Figure 1: FlipMe physicalizes remotely located learning activity. As educational video content is played, FlipMe indicates peer activity through flipping top feedback.

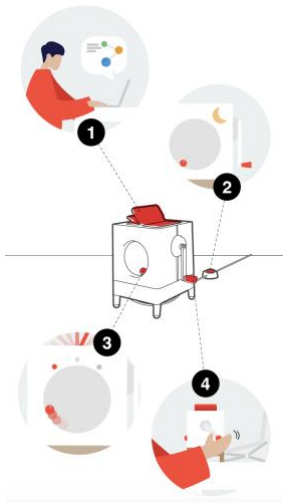

Figure 1: FlipMe Features 1) Physicalizing peer's learning activity: 'book page flipping' metaphor, 2) Sleep mode for concentration, 3) Connected common goal indicator 4) Tactile interpersonal communication through rotating handle.

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

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Abstract
Online learning continues to see rapid growth with millions of students now engaging online and remote courses seen as convenient alternatives to conventional classroom-based teaching. Despite these advantages, online courses suffer from high drop-out rates. Prior research has suggested limited opportunities for social interaction between students may contribute to these undesirable outcomes. In order to address this challenge, we developed FlipMe, an Internet of Things companion augmenting peer-to-peer interaction in real time. We report a pilot user study to explore the potential of FlipMe as a design intervention to increase peer-to-peer learning while viewing online video content. Initial findings indicate that FlipMe's tangible interface and feedback design features have the potential to promote peer interaction in online learning.

Author Keywords
Online Learning; Interpersonal Communication; Tangible Interface; Peer Learning

CSS Concepts
• Human-centered computing~Human computer interaction (HCI) • Human-centered computing~Interaction devices

Figure 3: High-fidelity, FlipMe functional product prototypes connected to internet server.

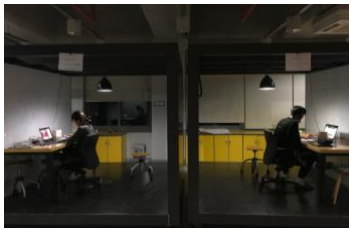

Figure 4: User study set-up. Participants communicate only through paired FlipMe products and social media.

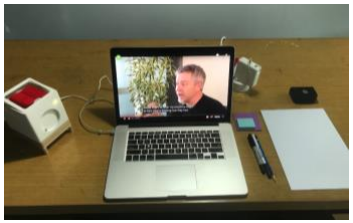

Figure 5: Participants free to utilize FlipMe, a laptop PC, A4 writing paper, pen set and post-its. Cameras installed in the ceiling to record activity.

Introduction

Millions of people around the world now use online learning as a convenient and inexpensive alternative to classroom-based education [1]. However, online learning and its associated platforms for communication face many critical challenges. Dropout rates are high. The traditional culture of peer-to-peer learning through mutual support is also often absent due to the impersonal nature of virtual classes [2]. In contrast, peer learning activities, defined as activity that involves multiple students learning from and with each other [3], have the potential to improve student engagement and the quality of learning experiences [4]. Previous studies reveal that social factors can influence students' expectations of peer learning [5]. For example, social interaction, and the resulting collaboration between peers, was identified as fundamental to improving the quality of online learning experiences [6]. However, other studies argue that social activities, such as forum discussion, are ineffective in stimulating communication [7]. In order to enhance online communication and discussion within an online learning context, HCI scholars have suggested digitally-oriented solutions as a means to support more active participation [8][9].

In classroom contexts, students can communicate and interact face-to-face, with tangibility playing an essential role in individuals recognizing and affecting their environment [10]. In contrast, traditional screen-based interfaces, associated with online learning, are limited to conventional digital interactions [11]. Tangibility has the potential to convey information to and between people in memorable and intuitive ways through physicalized data [12]. The current project aims to improve online learning experiences through a tangible interface: to provide opportunities for enhanced communication by physicalizing peer's learning activity in order to solicit the necessary social interaction to drive more engaging learning experiences. In addition to tangibility, we applied metaphor [13] to provide an understanding of unfamiliar interactions through metaphoric relation to known contexts and iconic learning artifacts (i.e., flipping book pages, sharpening a pencil).

Related Work

The current project aims to support improved communication while engaging with online video content. For this, computer-supported physical data representation (*Data Physicalization*, *Tactile Communication)* were adopted as an approach to improve peer-to-peer communication [14]. *Tactile Communication* embodies emotional and functional qualities that screen-based interaction such as text and images cannot provide. For example, it has been shown to be beneficial for expressing sympathy and persuasion [15]. In addition, tangible interpersonal communication can convey fun experiences, as revealed by Fogg et al.'s early study [16]. Likewise, *Data Physicalization* leverages perceptual exploration to facilitate understanding, bringing data into the real world, thereby fostering engagement [17]. Previous studies have employed tangible tabletop interfaces to physicalize abstract information about participants' behavior through kinetic motion [18] or shape [19]. Other studies [20][21] have indicated how *Data Physicalization* may help the perception of information through implicit, expressive signifiers.

FlipMe

FlipMe is an IoT (Internet of Things) companion that aims to augment peer-to-peer interaction for active

online-learning (Figure 1-3). We designed FlipMe through a metaphoric approach to express learning activities familiar to student users (i.e., flipping-book feedback). A flipping top provides real-time feedback through a 'reading-a-book-like' motion, triggered by a paired student's viewing of video content. Group study activities are further expressed through a 'rolling-ball' feedback. A rotatable handle provides a nudging function for peer-to-peer interaction (Figure 2). Product hardware was developed using CAD (computer-aided design) modeling software. Based on material and shape complexity, 3D printing, laser cutting, and CNC (Computer Numerical Control) machining were used in the manufacture of working prototypes. For real-time parallel control, Mbed was used as an operating system for step motor rotation measurement, servo motor angle control, and internet communication. The handle's rotating pattern is divided into 10 levels and recorded via user input, with data reported to the Internet. The 'rotation angle' per 1 second to 'rotation index' is: *0 ~ 17 degrees= 1, 342 ~ 359 degrees= 10*. A server runs through the express framework of NodeJs and hosts two websites to connect to a pair of FlipMe devices, communicating with two devices before providing appropriate commands.

Methodology

An in-lab study to evaluate FlipMe's potential to stimulate peer-to-peer communication when engaging with online video content was conducted. 20 university students (22-32 years, 8 female 14 male), were recruited. Participants were grouped in pairs with the same (4 pairs) and different (6 pairs) learning styles [22]. Pairing in terms of learning styles was adopted to explore the influence of learning style upon video watching behavior [2]. Two FlipMe working prototypes (Figure 3) were connected through an internet server within a lab environment (Figure 4), with participants situated at remotely located spaces (Figure 4, 5). Introduction and overview (10 minutes), learning session (60 minutes), discussion session between participants (15 minutes) and a retrospective interview (10 minutes) were recorded. In the learning session, participants were provided with a 24-minute video from Udacity's Intro to the Design of Everyday Things [23]. The video length matches that used in related prior work [24]. Data consisted of quantitative data logged on the internet server and transcribed interview responses. Data was composed of four major components: video viewing pattern, Handle spin frequency, message frequency, and participant learning style category. Qualitative interview responses were analyzed through an affinity-diagramming method. The pilot study, while limited in scope, was designed to initially evaluate the concept's potential to motivate students in online learning.

Findings

An analysis of interview responses indicated how the use of FlipMe's spinning handle nudge feature, and associated flipping-book feedback stimulated engagement in video content. For example, P14 stated *"At the beginning of the experiment, I was watching YouTube. However, I felt that I also need to study once I realize my friend was studying."* The use of social media (messaging) was also found in communication between paired peers. P13 responded, *"I spun the handle first, then my friend sent a message to ask the reason for spinning. We started to chat about the product first and then about the video."* These results illustrate the ways in which FlipMe worked as stimulation to engage with video content. Responses

Participant number	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

Table 1: The table shows frequency of spinning a handle and online messages by each participant. From P1, the experiment was conducted by pairing two people in order.

provide evidence to suggest the physical handle interaction and flipping-book feedback stimulated interaction between peers. Subjects also indicated positive responses to the FlipMe product, *"I do like the chewy sound as cards were flipping, it was white noise for me."* Peer feedback on the benefit of FlipMe also resulted in increased efforts to interact through the product, *"When my friend replied that my handle action worked on him, I continuously rotate it to see my friend's reaction."* On the other hand, six out of 20 participants remarked on the device's distracting sound. Thus, the initial study indicated differences in how intrusive the concept was seen to be.

In addition, a statistically significant correlation between the frequency of handle turns, and the number of messages exchanged was identified (*Pearson's r = 0.81*, Table 1). This result indicates that participants who messaged frequently were also turning FlipMe's handle at an increased rate while those who messaged sporadically showed lower frequency rates of handle turning. Relatedly, seven participants (P5, P12, P13, P14, P16, P17, P18) directly citing the rotating handle as a means to communicate. For example, *P5* mentioned, *"I wanted to draw the attention of my friend. There was something I wanted to say in the chat"*.

Discussion and Future Work

An initial user-study has indicated FlipMe's potential to encourage more active engagement in peer learning activities during online learning when viewing video content. A significant relation between handle spin frequencies and messaging was identified. Based on these outcomes, we speculate that *Physicalization* and *Tactile Communication* have the potential to provide enhanced communication in online-learning, but that benefit depends upon the particular learning approaches of individual users. More work is required to flesh out these findings. For example, as online learning often happens at different times, an in-the-wild implementation of the concept will likely need to be supported by further tools or coordination systems that enable remote students to partner and study simultaneously. Future work should also examine how learning styles [25] impact the usefulness of our approach. In addition, although FlipMe provided opportunities for novel interactions, other studies should explore how different types of physical interaction (i.e., press, push, pull) may implicate peer-to-peer communication in online learning. Finally, FlipMe's physical flipping-book feedback approach indicated enhanced engagement in video content. Other studies could explore how richer, physical interactions can promote enhanced communication when engaging other online learning content (i.e., images, texts, quizzes, tests, etc.).

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Video link

https://youtu.be/D_eXj0AkfuY

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