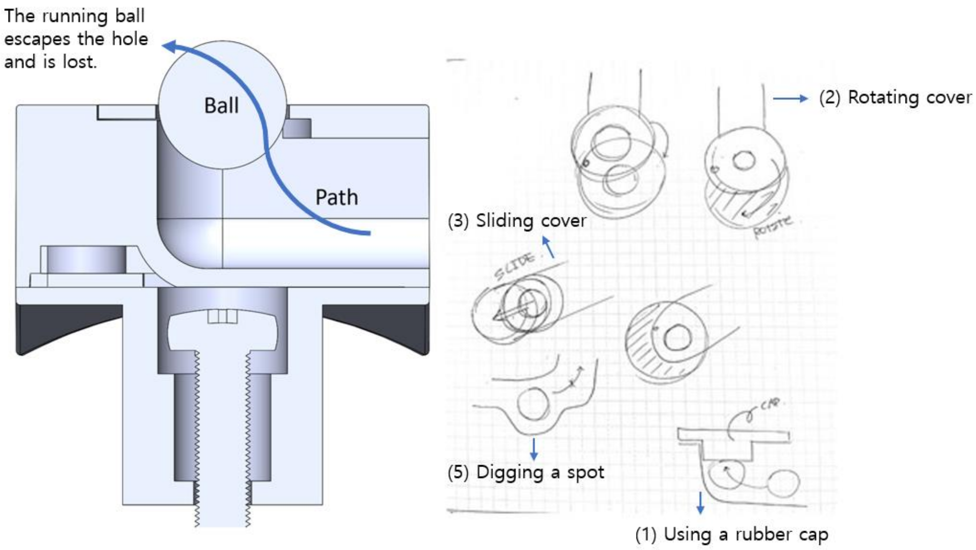


Figure 27. Critical usability problem (left) and solution sketch (right) of U.CUBE

Among these ideas, we chose to insert magnet as a solution to enhance usability without degrading appearance design. In order to materialize this proposal, we have manufactured more than thirty testbeds to experiment with various combinations of magnets while proceeding magnetic simulation and repeated the test.

The first testbed was manufactured to find the optimal magnet numbers and badges in assumptions to use ND magnets in Ø3×6mm. Testbed prototypes were made by using FDM 3D printer. (See Figure. 28).

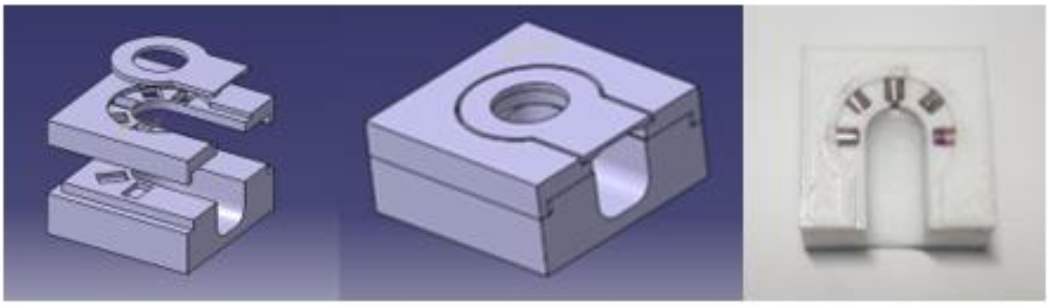


Figure 28. Modification of corner to a circular shape with radius of 2mm for the improvement of rotation function

In order to determine the location of the magnet for the experiment, circular magnets were diversely located as shown in the Figure. 29 performing simulation as to how magnetic lines were distributed in the passage of beads. As a result of the experiment on the testbeds, the magnets turned out to catch the ball the most if two poles were located in the same direction.

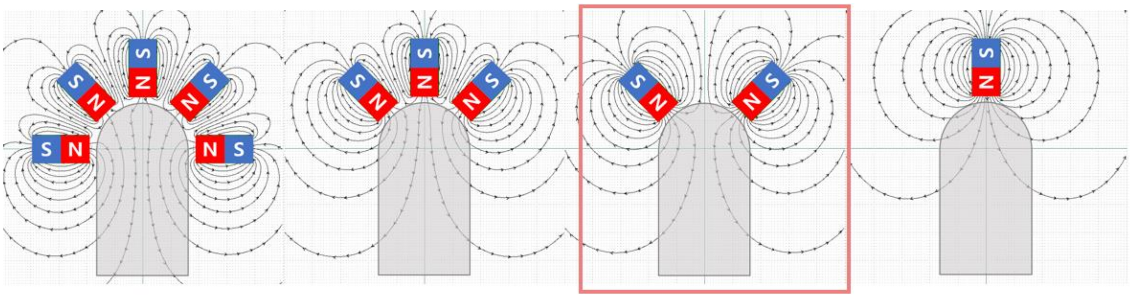


Figure 29. Magnetic line from the number of magnets

However, we ended up knowing how difficult it would be to assemble if distributing two poles of a magnet were distributed in the same direction while proceeding the experiment. In other words, if distributing the same poles in the same direction as shown in the third image of the Figure. 29, one magnet tended to be distributed upside down. Therefore, it was not convenient to keep it in the right position. At the same time, it might cause poor assembly if wrongly inserting it in the reversed direction. Therefore, it is the most efficient to use one magnet in terms of assembly. Hereupon, we came up with a curve-shaped magnet covering the maze path as shown in the Figure. 30.

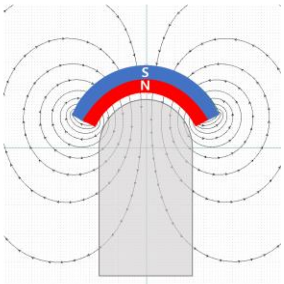


Figure 30. Magnetic line of a single curve shaped magnet

However, it was not possible to find such the shaped magnet in the market. Therefore, there was a burden on costs if newly developing them. As an alternative, we have reviewed various rectangular magnets sold in the market. As a result, we thought the magnet with the length of 6mm*, width of 3mm*, and height of 4m was appropriate as shown in the Figure. 31. It was decided to determine the detailed design with parametric design.

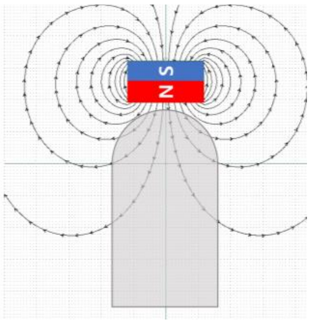


Figure 31. Rectangular magnetic lines distributed to the area to catch a ball

In order to well catch a ball by using a rectangular magnet we chose, we needed to conduct parametric design to determine several important design parameters. Figure. 32 shows the position of magnet, path, bump, and structure to stably catch beads with four parameters we considered. First of all, we have determined the location of a magnet by deciding the distance from beads and also how strongly beads were attached to the magnet. Path determines how to effectively catch beads rolling from the curve and for moving beads not to be attached in the reverse. Bump is a device to reduce the momentum of moving beads. Whether to have a bump and the number of bumps were considered as design parameters. Lastly, structure for stably catching beads is that brads are attached to the following three points of top, wall, and below for stably catching beads without making them move.

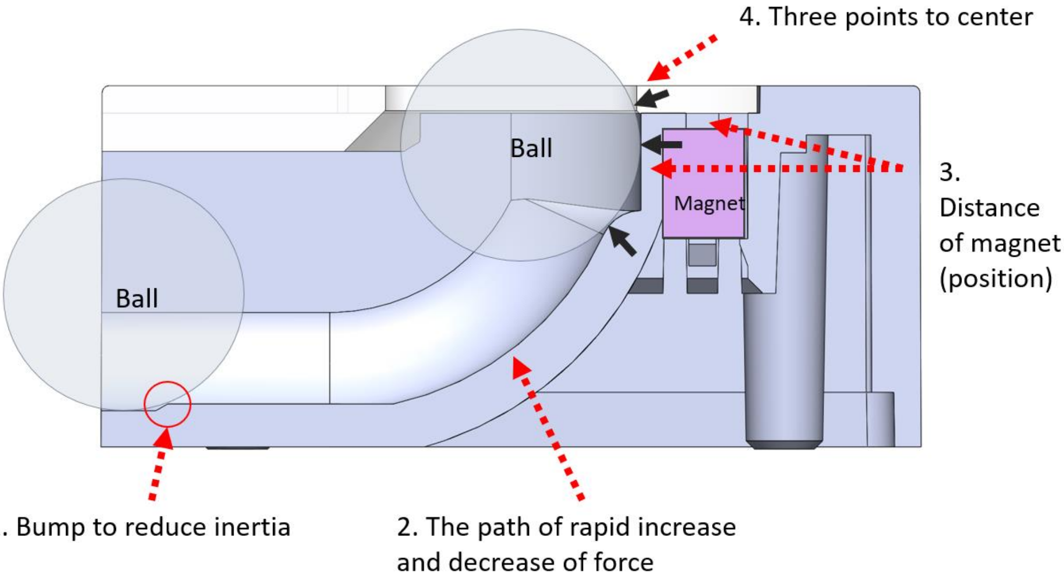


Figure 32. Parametric design of U.CUBE path

We have considered how the maximum length of a ball rolling on a straight line from a cube was 45mm while manufacturing them with different testbeds with a ball moving distance of 70mm to make tough conditions for having balls move as fast as possible (Figure. 33). A total of 41 testbeds were manufactured by using SLA 3D printer.

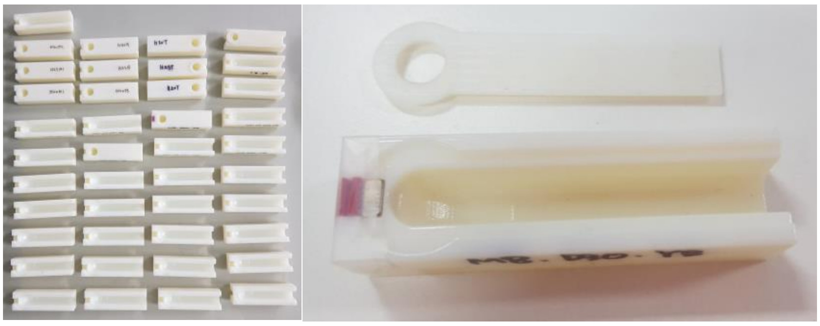


Figure 33. Test beds (left) and test bed example photo (right) for parametric design

We were not able to have considered all four parameters from the start. At first, the testbed that could only control the distance of the magnet and the ball were manufactured and experimented repeatedly, but the results were not satisfactory. As a result, measures were derived to enhance usability to the maximum satisfaction level, and finally, four design parameters were derived one by one.

In an experiment with different path curvature among the four parameters, the speed of the running ball was stable and the simple tapping when starting the ball determines the curvature and shape that best meets the conditions for the ball to beat its magnetic force and roll effectively. A total of more than forth testbeds were manufactured and repeated tests were conducted while the structure that holds the pump and ball stable were tested.

The experimental set for viewing the effect of ball catch according to the parameters was set the test bed at an angle of 60°, taking into account the cube angle conditions when the ball was taken out of the cube. The experiment was conducted by dropping the ball from one hole in the fixed testbed and counting the number of times the ball was caught at the other exit. Each experiment was performed 30 times for different parameter values. The design of the finally determined magnetic part was to have one pump, 0.7mm distance between the magnets and a champer on the windows, and the structure under the ball was a detailed structure with a bump of 3mm diameter.

Reflecting this revised design, five engineering samples were created, and six elderly people in their 60s and 70s were tested for usability and six 6-year-old children at the Munsu Silver Welfare Center and six at the UNIST Daycare Center. In addition, the Cube experts invited Cube teachers from the South Gyeongsang chapter of the Korea Cube Academy to explain about U.CUBE and listen to the general opinion. (See Figure. 34). As a result, we were able to get fairly positive feedback from users.

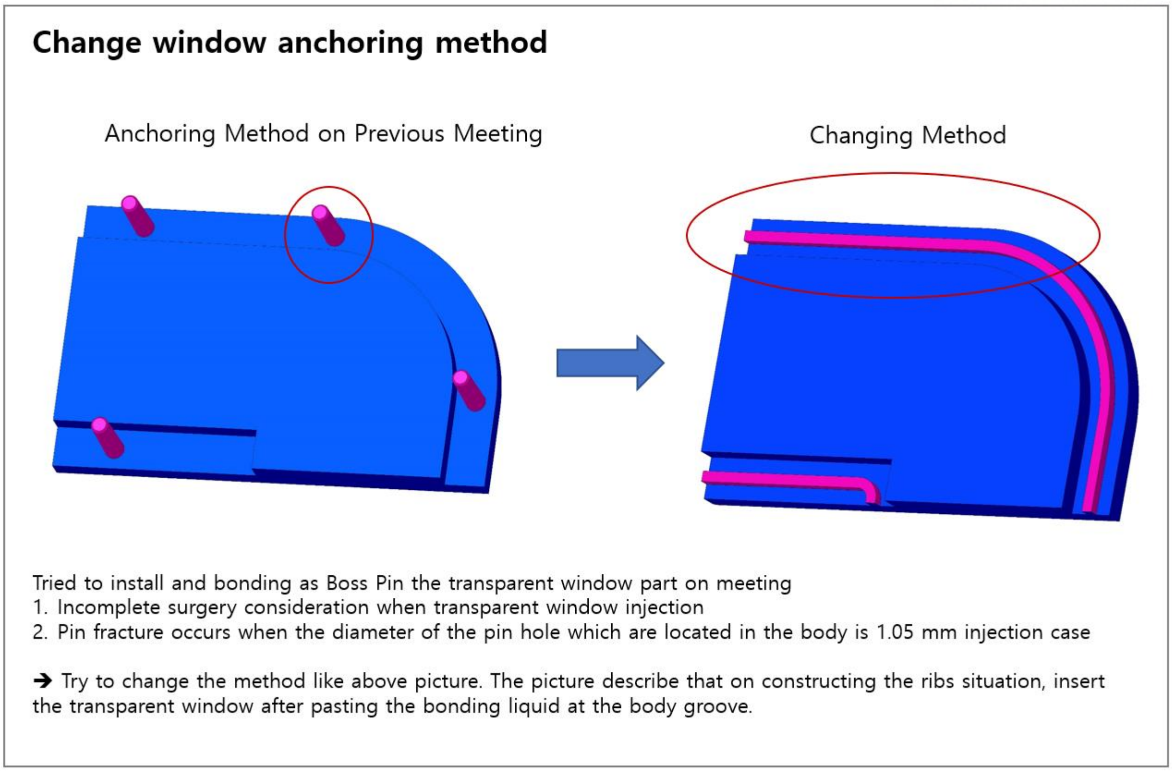
Figure 34. User test photo – For adults (top left image)(Source: Park, S.H. (2019)), For children (bottom left image), for cube class teachers (right)

As such, new design problems were discovered that were not found at the design stage by testing users at the design stage to improve usability, and the parametric design was a useful approach to improving usability.

3.2.3 Detail Design Considering Assembly and Manufacturing

The last detailed step of the Detailed Design & Test phase is the design phase considering assembly and manufacture. This phase is a stage to modify and supplement the design to reduce assembly time and manufacturing costs. In addition to detailed design modifications in 3D CAD Modeling, mold design modifications were also made, design was confirmed through the suggested prototype, and most design items were completely and finally finalized. Almost all design items were finalized when the U.CUBE was reviewed as the fifth injection, T4. In this chapter, I would like to discuss the design process of window combinations in particular, among other examples.

The U.CUBE has several types of transparent windows located on the surface of the block. Assembling these windows effectively and keeping them from being dislodged after assembly was a major consideration in the design. Fig. 35 shows a record of changes in the initial window design. In this initial design, the discussion with the designer was modified by considering how to combine windows using pins (upper left of Fig. 35) and by combining them into adhesive as shown below and right of Fig. 35 for concern of breaking windows when playing with them.



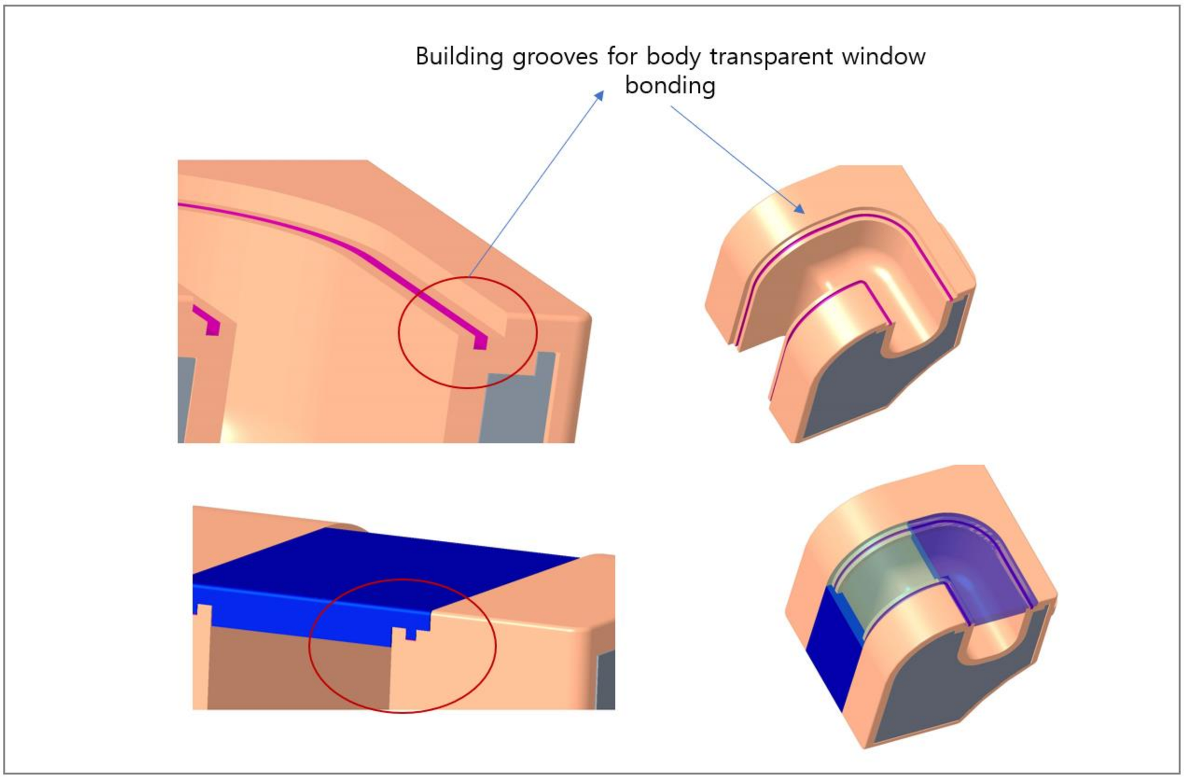


Figure 35. Record of modification for window anchoring method: Based on adhesive application from pin method

However, the way of handling adhesive might be harmful to the health of operators due to the smell of chemical substances when the manufacturing process is added for the assembly. At the same time, an issue has been raised for how it might take long to assemble. We have reviewed technical issues and pros and cons of assembly of windows in hook during the meeting with mold companies. As a result, the conclusion has been drawn for how the hook method was significantly outstanding in terms of assembly.

The shape of U.CUBE after the design in consideration of manufacturing and assembly is shown in the Figure. 36. The area for combining hook was created near the window that magnet areas, central screws, rotating parts, and rotating corner circular shape have been re-determined in detail, and other design items have been reflected.

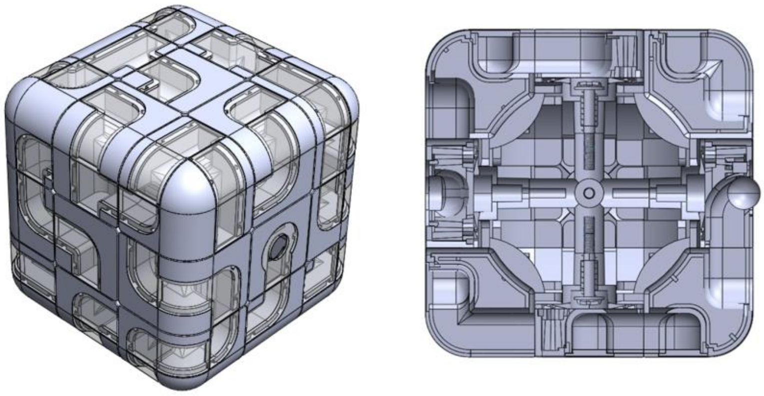


Figure 36. Shape (left) and cross section (right) of design completed U.CUBE

3.3 Design for Molding and Production

The final step in the development process of the U.CUBE product is the development stage of the mold and production process, which is the stage of reviewing molds and injection products and understanding the process to effectively manage production and assembly. At this stage, close cooperation and communication between stakeholders in the Supply chain were required. Each activity was affected by the work of different stakeholders, especially the schedules that required a response in the middle or outside, such as those that had to be delivered from outside or submitted to exhibitions or competitions, directly affected the work of the stakeholders, thereby facilitating the pace of progress.

At this stage, mold companies, injection companies, and our design team worked closely together, and the review of mold modification, trial and demonstration was conducted with a repetitive cycle. Figure 37 shows the tendency of this iterative cycle.

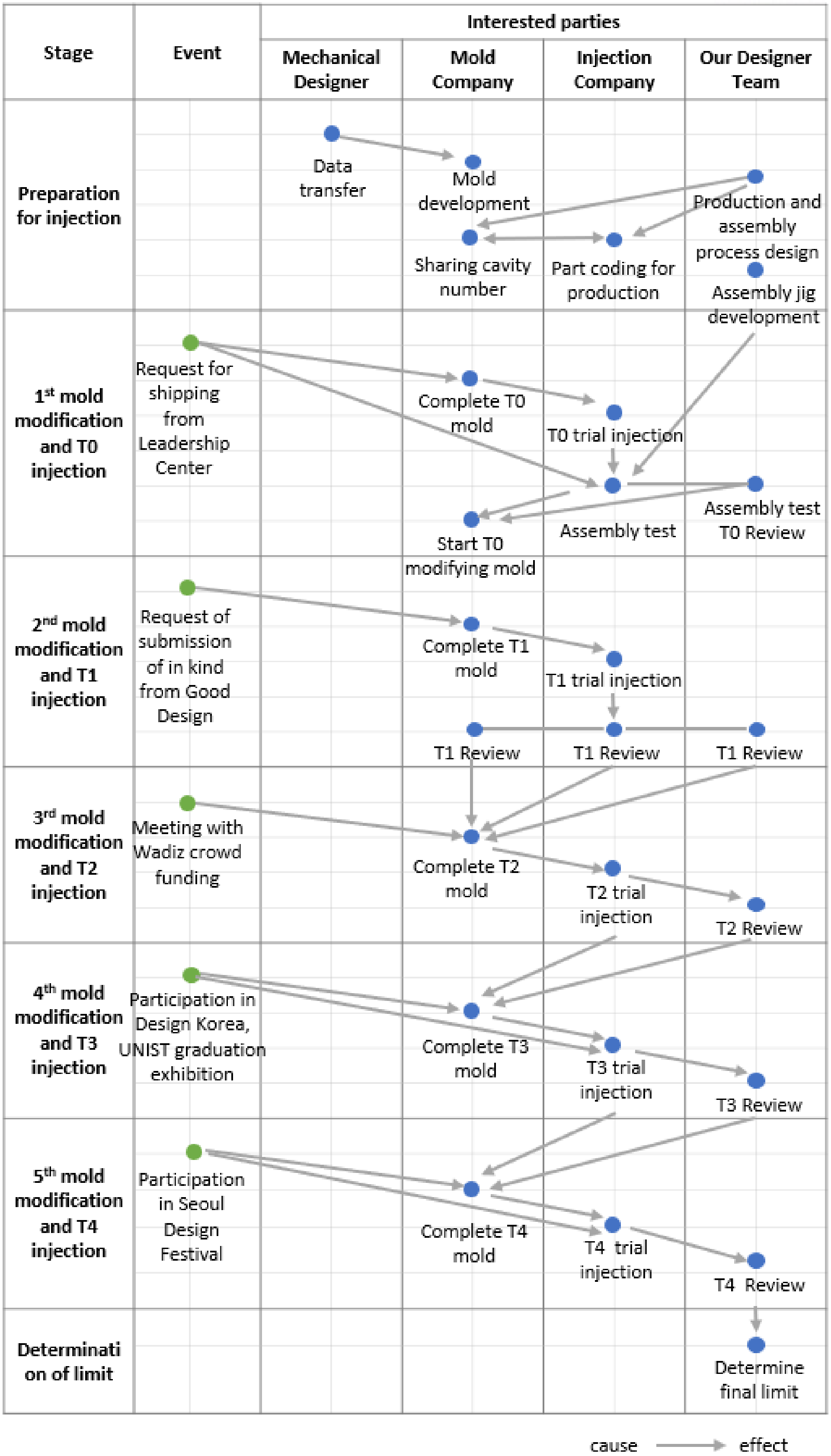


Figure 37. Repetitive modification and supplementary work for the improvement of molds and production process

This cycle took place until there were no further modifications when our design team reviewed the current events. There were 30 modifications when reviewing the T0 injection product, and the T1 injection product review reduced the number of modifications to 11. In phase T4, the modifications were reduced to three.

The color injection was tested as the number of corrections was reduced. Figure 38 shows the color samples tested for each number of current events. Up to T0-T2, the presentation from the left to the third, was projected in white monochrome, and at this stage, the focus was on modifications to the design centered on usability or functionality. In the T3 phase, two new color injection attempts were made ahead of Design Korea 2019 and the UNIST Graduate School graduation exhibition (Heo, 2019). Based on this test collar injection, our team selected lighter, light colors from Pantone color chips and visited the eyewear with the selected color code and decided on six colors. In T4, three of these six colors were newly extracted. (Rightmost in Fig. 38)

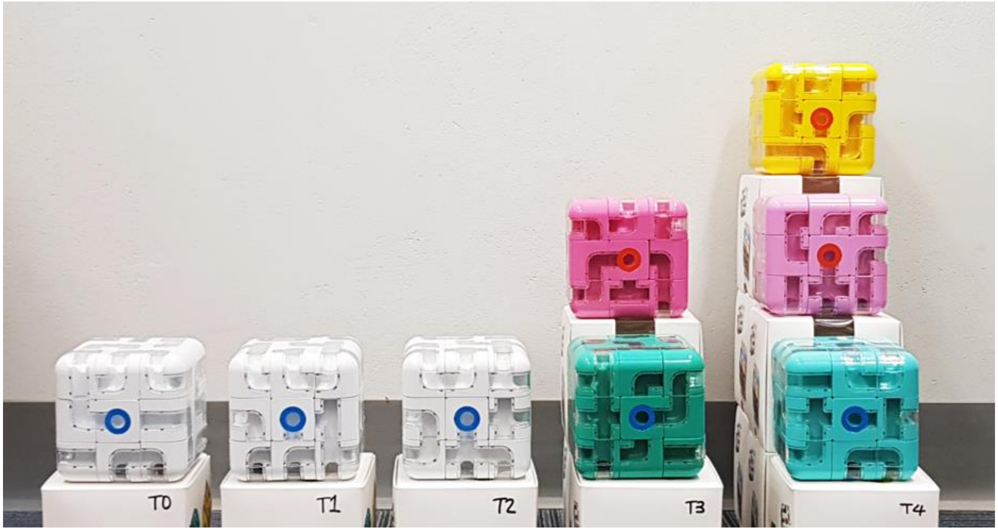


Figure 38. Exploration of trial manufactured goods and colors in each stage from T0 to T4

It was an important role of our team to manage and supervise in the mold and production process development phase. In the injection preparation phase, we have determined parts and molds coding and assembly processing and order to establish the production and assembly control system. In the repetitive mold modifying and injecting phase, we needed to control the schedule and the modifications of each trial manufactured good. Figure. 39 represents data made to identify parts, molds, and assembly processes of U.CUBE, and there were a total 137 parts in fifty types and total 102 processes for the entire process for U.CUBE.

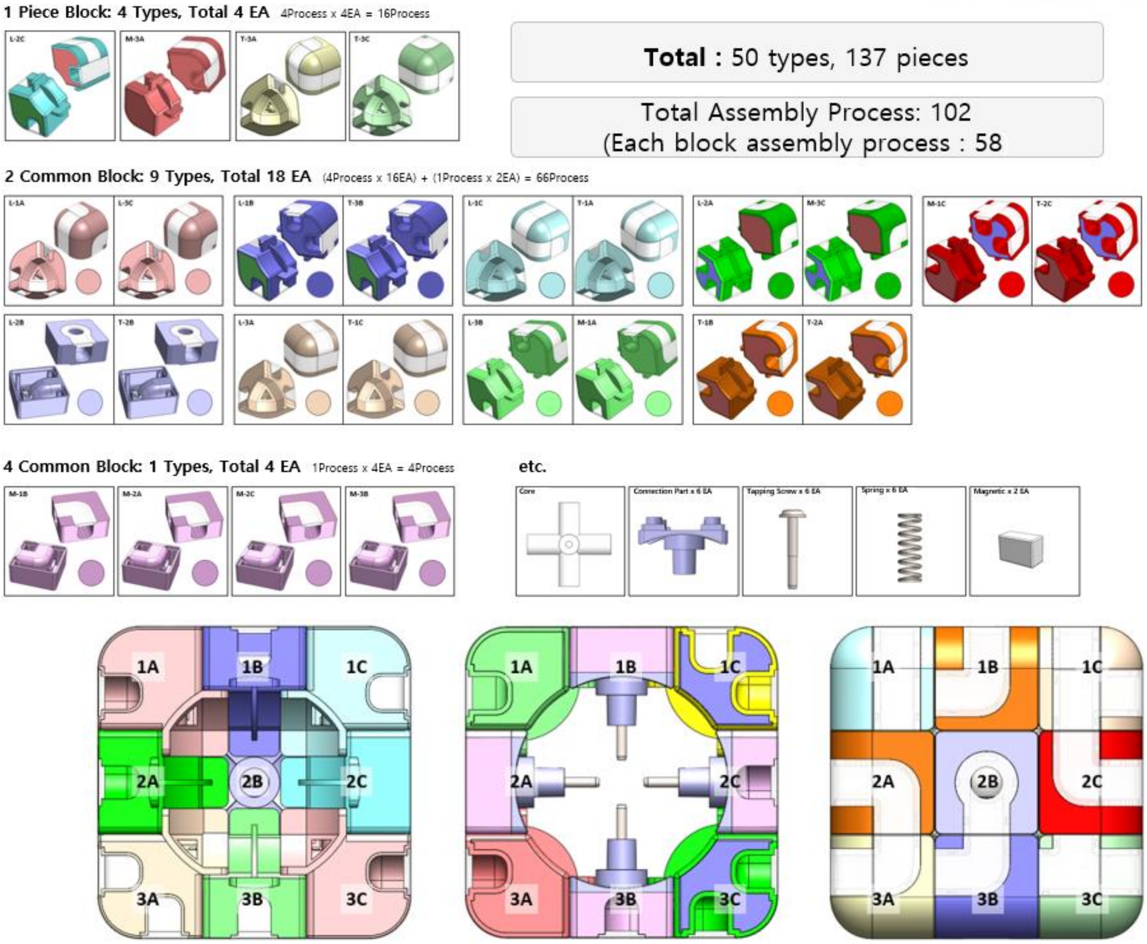


Figure 39. Review of part configuration and assembly process of U.CUBE

Other than these data, resources summarized with the unique names of parts, mold configuration, and cavity distribution helped us control stock of parts or non-conformance and effectively communicate with interested parties for the problematic parts. Hereupon, it is required for the design team to actively review trial manufactured goods and make visually well-organized data including code name or assembly manual to provide them as an efficient communication tool in order to produce high-quality products.

3.4 Product and Market Verification

In this chapter, it is intended to explain the verification methods and means on the superiority of products in consideration of inquiries to be solved in each stage and marketability from the conceptual design to commercialization. Related contents are summarized in Table 3.

Table 4. Verification contents and methods in each stage

Phase	Questions	How to verify product design and market	Verification tool
Concept Design	✓ Is there a possibility of commercialization? ✓ Will people like it? ✓ Can I start my own business?	- Reddot design awards (Winner) - Spark design awards (Gold prize) - IR Pitching Contest (1st Prize)	Rendering images Rendering video
		- UNIST undergraduate graduation exhibition - Mock investment exhibition	3D working prototypes
Detailed Design & Test	✓ Who would buy? Who is the best target user? ✓ What kind of cube does the buyer want? What kind of cube does User like? ✓ When, where and for what purpose to use cube? ✓ How do you want to play with a cube? ✓ How much do you want to live for? ✓ Will it sell a lot in the market?	- Selected as Good Design - Selected as Global Premium Living Goods	Photo image Real video
		- Design Korea2018 Exhibition - After-school cube teachers feedback - Feedback and Observation of Elderly People at Munsu Silver Welfare Center - UNIST Children's Daycare Center Observation	CNC high-fidelity prototypes
Design for Molding and Production	✓ Will people be satisfied with the cube now? ✓ How much will it cost? ✓ How much will you sell? ✓ How can I sell it?	- UNIST Leadership Center Sample Purchase - Design Korea2019 Exhibition - Seoul Design Festival Exhibition - UNIST graduate school graduation exhibition	Injection models Trademark Product package

During the concept design phase, there were questions about the superiority and commercial viability of U.CUBE in the idea verification phase. To validate the design excellence of U.CUBE, we have released U.CUBE to the Reddot Design Award and the Spark Design Award and ended up identifying that the concept of CUBE was internationally well recognized. At the same time, we were able to have confidence in the design concept of U.CUBE by receiving positive responses from visitors at the undergraduate graduation exhibition and the mock investment exhibition of the design fusion venture business foundation school. Questions about the possibility of commercialization were resolved with consultation with a patent attorney and by winning the grand prize at Design Convergence Venture Startup School IR Pitching Contest. The means used at this time were rendering images, rendering images, and 3D working prototypes.

In the Detailed design & Test phase, there were more specific and many questions that were related to users, buyers, and manufacturers. In particular, it was questionable whether the superiority of the concept design of U.CUBE would lead to actual purchase when it was made into a product. In order to verify this issue, we have used trial manufactured good of U.CUBE (high-fidelity working prototype) developed with high durability and completeness from multiple modifications of the design, proceeding the actual user test. At the same time, the final manufactured product is selected by submitting it to the GD's excellent design and the global lifestyle item making the product quality of U.CUBE well recognized to some extent. The advantage of trial manufactured goods was that it was possible to manufacture actual product photo images and videos. Therefore, it was feasible to use them as a means of advertisement for U.CUBE and confirm the possibility of commercialization of U.CUBE by showing them to people if opportunity allowed.

The user test was especially important at Design Korea 2018 event for the product verification method used in the Detailed design & test phase. More than 100 visitors came to the U.CUBE Exhibition booth and experienced U.CUBE. 78 of them responded to the survey, and the survey results addressed a number of commercial questions such as the U.CUBE's design, purchase intent, and sales price level. As explained briefly in the Chapter, 3.2.2, the questions in the survey consisted of seven categories: (See Appendix for survey forms.)

(1). Overall satisfaction (1 Very Low-10 Very High)
(2). Completeness of design (1 Very Low-10 Very High)
(3). Willingness to buy (1 No-5 Really Want)
(4). Preferred color type (One Color / Mixed Color)
(5). Reasonable price (min ~ max) at purchase
(6). Whom do you want to give it as a present?
(7). Improvement points and Ideas(recommendations)

According to the results of survey response data, the overall satisfaction on the products in question 1 turned out to be 8.35 in average out of 10 (1.44 of standard deviation) (See Figure. 40), where the completeness of design in question 2 turned out to be 8.74 (1.54 of standard deviation) out of 10, and the willingness of purchase in the question 3 turned out to be 3.89 out of 5 (0.91 of standard deviation) (See Figure. 41), and the preference of color style in question 4 turned out not to have a difference among other colors as it was a preference on cube in single color and mixed colors (See Figure. 42). Affordable price range in question 5 turned out to be highest in a range between 30 and 40 thousand Won when compared with the minimum price and the maximum price (See Figure. 43). Targets to present the U.CUBE in each age group in question 6 turned out to be diversely distributed (See Figure. 44).

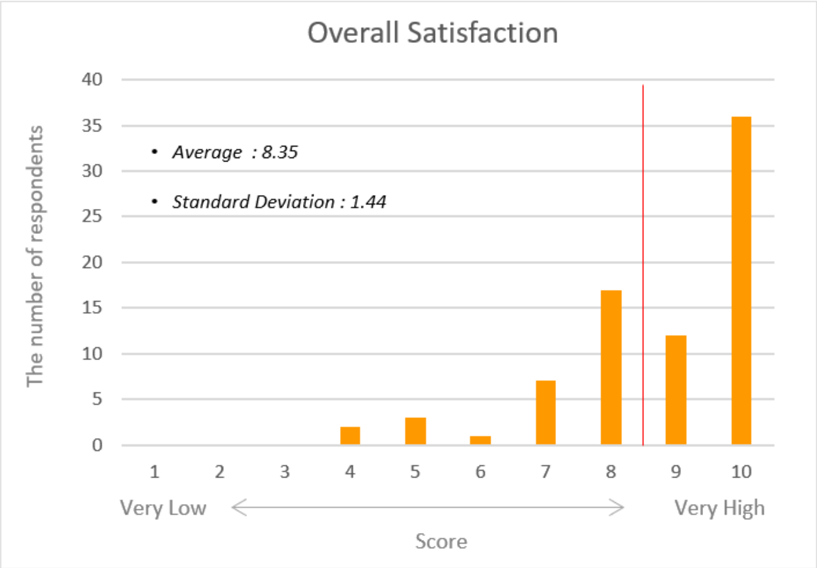


Figure 40. Results of user response analysis – Overall satisfaction

Figure 41. Results of user response analysis – Product completeness

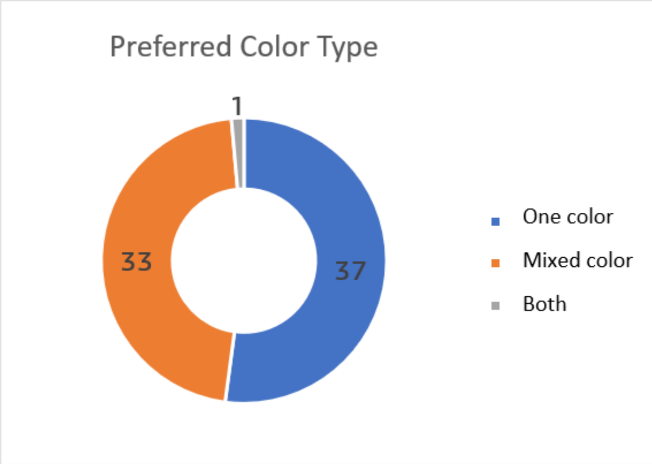


Figure 42. Results of user response analysis – Preferred color type

Figure 43. Results of user response analysis – Affordable price range

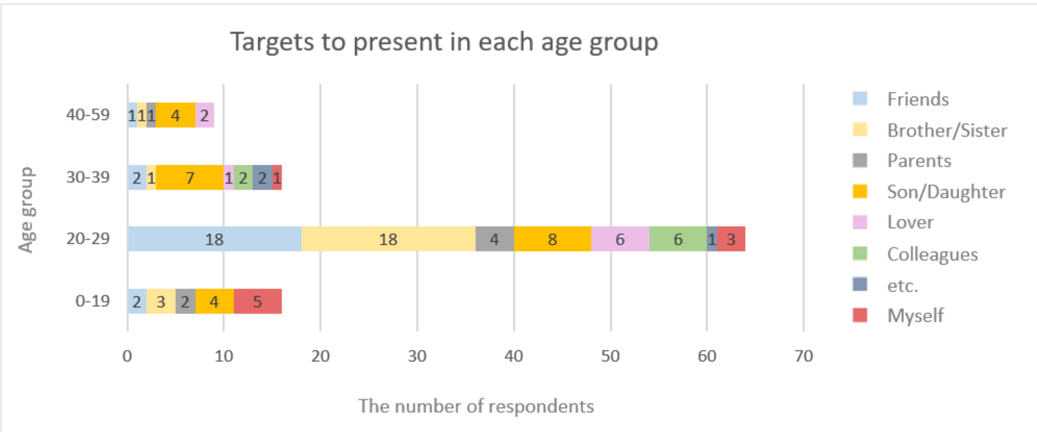


Figure 44. Results of user response analysis – Targets to present in each age group

Overall, we were able to identify the possibility of purchasing and using U.CUBE for all ages. The market approach was initially assumed to be a main target user for children over eight years of age with educational toys and to be able to expand the market to the adult age and the elderly. In addition, the overall satisfaction, completeness, and willingness to purchase were relatively high, we were confident about the merchantability and marketability before mobilizing funds into the mold production. At the same time, we were able to estimate the price of the consumer, thereby making a prior calculation of how much the manufacturing cost should be lowered and when the volume of the sale should be exceeded by looking at the distribution of the price range of the intent to purchase.

In the final stage, the development of molds and production processes, the merchantability and marketability of the U.CUBE were verified with the same products as the products to be sold. "Product" here refers to what contains the prototype manufactured through mass production method in a package developed for mass production after the design is complete. The first prototype developed this way also achieved the first sale of 220 units to UNIST leadership centers. This allowed us to speculate on the merchantability of the U.CUBE, as well as the selling price and the units of the quantity to be formed if sold in the form of B2B.

After the first prototype, we conducted repeated mold modifications and step-by-step prototyping and testing to solve problems found in the prototype. The third prototype (T3: Trial 3) developed after the third mold modification was exhibited and demonstrated at Design Korea 2019 and UNIST Graduate School graduation exhibitions, enabling visitors to check its completeness and marketability as a product. In addition, the Seoul Design Festival 2019 exhibited its fourth prototype (T4) and finally, just before the sale, pre-examination of its merchantability and marketability was conducted. During the five-day exhibition, running from December 4 to 8, 2019, we held an independent exhibition booth for U.CUBE and displayed 20 prototypes of total monochrome and mixed colors, as well as the block unit parts of U.CUBE. Over a thousand visitors visited the U.CUBE exhibition booth, and we allowed visitors to freely experience the U.CUBE. A survey of the marketability and marketing of U.CUBE was conducted from 353 of the visitors. Questionnaires refer to U&A marketing survey methods and organize questionnaires easily and simply in consideration of display characteristics. A U&A marketing survey is a survey of consumer behavior and awareness attitudes, with the aim of identifying basic data to establish marketing strategies (Ipsos Encyclopedia, 2016) Mainly, the status of the market can be identified, the buying and using patterns of consumers, and the perception of competing brands and products in the same area. Although this thesis does not cover the contents of this paper, based on the analysis results, the future development direction of product differentiation of U.CUBE, production and sales direction, and marketing strategy will be established.

Validation of the merchantability and marketability of products developed for market sale will require the product to be carefully prepared and implemented at each stage of development. In product design, commercialization, unlike concept design, can receive great rewards if it succeeds with big resources, manpower, and time-consuming activities, but if it fails, it will also come with great difficulties. Because there is no actual market response to a product until it is sold in the actual market, it is a good strategy to identify and correct its marketability and product quality through prototypes or pilot products that are produced at every stage of product development. In this regard, it was quite reasonable to say that we have verified marketability and merchantability step by step and supplemented the deficiencies on such occasions as developing the U.CUBE. When we decided to develop a commercialization as a student designer during the initial conceptual design phase, I had no idea of the way to the end and end of it. But looking back at the current situation where commercialized products were developed, I have continuously acquired knowledge, constantly solved questions, and consistently accepted challenges. In this regard, what the case for commercialization of U.CUBE suggests is that when a student design is developed into a product that is sold on the market, new knowledge must be absorbed with patience and constantly faced new challenges to address questions about marketability and merchantability.

4
Discussion

4

Discussion

It was a big challenge for me to go from concept design to commercialization while listening to the curriculum divided by each semester. Moreover, the existing product development or design process could not follow the existing product development or design process because the existing team of experts had different situations, such as the fact that it was in the middle of a degree program and the fact that it was an early business foundation team. Looking at the design process and the success factors of my case in which I commercialized U.CUBE in my degree course could provide good implications for students who try similar challenges to me or educators who want to develop new curricula with commercialization in mind. In this respect, this section is intended to discuss these two.

First, I would like to compare the product development process of U.CUBE with the four existing design processes discussed in the previous literature study (see Table 5).

Ulrich's design process model details the expertise and tasks required for product design and development according to product development stages. These are typical processes that can be found in product development teams and companies that are already well established. Comparing this process with the process of the U.CUBE I experienced, the development process of the U.CUBE did not divide the tasks according to the development stage, but our design team became the center and expanded its role in the task according to each situation. For example, we performed our duties as a design department in the early concept design, the idea conception stage and the concept stage. However, we performed tasks such as IR pitching to persuade investors instead of the general task of the design team in the idea verification phase. Comparing this to the tasks that take place during the company's development process, it can be seen as an act of planning new products and persuading top executives. Thus, Ulrich's design process will be able to compare with the work performed by the product planning team. In the development stage of the mold and production process, the role of our team has been extended to the role of managing and supervising mold development and production. This is a task performed by the Manufacturing Engineer and Quality Control Department in the design process model of Ulrich.

Despite these differences, there is much in common with Ulrich's product development process and the product development process of U.CUBE I experienced. Step by step the commercialization process of the U.CUBE can be described as a series of Concept Development, Detail Design, Testing and Refining, and Production Ramp-up steps presented by Ulrich. In addition, the tasks performed at each stage went through almost without exception. In this respect, Ulrich's product development process is a standard model that describes the steps and tasks that are generally required in the product development process, except for those of the experts involved in the development. Therefore, the steps and tasks presented by Ulrich could be a good reference if the product design students wanted to carry out the concept through commercialization and development.

Next, I would like to compare Ulman's mechanical design process with the U.CUBE design process. Ulman's design process model is written from the perspective of an instrument developer or engineer and contains relatively few parts about user testing compared to the parts about technical implementations. The U.CUBE went through a number of user tests, ranging from verification of concept design to verification of marketability of prototypes, and used a user-oriented design and development approach, including modifying design specifications based on these results. I believe this is because my mathematics in industrial design based on Human-center Design Approach has been established as a basic design approach. However, during the development process of the U.CUBE, the technical approach in the design process of Ulman was also used to solve design problems very effectively. When the user test was conducted with the third starting product, the Critical Usability rule had to be resolved, where the ball was ejected from the exit. At first, when we tried to solve this problem with the Human-Based Design Approach, it only provided a big direction, and eventually realized that the solution only came in a technical approach. We experimented with multiple prototypes, constantly changing design parameters until usability was satisfied while maintaining the human-center design application value. As a result, design parameters that are sufficiently satisfactory for use could be determined with great precision (up to 1/100mm in dimensions). This design process is part of Ulman's design process described as parametric design in areas that were not learned in industrial design curricula. Therefore, it is an important lesson that design approaches from various aspects should be used in product development.

Next, I would like to compare the Lean Startup process with the U.CUBE process. Questions such as design excellence, marketability, merchantability, and productivity were quickly identified during the U.CUBE process. To this end, it is common with the Lean Startup process that many working types are produced quickly and efficiently within given conditions to meet actual users to obtain feedback and to reflect them in product development. However, the production cost of the prototype was so high that it was not possible to produce as many prototypes as desired, and for this reason, it was not able to meet customers enough to verify the market and hypothesis. Instead, it can be said that the technicality and marketability evaluation through consultation with the patent attorney, the verification of design excellence through winning the design awards, and the recognition of excellence as a product through certification of good design are reasonable verification methods that we could take under given conditions.

In addition, the double diamond design process, the process of divergence and convergent process, was carried out in the conceptual design phase, but it was difficult to see clearly forming a process in the form of a diamond, in which the production and convergent process form a single cycle. As design items became more specific, the process of finding optimal values within a given parameter was continued rather than radially exploring the idea of solution.

In order to summarize the similarities and differences between the development process of the U.CUBE and the above four processes, see Table 4. To summarize this, the process of U.CUBE has gone through the product development sequence presented in Ulrich's model and performed the necessary tasks, but in terms of organization and process management, it has supplemented the development and verification process with limited resources and manpower, such as the Lean Start process, rather than the Ulrich process suitable for large enterprise processes. Further, the Detailed Design Phase used an engineering approach, such as Parametric design, which was introduced in Ulman's mechanical design process as a strategy for solving usability problems. It is difficult to say that the Double Diamond design process was actively used in a practical approach. However, considering that the design direction has been determined through various explorations and discussions within the team in the early stages of deriving design concepts and exploring solutions, the design direction has been used to some extent in the early stages.

Table 5. Similarity and difference of existing design process and U.CUBE development process

Comparing process	Similarity with U.CUBE process	Difference from U.CUBE process
Ulrich, Product Development Process	Went through the concept development, detail design, and testing and refinement, and production stage defined with the order of product development Followed duties to perform in the product development	Ulrich's process has divided duties in each department, but U.CUBE process did not classify the organizations or duties but expanded the roles in each situation from our design team.
Ulman, Mechanical Design Process	Determined the detailed design parameters with parametric design methods and repetitive experiment in the detail design phase	Ulman's design process focused on the product development in the perspective of engineer, but U.CUBE process has been proceeded with users for modifying the design specifications based on user test
Lean Startup	Manufactured working prototype and verified them rapidly and efficiently in given conditions with inquiries related to the marketability and commercialization to be verified prior to releasing the product	Not enough verification in the use of prototype due to high prototype manufacturing expenses in U.CUBE process. However, indirect verification method was used such as design award
Double Diamond Design Process	Determine main design solution through the divergence and convergence procedure in the concept design phase	Divergence or convergence has not occurred almost at all as it was clarified in which parts were to be modified with specific design items

As a result, the product development process of the U.CUBE can be interpreted as a combination and variation of the existing design process, and as a newly established setting for the terms of the business foundation team in the degree course.

Second, I would like to discuss the factors that enabled the commercialization of the U.CUBE.

First, it will be necessary to look at which degree programs aimed at starting a business at a science and engineering research-oriented university such as UNIST deal with key elements. As previously introduced in a survey of prior literature, MIT design X and KAIST's K-school are representative examples and programs that can be analyzed. The support provided by these programs consists of general degree courses and content directly related to other business foundations. These can be classified into human, physical and educational conditions, as shown in Table 6.

Human factors can be divided into experts and faculty who can business foundations, and communities that encourage business foundations and help create synergy. In the case of MIT designX, an expert with experience in starting a venture will participate as a mentor to the business foundation team in the curriculum. In the case of KAIST's K-school, the classes are run by faculty members who can provide theoretical and practical training on business foundations. What these two cases have in common with the existing degree process is that experts or faculty who have experience in starting a business or who have practical training on the business foundation site participate in the education. To illustrate this in light of the case of the U.CUBE, I received close and active guidance from a professor who has experience in business foundation and product development. Meanwhile, both MIT designX and KAIST K-school have platforms in place to help students who are willing to start a business get together and form a community. In MIT’s designX, it was found that the founding team was formed naturally in boot camp and this formed the founding team's community. In the case of K-school, a community was formed by holding regular meetings and allowing the company to have a network of business foundations in its daily lives through a communal dorm life called ‘Business foundation Village’. On the other hand, in my case, I started my own business with U.CUBE, and I did not have any community activities with the business foundation team. The reason for this is that the business foundation and commercialization development process I have been taking has been personally utilizing the curriculum of the UNIST Industrial Design major and the Graduate School of Design-Engineering and Convergence. In other words, the two programs I studied did not target student business foundations like MIT’s designX or KAIST's K-school, so the community itself did not exist. Of course, there are systems within UNIST that actively support business foundations, such as business foundation child care centers and business foundations. But the path I pursued to start a business did not overlap with the programs they provided, so I did not feel the need to participate in these programs in a consumptive manner.

Next, I would like to look at the material conditions the two universities support as a goal of starting a business. In the case of MIT and KAIST, physical conditions can be divided into financial support and space and facility support. For financial support, MIT’s designX was found to support interest-free grants per team on the program. On the other hand, in the case of the U.CUBE, I needed to prepare separate funds for its business foundation activities. I secured the necessary funds for the development of the U.CUBE by receiving loans through government subsidies, financial support for teachers' business foundation companies in schools, and technical guarantees. In the case of space and facility infrastructure support, my case is that both MIT and KAIST provided space and facilities at school. Looking at the detailed differences, the MIT’s designX also provides support for separate work areas outside of schools, and the KAIST K-school offers a business foundation dormitory. In my case, I was able to produce and experiment with things needed for development by actively using the public prototyping facilities, space, and lab of the Department of Design and Human Engineering and the Graduate School of Design-Engineering Convergence. Looking further into my case, if there were no public prototyping facilities, equipment, and a laboratory where only I could use it, I would have had great difficulty in starting a business and developing commercialization.

Finally, I would like to look at the educational conditions. In the case of MIT’s designX, practical training is conducted through the intensive boot camp and the four-month accelerator program. Unlike the existing education system, it can be judged to be more integrated, organic, and closer to practice than the existing single-title unit education under the theme of product development and business foundation. On the other hand, K-School will operate theoretical and practical courses related to business foundations based on individual subjects, not deviating from the existing educational framework. In addition, KAIST K-school operates jointly with 19 departments in the school, including physics, construction and environmental engineering, and new materials engineering, so that a variety of students can participate in classes. Judging from the information on its website alone, KAIST's K-school could be judged to have been conducting a business foundation education without any radical changes than MIT's Design-X, but MIT was also dominating KAIST in terms of public relations for successful business foundations. Comparing these two cases, it is necessary to enable product development and provide an organic and integrated education system to successfully lead business foundations. To illustrate this in the light of my case, I was able to acquire the theoretical knowledge necessary for business foundation and product development by completing a separate business foundation training course, not just a product development course, but also a real-life course while I was starting a business and taking a management course that is possible through my major selection as well as a design and education course. In this respect, I took necessary electives and used relevant knowledge in the practice of business foundation and product development in an integrated and organic manner.

Table 6. Classification of business foundation support of MIT design X and KAIST K-school and comparison with case of U.CUBE

Success factors		MIT design X	KAIST K-school	U.CUBE
Human Conditions	Experts or professors	Mentoring by experts with experience of leading venture	Faculty members for practical education in business foundation as well as education	Instruction by professors with practical experience
	Network and community	Form global network and community voluntarily by students with will of business foundation	Form community and network and proceed regular meeting through start-up village dorm for students with interest and will on business foundation including master's program students for business foundation and business foundation club	No community group with students with a will of business foundation
Physical Conditions	Financial support	Interest-free subsidiary funding	-	Financial support from school and loan from technical guarantee for companies for business foundation as well as separate support from government bodies
	Space and facility infrastructure support	Provide or support workspace	Available to enter business foundation dorm	Use of school space and facility
Education Condition	Education	Systematic practical education with four months of accelerator program as well as focused boot camp	Education for start-up related theory and operation of practice subjects and nineteen departments jointly	Students take subjects voluntarily as needed while proceeding the product development during the degree course and apply the knowledge on the practice

The terms and detailed factors of success in commercialization of U.CUBE are similar to those supported by the business foundation programs of MIT and KAIST, and others. Among them are those that are in existing universities' support for startups, but not in the case of U.CUBE, or have been replaced by others, and those that only appear in the case of U.CUBE. I would like to explain these based on the three conditions described earlier: MIT and KAIST.

First of all, human factors, support for networks and communities at MIT and KAIST did not exist in the case of U.CUBE. Considering the role of networks and communities supporting a business foundation at existing universities, it will serve as a stimulus and a window for information that allows students to go without giving up on the huge challenge of starting a business. In my case, these parts have been replaced by my will and the proper use of outside experts.

Unlike MIT and KAIST, which are specialized for business foundation in the second space and facilities, there was no space specialized for business foundation in the case of U.CUBE. However, the discussion needed for business foundation and product development was held closely at the office of the professor. In contrast to space, the ability to use design-specific fabrication facilities has helped create and test prototypes. Therefore, in the case of the U.CUBE, the facility was a more important success factor in terms of space and facilities.

The third educational condition is similar to the integrated curriculum of MIT design X and KAIST K-school, which is specialized for business foundation and can be found in the development process of the U.CUBE. However, since these subjects were not specific to a business foundation, individual subjects were personally used in conjunction with the purpose of product development and business foundation.

If we summarize these factors and explain the successful commercialization of the U.CUBE, we can distinguish them as follows.

- Human condition: Student will, experienced advisor guidance, and appropriate use of outside experts
- Material conditions: Equipment and facilities for financial support, design implementation, and testing
- Training Conditions: Integrated curriculum and linkage with Education Curriculum

Now, I would like to discuss the commercialization conditions and the implications of the detailed factors found in the case of U.CUBE(see. Table 7).

In terms of human condition, the student's strong will to commercialize the concept design is the most important human element of commercialization within the school, as it aims to achieve consistent goals and sustain the project for several semesters. The fact that I have not given up on commercialization for three years was also possible because I was determined to bring my design to the market. At the same time, the professional guidance of experienced tutors when students faced difficulties due to academic burden and lack of professionalism was a human factor to help overcome these difficulties. Although I was able to do it without much difficulty because I learned a lot from the curriculum, commercialization development required a completely different knowledge and skills from me. Therefore, the fact that I was able to receive professionalism at each level from my tutor who had expertise in product development was also an important factor that allowed me to overcome my lack of expertise and continue. This allowed me to quickly understand the first problems I encountered in the development process of the U.CUBE, and to further develop my professional expertise in product development compared to my colleagues who had completed the degree course together. However, both my professor and I were forced to put time pressure on each other because we had to participate in other classes and research within programs that were not specialized for commercialization. To overcome this, we have appropriately utilized outside experts when necessary. Therefore, this was also an important factor for commercialization.

In terms of material conditions, it is necessary to identify a number of possibilities, such as the investment and support systems that can be supported when planning commercialization, because, without resources, testing or mold development is impossible during the development process. In my case, as explained earlier, I solved the financial problem by receiving government funds, teachers' business foundation support funds, and loans from technology guarantees. The point to be discussed here is that we have actively provided the necessary resources in the process of commercializing the U.CUBE, even though these were not prepared from the outset. Students who study in existing business foundation programs naturally get connected to financial support, but in my case, I had to make efforts to calculate the necessary expenses at each stage and find sources to receive funding. Without the financial assurance of these efforts, the design of the U.CUBE would not have gone beyond the level of design ranching that shows the concept until today, three years later.

In my degree course, the provision of equipment and facilities in schools to review and modify design at all times in the course of financial support and product development was very important to successfully carry out commercialization development. The school's 3D printers, CAD-specific S/Ws, computers, and other equipment and facilities for prototyping have helped to quickly produce, experiment and validate prototypes. Without equipment, it would have been very difficult for schools to take the initiative in commercializing everything, as they would have had to rely on the outside world.

Integrated education courses and links to education curricula can be an important factor in education conditions. In terms of convergence between practice and theory, the curriculum is not designed to be integrated into the knowledge and skills required by product development, including design, engineering, and management. In the case of U.CUBE, I was able to acquire knowledge related to design, product development and business foundation activities in my graduate school during the master's course, and took courses such as marketing of the Graduate School of Convergence Management, financial accounting, big data, and new product development to acquire the knowledge needed for product development and company operation. And by using this acquired knowledge in practice, we combined theory with practice.

Linkage with the curriculum means that the curriculum was combined with the commercialization process to enable it to be commercialized during the school year. In the case of U.CUBE, concept development was carried out in undergraduate class, prototype was developed in the undergraduate creative design process to initially verify design concept and commercialization, and commercialization could be completed through the master's degree project. Therefore, the three-year independent curriculum was used for development by linking it to the subject of commercialization of the U.CUBE.

Table 7. Success factors and implications of commercialization of U.CUBE

Success factors of commercialization of U.CUBE	Detailed factors	Implications
Human conditions	Will of students	Pursue consistent goals at school for multiple semesters and continue project
	Instructions of experienced professors	Help overcome challenges due to lack of expertise and burden on learning for students
	Proper utilization of outside experts	In need of help from outside experts in an appropriate time due to time pressure on classes both for students and teachers
Physical conditions	Financial support	Not available to proceed mold development and test in the development process in case of lack of materials
	Equipment and facility for design realization and test	Great help with equipment and facility at school so that students and professors are able to review and modify the design all the times
Education conditions	Integrated education course	Learn integrated knowledge and technology in the integration of theory and practice and interdisciplinary courses
	Connection with education curriculum	Make it feasible to commercialize in integration of subjects and commercialization while attending school

I have discussed the design process and the commercialization factors of U.CUBE. Success in commercialization of U.CUBE is a very rare case when a specialized business foundation program has not been provided. In addition, it is a very precious case as design has led the entire process of product development. On one hand, it is regarded as a cornerstone to attempt commercialization as there was a practice-oriented and integrated education program for design and engineering provided by Design-Engineering Integrated Graduate School at UNIST.

5
Conclusion

5

Conclusion

This thesis introduced the examples of U.CUBE developed and commercialized during the degree course, and explained the product development process of U.CUBE and the success factors of the commercialization of U.CUBE.

The process of the U.CUBE was different from the company's product development process because a small number of design teams carried out the entire product development process, and because the curriculum and business foundation were linked, it was different from the typical business foundation process, Double Diamond Process. However, in terms of product development, the steps and tasks presented in Ulrich’s product development process were followed, and existing processes, such as the engineering approach presented in Ulman’s process, were used in part. Therefore, my product development process cannot be explained by just an existing process, and it can be explained by aggregating existing processes. This can be said to suggest that commercializing a product is not possible to operate with just one process, depending on the situation. It may also suggest that the Double Diamond process, which is mainly covered in design classes, may be only a small fraction of what the actual product development process looks like.

On the success factors of the commercialization of U.CUBE, the designX of MIT and K-School of KAIST, specialized programs for business foundation, were reviewed, and the case of U.CUBE was compared and analyzed. Through this, it was also found in the case of the U.CUBE that the factors of successful business foundation were human, physical and educational conditions, and these conditions could vary depending on the situation. Unlike the existing startup specialization program, the conditions for successful commercialization were not systematized at the U.CUBE, so in addition to the human, physical and educational conditions provided by the Graduate School of Design-Engineering Convergence, the mentors had to find and prepare their own conditions for successful commercialization.

I would like to suggest the following if I make a program based on concept design at my university or existing design university based on my case of success.

1. Opening classes in various fields where theory can be applied to practice

2. The curriculum of programs and subjects linked to the product development condition up to the level of commercialization as a condition of graduation

3. Systematic industrial linkage systems, such as IR pitching for subsequent stages, intellectual property rights, and technology transfer

4. Faculty of theory and practice who can operate the above three education programs professionally

5. Facilities and financial support to help students create and test a variety of prototypes without worrying about failure

6. A database of expert workforce, prototyping companies, factories, etc. formed at the school level where students can help with the work process, and a platform for students to access

7. Frequent consortiums with other departments to enable the development of high-tech, high-tech products

8. The atmosphere of encouraging and supporting business foundation and corresponding school regulations and systems

If these points are provided to students, they will be of realistic help in commercializing the concept design in their degree courses, and there will be more cases of successful commercialization. If students develop their own conceptual design and pursue commercialization, they can experience the entire process of product development and acquire living knowledge in each process. This experience and knowledge will help students demonstrate leadership in future product development processes. These raised students will be able to gain a high level of expertise and competitiveness to develop concept designs based on their understanding of the design implementation process. Thus, education that experiences commercialization in the course of a degree will bridge the gap between knowledge taught in schools and knowledge required by the industry, presenting a new paradigm for design education.

First of all, it would be a thrilling experience for a student to see his/her design already sold on the market before graduation, which would be a true way for design education to influence society.

While the success story of U.CUBE alone cannot generalize the process and conditions for commercialization, the commercialization case of U.CUBE itself will be a valuable guide for juniors who want to try commercialization based on their own designs in the future. In addition, the challenges and solutions that you face will help educators who want to develop new curricula for the purpose of starting a business.

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Appendices

- 1. Usability test data for optimal design of ball entrance using magnet
- 2. Issues to solve in trial manufactured good
- 3. Questionnaire used in the Design Korea 2018 user test and results of the improvement and recommendation
- 4. U & A marketing survey questionnaire used at Seoul Design Festival 2019
- 5. Press releases related to U.CUBE
- 6. Awards and Certifications

1. Usability test data for optimal design of ball entrance using magnet

In order to solve the critical usability problem of the ball running away from the entrance, our design team devised a method of catching the ball using magnets and conducted parametric design to realize the optimal design that satisfies the usability and functionality. The table below shows the data for the usability experiments with the test prototypes with the design parameters changed.

Experiment 1.

모델명	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	성공횟수	시도횟수	성공률	비고
H30M1	O	O	X	X	O	O	O	X	X	X	X	O	X	O	X	O	O	X	O	O	X	O	X	O	O	X	O	X	O	O	17	30	56.67%	
H25M1	O	X	O	X	O	X	O	X	X	O	X	O	O	X	O	X	X	X	X	X	O	O	O	O	X	O	X	O	X	X	14	30	46.67%	뚜껑떠있나?
H20M1	O	X	O	O	X	O	O	O	O	O	O	O	O	O	O	X	O	O	O	O	O	O	O	O	X	O	O	X	X	O	24	30	80.00%	잡힐때 자석 강하게 붙는 소리 남
H30B	O	X	O	O	O	X	O	O	X	O	X	O	X	O	X	X	O	O	O	O	O	O	O	O	O	O	O	O	X	O	22	30	73.33%	
H25B	X	X	O	O	O	O	X	X	O	O	O	X	X	X	X	X	O	X	X	O	O	X	X	X	X	X	X	O	X	O	12	30	40.00%	
H20B	X	O	X	X	X	X	X	O	O	X	X	O	X	X	X	X	X	X	X	X	X	X	X	O	X	O	X	X	X	O	7	30	23.33%	
H30T	O	O	O	O	O	X	O	O	O	O	O	O	O	O	O	O	X	X	X	O	O	O	O	O	O	X	O	O	O	X	24	30	80.00%	T는 날카운듯
H25T	X	O	O	O	X	X	O	X	O	O	O	O	X	O	O	O	O	O	O	O	O	X	X	X	X	O	O	O	X	O	20	30	66.67%	
H20T	O	O	O	X	X	X	O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	26	30	86.67%	

Experiment 2.

모델명	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	성공횟수	시도횟수	성공률	비고
H30M7B1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	30	30	100.00%	4번정도는 완전히나갔다가 다시 붙는 느낌이여서 각도가 높아지면 떨어질까 심긴함
출발						*X*								*X*							*X*							*X*			*26*	*30*	*86.67%*	
H25M7B1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	30	30	100.00%	
출발	*X*				*X*		*X*			*X*				*X*						*X*											*24*	*30*	*80.00%*	*30에 대비 공이 강하게 발사 아님*
H20M7B1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	30	30	100.00%	출발할때 다시 붙고 너무 강하다는 느낌이다. 출발실험도 필요하지 않나 싶음
의견	*0.7이고 범퍼 없으면?*																																	
H30M7B2	O	O	X	O	X	O	O	O	O	O	O	O	O	O	X	O	O	O	O	O	O	X	O	O	O	O	O	O	O	O	26	30	86.67%	두번째 범퍼에서 튀고나서 자석반대방향으로 공이 많이 이동해서 빠져나가는 듯
H25M7B2	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X	O	O	O	O	O	O	O	O	29	30	96.67%	
H20M7B2	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	30	30	100.00%	
의견	*0.7(H30,25)일때범퍼두개보다 하나가 나은듯*																																	
H30M1B1	O	X	O	O	X	X	O	O	X	X	O	O	O	O	O	O	O	O	O	O	O	X	O	O	O	O	O	X	O	O	23	30	76.67%	확실히 시작은 M7보다 잘되는데...
H25M1B1	O	O	O	O	O	O	O	O	X	X	X	O	O	O	O	O	O	O	O	O	O	O	X	O	X	O	O	O	O	O	25	30	83.33%	범퍼추가로 성공률 오르긴했음
H20M1B1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	30	30	100.00%	성공률도 오르고 좋지만 20은 구슬이 너무 아래에 있어 출발할때 깊게 눌러야하는 감이 있는듯
의견	*M1과 M0.7사이면 어떨까? & 20은 낮은감*																																	
H30M1B2	O	X	O	X	O	O	X	O	O	O	O	O	O	O	O	O	O	X	O	O	O	O	O	O	O	O	O	X	O	O	25	30	83.33%	
H25M1B2	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X	O	29	30	96.67%	
H20M1B2	O	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	28	30	93.33%	

Experiment 3.

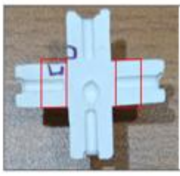
모델명	M	D	B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	성공횟수	시도횟수	성공률
H30_M7_D30_YB	7	30	Y	O	O	O	O	X	X	X	X	X	O	X	X	O	O	O	O	X	O	O	X	X	X	X	O	X	O	O	O	X	X	15	30	50.00%
	7	30	Y	O	O	O	O	O	X	O	O	O	O	O	X	O	X	O	O	O	O	O	O	X	O	O	O	O	O	X	O	O	O	25	30	83.33%
H30_M7_D30_NB	7	30	N																															0	0	
H30_M7_D35_YB	7	35	Y	O	O	O	X	O	X	O	O	X	X	O	O	X	O	O	O	O	O	O	O	O	O	O	O	X	O	O	O	X	O	23	30	76.67%
H30_M7_D35_NB	7	35	N																															0	0	
H30_M7_D40_YB	7	40	Y	O	X	O	O	O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	28	30	93.33%
H30_M7_D40_NB	7	40	N	O	X	O	X	X	O	O	X	O	X	O	X	O	O	O	O	O	O	X	O	X	X	X	O	O	O	X	X	X	O	17	30	56.67%
H30_M8_D30_YB	8	30	Y	O	X	O	X	X	O	O	O	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X	O	O	X	24	30	80.00%
H30_M8_D30_NB	8	30	N																															0	0	
H30_M8_D35_YB	8	35	Y	O	X	X	X	X	X	O	O	X	O	O	X	X	X	O	X	X	X	X	O	O	X	O	O	O	O	X	X	O	X	13	30	43.33%
H30_M8_D35_NB	8	35	N																															0	0	
H30_M8_D40_YB	8	40	Y	O	O	O	O	O	O	O	X	O	O	O	O	O	O	O	O	O	X	O	O	O	O	O	O	O	O	O	O	O	O	28	30	93.33%
H30_M8_D40_NB	8	40	N	X	O	O	X	X	X	O	X	O	X	X	X	X	X	X	X	X	X	O	O	X	X	X	X	X	X	X	X	X	O	7	30	23.33%
H30_M9_D30_YB	9	30	Y																															0	0	
H30_M9_D30_NB	9	30	N																															0	0	
H30_M9_D35_YB	9	35	Y	O	O	O	O	O	X	X	X	X	X	X	O	O	O	O	X	X	O	O	O	O	X	O	O	X	O	X	X	X	X	16	30	53.33%
H30_M9_D35_NB	9	35	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	1	30	3.33%
H30_M9_D40_YB	9	40	Y	O	X	X	X	O	X	O	X	O	O	O	X	X	X	O	O	X	O	O	O	O	O	X	O	O	O	X	O	O	X	18	30	60.00%
H30_M9_D40_NB	9	40	N	O	X	X	X	X	X	X	X	O	O	X	X	X	X	X	O	O	X	X	X	X	X	O	X	X	X	O	O	O	O	10	30	33.33%

2. Issues to solve in trial manufactured goods

Our design team solved the problems of the injected prototype by repeatedly modifying the mold and examining the injected prototypes. In the case of T0, there were more than 30 problems, but the second injection T1 had been reduced to 11 problems. The images below are lists of the problems found in T1 and T0, respectively.

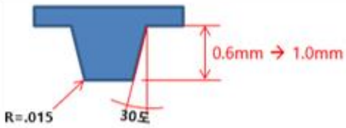
2.1. Issues of T0

1) 코어에 나사 조립치수 불량 해결을 위해 코어 살 빼기



- ✓ 4군데 살빼기

2) 코어 캡 높이 수정: 90도 회전 스냅 달성을 위해 현재 0.6mm인 코어 캡 길이를 1mm로 조정



- ✓ 1차로 코어로 자리를 잡고, 블록 회전시 걸리는 문제가 해결이 안되면 블록 코너에 라운드 처리하는 것으로 결정

3) 3번블록 상측과 하측 결합력 강화를 위해 보스핀을 현재보다 2배 길게 하고 빡빡하게 키워지도록 수정

4) 3번, 11번 블록 사각 밀핀 방향 바뀐 것 수정

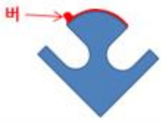
5) 3번 블록 다른쪽 사각 밀핀 벽쪽 길이 수정: 현재 벽이 얇게 솟아 오름

6) 블록 캐비티 넘버 수정: 12 → 10, 13→11

7) 창 이탈 방지를 위한 곡선형 후크 가이드 설치

- ✓ 1차로 라운드형 창에 수정 적용
- ✓ 평면 창은 상황 봐서 적용

8) 11번 부품 '버(burr)' 발생 원인 제거



- ✓ 변형코어 제짝이 맞는지 도면확인
- ✓ 수정 필요시 금형면 틈새 레이저 용접, 가공

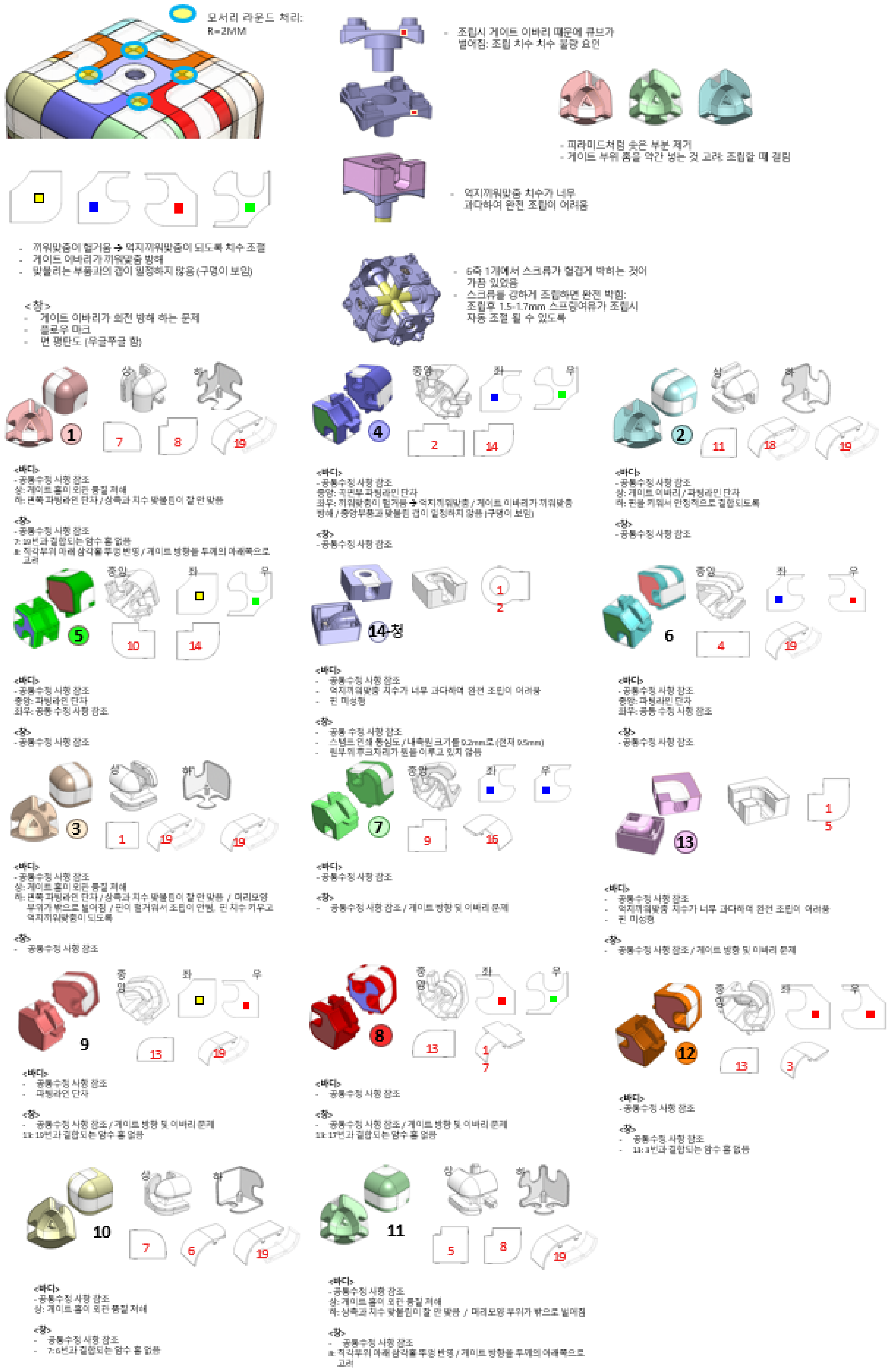
9) 블록 2,10,11번 하측 부품 캐비티 넘버 추가

10) 블록의 하측에 결합되는 부품이 벌어지는 문제 해결 위해 밀핀 제거

- ✓ 밀핀에 의해 바깥쪽으로 휘어짐
- ✓ 밀핀 제거

11) 가운데 블록 자석을 잡아주는 후크가 현재 하나만 역할을 함. 가로방향으로 양옆에 2개 후크에 살 붙여 줘야함

2.1. Issues of T1



3. Questionnaire used in the Design Korea 2018 user test and results of the improvement and recommendation

I entered the excellent student designer section under the name MazeCube in the Design Korea 2018. The product was exhibited in the booth, and visitors were able to experience MazeCube with a working CNC mockup. The survey was conducted on visitors who experienced them. First image below is the questionnaire used for the survey. Second image below shows the raw data that summarizes the improvements and recommendations, and the table that sorts them by category. The results of the other questions are covered in Section 3.4.

3.1. Questionnaire

Welcome to MAZE CUBE World

1. 제품 선호도 조사

1.1.

MazeCube에 대한 전체적인 만족도 평가 *

	1	2	3	4	5	6	7	8	9	10	
매우 낮음	○	○	○	○	○	○	○	○	○	○	매우 높음

1.2.

현재 MazeCube의 완성도는 어느정도라고 생각하시나요? *

	1	2	3	4	5	6	7	8	9	10	
매우 낮음	○	○	○	○	○	○	○	○	○	○	매우 높음

1.3.

MazeCube의 색상은 어떤 색이 가장 마음에 드시나요?

○ 단색

○ 색 혼합

1.4.

MazeCube를 구입할 의사가 있으신가요? *

	1	2	3	4	5	
구매할 의사가 없다	○	○	○	○	○	꼭 사고싶다

1.5.

MazeCube를 구입한다면 얼마 정도가 적당하다고 생각하시나요?

1.6.

MazeCube를 사용하며 개선했으면 하는 사항 (불편한 점)

1.7.

MazeCube를 선물한다면 누구에게 주고 싶으신가요? *
(복수 선택)

- ☐ 친구
- ☐ 동생
- ☐ 부모님
- ☐ 자녀
- ☐ 연인 (또는 아내)
- ☐ 직장동료
- ☐ 기타:

1.8.

기타 의견

2. Personal Information

연령대 : 10대 / 20대 / 30대 / 40대 / 50대 / 60대 이상   성별 : 남 / 여

3.2 Results of users' feedback about improvements and recommendations

소분류	설문자	개선사항
회전	9	조금 더 큐브가 잘 돌아갔으면
회전	10	잘 안 돌아간다
회전	17	돌릴때 좀 더 부드러웠으면 하는 점
회전	18	돌리는 부분이 뻑뻑하다
회전	19	돌아가는 느낌
회전	30	잘돌아가게 해주세요
회전	31	잘안움직여요
회전	33	부드럽게 잘 돌아가도록
회전	34	뻑뻑?
회전	39	잘돌아 갔음 좋겠다
회전	42	블록이 더 잘 돌아가면 좋을 것 같아ㅛ
회전	47	회전
회전	55	큐브를 돌리면서 서로 걸리는 부분
회전	62	돌릴 때 부드러웠으면 합니다
회전	64	잘 움직였으면
회전	71	돌릴때 뻑뻑함
사이즈	49	크기를 조금 작게
사이즈	52	사이즈가 좀 더 작았으면
사이즈	69	**너무 크고** 무거움
무게	2	**무게**
무게	35	멋져요, 아이들이 사용하기에 조금 무거운 감이 있네요
무게	41	무거워요
무게	43	무게가 너무 무거워요
무게	69	너무 크고 **무거움**
내구성	5	**내구성**
내구성	6	자꾸 빠짐
내구성	14	잘 부숴지지 않았으면 합니다. 튼튼
내구성	19	회전부의 내구성
내구성	36	다른 방향으로도 움직이면 좋겠다(뿌술것 같음)
내구성	44	부품빠짐
내구성	51	돌릴때 벌어지는 부분
내구성	53	연결이 튼튼했으면 좋겠다. 내구도 증가
내구성	54	잘부서지지 않게 만들면 좋을 것 같다
내구성	57	돌릴 때 큐브 조각들이 떨어질 것 처럼 벌어지는 것
내구성	60	살짝 벌어지는 감
내구성	65	부서질꺼 같아요
내구성	66	내구성 강화
내구성	70	내구성
내구성	73	고정
내구성	53	큐브를 돌리다가 걸리는 부분때문에 부품하나가 빠저버렸다
구슬	22	구슬이 너무 빠르다
구슬	40	구슬이 흐른다
구슬	72	구슬이 너무 빨리 움직입니다
구슬	10	구슬을 잃어버릴 것 같다
경로	5	**길이 잘 보이지 않음**
확장성	30	레고와 호환
스토리	56	스토리 연계, 구슬 자체가 캐릭터라던가, 구슬이 공주, 큐브가 마법의 성 등 재밌는 스토리 추가
색상	75	색상이 조금 다양했으면 좋겠습니다.
사이즈	74	사이즈가 여러 종류이었으면,,..
마케팅	2	색의 포인트를 브랜딩으로
마케팅	31	부모님 80세 치매예방용
디자인	53	컬러를 넣을 때 외부면 디자인을 곡선으로 해서 넣어도 이쁠 것 같다
난이도	20	단계별로 여러 개가 있었다면
난이도	24	너무 어렵다
난이도	38	레벨에 난이도
난이도	38	길의 단계수(최소 step_, 시간)
난이도	60	난이도 별로 있었으면 좋겠습ㄴ디ㅏ
구슬	79	구슬대신 보석(여성 target)
구슬	79	색구슬(출입구 컬러로) 헷갈리지 않게
^^	55	큐브 잡는 느낌이 좋아서 시간 남았을 때, 맘껏 편히 할 수 있어서 좋은 것 같아용
^^	56	출시되면 꼭 사고 싶습니다. 비주얼적으로도 구조적으로도 정말 마음에 들어요

스펙			아이디어	
회전	16		난이도	5
내구성	16		구슬(아이디어)	2
무게	5		마케팅	2
구슬(개선점)	4		사이즈(종류)	1
사이즈(개선점)	3		스토리	1
경로	1		디자인	1
			확장성	1
			색상	1

4. U & A marketing survey questionnaire used at Seoul Design Festival 2019

This is a simplified U & A marketing survey questionnaire used at the Seoul Design Festival 2019. Visitors to the booth experienced U.CUBE with the T4 prototypes and a total of 358 respondents answered the survey after use U.CUBE. Survey results are being analyzed.

제품명	성별	나이	연락처(이메일)
교육용 완구 "U cube(유 큐브)"			

안녕하십니까?
교육용 완구 전문 회사 '㈜아이디공간' 입니다.
저희의 창업 아이템, "U cube(유 큐브)"에 대한 소비자 반응 조사를 진행하고 있습니다.

본 조사는 고객의 의견을 수렴하여 보다 나은 제품을 만드는데 필요한 기초 자료 수집에 그 목적이 있습니다.
귀하께서 응답하시는 내용은 정답이 없으며, 비밀은 절대로 보장되며, 오직 통계적인 용도로만 사용할 것을 약속 드립니다. 귀하께서 응답하여 주신 내용은 본 아이템의 사업화에 큰 도움이 될 것입니다.
바쁘신 가운데 시간을 내어 주셔서 대단히 감사합니다.

㈜아이디공간 담당자

응답자 기본질문

SQ1. 귀하의 댁에는 자녀가 있으신 가요? 있으시다면, 성별/연령을 알려주시면 감사하겠습니다.

- (, 예: 13 세 남아 1 명과 7 세 여아 1 명)

SQ2. 귀하께서는 **"교육용 완구"**를 구매해 보신 적이 있으신가요? 언제 구매하셨나요??

(1) (있다, 없다)
(2) 구입시기:

SQ3. 귀하께서는 **"교육용 완구"**가 아이들의 성장기 교육에 얼마나 필요하다고 생각하시나요?

전혀 필요하지 않다	필요하지 않은 편이다	보통이다	필요한 편이다	매우 필요하다
1	2	3	4	5

SQ4. 귀하께서는 **"교육용 완구"**가 아이들의 성장기 교육에 필요한 이유가 뭐라고 생각하시나요?

-
-
-

(예: 창의력 개발, 언어 능력 개발, 등, 다수의 답변 가능)

컨셉 평가

유 큐브를 고객에게 실제로 보여주고 자유롭게 조작하도록 한다

문1-1. 귀하께서는 **'유 큐브(U cube)'**가 **전반적으로 볼 때 얼마나 마음**에 드십니까?

전혀 마음에 들지 않는다	마음에 들지 않는 편이다	보통이다	마음에 드는 편이다	매우 마음에 든다
1	2	3	4	5

문1-2. 귀하께서는 **'유 큐브(U cube)'**가 **아이들** 창의력 개발에 **얼마나 도움이 된다고** 생각하십니까?

전혀 필요하지 않다	필요하지 않은 편이다	보통이다	필요한 편이다	매우 필요하다
1	2	3	4	5

문1-3. 귀하께서는 **'유 큐브(U cube)'**가 **몇 살의 아동들이 사용하는 제품**이라고 생각하십니까?

- 세

문1-4. 귀하께서는 **'유 큐브(U cube)'**가 **현재 판매되고 있는 다른 큐브 완구들과 비교할 때 얼마나 차이가 난다고** 느끼십니까?

전혀 차이가 없다	별로 차이가 없다	보통이다	약간 차이가 난다	매우 차이가 난다
1	2	3	4	5

문1-5. 귀하께서는 **'유 큐브(U cube)'**를 **구입(사용)하실 의향**이 얼마나 있습니까?

절대로 구입하지 않을 것이다	구입하지 않을 것이다	구입할 수도 안 할 수도 있다	구입할 것이다	반드시 구입할 것이다
1	2	3	4	5

문1-6. 귀하께서 **'유 큐브(U cube)'**를 구입(사용)하실 의향이 있다고 했는데 **그 이유**는 무엇입니까?

문1-7. 귀하께서 **''유 큐브(U cube)'**를 구입하신다면 얼마가 적절하다고 생각하십니까?
(가격은 1,000원 단위로 기입해주세요)

최소 지불가격:

최대 지불가격:

제품 개선 아이디어

유 큐브를 고객에게 실제로 보여주고 자유롭게 조작하도록 한다

문2-1. 귀하께서는 **'유 큐브(U cube)'**를 구입하신다면 **선호하는 디자인은** 어떤 것인가요?

☐ 한 가지색만

☐ 여러가지 색 같이

문2-2. 귀하께서는 **'유 큐브(U cube)'**를 구입하신다면 **최초의 제품 상태는** 어느 것을 선호 하시나요?

☐ 완전조립 제품

☐ DIY 제품 (직접조립)

문2-3. 귀하의 **'유 큐브(U cube)'** 제품 안에 들어가는 **구슬의 색으로** 선호되는 색은 무엇인가요?

1번 [금] 2번 [로즈골드] 3번 [메탈] 4번 [흑진주] 5번 [백금]

▣ 응답해주셔서 대단히 감사합니다 ▣

5. Press releases related to U.CUBE

These are excerpts from U.CUBE articles published in the press.

5. 1. UNIST news. 2017. Dec. 12th (https://news.unist.ac.kr/kor/20171212-1/)

메이즈큐브(MazeCube)는 3차원 미로를 구성해 공을 움직이는 장난감이다. | 사진: 디자인 및 인간공학부

UNIST 은 12 월 12 일(화) 오후 2 시 제 2 공학관 디자인스튜디오에서 '디자인 쇼 UNIST 2017'의 개막식을 열었다.

디자인 쇼는 11 일(월)부터 15 일(금)까지 디자인 및 인간공학부와 디자인-공학융합전문대학원이 지난 1 년간 공들인 결과물을 전시한다. 졸업 작품과 대학원 수업 작품으로 이뤄진 이번 전시에는 학부 12 점, 대학원 18 점 등 총 30 점의 작품이 선보였다.

주목할 만한 학부 출품작으로는 '메이즈 큐브(Maze Cube)'가 있다. 양지현 학생(디자인 및 인간공학부)이 출품한 이 작품은 공이 지나갈 수 있는 3 차원 길을 만들어 미로를 푸는 장난감이다. 이 작품은 레드닷어워드 및 스파크 디자인 어워드 등 세계 유수의 디자인 대회에서 수상하며 가치를 인정받았다. 또한 최근에는 이를 이용한 학생창업도 진행 중이다.

5. 2. Nocut news. 2017. Dec. 12th (https://www.nocutnews.co.kr/news/4891123)

디자인 및 인간공학부와 디자인-공학융합전문대학원 학부생과 대학원생들이 지난 1 년간 만든 작품 30 점을 선보인다.

디자인 및 인간공학부 양지헌 학생의 '메이즈 큐브(Maze Cube)'는 공이 지나갈 수 있는 3 차원 길을 만들어 미로를 푸는 장난감이다.

이 작품은 레드닷어워드와 스파크 디자인 어워드 등 세계 유수의 디자인 대회에서 수상하며 가치를 인정받았다.

최근 이를 이용한 학생창업도 진행 중이다.

5. 3. Ilyo news. 2017. Dec. 14th (http://ilyo.co.kr/?ac=article_view&entry_id=284130)

이번 전시는 디자인적 사고와 공학적 구현을 겹합할 수 있는 디자이너 육성과 맞닿은 '양손잡이의'라는 뜻을 가진 영단어 '엠비덱스트러스(Ambidextrous)'를 주제로 졸업 작품과 대학원 수업 작품으로 이뤄진 이번 전시에는 학부 12 점, 대학원 18 점 등 총 30 점의 작품이 선보인다.

12 일 개막식에는 UNIST 교원과 학생을 비롯해 기업체 인사 및 공공기관 관계자 등 100 여 명이 참석했으며 세계적 디자인 공모전인 스파크 디자인 어워드의 대표 피터 쿠치니키(Peter Kuchnicki)가 참석해 눈길을 끌었다.

주목할 만한 학부 출품작으로는 '메이즈 큐브(Maze Cube)'가 있다. 양지현 학생(디자인 및 인간공학부)이 출품한 이 작품은 공이 지나갈 수 있는 3 차원 길을 만들어 미로를 푸는 장난감이다. 이 작품은 레드닷어워드 및 스파크 디자인 어워드 등 세계 유수의 디자인 대회에서 수상하며 가치를 인정받았다. 또한 최근에는 이를 이용한 학생창업도 진행 중이다.

5. 4. UNIST news. 2017. Dec. 21th (https://news.unist.ac.kr/kor/20171220-2/0)

UNIST, 디자인-기술 융합 벤처 아이디어 선보여

20 일(수) 울산롯데호텔서 디자인융합벤처창업학교 투자설명회 개최

창업 아카데미 함께한 10 개 디자인 주도 창업기업 수료식도 진행

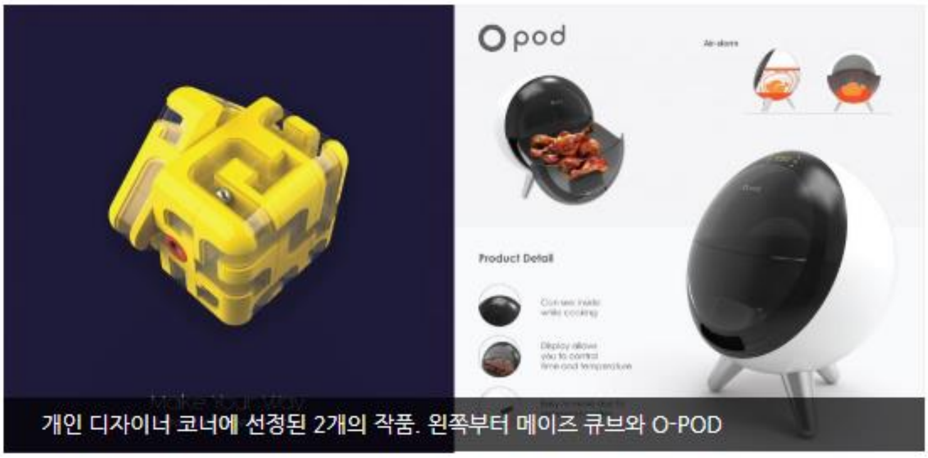
#2. 작은 공이 3 차원 미로 큐브를 통과한다. 큐브가 돌아가면 미로는 새로 생겨난다. '메이즈 큐브'라 불리는 이 장난감은 UNIST '플레이 앤 플라이(대표 양지현·박상진)'의 사업 아이템이다. 메이즈 큐브는 아이들의 창의성과 공간감각 증진을 위한 교육용 장난감 시장을 공략할 계획이다.

'디자인융합벤처창업학교 투자설명회'가 20 일(수) 오전 10 시, 울산롯데호텔 2 층 크리스탈볼룸에서 개최됐다. 이날 행사는 투자설명회와 창업 아카데미 수료식으로 구성됐으며, 실제 투자자를 비롯한 청중 70 여명이 참석했다.

'디자인융합벤처창업학교'는 산업통상자원부가 주관하고 한국디자인진흥원에서 시행하는 창업 지원 사업으로, 지난 4 월부터 전국 6 개 권역에서 시작됐다. 이중 울산·경남지역 주관기관으로는 'UNIST-울산창조경제혁신센터-울산대학교 컨소시엄'이 선정됐다.

수료식 중 진행된 시상식에서는 UNIST 학생 기업 플레이 앤 플라이가 투자유치를 위한 발표와 모의투자 부분에서 우수한 성적을 거둬 '최종평가회 최우수상'과 'IR 피칭 대상(Steve Jobs 상)'을 수상했다.

5. 5. UNIST news. 2018. Nov. 5th (https://news.unist.ac.kr/kor/short-news-20181105/)



디자인–공학융합전문대학원, '디자인코리아 2018' 출품

디자인-공학융합전문대학원에서 탄생한 작품들이 국내 최대 디자인 전시회인 '디자인코리아 2018'에서 출품됐습니다. 이번 전시는 지난 10 월 31 일(수)부터 11 월 4 일(일)까지 경기도 고양시 킨텍스에서 진행됐는데요. 행사의 주제는 '디자인, 혁신을 주도하다(K-Design DNA: Design Driven Innovation)'였고, UNIST 대학원생들이 제작한 7 개의 작품이 전시됐습니다.

전시된 작품은 척추교정기구, '애니바로(Anybaro)'와 난민구호품 상자를 이용한 장난감, '토이박스(TOYBOX)', 제 3 세대 구강청정기, '닥터 픽(Dr. Pik)', 차세대 유모차, '베이비킹(BabyKing)', 국내 최초 자율주행버스, '제로캡슐(ZERO Capsule)'입니다. 이들 전시품 외에 양지현 학생의 두뇌발달용 장난감 '메이즈 큐브(MazwCube)'와 윤자영 학생의 조리되는 동안 속을 볼 수 있는 에어프라이어, 'O-POD'는 디자인너 개인이 따로 전시할 수 있는 200 개의 공간에 선정돼 별도 부스로도 운영됐습니다.

5. 6. Munsu silver welfare center bulletin board. 2019. Feb. 26th
(https://www.betogether.or.kr/index.php?_filter=search&mid=gallery&search_keyword=%EC%9A%B8%EC%82%B0%EA%B3%BC%ED%95%99&search_target=title_content&document_srl=29171)

어르신들의 총명한 노후를 위해 울산과학기술원에서 개발한 치매예방치료 도구인 메이즈큐브를 체험하였습니다. 3 차원 경로를 구축하면서 미로를 해결하는 큐브를 가지고 창의력, 공간지각능력,집중력을 높일수 있어서 치매예방에 도움이 된다고 합니다. 좋은 체험의 장을 마련해주신 울산과학기술원 디자인 및 인간공학부 교수님과 관계자분들께 감사드립니다.

5. 7. UNIST Magazine 2019 Spring U-Startup. 2019. April. 30th

수업 시간에 탄생한 '메이즈 큐브' 100% Made in UNIST

(주)아이디공간

(주)아이디공간은 올해 1월 초에 세워진 따끈따끈한 스타트업이다. 양지현 대표(디자인-공학융합전문대학원 18)가 김관명 디자인 및 인간공학부 교수와 공동으로 설립했는데, 사업 아이템은 큐브에 미로를 결합한 '메이즈 큐브'다. 기말 과제에서 탄생한 아이디어가 제품화 개발이 완료돼 양산을 준비하고 있다.

1974년 헝가리의 건축학 교수 에르뇌 루빅(Ernoe Rubik)이 학생들에게 구조 기하학적 개념을 효과적으로 설명하기 위해 발명한 '루빅스 큐브(Rubik's Cube)'는 지금까지 전 세계에서 가장 많이 팔린 장난감 중 하나다. 이 큐브는 26개의 조각들을 이리저리 돌려 정육면체 각 면의 색을 동일하게 맞추는 퍼즐 게임을 하는 데 쓰인다. 얼마나 빠른 시간 내 맞추느냐가 관건이라 빛의 속도로 손을 놀리는 모습을 종종 볼 수 있다. 실제 큐브 달인들은 최단 회전 횟수를 전략적으로 계산해 0.00초 단위의 속도 경쟁을 벌인다.

이렇게 루빅스 큐브가 스피드 게임에 치중하는 데 반해, (주)아이디공간 양지현 대표가 개발한 메이즈 큐브는 미로를 빠져나갈 길을 만드는 게 중요하다. 큐브에 미로를 결합해 3차원 경로를 구축하며 구슬을 탈출시키는 보다 고차원적인 퍼즐 게임인 셈이다. 26개의 조각들을 돌려 맞추는 것은 동일하지만 색깔을 맞추는 것이 아니라 블록 표면에 새겨진 미로의 경로를 완성해야 한다. 그리고 맞춰진 경로를 따라 구슬을 이동시켜 탈출시키는 게 목표다.

메이즈 큐브의 묘미는 사용자가 직접 다양한 경로를 만들어가는 데 있다. 퍼즐을 푸는 성공 공식이 정해져 있는 루빅스 큐브와 다른 점이다. 게다가 여러 개의 구슬을 동시에 빼내기, 특정 색깔의 블록 지나지 않기 등 자신만의 게임 방식까지 고안할 수 있어 아이의 두뇌 개발과 집중력 향상에 효과적이다.

"출구를 향한 길을 찾기 위해 아이들은 다양한 시도를 하게 됩니다. 속도와 정답을 요구하는 게 아니라 방향성을 추구하는 방식이라 아이의 창의력을 증진시킬 수 있는 창의 교구입니다."

어린이들의 창의력뿐만 아니라 인지 능력 강화, 근육 재활 운동 등에도 좋아 노인 치매 예방에도 활용할 수 있다. 지난 2월 사용자 반응 조사를 위해 한 노인 복지관을 찾았는데, 메이즈 큐브를 사용해 본 노인들이 기존 치매 교구보다 훨씬 재미있다는 좋은 평가를 내놓았다.

기말 과제에서 사업 아이템으로 발전

메이즈 큐브는 양지현 대표가 2016년 디자인 및 인간공학부 시절 수강했던 3D 캐드(CAD) 수업의 기말 과제에서 탄생했다. 과제명은 '세상에 없던 아이디어를 3D 캐드로 직접 설계하라'.

"창의성 방법들을 적용하며 3D 캐드로 여러 블록들을 실험해 보면서 3차원의 큐브와 미로가 결합되는 아이디어를 떠올리게 됐습니다."

당시 수업을 이끌었던 김관명 교수는 수강생 30명의 과제 중 단연 돋보이는 아이디어였다고 칭찬했다.

"아무리 창의성이 뛰어난 아이디어라도 실생활에 적용할 수 없으면 의미가 없습니다. 메이즈 큐브는 창의적이면서 실제로 사람들에게 쓰일 수 있는 아이디어였습니다."

14년간의 현장 경험으로 다져진 김관명 교수의 날카로운 촉은 메이즈 큐브를 보자마자 발동했다. 우선 아이디어를 발전시켜 국제 디자인 대회에 출품해 볼 것을 권했다. 그 결과 2017년 8월 미국의 '스파크 디자인 어워드'에서 금상을 수상한 데 이어, 같은 해 10월에는 세계 3대 디자인 대회 중 하나인

> 사람들이 좋아할지 확신이 없었습니다. 이게 정말 될까 싶었는데, 여섯 살짜리 아이가 시간 가는 줄 모르고 메이즈 큐브에 푹 빠져 있는 모습을 보고 자신감을 얻었어요.

독일의 '레드닷 어워드'에서도 수상했다. 이와 동시에 양 대표는 김관명 교수의 지도를 받아 2017년 3월 특허 출원을 추진하고, 산업통상자원부와 한국디자인진흥원 주관으로 디자인 주도형 창업을 지원하는 디자인융합벤처창업학교에 지원하는 등 창업의 수순을 차근차근 밟았다.

"디자인융합벤처창업학교는 총 40팀의 창업캠프 수료팀 중 10개 팀을 선발해 창업을 지원하는 정부 사업입니다. 메이즈 큐브는 최종 평가회에서 가장 많은 모의투자를 받아 최우수상을 수상했을 뿐 아니라, 프로젝트 성과 부문에서 대상을 수상하면서 꾸준히 사업화를 진행했습니다."

스마트폰보다 더 재미있는 메이즈 큐브

이렇게 태생부터 남달랐던 메이즈 큐브는 양지현 대표가 참여한 2017년 디자인 및 인간공학부의 졸업 전시회인 'UNIST 디자인 쇼'를 통해 일반에 첫선을 보였다.

"그때까지만 해도 사람들이 좋아할지 확신이 없었습니다. 이게 정말 될까 싶었는데, 여섯 살짜리 아이가 시간 가는 줄 모르고 메이즈 큐브에 푹 빠져 있는 모습을 보고 자신감을 얻었어요."

즐거워하는 사용자의 모습을 직접 확인한 양 대표는 비로소 메이즈 큐브를 꼭 시장에 출시해야겠다고 결심했다. 그저 많은 이들이 즐겁게 사용할 수 있으면 좋겠다는 순수한 마음에서였다. 하지만 상용화를 위해서는 몇 가지 문제점을 보완해야 했다. 경로가 단순해 구슬을 쉽게 뺄 수 있다는 문제와 큐브를 돌리는 중간에 블록 틈새로 구슬이 이탈하는 등 예기치 않은 문제가 드러난 것이다.

그 후 약 1년간 구슬의 크기, 미로의 너비와 깊이, 투명창의 두께 등을 0.1㎜ 단위로 정교하게 시뮬레이션하며 설계를 수정했다. 퍼즐의 난이도를 높이기 위해 가운데 있던 구슬의 출입구 위치도 모서리로 옮겼다. 당시 김 교수와 양 대표가 얼마나 치열하게 고민했는가는 진행 과정을 깨알 같이 정리한 노트와 3D로 프린팅한 수많은 테스트 블록 더미만 봐도 알 수 있다.

"사용자 관점에서 보기 좋으면서 쓰기 편한가를 기준으로 문제점을 개선했습니다. 외관을 해치지 않는 범위에서 작동이 잘 되도록 사용자 편의성을 증대시켰죠."

업그레이드된 메이즈 큐브는 2018년 11월에 열린 '디자인코리아 박람회'에서 200여 명의 관람객들에게 다시 한 번 평가를 받았고, 더욱 강력해진 재미로 그들을 사로잡았다.

"한 분은 아이가 이렇게 집중하는 모습은 처음이라며 아이가 떼를 쓰면 스

> 아무리 창의성이 뛰어난 아이디어라도 실생활에 적용할 수 없으면 의미가 없습니다. 메이즈 큐브는 창의적이면서 실제로 사람들에게 쓰일 수 있는 아이디어였습니다.

마트폰을 주곤 했는데 이제 메이즈 큐브를 줘야겠다고 하시더라고요."

UNIST 디자인-공학융합전문대학원을 대표하는 1호 상품

2019년 1월 김관명 교수와 (주)아이디공간을 공동 설립한 양지현 대표는 본격적으로 양산화에 박차를 가하고 있다. 지난해 12월까지 개발 과정의 90%를 완료했으니 큰 산은 넘은 셈이다. 이제 금형 제작과 양산화를 위한 생산자금을 마련하는 것이 급선무. 이를 위해 크라우드펀딩(Crowd Funding)도 계획하고 있다. 빠르면 7~8월 중 시장에 제품을 출시할 수 있을 것이다. 이미 아마존코리아와 입점 미팅을 가졌고, 본격적으로 양산을 계획하면서 전휘수 학생(기계항공 및 원자력공학부 14)도 팀원으로 영입했다.

"메이즈 큐브가 수업 시간에 탄생한 만큼 앞으로 UNIST와 디자인-공학융합전문대학원을 대표하는 제품이 되면 좋겠습니다. 그러면 후배들에게도 좋은 본보기가 될 수 있겠죠?"

시장 출시 카운트다운에 들어선 메이즈 큐브. 과연 소비자들에게 어떤 반응을 얻을지 자못 기대가 크다.

Mini Interview

좋은 디자인은 많은 사람들에게 사용돼야

디자인 전공 학생들에게서 매년 좋은 아이디어들이 도출됩니다. 하지만 대부분 졸업 전시회로 끝나는 경우가 많습니다. 좋은 아이디어는 제품화돼서 궁극적으로 많은 사람들에게 제공돼야 한다고 생각합니다. 보다 전문적인 지도를 받으면 제품화될 수 있는 가능성을 훨씬 높일 수 있습니다. 제가 교수로서 꿈꾸는 모델도 수업과 연구를 통해 개발된 아이디어가 시장에 출시돼 실제 일상생활에서 사용되는 것입니다. 그래서 학생들의 아이디어가 상용화될 수 있는 시스템을 구축하고 싶은데, 메이즈 큐브가 그 첫 사례가 될 것입니다. 앞으로 Designed by UNIST, Made in UNIST의 성공 모델이 많이 나올 수 있길 바랍니다.

김관명 디자인 및 인간공학부 교수

5. 8. Seoul Economy news. 2019. July. 30th (https://www.sedaily.com/NewsView/1VLW9I720B)

루빅스 큐브가 스피드 게임에 치중하는 데 반해 아이디공간이 개발한 '메이즈 큐브'는 큐브에 미로를 결합해 3 차원 경로를 구축하며 구슬을 탈출시키는 보다 고차원적인 퍼즐 게임이다. 즉 26 개의 조각들을 돌려 맞추는 것은 같지만 색깔을 맞추는 것이 아니라 블록 표면에 새겨진 미로의 경로를 완성하는 것이다. 그리고 맞춰진 경로를 따라 구슬을 이동시켜 탈출시키는 것이다. 메이즈 큐브의 묘미는 사용자가 직접 다양한 경로를 만들어가는 데 있다. 퍼즐을 푸는 성공 공식이 정해져 있는 루빅스 큐브와 다른 점이다. 게다가 여러 개의 구슬을 동시에 빼내기, 특정 색깔의 블록 지나지 않기 등 자신만의 게임 방식까지 고안할 수 있어 아이의 두뇌 개발과 집중력 향상에 효과적이다.

김 교수는 양 대표에게 아이디어를 발전시켜 국제 디자인 대회에 출품해볼 것을 권유했다. 그 결과 2017 년 8 월 미국의 스파크 디자인 어워드에서 금상을 수상한 데 이어 같은 해 10 월에는 세계 3 대 디자인 대회 중 하나인 독일의 레드닷 어워드에서도 수상했다. 이와 동시에 양 대표는 김 교수의 지도를 받아 2017 년 3 월 특허 출원을 추진하고, 산업통상자원부와 한국디자인진흥원 주관으로 디자인 주도형 창업을 지원하는 디자인융합벤처창업학교에 지원하는 등 사업화 단계를 차근차근 밟았다.

5. 9. UNIST news. 2019. Oct. 29th (https://news.unist.ac.kr/kor/20191029-1/)

UNIST 창업기업의 제품 유큐브(U.CUBE)가 출시를 앞두고 좋은 평가를 받았다. | 사진: 김경채

올 연말 출시를 앞둔 UNIST 창업기업의 디자인 제품이 글로벌 시장 진출 경쟁력을 인정받았다. 시장 진출을 앞두고 긍정적 평가를 받은 '유.큐브(U.CUBE)'는 향후 제품 판매에 청신호를 켰다.

디자인-공학융합전문대학원의 김관명 교수와 양지현 대학원생이 창업한 ㈜아이디공간(대표 김관명, 양지현)의 '유.큐브'가 지난 18 일(금) 산업통상자원부와 한국디자인진흥원이 주관하는 우수디자인(Good Design) 상품에 선정됐다. 이어 22 일(화)에는 한국디자인진흥원이 선정하는 '글로벌 생활명품'에 이름을 올렸다.

5. 10. Nocut news. 2019. Nov. 11th (https://www.nocutnews.co.kr/news/5241371)

유니스트(UNIST, 울산과학기술원) 산업디자인 전공 학생들이 졸업 작품전시회를 마련한다.

유니스트 디자인 및 인간공학부와 디자인-공학융합전문대학원은 11 일부터 15 일까지 '반복의 여정: 끝없는 질문의 연대기'를 주제로 2019 디자인 위크를 연다.

디자인 과정에서 끝없이 이어지는 질문들에 대해 학생들이 능동적으로 답을 찾아낸 결과물을 선보인다는 의미를 담았다.

학부생 8 명과 대학원생 7 명이 작품전시회에 참가했다.

13 일에는 올해 졸업생이자 디자인 창업기업 ㈜아이디공간의 공동 대표를 맡고 있는 양지현 대학원생이 직접 디자인한 유.큐브(U.CUBE) 제품에 대한 설명회가 있을 예정이다.

이번 디자인 위크에 전시된 작품들은 오는 12 월 4 일부터 8 일까지 서울 코엑스에서 진행되는 '서울 디자인 페스티벌'에 전시될 예정이다.

5. 11. PowerKorea magazine. 2019. Dec

큐브계의 새로운 혁신, UNIST에서 발명된 유큐브

유큐브, 창의력 발달·근육 재활 운동·노인 치매 예방에 좋아

Introducing a new concept U.CUBE that can compare with Rubik's Cube

많은 사람들이 어렸을 적 큐브 놀이를 해본 기억이 있을 것이다. 우리가 보통 알고 있는 큐브는 헝가리의 건축학 교수 에르뇌 루빅이 발명한 '루빅스 큐브(Rubik's Cube)'로 총 26개의 조각들로 구성된 정육면체를 이리저리 돌려가며 각 면에 있는 조각들의 색을 동일하게 맞추는퍼즐 게임이다. 숙련된 큐브 달인들은 더 빨리 맞추기 위해 손이 안 보일 정도의 속도로 퍼즐을 돌리기도 하고, 0.00초 단위로 기록이 갈리기도 한다. 이런 특징으로 루빅스 큐브는 지금까지 전 세계에서 가장 많이 팔린 장난감 중 하나로 높은 위상을 갖고 있다. 새로운 기능을 갖는 큐브 제품은 단순히 어린이 장난감에 그치지 않고 창의력을 발전시킬 수 있는 교구이며, 도전을 즐기는 성인들에게도 인기가 있다. 또한 손을 사용하여 맞추기 때문에 어르신들께는 인지 능력 강화나 재활 운동 제품으로 사용될 수 있다. 이런 측면에서 기존의 루빅스 큐브와는 다른 '유큐브(U.CUBE)'를 개발한 디자인 창업 기업 ㈜아이디공간이 주목을 받고 있다. 이에 월간 파워코리아는 ㈜아이디공간을 만나 인터뷰를 진행했다.

글 | 강진성 기자 wlstjdxp@naver.com

U·CUBE U·CUBE U·CUBE

학부 수업에서 출발한 유큐브(U.CUBE)

유큐브는 2016년 울산과학기술원(UNIST) 산업디자인 전공에 개설된 '3D CAD' 과목의 기말과제로 양지현 양(현 ㈜아이디공간 대표)이 제출한 아이디어로부터 시작되었다. 당시 이 과목을 담당하였던 김관명 교수(디자인-공학융합전문대학원장, 산업디자인 전공 부교수)는 디자인과 공학을 융합하여 세상에 없는 자기만의 제품을 디자인하라는 과제를 학생들에게 내주었다.양 대표가 디자인하여 제출한 것이 바로 큐브 형태와 미로를 결합한 새로운 개념의 장난감이었다. 당시엔 미로와 결합한 큐브라는 뜻에서 '메이즈 큐브'라고 불렀지만, 사업을 시작하면서 '유큐브(U.CUBE)' 라는 상표를 개발하였다. 여기서 '유(U)'는 너의, 유니스트, 유니크, 울산 등 다양한 의미를 담고 있다.

양 대표의 아이디어를 보고 김관명 교수는 단순히 수업 과제에서 그칠 것이 아니라, 실제로 시중에 내놓고 싶다는 생각이 들어 디자인을 정리하여 국제 디자인 대회에 출품을 했다. 그 결과 '메이즈 큐브'로 2017년 스파크 디자인 어워드에서 금상을 받았고, 세계 3대 디자인 어워드 중에 하나인 레드닷 디자인에서도 수상을 했다. 이어서 산업부의 디자인융합벤처창업학교에서 최우수상을 받아 창업자금을 확보하였다. 양 대표가 디자인-공학융합전문대학원 석사과정에 진학하여 김 교수 연구실의 지도학생으로 들어오면서 양 대표와 김 교수는 본격적으로 '유큐브'의 상용화 개발에 착수하였다. 이를 위해 양 대표는 '유큐브'의 개발을 석사 연구과제로 정하였고, 정부사업에 지원하는 한편, 학교의 자원과 설비를 최대한 활용하여 '유큐브'를 개발하였다. 수많은 설계 수정, 시작품 제작과 테스트를 거친 결과, 김 교수와 양 대표는 2018년 12월에 양산을 논의할 수준의 개발 단계에 이르렀고, 2019년 1월 ㈜아이디공간을 함께 창업하였다.

김 교수는 창업을 결심한 원인 중 하나로 "학교에 있다 보면 학생들이 창의적이고 놀라운 아이디어를 많이 낸다. 그러나 그러한 아이디어는 과목이 끝나거나 학생들이 졸업을 하게 되면 그냥 사장되고 만다. 유큐브의 아이디어를 봤을 때 상용화할 수 있겠다는 생각이 들었고, 그렇게 되면 학생들의 디자인이 사람들에게 실질적으로 사용될 수 있고 그것은 사회에 매우 큰 기여를 하는 것이다. 또한 이러한 사례가

Rubik's Cube invented by Hungarian inventor Erno Rubik is one of the most sold toys in the world. Many people have challenged the perfecting the color groups in the shortest time and win or lose is decided at 0.00 second difference. Apart from this speedy figure-out competition, Rubik's Cube helps people develop creativity, cognition ability and even rehabilitation.

While studying at Ulsan National Institute of Science and Technology (UNIST), Jihyun Yang developed her idea of 'U.CUBE'. She was under a task to make one of a kind product in the world from an industrial design professor Kwanmyeong Kim. She

▲(주)아이디공간 멤버 정수인(직원), 양지현 · 김관명(공동대표) | Suin Jeong, Jihyun Yang and KwanMyung Kim

많아지면 교육적으로도 새로운 가능성을 제시할 수 있다. 이러한 까닭에 지현 양과 함께 ㈜아이디공간을 창립했다."라고 밝혔다.

획기적인 유큐브와 후속 모델

유큐브는 미로로 된 큐브에 구슬을 넣어 큐브 블록들을 움직여 반대쪽 구멍으로 구슬을 빼내는 퍼즐이다. 기존에 유행했던 루빅스 큐브는 색깔 면을 빨리 맞출 수 있는 공식 같은 게 정해져 있다면, 유큐브는 공식이 없고 머리와 몸을 동시에 사용하여 본인만의 탈출 방법을 찾아내는 데 초점을 두고 있다. 미로를 맞추어 구슬을 탈출시키는 기본 게임 룰에서 구슬을 여러 개 넣어 동시에 탈출시키기나, 특정 색상 블록은 지나지 않고 구슬 이동시키기와 같이 자신만의 새로운 게임 룰을 고안할 수도 있다. 또한 3차원 미로를 계속적으로 맞추다 보면 공간지각력을 기를 수 있고, 중력과 블록의 회전을 이용하여 볼을 이동시켜야 하기 때문에 소근육 운동에도 도움이 된다.

사용자들이 더 다양한 방식으로 유큐브를 즐길 수 있게 하기 위해 김 교수는 두 가지의 후속 모델을 생각하고 있다. 현재 유큐브는 가로 세로 9cm의 크기를 가지고 있는데, 기존 큐브는6cm의 크기이다. 그래서 기존의 큐브가 익숙한 사람들이나 아이들을 위해 '유큐브 미니' 버전을 생각하고 있다. 김 교수가 고안하고 있는 또 다른 후속 모델은 기존 유큐브에 난이도를 추가한 방식이다. 현재 유큐브에 구슬을 넣으면 양방향으로 다 흘러갈 수 있지만, 한 방향으로 밖에 못가거나 함정이 있는 식의 '유큐브 콤플렉스'를 생각하고 있다. 또한 유큐브에 들어가는 개별 미로 블록을 사용자들이 구매하여 자기만의 큐브를 조립할 수 있는 '유큐브 DIY' 버전도 생각하고 있다고 한다.

㈜아이디공간과 유큐브의 미래

유큐브는 창의력 발달에도 좋고, 큐브퍼즐 자체가 손을 사용하여 하는 놀이이다 보니 근육 재활 운동이나 노인 치매 예방과 같이 의료용으로 쓰일 수도 있다. 김 교수

borrowed the shape of Rubik's Cube and added a maze to it: thus born was 'maze cube' which now calls U.CUBE. (U stands for UNIST) Encouraged by the professor, Yang brought it to the 2017 Spark International Design & Architecture Awards and won the gold prize which led to another prize at the reddot design award. Seeing a huge potential of the cube, Yang and her professor Kim joined hands and launched ID Space at the dawn of this year.

You play U.CUBE by inserting marbles onto the maze cube to assemble the individual cubes to exit the marbles to the opposite hole. If Rubik's Cube is about putting the puzzle together in speed, U.CUBE is about finding the exit. Unlike Rubik's Cube, you

U·CUBE U·CUBE U·CUBE

에 따르면 재활의학과 교수들과 유큐브를 치매나 뇌졸중, 손 마비 등의 치료 목적으로 사용하기 위한 임상실험을 계획 중이라고 한다.

현재 다양한 곳에서 유큐브에 관심을 가지고 있다. 유니스트 리더십센터에서는 과학영재캠프에 참가한 중·고등학생들에게 기념품으로 지급하기 위해 이미 220개의 유큐브를 구매하였다. 이외에도 실버센터와 창의활동을 하는 태권도 도장에서도 많은 관심을 보이고 있다. 올 초 ㈜아이디공간은 한국큐브협회 부산경남지부 임원들과 미팅을 한 결과, 초등학교 방과후 프로그램에 유큐브를 도입하자는 데 동의하였다. 곧 ㈜아이디공간과 큐브협회가 유큐브 놀이 방법에 대한 책자 개발을 추진할 것이 예상된다. 유큐브의 본격적인 양산을 앞두고, 12월 4일부터 8일까지 ㈜아이디공간은 코엑스에서 열린 서울디자인페스티벌에 유큐브 부스를 열어 사전 시장 반응을 테스트하였다. 많은 방문객들이 유큐브에 대한 큰 관심을 보였으며, 출시 알림을 요청한 방문객 수만 천명이 넘었다고 한다.

양 대표는 "지금까지 3년 정도 개발하여 상품화에 성공하였지만 이제 시작이라고 생각한다. 곧 크라우드 펀딩에 들어갈 예정이며, 내년에는 본격적으로 국내외 판매를 시작할 예정이다. 유큐브를 다양한 사람들에게 선보여 많은 피드백을 들으려고 한다."라며 유큐브의 양산을 앞두고 포부를 밝혔다.

또한 김 교수는 "㈜아이디공간이 발전하여, 학교에서 나온 좋은 아이디어와 기술들이 더 쉽게 상용화 개발될 수 있는 길과 문화를 만들고 싶다"고 덧붙였다. 이렇듯 새로운 개척자 역할을 수행하고 있는 ㈜아이디공간의 행보가 점차 기대되고 있다.

can use one marble or more or make up your own rules. The size of the cube is 9 centimeters both vertical and horizontal and it normally takes 5 minutes to exit the marbles but 2 to 3 minutes if skilled. Currently, Kim is working on mini cube for children and assemblable cubes for DIY.

U.CUBE, says Yang and Kim, helps us improve creativity and muscle movement of the hand and arms and prevent Alzheimer's. 220 U.CUBEs were given to middle and high school students at the UNIST Science Camp and a number of welfare centers and martial arts studios are currently showing interest. The Korea Cube Society, on the other hand, proactively suggested using U.CUBE as a play material for children after school.

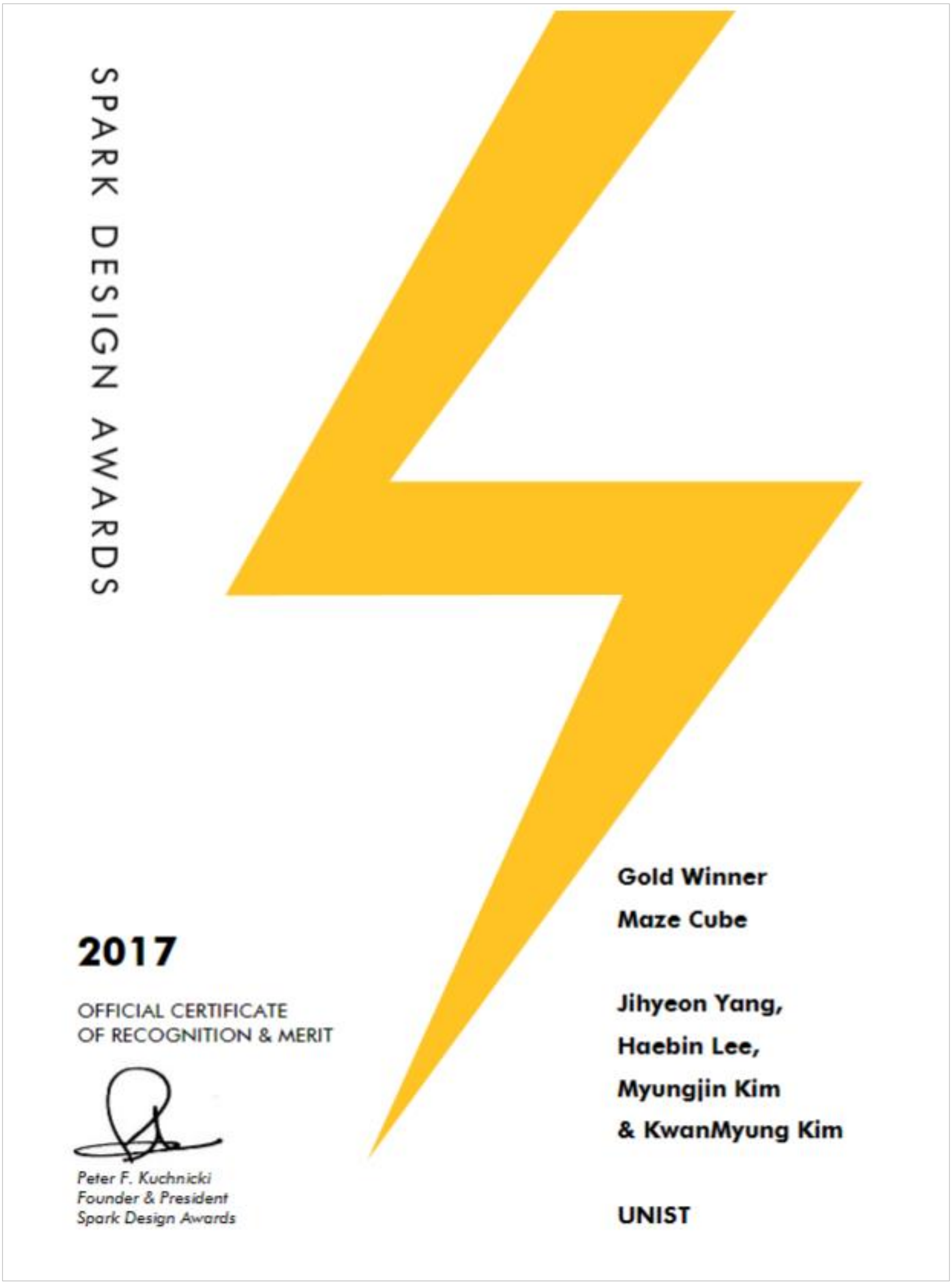
Yang says that it has taken about 3 years to develop the cube but she is in the beginning stage business-wise; adding that she is working on cloud funding from this month and start selling it on the market from next year.

▲200만호 특허증 및 100만호 디자인등록증 수여식(맨 오른쪽이 김관명 교수)

6. Awards and Certifications

Evidence of the design awards and certifications received by U.CUBE (original name MazeCube) from 2017 to 2019 has been attached.

6. 1. Spark design awards 2017 Gold winner


SPARK DESIGN AWARDS

2017

OFFICIAL CERTIFICATE
OF RECOGNITION & MERIT

Peter F. Kuchnicki
Founder & President
Spark Design Awards

Gold Winner
Maze Cube

Jihyeon Yang,
Haebin Lee,
Myungjin Kim
& KwanMyung Kim

UNIST

6. 2. Reddot award 2017 winner

reddot award 2017
winner

The award "Red Dot" for high design quality, expressing innovation
in form and function in an exemplary manner, is presented to:
Die Auszeichnung „Red Dot" für hohe Designqualität, die in beispielhafter
Weise Innovation in Form und Funktion ausdrückt, wird verliehen an:

Maze Cube

Prof. Kim KwanMyung, Kim Myungjin, Lee Haebin, Yang Jihyeon
South Korea

Singapore, 18 October 2017

Prof. Jure Miklavc
Slovenia

Prof. Dr. Ken Nah
South Korea

Nils Toft
Denmark

Ken Koo C.K.
President, Asia
Singapore

Professor Dr. Peter Zec
Founder & CEO of Red Dot
Essen, Germany

6. 3. Asia Design Prize 2019 Finalist

ASIA DESIGN PRIZE

2019

Jihyeon Yang   Hwisu Jeon   KwanMyung Kim

ENTRY INFORMATION

TITLE **MazeCube Plus**

COUNTRY **Korea**

AFFILIATION **UNIST**

FINALIST SELECTION

Asia Design Prize certifices that you are a finalist of the Asia Design Prize 2019. You have been chosen as a finalist of the Prize through the intense screening engaged by 25 judges from 6 countries around the world.

JUDGES

Prof. Yoshimaru Takahashi - Prof. Hans Tan - Prof. Jaeho Kim - President. An Luo - Director. Tetsuya Matsumoto - Director. Michi Del Rosso - Prof. Bao Haimo - Prof. Mengcong Zheng - Prof. Gou Rui - Director. Virginia Lung - Prof. Yuxiang Kuang - Prof. Kang Bumkyu - Prof. Taesun Kim - Director. Keiko Akatsuka - President. Masuo Fujimura - Prof. Fangliang Wang - Director. Emi Kawasaki - Director. Wang Guanhua - Prof. Gan SenZhong - Director. Aidin Ardjomandi - Prof. Huang Yuexin - Prof. Lai Yueh Hsing - Prof. Sunah Kim - Director. Bob Lei - Director. Fan Shizhong - CEO. Doyoung Kim

6. 4. Selected as a Good Design product

확인서 Certificate of Confirmation

우수산업디자인상품선정증

접수번호 : G2019A04-00196

상품명 : 유-큐브

브랜드명 : 유-큐브

형식명 : 유-큐브

회사명 : (주)아이디공간 / 유니스트

디자이너명 : 양지현

김관명

위 상품은 「산업디자인진흥법」
제6조 제1항 및 같은 법 시행규칙 제7조에 따라 우수산업디자인상품으로 선정되었음을 증명합니다.

kidp 한국디자인진흥원 원장 윤 주 현

EUNE Juhyun President & CEO, Korea Institute of Design Promotion

6. 5. Selected as a Global Premium Living Goods

글로벌 생활명품

Global Premium Living Goods

No. 19-871-21

글로벌 생활명품 선정증

Certificate of Global Premium Living Goods

제품명 PRODUCT

유큐브

U.CUBE

회사명 COMPANY

아이디공간

ID SPACE

위의 제품은 산업통상자원부가 주최하고 한국디자인진흥원이 주관하는 글로벌생활명품에 선정되었음을 인증합니다(유효기간 2019. 11 - 2022. 12).

This is to certify that the product above has been chosen as Global Premium Living Goods. The program is hosted by Ministry of Trade, Industry & Energy and organized by Korea institute of Design Promotion(valid from Nov. 2019 to Dec. 2022).

2019. 11. 06.

산업통상자원부 장관 **성 윤 모** [산업통상자원부장관인]

Ministry of Trade, Industry & Energy **Sung Yunmo / Minister**

산업통상자원부 Ministry of Trade, Industry and Energy

kidp 한국디자인진흥원 KOREA INSTITUTE OF DESIGN PROMOTION

6. 6. Trademark application

상표출원공고 40-2019-0146578

(190) 대한민국특허청(KR)
출원공고상표공보

(260) 출원공고번호 40-2019-0146578
(442) 출원공고일자 2019년12월30일

(611) 상품분류 11판 28
(210) 출원번호 40-2019-0150425
(220) 출원일자 2019년10월01일

(731) 출원인
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(740) 대리인
제일특허법인(유)

담당심사관 : 은성희

(511) 지정상품(업무)

제 28 류

완구, 작동완구, 장난감, 어린이성장용 완구, 아동용 다양한 활동 완구, 유아용 다양한 활동 장난감, 동작완구, 블록완구, 놀이용 공, 완구용 인형, 퍼즐, 육면체형 퍼즐, 신체단련기구, 신체재활기구, 스포츠용구(등산용구/골프용구는 제외), 운동기계, 운동기구, 필라테스운동용 바, 운동용 공, 운동용 플랫폼,

상표견본

U·CUBE

- 1 -

6. 7. Patent registration

공개특허 10-2018-0135661

(19) 대한민국특허청(KR)
(12) 공개특허공보(A)

(11) 공개번호 10-2018-0135661
(43) 공개일자 2018년12월21일

(51) 국제특허분류(Int. Cl.)
A63F 9/08 (2006.01)
(52) CPC특허분류
A63F 9/083 (2013.01)
A63F 9/0838 (2013.01)
(21) 출원번호 10-2017-0074014
(22) 출원일자 2017년06월13일
심사청구일자 2017년06월13일

(71) 출원인
울산과학기술원
울산광역시 울주군 언양읍 유니스트길 50
(72) 발명자
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양지현
울산광역시 울주군 언양읍 유니스트길 50
김명진
울산광역시 울주군 언양읍 유니스트길 50
(74) 대리인
리앤목특허법인

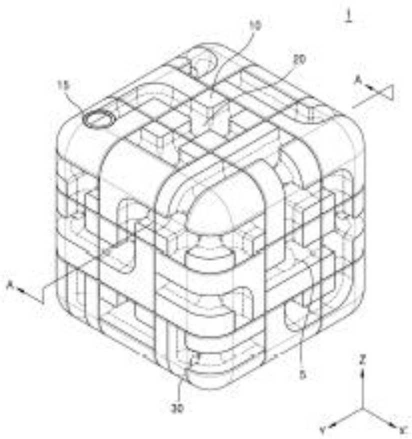
전체 청구항 수 : 총 19 항

(54) 발명의 명칭 **미로 형태의 큐브 블록**

(57) 요 약

본 발명은 미로 형태의 큐브 블록을 개시한다. 본 발명은 외측면에 적어도 하나의 홈을 가지는 복수개의 단위 블록들 및 상기 복수개의 단위 블록들 중 어느 하나의 단위 블록으로 유입되어 상기 홈을 따라 이동하는 이동볼을 포함하고, 상기 복수개의 단위 블록들을 회전하면, 이웃하는 단위 블록의 상기 홈이 연결되어 상기 이동볼이 연결된 상기 홈을 따라 이동한다.

대 표 도 - 도1



- 1 -

Executive Summary in Korean

Commercialization of an Academic Outcome: a Case Study of U.CUBE

U.CUBE 는 블록의 입구에 구슬을 넣고 반대 면의 출구로 구슬을 빼내기 위해 미로를 맞추는 큐브 형태의 교육용 완구이다. U.CUBE 는 학부 산업디자인 교과과정에서 컨셉이 개발된 이후, 석사학위 과정을 통해 상용화 개발되어 창업 및 시장 진출에 성공한 매우 드문 사례이다. 본 논문에서는 U.CUBE 의 성공 사례가 갖는 디자인 프로세스의 특징과 교육환경에서 U.CUBE 의 상용화를 가능하게 했던 요인들에 대해 다루었다. U.CUBE 의 디자인 프로세스의 특징은 U.CUBE 가 개발되어온 과정을 기존의 디자인프로세스들과 비교하는 방식을 통해 있는 그대로 상세히 설명하였다. U.CUBE 의 성공 요인들은 창업에 특화된 기존 교육과정들의 제도와 특징들을 분석함으로써 도출하였다. 이를 통해 본 논문은 후배 디자인 학생들이 학위 과정 동안 자신의 디자인을 상용화 개발하고자 할 때 필요한 지침을 제공하고자 하였다. 또한 교육자들이 디자인 창업과 상용화를 목표로 하는 교육과정을 도입할 때 참고 자료의 역할을 하고자 하였다.

먼저, U.CUBE 의 제품개발 과정을 살펴보면, 크게 '컨셉디자인,' '상세 설계와 테스트,' '금형과 생산을 위한 설계'의 3 단계로 나눌 수 있다. 컨셉 디자인 단계는 다시 아이디어 발상 단계, 아이디어 구상 단계, 아이디어 검증 단계의 세 단계로 세분화할 수 있다. 상세 설계와 테스트 단계는 초기 상세 설계, 사용성 개선을 위한 상세 설계, 제조를 고려한 상세 설계 단계로 세분화할 수 있다. 마지막으로 금형과 생산을 위한 설계 단계는 준비 단계와 다섯 번의 금형 수정 및 시 사출 과정을 거쳐 최종 양산 품질의 한도 설정하는 단계로 구분할 수 있다.

U.CUBE 개발 과정은 산업디자인과 학생이 학위 과정 중에 초기 창업팀을 운영하며 진행된 것으로, 기존의 제품 개발 및 디자인 프로세스와 유사점과 차이점이 있다. 전반적인 제품 개발 단계와 수행한 직무의 측면에서는 Ulrich 가 제시한 프로세스와 유사한 면이 있지만, 소수 인력으로 운영한 창업 기업의 특성상 여러 직무를 조직적으로 수행할 수는 없었다. Lean Startup Process 와 비교하면, 빠른 프로토타입의 제작과 시험을 통해 사용자 피드백을 빠르고 효과적으로 반영하는 방식의 개선 과정을 추구하였지만, 프로토타입 제작비용이 비싸 이 방식만을 사용할 수는 없었다. 대신 전문가나 전시회 등과 같이 디자인 개발 과정에서 효과적으로 사용할 수 있는 다양한 방식을 검증 수단으로 사용하였다. 상세 설계와 테스트 단계에서는 Parametric Design 과 같이 Ullman 의 'The Mechanical Design Process'에서 소개된 방법을 사용하였다고 할 수 있다. Double Diamond Design Process 의 경우 U.CUBE의 초기 아이디어를 도출할 때 사용하였다고 할 수는 있겠으나, 그 이후 단계에서는 실질적인 활용이 거의 없었다. 이는 이 프로세스가 가진 추상성 때문에 사용성이나 기능성에 대한 개선과 같이 상세 디자인 업무가 수행되는 단계에서는 활용되기 어려운 측면이 있기 때문이라고 할 수 있다.

U.CUBE의 각 개발 단계에서는 디자인의 심미성, 제품의 성능, 사용성, 상품성, 시장성과 같이 상용화를 위해 필수적으로 갖추어야 하는 항목들을 검증하고 완성해 나가야 했다. 이를 위해 변리사로부터

기술성과 시장성에 대한 의견 청취, IR 피칭에서의 피드백, Reddot Design Award 와 SPARK Design Award 에서 수상, 우수디자인과 글로벌 생활명품으로 선정, 학교 졸업전시회와 디자인 코리아 2018, 디자인 코리아 2019, 서울디자인페스티벌에서 사용자 관찰과 설문조사 등과 같은 검증 방법을 사용하였다. 이러한 방법들을 시도할 수 있었던 것은 디자인-공학 융합전문대학원의 학위 과정에서 주어진 조건을 최대한 활용하였기에 가능하였다고 할 수 있다.

창업에 특화된 기존의 교육과정을 분석하고, 이를 U.CUBE 의 사례와 비교함으로써 U.CUBE 의 상용화 성공 요인을 발견할 수 있었다. 대표적인 창업 특화 교육과정 중, 해외의 사례로는 MIT 의 design X 가 있었고, 국내의 경우, KAIST 의 K-school 창업융합 전문석사 과정이 있었다. 먼저 두 교육과정에서 제공하고 있는 창업 특화 제도들과 이들 교육과정에서 나타나는 특성들을 분석하고 분류하였다. 이를 바탕으로 U.CUBE 의 개발 과정에서 유사한 것들이 어떻게 발생하였는지 비교 분석하였다. 또한 U.CUBE 개발과정에서만 나타난 특이 사항들도 분석하였다. 이를 통해 결과적으로 발견한 U.CUBE 의 상용화 성공 요인은, 인적 요인으로 학생의 의지, 실무 경험이 있는 교수의 지도, 적절한 외부전문가의 활용이 있었다고 할 수 있으며, 물적 요인으로 재정적 지원, 디자인 테스트를 위한 장비와 설비가 중요하였다고 할 수 있으며, 교육적 요인으로 통합적인 교과목, 단일 교과목들의 순차적 연계 및 융합이 주요하였다고 할 수 있다.

본 논문에서는 석사학위 과정 동안 U.CUBE 의 컨셉 디자인 과정에서부터 상용화 개발을 거쳐 양산 및 시장진출 과정까지 프로세스적 측면과 상용화 성공 요인의 측면으로 기술하고 이것을 독자들에게 공유함으로써 다음과 같은 부분에 이바지를 할 수 있을 것이다. 첫째, U.CUBE 의 상용화 개발 과정이 일반적인 제품디자인 및 제품개발프로세스와 어떻게 다른지를 보여줌으로써 향후 본인과 같이 학위 과정 동안 디자인을 상용화하고자 하는 후배들에게 지침이 될 수 있을 것이다. 이 논문을 읽는 후배들은 학교에서 배우는 여러 디자인 과정과 방법들이 정답이 아닐 수 있다는 것을 알게 될 것이며, 실무에서는 다양하고 폭넓은 방법들을 통합적으로 사용해야 한다는 것을 알 수 있을 것이다. 무엇보다도, 이론에 그치는 것이 아니라 도전하고, 그 도전 속에서 자신의 전문성이 확장된다는 것을 이해할 수 있을 것이다. 둘째, 학위 과정에서 상용화에 성공한 U.CUBE 의 사례는 향후의 디자인 교육자들이 창업과 상용화를 목표로 하는 디자인 교육과정을 개발하는 데 좋은 참고 자료가 될 것이다. U.CUBE 는 창업과 상용화 개발에 특화되지 않은 교육환경에서 성공한 드문 사례이다. 따라서 이 논문에서 밝힌 U.CUBE 의 상용화 성공 요인들은 우리 교육에서 어떤 것들이 더 개선되면 학위 과정에서 디자인의 상용화가 가능한 교육 프로그램을 설계할 수 있을지에 대한 단서를 제공할 수 있을 것이다.

마지막으로, 이 논문에서 소개한 U.CUBE 의 개발 사례가 많은 후배와 교수님께 소개되어 디자이너가 더 폭넓은 전문성을 갖추고 기업가 정신으로 제품개발과 사업화에서 리더십을 발휘하는 방안들이 적극적으로 모색되기를 기대한다.

핵심어: 제품 디자인, 제품 개발, 디자인 상용화, 디자인 창업, 제품 개발 프로세스, 산업 디자인 교육, 창업 지원 교육

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김관명 교수님 감사합니다. 학부생 때부터 지금까지 가장 가까운 거리에서 밤, 낮, 새벽, 주말, 주중 할 것 없이 한결같이 아낌없는 가르침을 주신 덕분에 자신의 한계에 부딪힐 때마다 앞으로 나아갈 수 있었습니다. 교수님을 만났기에 시작도 목표도 생길 수 있었습니다.

이희승 교수님과 이경호 교수님 감사합니다. 상용화 과정의 막바지에 다다른 이번 학기에 모든 것들을 포기하고 싶은 순간들이 많았는데 교수님들 덕분에 몸과 정신을 지탱할 수 있었고, 연구에 대해 더 배울 수 있었습니다.

이면우 교수님 감사합니다. 디자인에 대해 하나도 모를 학부 2 학년 1 학기 때 뵌 이래로 저의 전반적인 디자인 학업 생활에 큰 영향을 미쳤습니다.

함께 일한 박상진 오빠, 정수인 양, 김지수, 전휘수 감사합니다. 상진 오빠가 있었기에 맨 처음 창업을 시도할 수 있었습니다. 또한, 수인 양이 서울디자인페스티벌 행사 운영을 포함하여 많은 일을 적극적으로 많은 도움을 주었기에 여러 성과를 달성할 수 있었고 저 역시 일하는 법을 배울 수 있었습니다. 지수와는 디자인 작업을 몰입해서 같이하면서 즐기며 일할 수 있었습니다. 그리고 제가 가장 아플 때 힘들게 도와준 휘수의 노력이 있었기에 많은 문제점을 해결할 수 있었고 아플 때에도 디자인 코리아 2018 등 행복하게 임할 수 있었습니다.

박경 대표님, 제이원 박은석 대표님, 미성테크 김순호 대표님, 창명산업 박성우 대표님, 3D 프린팅 첨단생산 기술연구센터 박성원 선생님과 이우열 선생님 감사합니다. 모르는 게 많고 어리숙한 저와 개발에 까다로운 점들이 많은 U.CUBE 를 화 한번 내시지 않고 대해 주셔서 저와 U.CUBE 는 여기까지 발전할 수 있었습니다.

큐브 픽쳐스 서영빈 대표님과 최영훈 작가님, UNIST 김경채 선생님과 김석민 선생님 외 UNIST 대외협력팀 감사합니다. 지속적인 U.CUBE 촬영과 홍보에 도움을 주신 덕분에 U.CUBE 가 세상에 많이 소개될 수 있었습니다.

문수 실버 복지관 박성혜 선생님과 정학수 관장님, 복지관의 어르신들, UNIST 어린이집 선생님과 어린이집의 사랑스러운 아이들, 아이들의 부모님들께 감사합니다. 대가를 바라시지 않고 U.CUBE 를 응원하는 마음에서 사용자 테스트와 영상 촬영의 기회를 마련해주신 덕분에 저도 몰랐던 U.CUBE 의 가치를 발견할 수 있었습니다.

김효진 선생님, 강우정 선생님, 김현희 선생님 외 디자인학부 행정실 선생님들께 감사합니다. 제가 마음껏 일을 벌일 수 있었던 것은 친언니처럼 응원해주시고 행정적 무대를 마련해주신 선생님들 덕분에 가능했습니다.

연구실의 오빠들 - 이해빈, 김명진, 주상진, 박재한, 김상윤, Tufail 에게 감사합니다. 해빈 오빠와 명진 오빠는 3D CAD 수업 조교로 제가 처음 3D CAD tool 을 익히는 데에 도움을 주었고, 덕분에 이 수업에서 U.CUBE 의 초기 컨셉 디자인이 나올 수 있었습니다. 또한, Tufail 오빠를 통해 연구 활동에서

어려웠던 점들을 쉽고 심리적으로 편안하게 배울 수 있었으며, 연구실에서 주상진 오빠와 박재한 오빠, 김상윤 오빠에게서 작지만 하나씩 모여 태산 같은 도움을 받았습니다.

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융합경영대학원 이도준 교수님, 상철님, 재웅님, 지완님, 건철님, 영섭님, 호재 오빠, 태규님 감사합니다. 경영과 창업이 막막하게 느껴졌을 때 융합경영대학원 교수님과 학우님들의 격려와 에너지 덕분에 숨을 쉬었습니다.

김익수 위원님, 이형석 컨설턴트님, 신성안 교수님, 육기철 선생님, 리더십 센터 이규옥 선생님, 기술사업화센터 황윤경 교수님, 산학협력단 배성철 단장님, 그리고 UNIST 창업 진흥센터 선생님들께 감사합니다. U.CUBE 와 저를 생각하여 주신 현실적인 도움, 조언은 무엇과도 바꿀 수 없는 값진 것들입니다.

YLA 15 기를 비롯하여 각종 전시와 행사에서 진심으로 응원해주신 모든 분께 감사드리며, 그분들과 더 닿을 수 있도록 영상 제작에 참여해주신 UNIST 학우분들, 그리고 장성원, 김태윤, 허남철 오빠에게 감사합니다. 또한, U.CUBE 의 가능성을 알아봐 주시고 협력해주신 리노디바이스 분들과 큐브 교실 선생님들, 저의 디자인적 성장을 위해 가르쳐 주신 디자인 및 인간공학부와 창의디자인공학과 모든 교수님께도 감사드립니다.

연구와 학업, 창업 짊어져야 하는 것들이 버거울 때 마음으로 짐을 함께 들어준 원형석, 최재혁, 양재성, 그리고 부모님과 할머니께 감사드립니다. 특히나, 걱정스러운 마음에 그만 관두라고 할 수도 있었을 법한데 단 한 번도 아픈 말을 내뱉지 않고 믿음과 응원해주신 부모님 사랑합니다.

인복이 많아 지면에 다 쓰지 못했지만 모든 분께 감사하고, 끝으로, 저의 모든 성취를 가능하도록 지원해 주신 한국디자인진흥원에 대해 진심 어린 감사를 표하고 싶습니다.

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