Augmented Reality as Wearable Technology in Visualizing Human Anatomy

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**INTRODUCTION**

This paper presents an investigation that aims to enhance understanding of augmented reality (AR) as an interactive affordance in the meaning-making of the lungs and respiration system in anatomy and physiology in a nursing education setting through the application Anatomy Alive.

The technology and the visual image of the lungs in human anatomy gives the students access to wear ‘real’ pictures of lungs ‘in situ’. The design focus of the visual image has the purpose of stimulating sight, and the development of the technology of the app is based on a principle of design related to photographic resemblance of the lungs so it can be used as wearable technology (Buhl & Rahn, 2015).

The aim of the investigation is to explore how AR as a wearable technology and as a connection between technology, body, and picture in a pedagogical setting, based on Inquiry-Based-Science-Education (IBSE) and a theory-generating practice, can facilitate learning about the complex anatomy and physiology of the human body.
The research question is how AR can be involved in nursing education as a pedagogical affordance to facilitate learning of human lung anatomy and respiration. The hypothesis is that the IBSE-approach together with AR-pictures projected directly on the body—as a wearable—can facilitate visual learning as a way to knowledge acquisition.

**RESEARCH METHOD**

The project was designed according to a design-based research (DBR) method (The Design-based Research Collective, 2003; Amiel & Reeves, 2008). DBR searches to design a change and at the same time test what happens in three different iterations when the change is being implemented for the purpose of generating new knowledge and an improved practice (Buhl & Rahn, 2015).

The hypothesis is that this approach, together with AR projected directly onto the body, can facilitate visual learning as a way to knowledge acquisition. Through guided-inquiry, the lecturer submits a problem to be solved, and the students themselves control how the problem is to be solved and investigated (Frisdahl, 2014).

Methodologically, it is based on theory-generating practice, which is constructed on the idea that in the act of processing information knowledge is generated about a content, which through reflection is being externalized and conceptualized (Buhl, 2013b; Buhl & Ejsing-Duun, 2015).

Theory-generating practice describes using video as a mean to academic improvement. The theoretical framework is based on the idea that learning results from situations where practical experience is transformed into theoretical knowledge. These
situations are called theory-generating practices, and they contain a methodology that connects bodily presence and analytic distance to empirical data (Buhl, 2013a).

Learning, teaching, and facilitating can be seen as social and perceptual practices, where all the participants—students, lecturer, and technology—in the given context are actors in a process in which there is generated knowledge.

In this study, theory-generating practice is used both to investigate students’ use of AR and as an approach to investigate a lecturer’s methodology used in the analysis of the practice where AR is used.

The bodily experience of being present in the learning situation is important; the students include their own bodies in the learning process by ‘wearing’ the lungs ‘in situ’. The bodily experience and the inter-relational exchange in the learning situation affects the meaning-making of a situation.

The methodological approach of theory-generating practice that the lecturer uses, shows how it can be worked with video recordings of an instructor teaching a lesson and the investigator taking part in the lesson, and how both are using the video recordings as analytic material.

The goal is to generate data that can be used in the development of education and research. One gets a double role as lecturer and investigator, which means that one, as a lecturer, internalizes how the pedagogical IBSE approach to education takes place, and one internalizes as the investigator knowledge about it, when investigating with a video recorder and analysing of the recordings. It can be difficult to have an analytical distance from my one’s teaching, and the distance shall make one capable of adding a theory-based perspective on one’s teaching profession and creates possibilities for improvement.

**EMPIRICAL FRAMEWORK**

The application Anatomy Alive was iterated three times in anatomy and physiology lessons (60 minutes) in three different classes. The lecturer is a facilitator through the lesson and the investigator of the empirical data (Buhl, 2013a). The data is empirically based on three iterations according to DBR, including 25, 30, and 25 nursing students in an anatomy and physiology lesson, where the class was divided into six groups and the students were given a problem to be solved together in the group (Buhl & Rahn, 2015).
The empirical data consists of video recordings of the lessons and the students’ written assignments and their evaluations of the lessons. The analysis of data was done according to Bezemer’s and Jewitt’s multimodal approach (2010) for the purpose of identifying the relation between technology, body, and picture in the specific use of the app in a situation of learning.

The analysis of the data illustrates what students do in describing what they visualize from the application, how they interact in the room, and how they are in search of knowledge from the app.

RESULTS
The aim of this paper was to explore how AR as a wearable technology and as a connection between technology, body, and picture in a pedagogical setting based on IBSE and a theory-generating practice could facilitate learning about lung anatomy and respiration.

The results show that with the IBSE approach the students can take the time and the actions around the AR picture that are necessary to understand the lungs in the human body, as opposed to when the teacher is setting the pace for teaching the subject.

The students in the first and third iterations showed involvement and that they are explorative in the process and their observations. The students showed surprisingly elaborate responses in their written assignments. The video recordings show that in first and third iterations particularly actively groups of students in discussions, eager to share their observations with each other. The students showed openness about their knowledge and how their observations on the iPad are understood.

The progression of the process was stopped by the technology's lack of capacity; the capacity is to show the lungs from front and behind.

The results from the three iterations show how attempts at improvements of technical issues in the application leads to improved quality in the learning process. An improved illusion of the ability to see the lung was created, because in the first iteration the picture was shaking, and the students wondered about this.

Another technical change between the first and second iterations was on an institutional level about the app and increased focus on availability, spread, and making the app user-friendly (Kjærgaard, Kjeldsen, & Rahn, 2015). This resulted in fact that the image was been projected onto paper, which was applied to the use of the app in the second iteration. In contrast to the T-shirt, the paper evoked something else, and the interaction
between technology, picture, and body was in many ways lost in the second iteration, and the students changed their behaviours. The students did not move around the body the same way they did in first and third iterations. Some groups took the image of the body and put it on the wall to better see the picture, as a picture in a textbook. The paper created a book-reference rather than a body-reference, and the students established the situation and communication with the cultural references—in this case a book—that they are used to using.

The fact that there was movement created when the picture was projected on a physical body seems to establish a linkage that creates special advantageous conditions to visual learning. What is unique is that the lungs are shown with the movement of a ‘body in situ’, and there is no need to transform knowledge from a 2D-model from the textbook to the physical body. It seems that the involvement of the physical body makes the cognitive translation easier between codes and meaning.

The analysis of the video recordings in all three iterations has revealed some ethical perspectives relating to obese students’ body appearance when wearing the T-shirt with the image versus the image printed on paper, because the T-shirt must be very narrow or else the AR picture does not appear.

These empirical findings were becoming apparent after three iterations, when the obese students were being modest and would not wear the T-shirt and have the same participation in the group as the other students with normal body appearance. This will have an impact on the way technology wearables are designed in the future and needs to be considered so as not to exclude certain users.

The problem could be solved with an AR technology that is real-time sensor-based and not dependant on a T-shirt, but rather on small tags that are placed on the body. The ethical considerations of bodily inclusion and obstacles would be interesting to investigate in further studies.

The three iterations indicate that there is visual-learning potential in the use of AR as a wearable technology when it is connected with an IBSE approach where the students are supported in an explorative and problem-solving practice of learning.

Results from the first iteration are further described in Rahn and Kjærgaard (2014), and results from first and second iterations are described in Buhl and Rahn (2015).
REFERENCES


