Fostering Kinesthetic Literacy through Exertion in Whole Body Interaction

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CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-930-5/10/04.

Abstract
A sedentary lifestyle contributes to many of today's physical health problems such as obesity. We suggest that fostering **kinesthetic literacy** addresses this problem through learning: learning to move and moving to learn. In this paper, we present *Pushing Pixels*, an augmented bodybuilding system for exploring the role of exertion in supporting the development of kinesthetic literacy through reciprocal guidance and motivation, or communal engagement. Our system examines synchronicity in asynchronous participation of a tangible exertion interface where participants can perform at different locations, even at different times. We aim to contribute to the understanding of whole body interaction by exploring the potential of exertion interfaces to support positive effects on physical and emotional wellbeing.

Keywords
Kinesthetic literacy, exertion, whole body interaction, communal engagement, movement, body, tangible, synchronicity, asynchronous, exertion interface, exergame, performative interaction

ACM Classification Keywords
H.5.2. User Interfaces, K.3 Computers in Education

General Terms
Learning, health, bodybuilding, gym, pervasive gaming

Figure 1. Pulley machine.

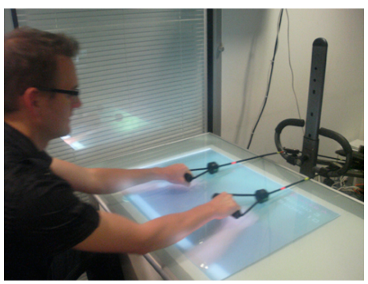

Figure 2. Pushing Pixels.

Introduction
Exercise is known to have positive effects on physical and emotional wellbeing. However, recent research shows that there has been a rise in sedentary lifestyle-related illnesses and in particular, obesity is on the rise in both children and adults [2]. We believe *exertion interfaces* offer an opportunity to reverse this trend. By *exertion* we mean interactions with technologies that require intense physical effort from participants [6,7]. Exertion interfaces offer an opportunity to explore how novel technologies can promote positive effects on personal health, moral character and the human spirit. However, a lack of understanding of this relationship exists. We are interested in understanding the role of design in facilitating this relationship and in particular, in learning contexts. Our goal is to contribute to the understanding of whole body interaction [5] by exploring the potential of technology to support *kinesthetic literacy* via an exertion interface called *Pushing Pixels.* Our interface aims to promote physical and emotional wellbeing through asynchronous "communal engagement" [10].

Kinesthetic Literacy
We see kinesthetic literacy as having two major learning objectives: *learning to move*, and *moving to learn* [1]. *Learning to move* asks participants to focus on an understanding of the body in order to acquire the skills and techniques that are required to participate in physical activities. Doing so allows participants to take control of their body and to know its range and capacity for movement. Learning in this context often focuses on "fine-tuning" motor control [9,10] and fundamental aspects of movement such as hand-eye coordination, coping with space, speed and distance. In *moving to learn,* the physical activity is the context for a means of learning. For example, in previous work [9,10], we explored how a tangible, exertion interface can be used to learn about basic science concepts such as the concept of acceleration. Doing so can reveal information about social skills, competition and cooperation, and knowing when and why different movement actions are appropriate and effective as well as contribute to an understanding how aspects such as "witting" transitions in performative behavior [2,10,11] (i.e. transitioning from observer to participant to performer) can be applied in learning contexts.

Pushing Pixels
Prior studies suggest that when using exertion interfaces, *synchronicity* is a key element in informal and experiential learning contexts [9] and is particularly relevant when multiple players are engaged in the activity. Inspired by this notion of synchronicity, we have explored its use in operating a system in unison to foster the development of kinesthetic literacy. We extended this notion of synchronicity with the concept of communal engagement – where multiple participants can create something together (rather than compete against each other) by building on the previous person's exertion activity. We believe this 'building upon' provides a temporary support mechanism (scaffolding [4]), for fostering kinesthetic literacy through reciprocal guidance and motivational encouragement.

For our study, we modified a piece of exercise equipment that usually functions as a "pulley" for upper-body exercises (Figure 1 & 2). Motion data was

Figure 3. Visual feedback is overlaid over video on the interactive surface. Boxes indicate correct repetition out of synch (hollow) or correct repetition in sync (solid) with previous player.

captured in real time via wireless sensing and sent to a PC which then converted the motion into real-time audio and visual feedback [10] using Processing (processing.org).

Participant interaction with *Pushing Pixels* is as follows: Player A sits in front of the machine, and pulls the weights with both arms from almost extended arm-length to the chest and back. Player A's movements are tracked and recorded from above using a webcamera pointing downwards. Player A's movements are then played back to the next participant on an interactive surface [8], and it is Player B's task to synchronize with Player A's movement and form. On Player A's second turn, s/he must synchronize to Player B's movements – the activity repeats for three rounds.

With our system, proper form is defined as smoothness of movement as well as where movement starts and ends. As such, Player A's movements set the benchmark for Player B and Player B's movements set the benchmark for Player A. It is important to note that Participant B does not have to be physically present nor available at the same time as Player A. Movement is played back on the interactive surface only when a participant chooses to engage in the activity.

The goal of the system is to accumulate a collective score through a 'grinding' process – where participants engage in repetitive movements in order to improve their score (Figure 3). To do so, participants must 1) correctly complete as many (or more) full repetitions as the previous player using proper form, and 2) maintain synchronicity with the each other across turns. Since our system requires intense exertion, after a few repetitions the typical participant usually experiences difficulty in keeping proper form, hence the challenge lies in the combination of the number of repetitions and in maintaining good form.

The system provides both audio and visual feedback about synchronization and form of: individual exertion, another participant's exertion, synchronicity between movements and, collective exertion. A box appears every time a participant completes one full repetition (Figure 3). The box will appear solid if participants are in synch and an audio clip plays "You got it!" The box appears hollow if they are not in synch and no audio clip plays. Spacing between the boxes indicates the participants' rhythm and timing; consistent rhythm will produce boxes that are evenly spaced whereas inconsistent rhythm will produce boxes that are unevenly spaced. Players can collect a maximum of 20 boxes in one turn. The score is incremented one point every time players are in synch. The score is collectively incremented so that it accumulates over all three rounds.

Informal testing

A medical doctor was consulted prior to the study to assess the possible **physical risks** involved with conducting the testing, particularly in relation to the type of motion that participants would be asked to do. In addition, our study was submitted and approved by an ethics committee prior to physical testing. Before beginning the activity, participants were given an overview of the study which included the risks involved with physically demanding participation, asked if they had any injury or medical condition which would prevent them from this kind of exercise, and then asked to sign a consent form. Participants were given a guided walk-through; one of the investigators began with a brief explanation of how the system worked as well as a short demonstration of the system in action. Participants were then offered the opportunity to ask questions.

Discussion

In terms of **personal health**, the use of digital recording to measure and review performance allowed participants to become aware of their own and other's performance which caused them to laugh out loud, indicating feelings of enjoyment. A focus on rhythm led participants to engage in "performative interaction"[10]. Participants demonstrated good **moral character**, often verbally encouraging each other, indicating that participants developed respect for others and responded sensitively to the physical movement contribution of others. Communal engagement and video replay allowed participants to explore the aesthetic quality of movement, to persevere despite increasing fatigue or physical discomfort, and to reflect on the **human spirit**, before, during and after interaction. However, designers must strike a careful balance between physical risk and pleasure. For example, tiredness affects participants' **loci of attention** so appropriate feedback (e.g. audio vs visual) should be applied. Since the body is used as an input device, **orientation** and **positioning** as well as **manner** of movement must be correctly and safely applied so that the participant can develop an appropriate **frame of reference** to reduce any physical risk.

Summary

In *Pushing Pixels*, kinesthetic literacy occurs as players are guided and build upon each other's movements while exploring their own bodily capabilities. Initial results indicate that kinesthetic literacy in exertion interfaces has both practical and social implications. Future applications could include: as a demonstration of how to use exercise equipment more efficiently; connecting distance participants so that exercise buddies who live apart can maintain the social motivation that comes from exercising together; or in educational settings to encourage communal engagement in learning contexts. We intend to explore these and other aspects in future applications.

Acknowledgements

Funding for this study was provided by the EPSRC UbiComp Grand Challenge Initiative Early Career Exchange (Grant number EP/F013442/1) and the EPSRC Designing Tangibles for Learning (grant number EP/F018436). Many thanks BigDog Interactive for equipment support; to Diane Carr (LKL) for discussions on games research; Nick Bryan-Kinns for technical assistance with audio; and, to those who participated in the study.

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