FlipMe: Exploring Rich Peer-to-Peer Communication in On-Line-Learning

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ABSTRACT

FlipMe is an IoT (Internet of Things) companion augmenting peer-to-peer interaction for active online learning. Online learning continues to see rapid growth with millions of students now engaging online and remote courses as convenient alternatives to conventional classroom-based teaching. Despite these advantages, online learning can suffer from limited opportunities for peer-to-peer engagement between students, resulting in high drop-out rates. In order to address this challenge, we developed FlipMe. The FlipMe design provides three different tangible interfaces. First, the flipping top interface provides physicalized data of peer learning activities in real time. Second, a physical nudge function, through the interactive handle, is provided to support peer-to-peer interaction. Finally, group study activity is expressed through a playful 'rolling-ball' feedback. The result of in-lab user study showed that FlipMe encourages users to study through demonstrating learning activities between peers. In addition, we discovered that users are engaged and play with FlipMe as a playful companion to stimulate more active learning during extended study sessions. Lastly, we found that users had attachment through FlipMe's aesthetic and also analog book flipping motion and sound. Through this distinctive approach FlipMe can play a motivational role for students to study actively with their peers. To sum up, this thesis contributes to the improvement of peer learning activities in online leaning through 1) designing and implementing the tabletop IoT companion providing information on peers' learning activities and opportunity to communicate in online learning context, and 2) evaluated how a tangible interface can promote peer leaning activities and reveal the value and potential of FlipMe. 3) We suggest a mobile application screen that is designed to connect learning experience in both on/offline learning environment mutually.

Keywords: Interactive Learning Companion; Interpersonal Communication; Tangible Interface; Peer Leaning;

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Tables

Figures

Table of Contents

1. INTRODUCTION

1.1. Background

Millions of people around the world are now using online learning services (Dhawal Shah, 2017), defined as any form of learning conducted partly or wholly over the internet. However, online learning, and its associated platforms for communication, faces many crucial challenges. First, dropout rates in online learning far exceeds its traditional, class room-based equivalents. Although dropout rate is depending on both the quality of the course and student ability, approximately 90% of all students do not complete their online course. This is largely due to low student engagement and the challenges of self-controlled learning activity (Hong Lu, 2007). Second, students studying in on-line-learning environments, such as Udacity (Udacity.com), Coursera (Coursera.org) and Khan Academy (Khanacademy.org), suffer from a lack of quality communication with peers because of limitations related to remote locations of individual on-line learners. In addition, unlike the traditional classroom context, most online learning platforms provide dramatically lower ratios course instructors to students such as edX (Edx.org). As a result of limited opportunities for peer-to-peer communication, as well as very large student cohorts compared with comparatively few instructors. Since communication with peers and achieving feedback from instructors are beneficial factors to student's learning experience and outcome (Hong Lu, 2007), the promise of accessible and convenient online learning faces many challenges, not least in providing for the necessity of communication between students as part of a richer learning experience.

Peer learning activities, described as any learning activity that involves multiple students learning from and with each other to attain educational goals (O'Donnell, A. M., 1999), when working appropriately, can improve students' engagement and the quality of the overall learning experience (June Ahn et al., 2013). In addition, providing increased opportunity for peer-to-peer engagement may help overcome issues of ratio between students and course instructor through students communicate. Thus, addressing the challenges students face during the course work rather than relying on achieving personal feedback from the course instructor.

Previous studies revealed that social factors influence students' expectations of peer learning and their resulting behaviors (Boud et al., 2014). Also, social interaction and collaboration with peers are one of the fundamental characteristics for high quality online education program (Cercone, 2008). For these reasons, we focused on social interaction as a key factor to motivate students in peer learning activity.

After exploring the advantages of peer learning activities as above, we observed limitations in conventional online learning system. For example, research has suggested that social activities, such as discussion in forums in existing online learning platforms, are less effective in interactive communication than learning in daily life (Thomas, 2002). This debate has been pointed out as a disadvantage of screen-based approach compared with physicality of interaction. In the real world, for example, tangibility plays an important role for people in recognizing and affecting the environment (Johnson, M, 1987). On the other hand, traditional screen-based interfaces, in contrast, tend to limit our sense of touch and our physical interactions within a plastic keyboard or a pointing device (Ishii et al., 1998). In contrast, tangibility has the potential to convey information to and between people in memorable and intuitive ways through physicalized data (Zhao, 2006). As indicated by Zhao (ibid), this then makes behavioral change more likely.

In this regard, the current project aimed to improve the current peer learning experience in on-line-learning through a tangible interface approach, providing the opportunity for interpersonal communication and physicalizing peer's learning activity in order to promote the social interaction crucial to more engaging learning experiences.

1.2. Research Aim and Method

The purpose of the current research is to provide greater learning motivation through an interactive product that supports peer learning activity.

Through literature review and preliminary semi-structured interview with online learning stakeholders, we developed an interactive product providing peers' learning activity data and the opportunity to communicate abstractly. We then further achieved understanding on the affect and value of the product through a user study.

First, we begun to understand behaviors and opinions of learners and tutors regarding online learning. In addition, we explored the methods of data physicalization and communication for remotely located users to understand the advantages and limitations of tangible interface. Finally, we defined design requirements through the understanding derived from the preliminary study, which were then applied to the final design solution.

Second, through reflecting the design requirement, we suggested various concepts related to tangible interfaces that may evoke peer learning activity for students learning online. Through iterative prototyping with various interaction approaches, we developed the interactive product providing information on real time peer learning activity through data physicalization methods and the opportunity to communicate through a non-verbal approach.

Third, we understood the user experience, value and the challenges of our design through an in-lab study. We installed the final prototype in the artificially created learning space and conducted observation and interview. Initially, participants were recruited through learning style questionnaires (Kolb, 1984, p. 38), and matched in pairs related with the same or different learning styles. The main reason for applying Kolb's learning style was that combination of same or different leaning styles in online learning conveys different level of communication pattern (Edward John Perantoni, 2010), thus we have set groups in counterbalance to see if learning styles make any difference in use of FlipMe. We then conducted retrospective interviews at the end of the observation sessions. After that, we interpreted the raw data from two interactive products in pairs. This data was triangulated with dedicated web browser data and qualitative data from interviewing.

Finally, we discuss some issues to be considered when designing tangible interfaces to enhance peer-to-peer learning activity. Through achieved quantitative and qualitative data from the user study, we were able to understand the limitation and challenges of our FlipMe design. Eventually, we suggest improved product design reflecting the user study and conceptual mobile application design dedicated to peer learning activity.

1.3. Research Scope

In this study, as a thesis in the field of design, we focus on developing a peer-to-peer communication device through a tangible interface, explore applications and discuss the value of our design intervention. Therefore, this study focused on understanding the user experience rather than presenting optimized theories for effective communication and data physicalization of peer learning activity. In addition, we designed the novel peer learning-focused mobile application to suggest mutually harmonized learning experience online and offline through both mobile application and interactive product design.

1.4. Thesis Structure

This paper is composed of six chapters in total.

Chapter One describes the research background, aim and methods.

In Chapter Two, we present process and findings of our preliminary study. First, we conducted semi-structured interview to understand the learners and tutors' experience in on-line-learning. We also explored related literature works based on understanding from the interviewing. This then provided

foundational knowledge in tangible interface designs for data physicalization and interpersonal communication.

In Chapter Three, we suggest an interactive table-top companion named FlipMe which physicalizes peer's learning activity data through flipping card mechanism and the common goal indicator. The concept also provides ambient communication methods. In this Chapter, we described the iterative design process for designing FlipMe.

In Chapter Four, we address the procedure of a user study through FlipMe and its results and through an analysis of both quantitative and qualitative data.

In Chapter Five, we discuss the limitations and directions to improve FlipMe based on the previous user study and propose dedicated conceptual mobile application designs to provide improved experience in peer learning activity in on-line-learning that are mutually harmonized to the table top companion product design.

In Chapter Six, we present the outcomes and contributions of the research, and suggest further works and directions.

2. PRELIMINARY STUDY

2.1. Semi-structured Interview with Learners and Tutors

The purpose of the semi-structured interview with online learning platform users was to explore the context of how students study in online courses and affect each other through communication and discussion online.

For this, we conducted the semi-structured interview with 3 graduate students aged from 26 to 28 years old (2 female, 1 male, S1-S3), and two university tutors and one high school tutor aged from 32 to 33 years old (2 female, 1 male, T1-T3).

Table 1. Design requirements

Participants' statement	Interpretation	Design requirement
"I feel uncomfortable / responsibility if I don't watch video lectures because I may affect negatively my team member."	Social responsibility plays the important role motivating to watch video lectures	Visualize progress of group members
"We pin our works on the wall. At that moment, I care a lot not only their direct comments but also micro things such as whispers, Wow sounds and so on. This helps me to evaluate my work by myself."	The micro / non-verbal interaction also helps students to evaluate themselves	Give/take micro interactions like knowing nodding of your friend
"I feel I'm the only one spending my time in front of computer to watch the lecture. In contrast, I feel alright if I am surrounded by my colleagues to take lectures together."	Peers motivates peers to engage more on online lecture. Existence of colleagues at the same time/space is motivating	Peer to peer motivation system
"Group work is significant but there is no answer to make perfect group. SO always mixing up members if some show worse performance. It is because individual students learning styles are all different."	Learning styles of individual students are different. It affects the teamwork/outcome a lot	Matching learning style

Then two core insights were that, the existence of colleagues and non-verbal communication motivates students to engage to the class and plays the important role in discussion moment, were achieved. S1 said "I am more likely engaged in physical classroom because I am surrounded by my colleagues studying at the same time in the same space." Also, S2 addressed that she catches non-verbal communication elements such as whispering, smiling or interjections like "wow" and it helps her to judge her work unlike the online discussion that they only can communicate in writing. Like above, various insights were gathered through the interviewing and they were organized through affinity-diagraming, then finally arranged design requirement (Table 1).

2.2. Related Works

The core value of this study is to visualize peers' learning activity and provide opportunity for interpersonal communication through tangible interfaces. To then observe if the methods are valuable for students or not. The research direction was inspired by the semi-structured interview described above. The following sections We explore various approaches and limitations of tangible interfaces for both data physicalization and interpersonal communication through related works.

2.2.1. Data Physicalization Through Tangible User Interface

One of the key design elements of this study is to visualize the learning activities of peers to help people explore, understand and communicate through computer-supported physical data representations, so-called "*Data physicalization"* (Jansen, 2015). Data physicalization may be beneficial such as, leveraging our perceptual exploration skills, facilitating understanding and learning, bringing data into the real world and fostering public engagement in the number of favorable situations (Yvonne Jansen, 2015). With this, we explore previous studies in terms of data physicalizaion and learn common characteristics, advantages and challenges.

2.2.1.1. Abstract and reflective information through unobtrusive interaction methods

One of the initial studies that physicalizing data through kinetic motion, was a study of Pinwheels by Ishii (2001). 40 computer-controlled pinwheel presented ambient information of human's activities, such as physical movement like people walking in the museum or online activity like emailing. For example, if the system detects the email containing a large volume of attached files, several pinwheels span, while only a few pinwheels span with small sized emails. Likewise, Calm Station (Kim, 2017) allows users to remain focused while doing desk work, reading, or realizing by transferring distracting notifications, including updates and messages (Figure 1, left). LOOP (Sauvé et al, 2017) introduced a physical artifact that changes its shape according to the activity data of the owner, providing an abstract visualization (Figure 1, right).

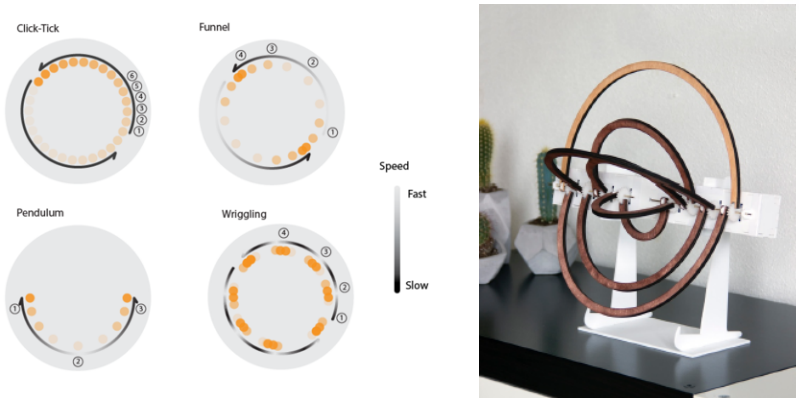


Figure 1. Examples of abstract and reflective information through not disturbing interaction methods. Calm Station(left) and Loop(right)

Both cases provide abstract information but several types of reflective information with simple product compositions. For example, Calm Station demonstrates various types of mobile phone notification through the speed and pattern of the rolling ball. LOOP provides activity data gathered by activity tracker such as smart watch through each circle, with the circles representing days of the week (Monday to Friday).

2.2.1.2. Physicalizing data through metaphors

Although we decided to provide abstract and reflective information, the form and/or motion of visualization of peer's learning activity in the context of learning was missing. In order to create the appropriate signifier, we investigated existing studies related with conveying physicalized data form through metaphors. Feather, Scent and Shaker (Bill Gaver, 1996) described three experiments in designing for minimal, expressive communication that are aimed at supporting implicit, personal, and expressive communication. Firstly, a Feather concept (Figure 2), is constrained by a transparent plastic cylinder, and lifts and falls naturally as it is flying by wind, once the paired partner touches interactive picture frame. An indoor Weather Stations (William W. Gaver, 2013), especially Wind Tunnel, consists of a tiny 'forest', made of paper, enclosed by a transparent pavilion miniature. Once the station detects the wind at home, it controls a small fan inside the forest's enclosure, which amplifies the gusts to create miniature storms that visibly blow the 'trees'.

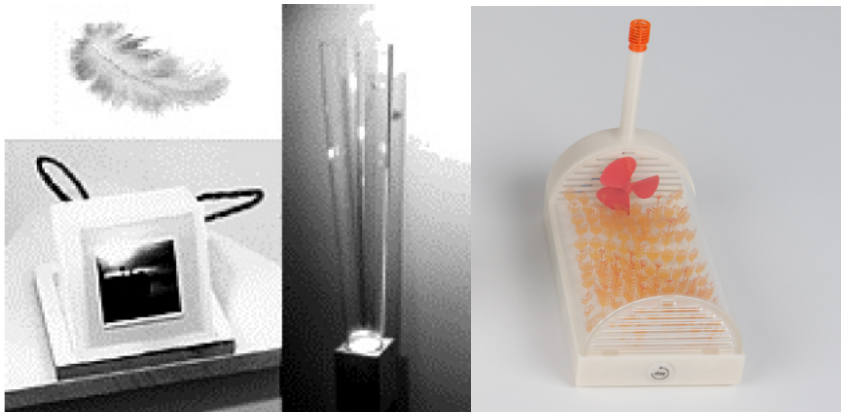


Figure 2. Feather(left) and Scent(middle) and Wind Tunnel(right)

2.2.2. Interpersonal Communication Through Tangible Interface

Interpersonal communication through tangible user interface has been studied for several years in the HCI (Human Computer Interaction) field. It is because it plays emotional and functional roles that screen based interaction such as texts and images cannot provide. Particularly, tactile communication is beneficial for expressing sympathy and persuasion (Jones, 1985). In addition, interpersonal communication through tangible interface conveys fun experiences that were revealed by one of the earliest study (Brave, 1997). Thus, we provided a tactile feeling to a relatively passive context: studying at one's own.

Ultimately, existing works as a starting point in the current project to provide a motivational factor for each peer to stimulate learning activity thorough a tangible user interface. For that, through the related works regarding interpersonal communication, we discussed various interaction methods, considerations, and challenges for communication.

2.2.2.1. Tangible interface for expressing movements or gestures

The InTouch (Brave, 1997) system provides a physical communication channel between people in remote locations. In other words, two geographically distant people can cooperatively move, fight over the rollers, or feel the other person's manipulation of the roller (Figure 3). In addition, HandJive (Fogg, 1998) is a product that allows remote play through haptic communication (Figure 3). Specifically, it fits in one hand and moves in interesting ways, sends and receives movements to another paired device. From both studies, we learned aspects to deal with 'play' experiences. For example, fun is highly subjective, thus one may feel fun but another may not.

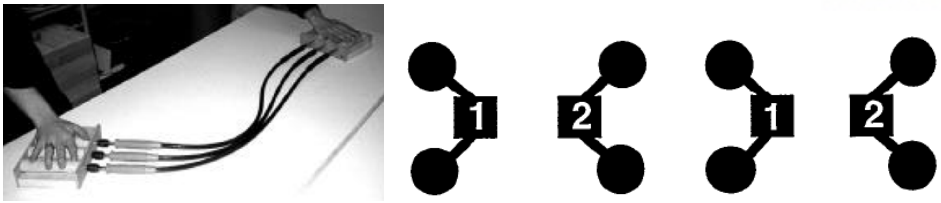


Figure 3. Prototype of InTouch (left) and interaction patterns of HandJive (right)

2.3. Summary and Reflections

In this chapter, through initial interviews with stakeholders, we were able to identify four design requirements derived from learners in online learning contexts. A literature review, we were able to further understand proper methods for demonstrating physicalized data and interpersonal communication through tangible user interfaces.

For example, we found common factors that previous study of tangible user interfaces provided *'abstract and reflective information'*, and they conveyed *'unobtrusive'* approaches in *'aesthetic'* forms. That are three of six design strategies for lifestyle behavior change (Consolvo, 2009) which may help students to change their behavior in learning context. Through this understanding, we designed the product that provides ambient information which augments learning activity through kinetic movements. In addition, we provided an opportunity of *'control'* for users, which is one of the six design strategy (ibid), to be notified peer's interaction or not. This control function was, also, inspired by BJ Fogg's previous study that the interpersonal communication induces pleasant experience among connected users, however such playful element has a relative concept according to the audience. Thus, we contemplate to provide selective modes of inactive the system as the user wants not to be disrupted.

3. FLIPME

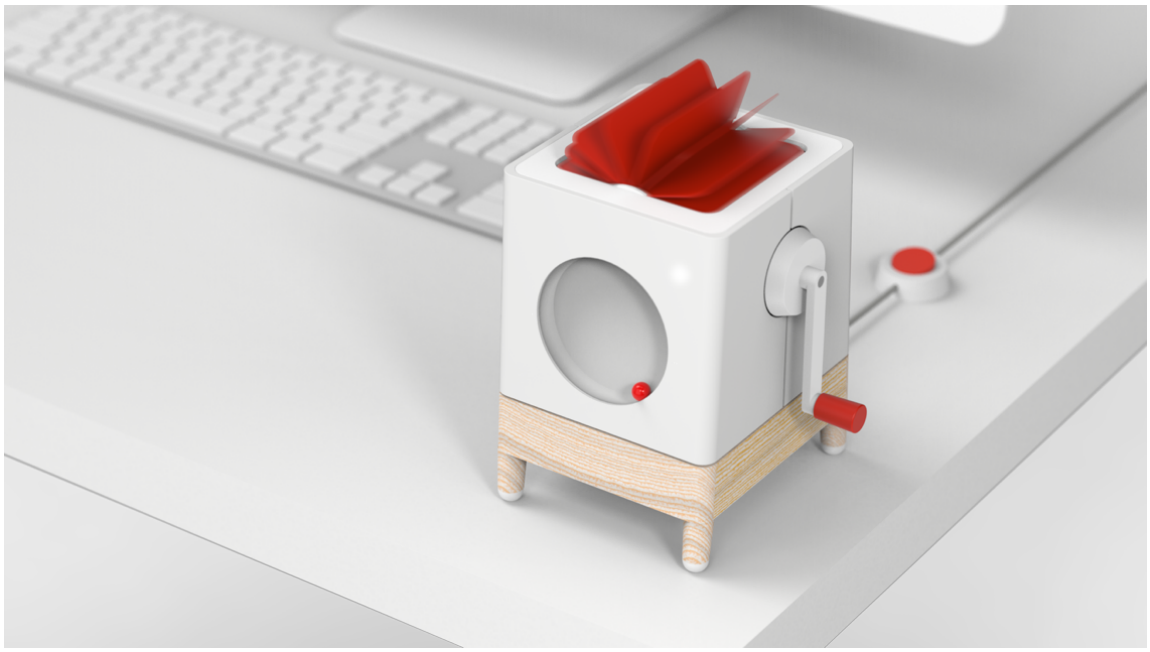


Figure 4. FlipMe: cards flipping condition when a peer is studying

3.1. Design Features

FlipMe is an IoT (Internet of Things) companion, augmenting peer-to-peer interaction for active online learning (Figure 4). FlipMe provides physicalized data of peer's learning activities and increases peer-to-peer communication opportunity (Figure 5). First, a flipping top provides real-time feedback on peer study activities with the 'reading-a-book-like' motion. Group study activity is expressed through a 'rolling-ball' feedback to the product's front. Lastly, the rotatable handle provides not only fidgeting by oneself but nudging for peer-to-peer function. All of these three features are designed to motivate students to social interaction and collaboration, one of the most significant aspects for high quality online learning (Douglas Nisbet, 2004) The main functions and features of FlipMe are outlined in the following sections.

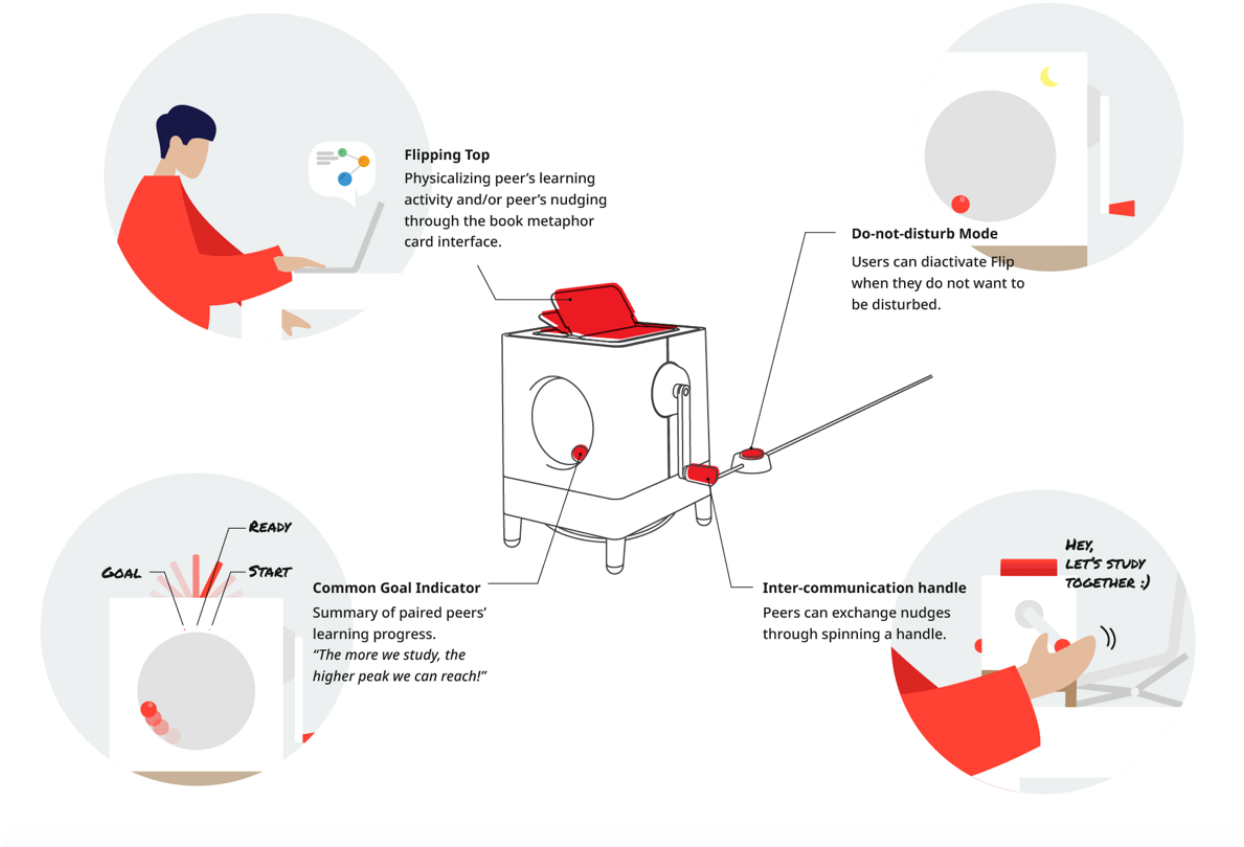


Figure 5. Design features of FlipMe

3.1.1. Real-time Feedback on Peer Learning Activity

Through the book flipping metaphor on top of the FlipMe, students can inform peers of their learning activity status. For example, when a paired colleague begins to study dedicated online educational contents, the personal learning companion starts to flip as if the paired colleague is reading a book through the flipping top part of the product. With this, we wanted users to be motivated naturally to study together with his/her peer rather than traditional motivation methods such as rewarding or punishment by score system.

3.1.2. Tactile Interpersonal Communication

FlipMe provides opportunity to communicate between peers, offering higher engagement and a more playful experience. The purpose of the handle design was so that a user may rotate the handle when (s)he wants to start learning together and/or discuss about the educational contents they are watching at the same time and/or to nudge the peer to complete the goal (roll to ball till the end). As a student rotates the handle, it transmits the same number of spins to the friend's flipping top part of the product.

The handle design was inspired by the pencil sharpener that we can see easily on the desk as well as books.

3.1.3. A Common Goal Indicator

A ball placed in the frontal face starts to move when one and/or two peers start to watch a video, and it reaches the end of the part once the two paired students finish the task to complete. In this way, students can check the progress of their study task abstractly also they may motivate each other to finish the goal in a collaborate manner. The goal oriented visual presentation also meets the goal setting theory (Locke, E.A., 2001) that should be easy to gauge the progress and inform when the user has achieved the goal. When the deadline of certain chapter finishes, the ball moves back to the start line and the collaborative race will begin again. The design intension for this part was to provide collaborative attitude to motivate peers in a competitive atmosphere.

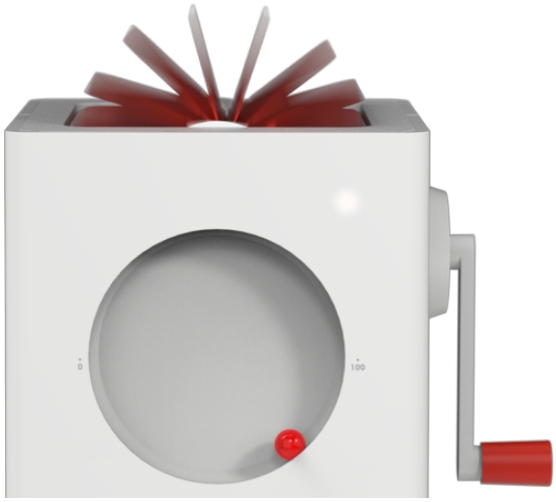


Figure 6. Flipping card, Common goal indicator and the interactive handle

3.2. Interactions

FlipMe provides several features, such as the status of peer's watching educational video contents, progress towards common goal and opportunity for interpersonal communication (Figure 6 and 7). And for them, which are the core interaction points, we added red color to provide predictability. We believe the color strategy conveyed both signifier and affordance that user instantly can utilize the product efficiently.

In detail, FlipMe informs peers' learning activity, especially watching online video contents, through the card flip mechanism on top of the product. While the flipping part is working, it not only provides the visual signal as if friends are flipping the book pages but also provides a paper flipping sound which

may catch the attention to inform whether a user is studying. In case the student wants to notify the peer more directly when watching a video that only provides same pattern and speed of card flipping, (s)he can rotate the handle on the right side of the product through certain patterns or speeds. The handle recognizes and provides user's spinning through nine different patterns so that it provides various information types to a peer's connected FlipMe. Lastly, the rolling ball location represents two paired students' video watching progress. It moves through nine different steps according to mapped the length of video contents or list of videos. For example, if the rolling ball path is mapped with 30mins video and only one user watched 30mins in all, the location of the ball will be in the middle of the path (50%). Through this, peers can track each other's learning progress abstractly.

Figure 7. Interaction scenario. When the user(left) begins study and/or rotates the handle, the FlipMe of the peer (right) physicalizes the user's learning activity or nudge

3.2.1. Initial Prototyping

In order to achieve students' engagement in online learning through providing physicalized data and nudging peers directly, we initially separated two different functions with two tangible interfaces, since they (flipping and poking) have different characteristics and roles (Figure 8). On the one hand, as a peer starts a learning activity, the cube shaped product starts to flip cards. On the other hand, users can poke the elastic part on top of the product then the peer will recognize a friend's poke through soaring form of the flexible top part of the product. The interactions were clear that we can be informed if a paired peer is learning through a reading a book motion and nudge friends through poking. However, the poking interaction was introduced several times by previous studies (Tsimeris, 2015) and these products had a lack of connection, thus we suggest the final concept and prototyping through an iterative prototyping process to improve the 'flip' concept (Figure 9).

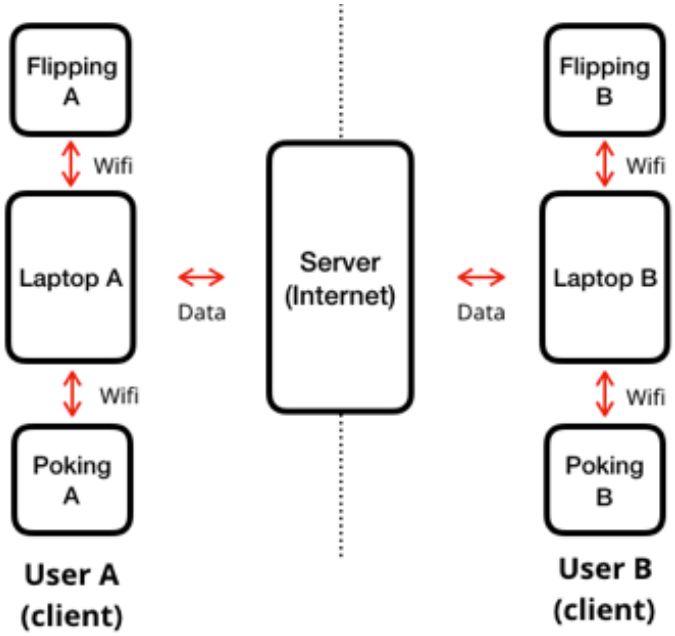


Figure 8. Initial system communication design

Figure 9. Iterative prototyping process: Initially, products are divided into each interface types. 0)'Poking' prototyping, 1)Common goal indicator prototyping, 2)'FlipMe' 1st generation and 3)Housing structure of FlipMe 2nd generation.

3.3. Implementation

3.3.1. Hardware

Firstly, all parts of FlipMe were designed using CAD (computer-aided design) modeling (SolidWorks 2018). Based on material and/or complexity of shapes, we utilized different fabrication methods. For example, a 3D printer (Objet Eden 260) was utilized for complex shapes or parts required to be color sprayed, and plate type parts were fabricated by Laser cutter (Universal laser system), and for wooden material, CNC (Computer Numerical Control) was utilized for manufacturing (Figure 10).

3.3.1.1. Main body

The main body was designed with a height (144 mm, including legs) and the inclination (86°) so that a user could easily be able to observe main interfaces on top and in front. Particularly, it requires durability more than typical product design mockups, since the design was composed of several parts. The thickness of the body is 4mm and to assemble both sides of the bodies firmly, 2mm of embossed and engraved from each part in both cross-sections were designed so that durability and clean parting line could be achieved. Once the body parts were printed, they were washed through high power hydraulic sprayer to remove support materials (Figure 11). Then the parts were painted through surface air spray and mat-white color spray (TESTROS enamel spray). In addition, the white color LED was installed to provide information such as on/off status of the product, indicating if the user is rotating the handle and to error report.

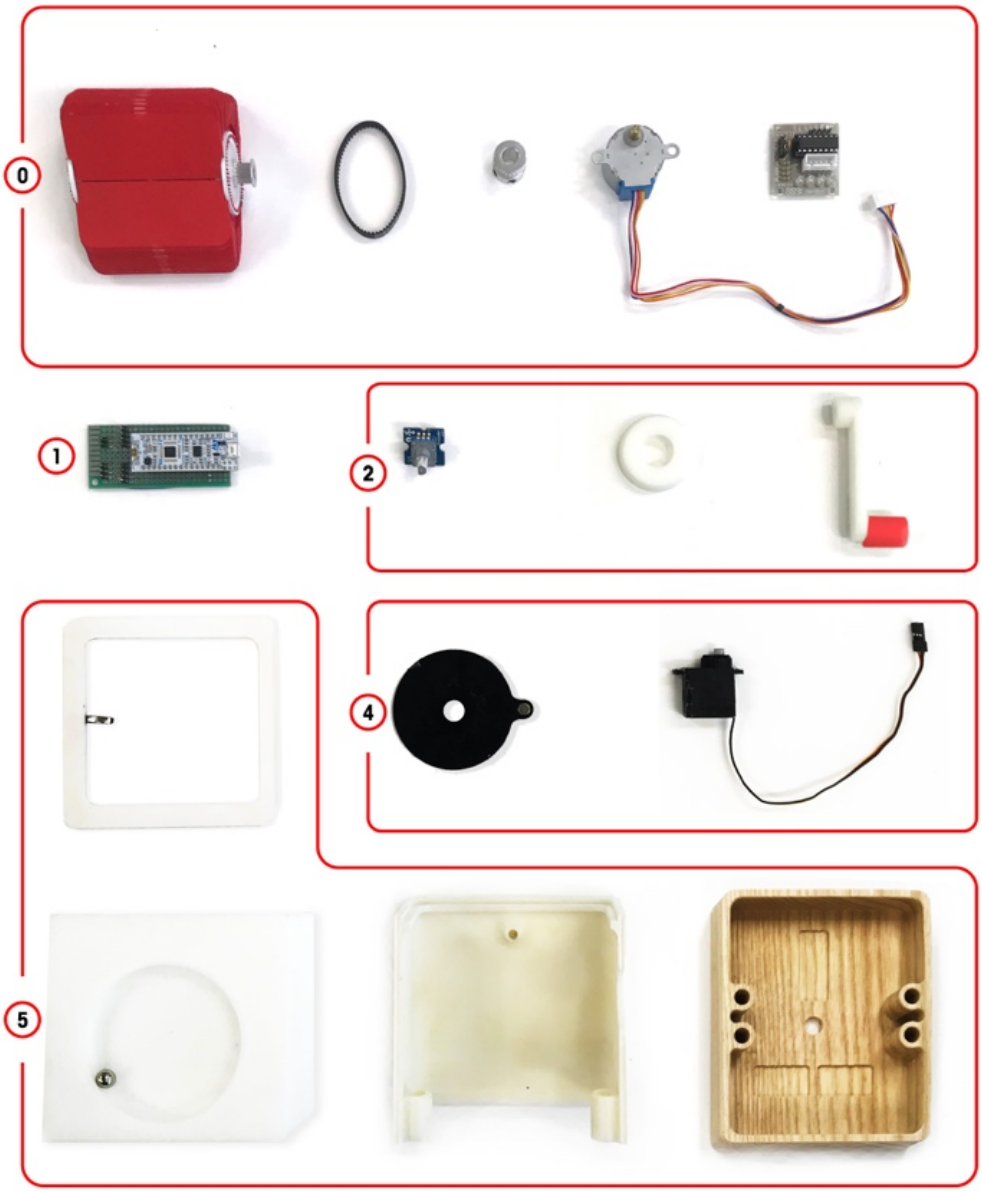


Figure 10. Components of FlipMe prototype: 0)FlipMe components with flip cards, timing belt, pulley, step motor and step motor driver, 1)MCU with Wi-Fi module, 2)Handle components with rotary encoder, rotary encoder holder and handle, 3) Housing with rid, (front part)

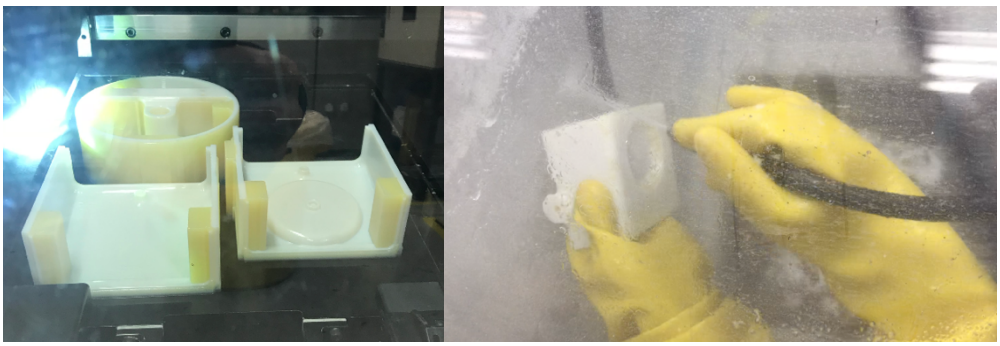


Figure 11. 3D printing by Objet Eden 260 and process of removing supporter

3.3.1.2. Common goal indicator design

A neodymium magnet with a diameter of 8mm was used to provide information of progress of the common goal to the front side of the body (Figure 12). The neodymium magnet was installed to roll along a circular embossing area of 64mm in diameter. In order to implement the movement of the ball type magnet, two gears with a gear ratio of 1:1 with a diameter of 32mm were cut by the laser cutter and were plugged with 180 ° servo motor and the plate with small cylindrical magnet installed on the backside of the circular embossing area. Finally, as the servomotor starts to turn, the plugged gear turns itself them transmit the rotation to another gear installed with the plate on the backside of the circular embossing area, then consequently, the cylindrical magnet on the backside of the body rotates the ball-shaped neodymium magnet in front.

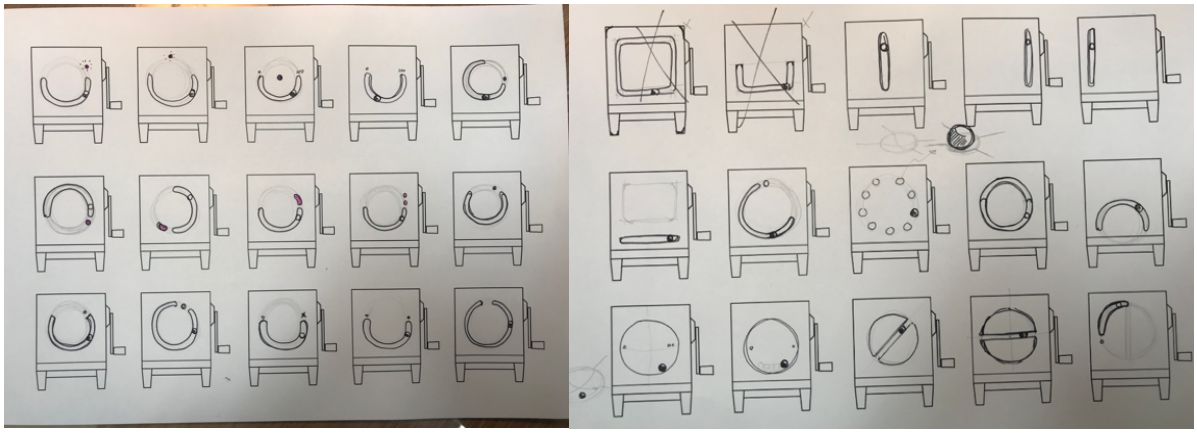


Figure 12. Interface samples before dot-voting process

3.3.1.3. Book metaphor flipping part design

To design the flipping card mechanism, we studied flip clock's mechanism first. The most challenging part to the flipping card mechanism design was to find the proper material for the cards which are supposed to have proper flexibility, durability and thin enough thickness to not have congestion while cards are spinning. In conclusion, polycarbonate sheet with 1mm was selected and cut by later cutter set with power 5%, speed 4%, PPI (500) and thickness 1.00mm. Once cards were cut, mat red color paint spray was used to color them (Figure 13). After that the rest of the product with small aluminum needle (0.3mm) was designed to hold and release the card properly as book pages are flipped. In total, 48 finished cards were used to provide information of peer's learning activity. Finally, to rotate the cards, a timing belt (130mm) and pulley (15cogs, ⌀5mm) brought the power from the step motor.

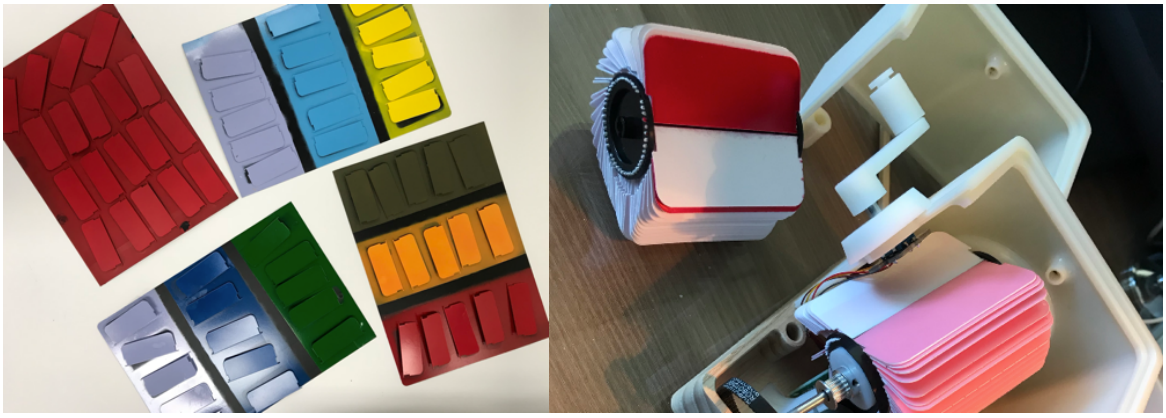


Figure 13. Flipping cards' color variation trials and cards holding mechanism

3.3.1.4. Handle

The interior design of the handle was considered to install a 360° rotary encoder module (Grove-Encoder) which senses the number of rotations of the handle by a user to the MCU (511-Nucleo-L432KC) to provide same pattern/number of rotating to the paired peer.

3.3.1.5. Wooden lower body

The wooden material was considered to improve the aesthetic by various use of different materials. Ash as a solid wood was selected to provide the natural beauty of grain. In order to prevent the breakage during CNC machining, the minimum thickness was kept in 6mm, and while CNC machining, grooves were made for a peripheral design where the electronic parts such as motors can be inserted. Also, to have slightly inclined leg, the inclined foundation was manufactured initially to hold the material for the legs inclined with 82° (Figure 14). Once all wooden parts were prepared, mat type varnish was painted to keep the product from distortion or widening which are typical problem of manufacturing wooden product. Lastly, on the bottom area of the wood, the cable holder which is 3D printed was installed.

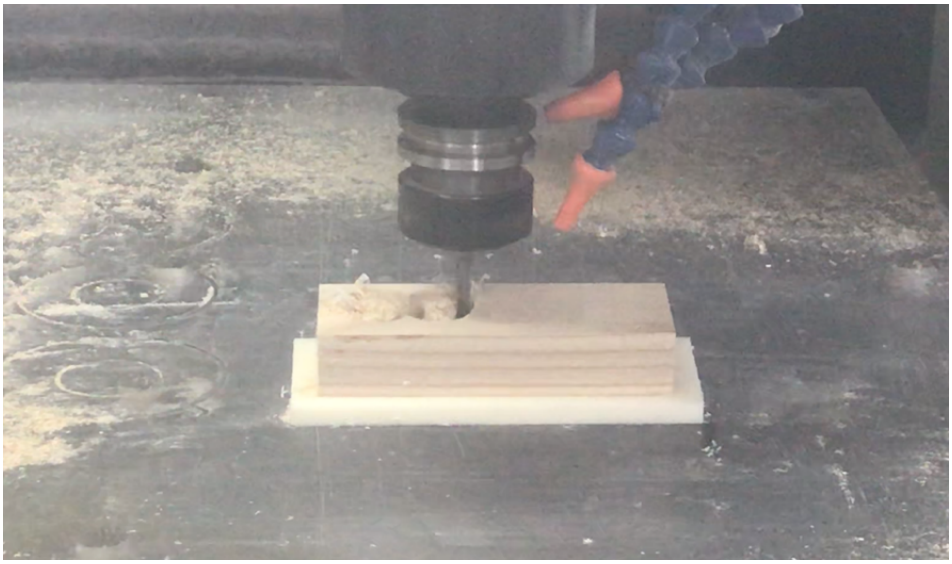


Figure 14. CNC machining for inclined wooden legs based on inclined

3.3.2. Software

First of all, real-time parallel control is needed, so we used Embeds. It is because the rotation measurement, the step motor rotation, the servo motor angle control, and the internet communication are all concurrently performed, the implementation of this function is easier on the ARM cortex board than when using Arduino.

As for the algorithm, the most basic task was the server that exists on the Internet and real-time transmission and reception. It communicates with the Internet server at intervals of at least 2 ~ 4 seconds. If the control of the step motor is necessary due to watching the video of the user or manipulating the handle of the other party, execute the control command (Pattern execution, continuous low-speed rotation).

In the case of the handle, its rotating pattern is divided into 10 levels and recorded by the user's input as one rotation per second, and the data is immediately reported to the Internet). For example, the 'rotation angle' per 1 second to ‘rotation index’ is 0 ~ 17 degrees= 1, 18 ~ 35 degrees= 2 ... 342 degrees ~ 359 degrees= 10.

Lastly, the server runs through the express framework of NodeJs. It reports for hosting for two websites and communicating with two devices and giving the appropriate commands to the device or website according to the experimental environment (experimental value) (Figure 15).

Figure 15. The pair of working prototypes connected to the internet server

4. USER STUDY

4.1. Study Aim

Through the lab setting learning environment and a given learning task, we conducted an in-lab study to evaluate the value of FlipMe's essential functions in a relatively short period of time. Through the experiment, we aimed to gain an understanding of the following: First, would the subjects be aware of the learning of friends visualized through the level of the cards and beads, and will there be a change in behavior or thinking. Second, in what context will the handle be used and how will each participant react. Lastly, do learning styles make any difference in utilizing the given device?

4.2. Methodology

4.2.1. Participants

The experiment was conducted with 22 students from 22 to 32 years old (8 female, 14 male, P1-P22). All subjects had experience in online education and asked to complete Kolb's learning style questionnaire (Honey and Mumford, 2006). We adopted the use of the Kolb learning styles because, groups in different/same learning styles have different types of communication types (Neese, 2016). And such we wanted to have different group compositions by pairing the same and different learning styles. Also, all participants were asked to choose a friend to participate the experiment as a group, since the experiment was designed to observe the interaction between peers. Finally, all teams were composed of friends or colleagues with 4 teams with same learning styles (P1-P2, P3-P4, P9-P10, P19-P20) and 6 teams with different learning styles (P5-P6, P7-P8, P11-P12, P13-P14, P15-P16, P17-P18) (Table 2).

Table 2. Participants' learning styles

Participants	Learning Styles	Learning Style Correspondence
P1 – P2	Assimilator – Assimilator	Same
P3 – P4	Diverger - Diverger	Same
P5 – P6	Assimilator - Converger	Different
P7 – P8	Accomodator - Assimilator	Different
P9 – P10	Assimilator – Assimilator	Same
P11 – P12	Converger - Diverger	Different
P13 – P14	Assimilator – Accomodator	Different
P15 – P16	Diverger – Assimilator	Different
P17 – P18	Diverger - Converger	Different
P19 – P20	Accomodator – Accomodator	Same

4.2.2. Method

An In-lab study was conducted to observe the possibility and limitations of how participants experience the FlipMe concept in a relatively short period of time. A total of two FlipMe's connected through an Internet server were created. Experiments were conducted in two independent spaces where there is no interference so that participants could experience interact between each other in remotely located spaces, although the two spaces were co-located within the same larger room space. The independent space assigned to the individual was a cube-shaped booth, and the wall was made of a whiteboard to record notes (Figure 17). Each cube contained a FlipMe prototype, a desk, a chair, a personal computer (MacBook pro, Apple), A4 writing paper, a pen (pencil, highlighter), a post-it, a multi plug and a simple snack. A camera was installed on the ceiling of the cube (Figure 16).

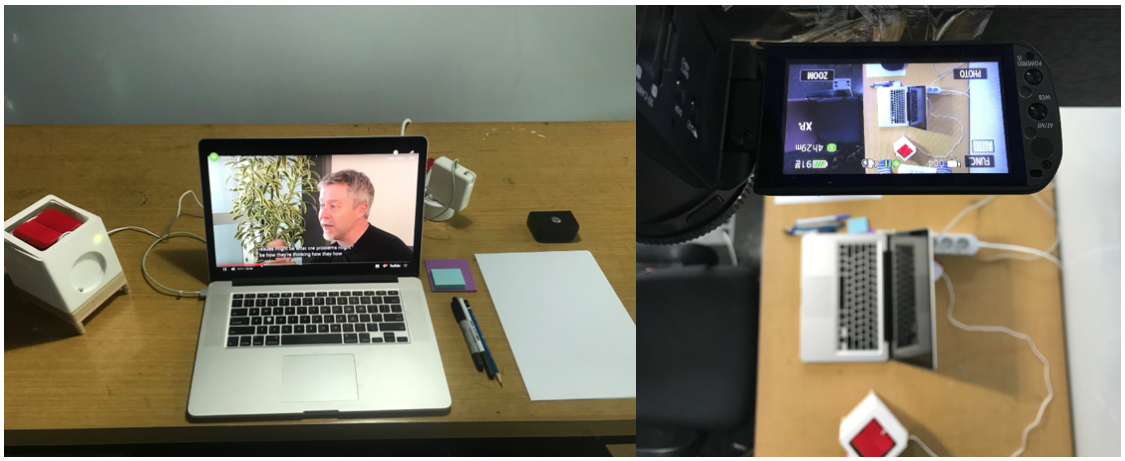


Figure 16. In-lab experiment setting

The purpose of providing the space was to allow the user to simulate his own workspace without any inconvenience. For this purpose, participants were instructed to bring with them personal computer, writing instrument and so on.

We conducted pilot tests with participants who had two usability test facilitation experiences. The experiment was conducted through the procedure of the entry question (10 minutes), the video observation (40 minutes), the discussion session between participants (15 minutes) and the retrospective interview (10 minutes). Through the pilot test, we learnt various aspects to be improved for the main study as follow:

- Quiz from the worksheet should be dependent on video content, which is important for logging data from multi choice quiz that is easier to be answered through Googling.
- 40 mins of observation session is too short to bring the natural behavior from participants. As they have 40 mins free time, they immediately had to spend time to answer the questions. So that we decided to provide one hour.

- Finally, we added experiment details such as online communication opportunity (Slack, 2018) that participants can discuss.

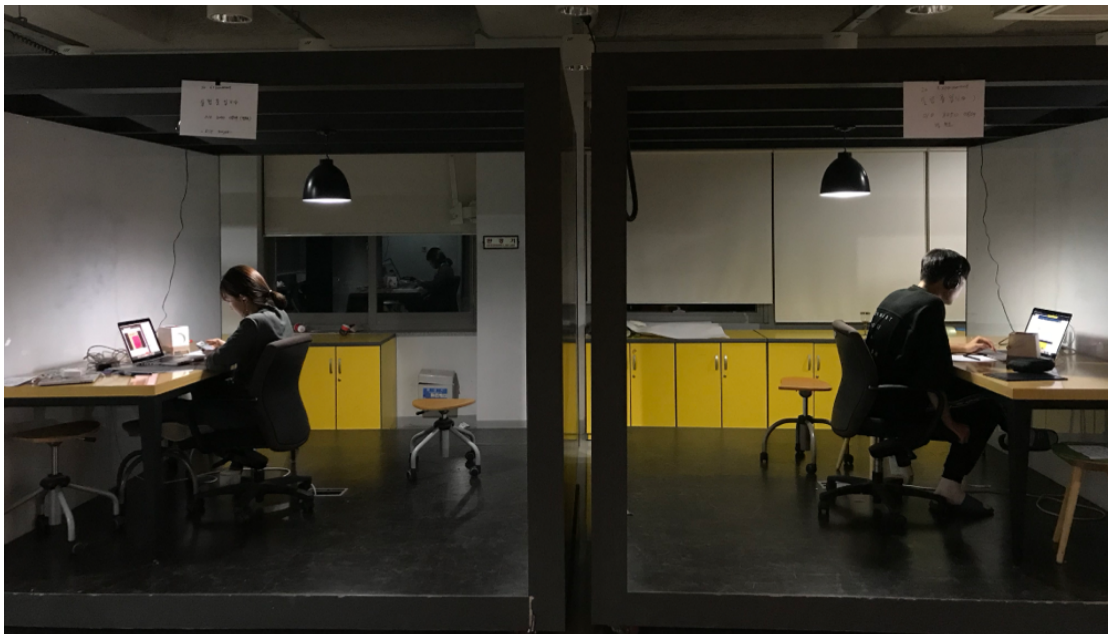


Figure 17. Video ethnography (Fly on the wall)

For the main experiment, after the explanation of the experiment, we provided the results of learning style result sheets (Figure 18), and at the same time, we wanted to create familiarity and consensus by allowing the two subjects to share stories related to the brief for 5 minutes.

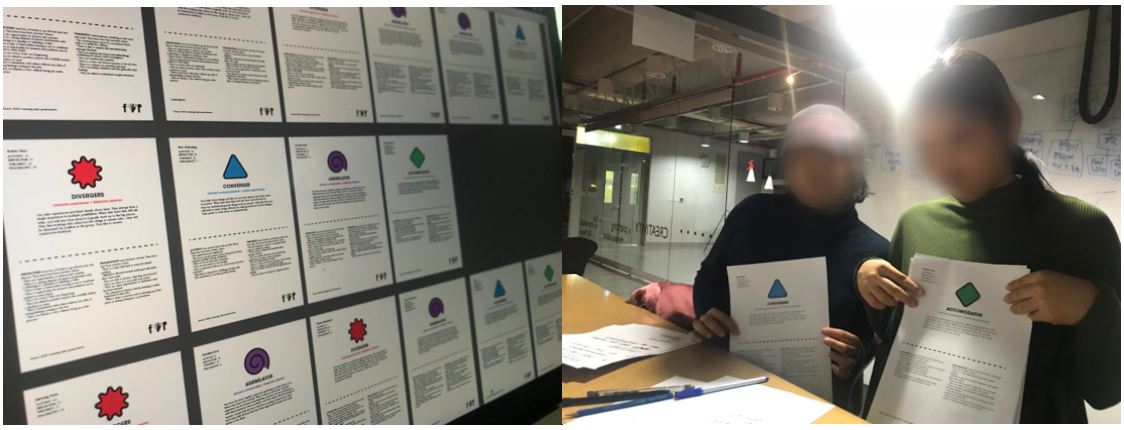


Figure 18. Learning style results for team building and for ice breaking at the beginning of the interviewing

Then, participants were profiled through entry questions, and subjects entered each cube and were allowed one hour of free time to use their work, on condition that answering the worksheet. The reason, for video watching was not compulsory even if it is core data source of users' behavior during

the free time, was to avoid eventuality and coercion that in-lab study has. A 24-minute video (Affordance and signifier, Don A. Norman, Udacity) was provided as a source for solving the problem. The video and questions are basic level contents. The questions were designed not to be solved with multi check questions by googling only, but provided open questions that can be discussable between peers once they finish the video. The length of the video content was set to be similar to the length of the previous study exploring the dropout rate of students during video viewing (Justin Pope, 2015). Lastly, after an hour of free-time observation session, we started with a brief discussion of the given discussion questions, and conducted retrospective interview about the experience of using FlipMe.

4.2.3. Interview Design

The main purpose of the interview question design was to explore how participants consume the online content that was captured through the entry question and to change the behavior or psychology of the situation where peer-to-peer communication was possible through FlipMe. In addition, usability, advantages and disadvantages of interaction with the tangible interface and so on. For this, interview questions were designed in order to provide the most natural use experience in a relatively unnatural use/interview Environment. In this regard, we asked questions about the situation and experience of product use, rather than detailed questions about the product itself (Table 3). Interviews were voice-recorded for later analysis.

Table 3. Debriefing / Retrospective interview question design

Debriefing / Entry questions	
Core question: To obtain core value / issue of the experience	**Supportive question:** To draw clearer context of use and reasons
Do you have the recent experience about watching online educational contents?	What was good? What was bad?
How do you normally (start to) watch/read given contents(homework) until the deadline (next class)? Ask to describe based on date (Mon to Fri)	Why do you…? Any issues faced?
How do you normally communicate / discuss regarding the course with your friends on/offline?	Why do you prefer…? In what purpose do you normally? Any inconvenience in online discussion?
Can you tell me any particular behavior to watch (educational) video content? e.g.) Some watch it 1.5x speed	Why do you prefer…?
Retrospective interview questions	

What activities did you do in order to solve the problem at the beginning?	Why? Was it effective? Who started watching video? Can you describe at that moment?
Have you finished given video contents?	From when? In what context did you start? Can you describe at that moment?
Have you used the handle?	Can you describe the moment you used the handle? Why you want to use? What have you felt? Any suggestion?
Can you describe when the ball started to move?	What was your reaction? Why? Any suggestion?
Can you rank among three main motions: flipping when the peer is watching, flipping with pattern when the peer is spinning and the ball location?	Why it was the best for you? With that, what have you done/felt? Why it was the least satisfying? Any suggestion?

4.2.4. Data Logging

Data was logged from two sources for about 1200 minutes and both types of data were logged to an AWS (Amazon Web Service) on the Internet. The source of the data logging is the YouTube player link connected to the Internet server and various sensors of FlipMe (1, 2) such as rotary encoder. The data log gathered from the FlipMe sensors were sent to the ARM cortex (MCU) and through the Wi-Fi module it was delivered to the online server. Also, each participant's learning style was logged through Kolb's learning style questionnaire generated by Google survey sheet. Lastly, the number of correct answers (0 to 3) from the dedicated worksheet was calculated. The raw data logged by one user was, the number of connected users (1, 2), the user ID (User1, User2), learning style, the current video playback interval (0-1440 seconds, total 24 minutes) video play status (during playback, stop), the spin frequency, the message frequency and the number of correct answers. All data types were reported every second based on the current time. In addition, text message frequency that is logged in Slack (Slack.com) which is the professional communication platform's chatting room and the number of correct answers from paper worksheet were counted manually. By logging the data above, we tried to see what activities related to online learning of peers are exchanged through FlipMe.

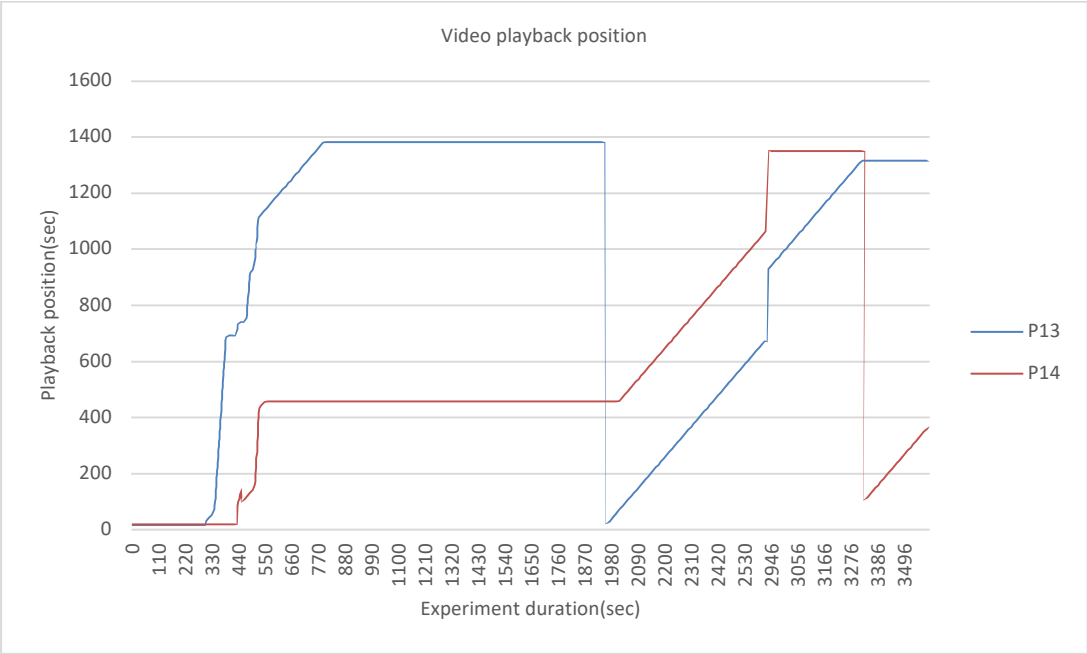
4.3. Methodology

Data consisted largely of quantitative data logged on an Internet server and transcription qualitative data obtained through interviews. The quantitative data is composed of three major components for each user: video viewing pattern (start and end, total viewing time), spin frequency and message frequency. On the other side, qualitative data was analyzed through the affinity-diagramming method.

4.3.1. Quantitative data

In order to analyze quantitative data, we collected 4 types of variables: watching video (as time), spinning handle (as frequency spins), learning style (as category) and messages (as frequency).

First, we compared video playback position and spin frequency between two paired peers. It was to observe if physicalizing peers' learning activities through the tangible interface motivated the users to engage in the provided video content. The experimental results (Figure 19) show that physicalizing learning activities, such as watching video of each peer, and providing interpersonal communication opportunity within learning context promoted mimicking behaviors between participants. In order to understand why they showed a similar behavior pattern, we asked questions at the retrospective interview and P14 replied *"At the beginning of the experiment, I, actually, was watching 'YouTube' game channel. But I felt that I also need to study once I realize my friend is studying."* P13 said, *"I spun the handle first then my friend sent a message to ask the reason for spinning. Then we started to chat about product first then about the video."*



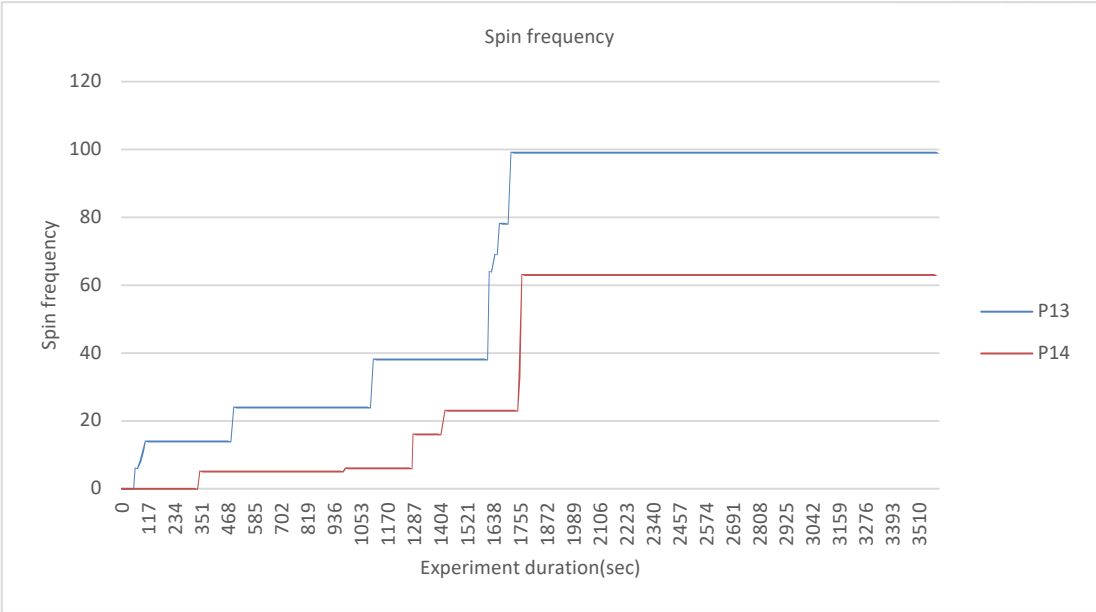
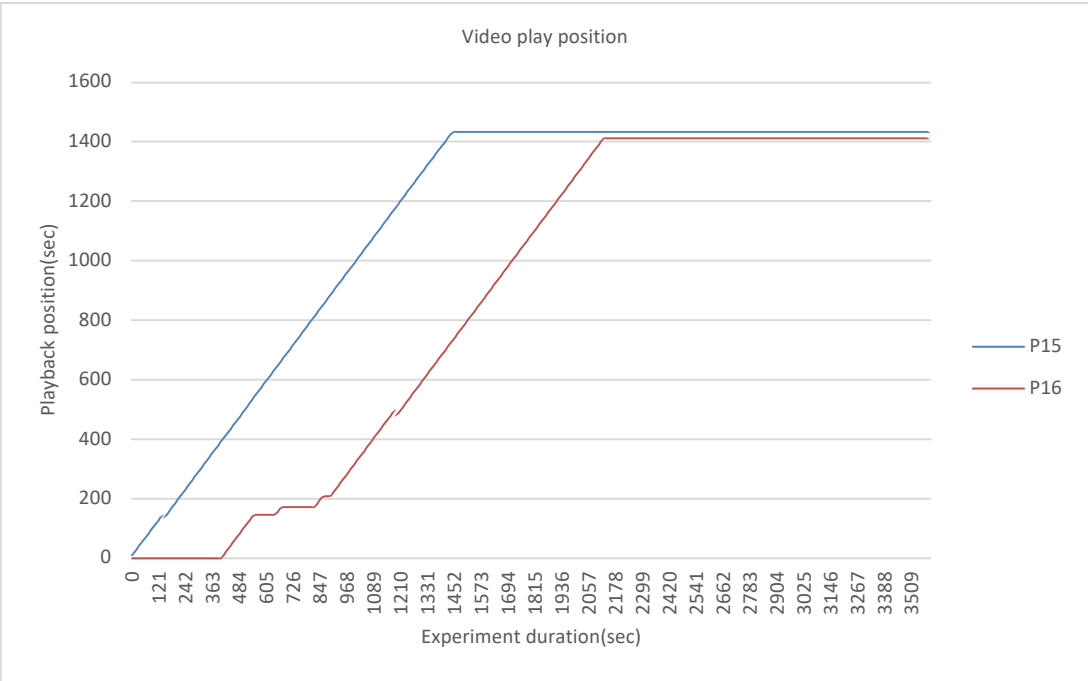


Figure 19. Line charts that we can observe that participants mimicked each other's behaviors. Participants showed similar pattern of playing video(above) and they used inter-communication handle accordingly(below)

On the other hand, such mutual motivation did not occur in all subject groups (Figure 20). Some noticed that the cards would turn around, but they (P7, P8, P9, P10) wanted to keep their own learning patterns that is familiar with him. For example, P5 said *"I do not care what others do. I have my own watching pattern."*. On the other hand, some (P11, P16, P20) did not recognize the difference between speed of flipping when the peer is watching video and peer is rotating a handle.



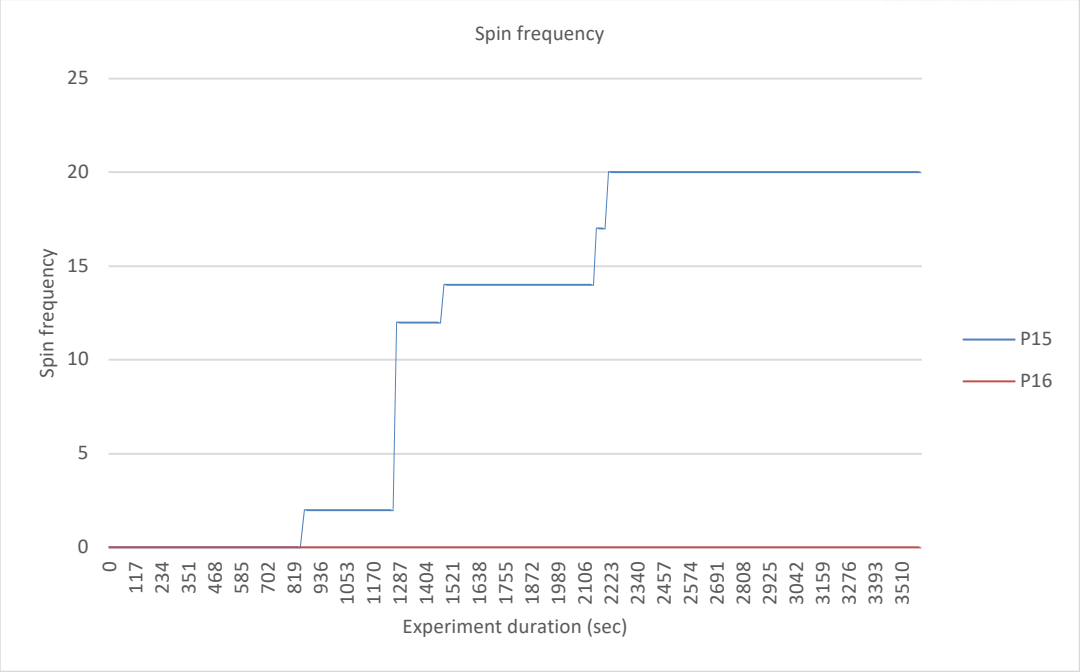


Figure 20. Raw data showing visualizing peers' learning activity does not motivates each other participants. The line chart above shows each participant watch videos by their own watching pattern (proved by retrospective interview with P15, 16), and both participants did not show interaction through utilizing a handle at all (below)

However, correlation between the number of turns of the handle and number of messages exchanged (Table 4) was high (Pearson's r = 0.81), suggesting that participants who messaged frequently were also likely turn FlipMe's handle frequently.

Table 4. Spin and message frequencies among participants (N=20)

Participants	Spin frequency	Message frequency
P1	0	25
P2	9	53
P3	24	0
P4	11	0
P5	46	49
P6	25	43
P7	4	8
P8	0	2
P9	0	0
P10	0	0
P11	0	2
P12	2	4
P13	97	162
P14	58	150
P15	20	94
P16	0	61
P17	30	8
P18	3	10
P19	1	0
P20	5	0

In addition, we discovered the possibility that the learning style may be the factor of frequency of spinning the handle and sharing text messages (Table 5). The data of Group 5 (P9-P10, Min), Group 7 (P13-14, Max) are excluded as outliers. The mean value of spin frequency from *Diverger style* (Kolb, 1984, p. 38), was the highest, and message frequency in the same learning style showed the second highest mean value too. In contrary, the highest value of message frequency was observed from *Assimilator* learning style participants who have the second highest mean value in spin frequency. This represents that students with learning styles -Divergers and Assimilators- are more active in communication through both online and offline channels.

Table 5 Spin and message frequencies by learning styles

Learning styles	Spin frequency (avg.)	Message frequency (avg.)
Divergers	17.4	21.2
Convergers	9.3	18.3
Accomodators	3.3	2.6s
Assimilators	11.0	38.0

4.4. Findings

4.4.1. Physicalized Learning Activities Encourage Each Peer

By visualizing the peer 's learning activities as the most central design intent, about 50% of the subjects expressed feelings of motivation to study. It is believed that this can be a positive reinforcement through a positive object: friends rather than reward or penalty through course score that is given from traditional on/offline classrooms.

- P1 commented *"It seems that having a friend studying a lot before me is enough stimulation. I seated at the desk."*
- P12 addressed *"I'm the person who take time to be ready to study. But…"* P4 P12 P17 P19 expressed the effect of physicalized status of peer's learning activity. P17 said *"My friend started studying first. So, I did not do other things and I studied too."*
- P13 replied *"I watched the game on YouTube and I felt my friend studying. I also wanted to finish the video and sleep."*
- P8 P16 described flipping interaction *"Studying became visualization and I felt more pressure."*
- P8 added *"I felt pressure, but because of the team project, I wanted to be able to help quickly."*

In addition, some subjects applied flipping condition as online status on a social media, so they

wanted to communicate in real time.

- P7 said *"I started studying first, and my friend noticed that I studied too. When my friend stopped, I thought I should ask him something."*
- P8 *"When I just found something, I realized that my friend was studying. So I wanted to share what I found. I wanted to rush before my friend finished studying (before the card stopped)."*

However, in the way of giving information during studying, subjects' opinions were divided about motion or sound. We will discuss the issue in discussion.

- P4 P5 P9 P10 P15 P17 described "*But when I was studying, I was disturbed when I had to concentrate."*

4.4.2. Book flipping metaphor added emotional value

About one third of the participants positively evaluated that the book flipping metaphor fulfills the emotion.

- P6 P13 described *"The feeling of passing through the book through analog way added sensitivity."*
- P1 mentioned *"I am going to take out my cell phone when the place is too silent, but I hear the sound of the card running and I do not use my cellphone because it seems like watching me friendly."*
- P14 described *"I do like the chewy sound as cards were flipping", "It was white noise for me."*

However, I was also able to get some detailed advice on slowing down the speed of cards flipping a little more.

P20 gave me an advice *"As if we read a book and flip pages for real."*

4.4.3. Interpersonal playful-haptic communication

We wanted the handle to play a role as a communication channel to communicate with friends, but at the same time, many people unexpectedly played with FlipMe through rotating a handle to flip each other's devices. Fortunately, the handle played the role of communication channel for educational purpose between two peers located in remote spaces.

- P5 mentioned *"I wanted to draw the attention of my friend. There was something I wanted to say in the chat, and when I did not answer the chat window, I gave notification a little more."* P2 said *"I feel we are much closer each other once I realized my product was flipping by my friend flipping his product."* I believe this comment is connect to the insight from one of the interviewees mentioned about coexistence with friends helps to focus on learning. P14 told *"I sent a note, turned the steering wheel, turned the steering wheel, and sent a note."* Lastly P17

said *"I finished my studies and I turned around to see if my friends could finish it fast."*

Interestingly, some subjects were playing with FlipMe as well as they were playing by themselves or with friends.

- P1 described *"I hear the sound of the card running and I do not use my cellphone because it seems like watching me friendly."*
- P4 P12 P13 P14 P15 P18 P19 P20 addressed *"When I was bored during my study, I was able to get rid of the boredom through spinning the handle. The light-only flickering feedback was less effective though."*

For some we noticed that they use FlipMe as a tool to play with each other rather than just talking about study.

- P12 P13 P18 commented *"When my friend replied that my handle action worked on him, I continuously rotate handle to see my friend reaction."*
- P16 said *"I used a handle to show off me just finished the study."* P20 described *"I rotated the handle because she seems studying too much. So, I wanted to disrupt her."*

This issue, which may act as an obstacle rather than a motivation for learning will be mentioned at discussion chapter.

4.4.4. Rolling Ball Promotes Collaborative Attitude

In order to help collaborative learning, which is a key element of peer learning activity, we designed an indicator which demonstrates a common goal / progress rather than personal progress and goal setting which are exciting solutions we can see in most mobile apps. Through this, majority of people (6 participants, excluding pilot test) described it was motivational through using a term 'Reach' rather than 'Complete' to the goal.

- P1 P4 described *"It was interesting to see the beads go back to gravity in the plane. I played with the ball as well."*
- P1 P8 said *"The ball type magnet motivated me to achieve my goal as I rolled a big ball at a childhood."*
- P8 connected to the location of the ball to discussion timing *"I wanted to discuss with my friend when the beads reached the end. I would have seen his friend."*
- P15 addressed *"The pleasure when the ball goes to the end!"*
- P12 P20 *"While concentrating, I was glad to see the bead which was far away."*

Some have expressed anxiety that they should not be disturbed subject to reach to the goal. However, the researchers found that an appropriate sense of tension is necessary in the context of online learning (Renee Jain, 2015).

- P2 explained *"I am still starting, but my friends have done so much, how can this friend do so efficiently? I also felt anxious / irritable."*

However, there was also a difference between the positive opinion that abstract information can be learned quickly and the users who were suspicious of inaccurate / unfamiliar range setting.

- P20 commented *"It is abstract but I can guess how much I studied easily."*
- P3 P16 *"The range of beads was confusing. There is no indicator."*

4.4.5. Relationship between the number of spinning a handle and messages

Correlation between frequency of turning a handle and text messages was high. This suggests that participants integrated the wheel turns in their emergent communication styles - those who regularly corresponded also regularly used the wheel, while those who messaged sporadically also showed lower use rates for the handle.

4.4.6. Relationship between learning styles and interactive activities

We discovered the relationship between participants' learning styles and their frequency of spinning the handle and text messages. *Assimilator* and *Diverger* showed the highest value in both spin and message frequency. Both learning styles are close to 'Reflective Observation' on processing continuum which is about *'How people do things'* (Figure 21). Kolb (Kolb, 1984, p. 38) described this learning styles close to *'Reflective Observation'* as below: *"REFLECTORS want lots of breaks to go off and read and discuss."*.

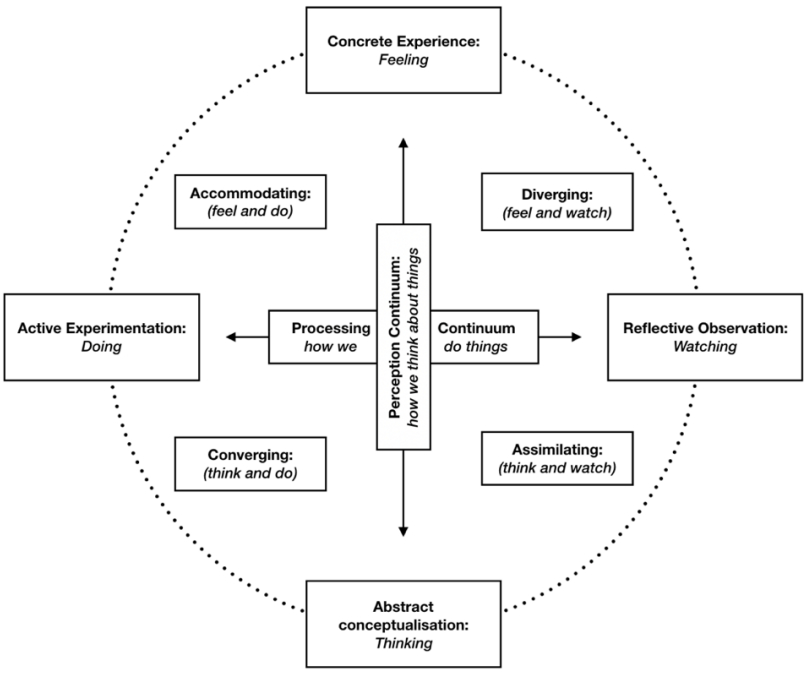


Figure 21. Kolb's Combined Learning Cycle. We discovered Divergers and Assimilators, who are more likely communicate actively in Kolb's theory, used FlipMe's handle more frequently than other learning styles.

4.4.7. Temporal Notification

Also, there was peculiar but interesting opinion about flipping notification as it is self-destructing message.

- P5 explained *"The tremendous amount of red marks on the mobile app icons are a big burden for me. But the motion of FlipMe is unobtrusive at all. Because when I see notification I can respond if I want to. It will be gone even if I do nothing."*

4.4. Summary

We could answer the research question *To what extent does the intervention influence 'active learning'. And, does learning style make a difference?* through findings from the user study. Although tangible interfaces of FlipMe have no significant relationship to motivate peers to study immediately, it is optimistic that participants were realized and started to contemplate the study timing by themselves once they recognize that their friends are studying. This is evaluated by the retrospective interviewing that the information of flipping card and the location of the ball promotes people to recognize the given task (answering worksheet in our experiment). In addition, we observed high correlation between turning the handle frequency and exchanging message frequency which represents participants utilized the handle in their communication style correspondingly. For example, participants who are more active in communication online turned the handle more often. In addition, we found that those who regularly communicate also regularly used the handle were from certain learning styles: *Divergers* and *Assimilators*. These learning styles are well-known for active discussion evaluated by Kolb. This result suggests that the handle plays an encouraging role to students to interact socially in educational contexts. Further, this finding may apply in mobile application design in future work. For example, students who are *Diverger* or *Assimilator* will be matched with relatively inactive in inter-communication. On the other hand, the handle was utilized by more than half the participants as playful interaction / communication channel rather than educational communication trigger that was the initial design intension. This can be an obtrusive factor in the learning context where students need a concentration.

5. DISCUSSION

In this chapter, we propose the following discussion points achieved from user evaluation findings, and address limitations. Finally, application proposals will be described at the end of the chapter.

5.1. Discussion Points

5.1.1. ASMR vs. Obtrusive noise

Through retrospective interview sessions, we asked participants about their experience of using the flipping top interface informing peers learning activity. We observed conflicting opinions among participants. 58% of participants mentioned that they did not mind or were not motivated towards movements and sounds provided by the card before starting the study (P1, P4, P6, P7, P8, P12, P14, P16, P17, P19, P20). However, some participants (P4, P5, P9, P10, P15, P17) mentioned that the sound and the motion are obtrusive and/or unnecessary information while they are studying already. In contrast, others (P1, P6, P13, P14, P20) described the flipping sound positively such as white noise, rhythmical sound and paper book flipping sound while they were studying. According to this, we understood individuals consider the flipping sound and motion as white noise or obtrusive element depending on learning styles and personality (Adrian Furnham & Lisa Strbac, 2010), we propose two different scenarios that users may be less disrupted by the product while they are studying.

5.1.1.1. Scenario 1: Watching condition and status of product are connected.

- User1 begins the video → if User2 is not studying yet → product of User 2 flips
- User1 begins the video → if User2 is studying → product of User 2 doesn't flip
- The above algorithm also holds true for the opposite case.

5.1.1.2. Scenario 2: Sleep button

- Sleep mode ON → the product does not react
- Sleep mode OFF → the product reacts related with peers' learning activity

5.1.2. Playful-Haptic Interpersonal Communication

The initial concept of designing a handle was nudging through abstract information to study video content together online. With this, some participants used the product concept according to the design

intent (P2, P5, P13, P14). However, others unconsciously turned the FlipMe into a fidgeting device to help think while studying (P4 P12 P13 P14 P15 P18 P19 P20). On the other hand, some said that they just wanted to play with a friend at break time (P12 P13 P18 P16 P20).

To overcome the above design limitation further iterations of the FlipMe concept will look to embed playful experiences with peers, and suggest that the opponent who receives the signal can selectively communicate through sleep mode ON and OFF. Because fun is a relative term: What is fun in one context may not be fun in another (BJ Fogg, 1998). With the addition of the Sleep mode, various product statuses can be provided by changing the lighting of the front panel (Figure 21, on, off, Sleep mode, Error occurs and system loading).

5.1.3. Table-top Companion Attachment

As a table top product, one of the most important elements in design and fabrication is aesthetic (Donald A. Norman, 2004). Furthermore, we believe it is important for the product to provide emotional affection as an intermediary between users and friends. One subject also had attachment as a companion of the product itself (P1) and said visualize 'study' was a pressure to study but it was an appealing through delightful looking of design (P8). As an emotional factor related to the interaction, some said that the motion of flipping top reminds the motion and the sound of when they read a book and it stimulates emotion (P6, 13, 14, 20). Through the follow-up study, it is feasible to find suitable size or to find and provide a favorable interface through quantitative investigation.

5.1.4. Predictable Information

Some have said that the information on the front-side collaborative metaphoric indicators is ambiguous. (P3, 16, 20) In order to solve this problem, we intend to provide the following information by applying indications such as scales, which is a familiar gaging concept (Figure 22).

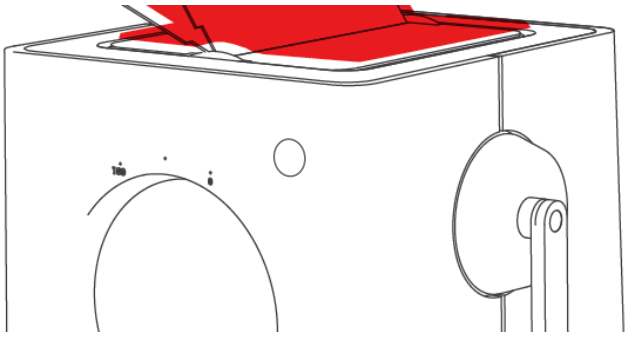


Figure 22. Predictable indicator design: The dot in the middle represent 'Ready' status, and the ball starts from '0' once the new deadline starts, then the ball turns clockwise and reaches to the '100' as all peers complete the goal. The eye-like light demonstrates device's condition: On, off and sleep mode

5.2. Limitations

5.2.1. Study Environment

An in-lab study designed as an efficient and probable study was an opportunity to learn various aspects from users that we could not consider during the prototyping process. However, it has been challenging to understand how the product actually affects the long-term user experience of online learning context through the artificially set spaces for a limited time. As an example, some responded in the entry interview that they would postpone viewing video contents with deadlines as much as possible. However, at the observation session for one hour, the participant played the video as soon as free time was given. In addition, while we discovered the relationship between the usage of handle design and participant's communication type, the sample was too small for further stats on subgroups. For the reason, we suggest an interpretative/speculative analysis through the relationship between learning styles and the frequency of interactive activities.

5.2.2. Measuring Online Discussion

Online discussion is the most important index to increase the learning outcome (Carmel Kent, 2016). In this experiment, we tried to check the quantity of the online discussion as the number of text messages exchanged in relation to the frequency of use of the handles. However, it was difficult to measure whether online discussion was active simply by the number of messages. For example, the number of daily messages differs greatly depending on the degree of familiarity. In a follow-up study, we will be able to learn how to measure the quality and quantity of online discussion related with group interaction through channels and the accurate measurement process (Douglas Nisbet, 2004) and find out the relationship with the product.

5.2.3. Improvement of Mechanical Structure for System Stabilization

FlipMe is a product with a several motions. The card runs and the user turns the product by hand. We have seen several errors while testing a product or even doing a user study, but what we have found so far was that there was interference between internal electronic parts, such as the MCU, while the card is spinning or the user lifts the product or rotates handle too fast. Fortunately, we could improve the instability of the product during the in-lab study relatively quickly. However, I am concerned that this error or the interference of the observer may have ruined users' realistic experience. Especially, it is very difficult to respond momentarily during the field study. Therefore, it is necessary to design a safe peripheral for subsequent studies for a field test.

5.3. Application Proposals

The advantage of online experience is that people can study anytime, anywhere. In addition, , some researchers addressed that the existing online education platforms are not particularly designed for peer learning activities. For both issues above, I proposed key screens of novel mobile application design that peers will be able to influence each other socially.

At the beginning of the mobile app user experience, users will achieve own learning style characters (Figure 23), through answering dedicated learning style questionnaires. Then members of the team will be grouped by team-balancing algorithm. For example, people choose same subjects and/or in different learning styles which is beneficial for peer learning activities (Brian Neese, 2016).

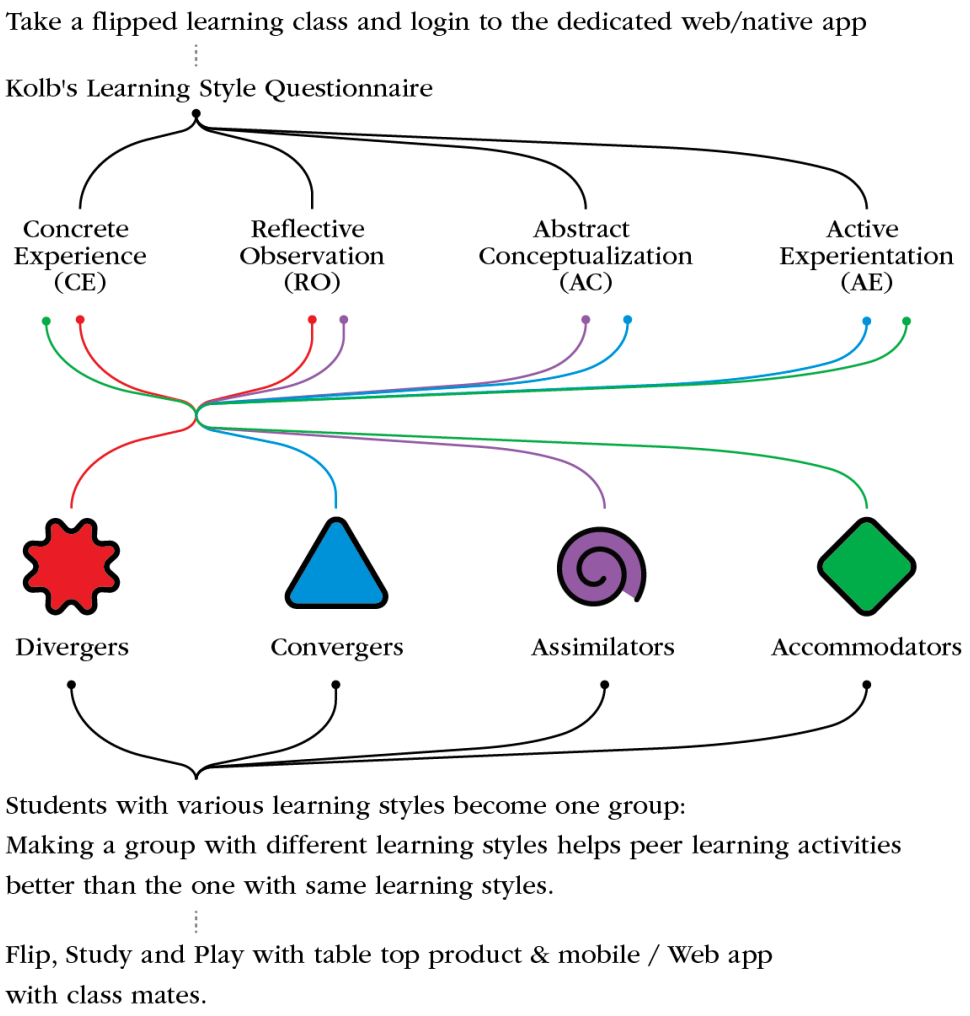


Figure 23. Profiling process to have own characters based on Kolb's learning styles

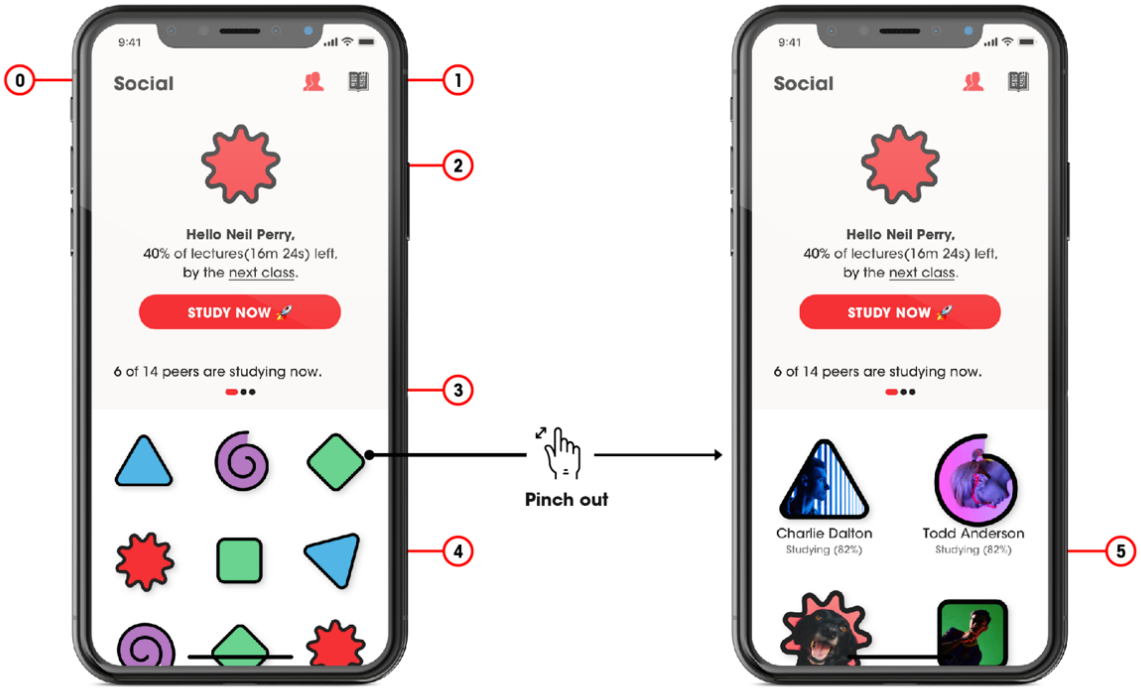


Figure 24. Key screen design and workflow on Homepage

The FlipMe app's main page (Figure 24) provides information of peers' learning activity unlike existing online learning providers. 0) Screen title, 1) Social / Lectures buttons, 2) Personal profile: My name, Video contents to watch, Deadline and Video play Call to Action button, 3) Breadcrumbs: Peers (My team) - All users – Rankings, 4). Other users are indicated as their own learning style symbols. Students' symbols that currently watching educational video contents spins as similar interaction with product design which flips(spins) cards when it recognizes my friend is studying, 5) When the user zooms in the symbols of friends, more specific information of peers are shown.

Figure 25. Key screen design and workflow on video play screen

Lastly, students can communicate on the specific time of the video (Figure 25), also can add a discussion point on any area. 0) Symbols on the screen is the location of peers' discussion, 1) Peer list: User can check online/offline friends on this video contents, 2) The graph indicates the number of peers' activities such as discussion on the specific part of the video.

6. CONCLUSION

6.1. Summary and Contribution

FlipMe, a tabletop companion providing an opportunity to observe peer's learning activity and communicate with playful interaction. A user-study showed FlipMe's potential to encourage each paired student to more actively engage in peer learning activities during online learning, and specifically when viewing video content. The result of an in-lab study conducted with 22 participants (two participants paired in one group) indicated that FlipMe increased users' deposition to engage one another while watching video content related to course material. This was achieved through FlipMe's unique, physicalized peer learning activity interaction (rotating a kinetic handle) and feedback (flipping top). Moreover, we discovered that participants were more likely to engage in the leaning activity to reach a learning goal if they had a common task to complete with a paired peer. With these results in hand, we suggest that the tangible interface through physicalizing peer's learning activity and providing tactile interpersonal communication, was able to promote more active peer learning through social interaction. In addition, we discovered a correlation between rotating frequencies of FlipMe's kinetic handle and frequency of online messaging between peers. We interpret this result as evidence of integration of peer-to-peer communication through FlipMe's communication approach. Participants integrated handle rotation in their learning / communication styles. We believe this indicates the participants felt more engaged through FlipMe's opportunity for a more tactile and auditory rich interaction in addition to their usual text message base communications.

6.2. Further Study

Although we proved the effect of tangible interface for peer learning activity in online learning context, the sample used in our validation study with the FlipMe prototypes was relatively small. Likewise, the empirical study was conducted within a deconextualized experiment environment. Future studies may wish to take other approaches. For example, long-term deployment may reveal different use habits. Also, although FlipMe provided opportunities for novel interactions, other studies may wish to explore how different types of physical interaction (i.e. press, push, pull) may implicate peer-to-peer communication within the online learning space. Finally, FlipMe's physical flipping feedback approach indicated enhanced engagement in video content. Other studies may wish to explore how richer, physical interactions may promote enhanced communication when engaging other online learning content (i.e. images, text, quizs, tests ect).

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FlipMe: Exploring Rich Peer-to-Peer Communication in On-Line-Learning