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The Effectiveness of Mime-Based Creative Drama Education for Exploring Gesture-Based User Interfaces

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ABSTRACT

User interfaces that utilise human gestures as input are becoming increasingly prevalent in diverse computing applications. However, few designers possess the deep insight, awareness and experience regarding the nature and usage of gestures in user interfaces to the extent that they are able to exploit the technological affordances and innovate over them. We argue that design students, who will be expected to envision and create such interactions in the future, are constrained as such by their habits that pertain to conventional user interfaces. Design students should gain an understanding of the nature of human gestures and how to use them to add value to UI designs. To this end, we formulated an 'awareness course' for design students based on concepts derived from mime art and creative drama. We developed the course iteratively through the involvement of three groups of students. The final version of the course was evaluated by incorporating the perspectives of design educators, an industry expert and the students. We present the details of the course, describe the development process, and discuss the insights revealed by the evaluations.

KEYWORDS

design education, user interface design, gestural interaction, creative drama, mime art

Introduction

The term 'gesture' denotes a movement or position of a human body part that conveys meaningful information (Kurtenbach & Hulteen 1990). Recently, through developments in sensor and computer vision technologies, user interfaces (UIs) have appeared that can accept gestures as input for computing applications. Current gesture-based UIs can detect and recognise gestures performed in mid-air, without requiring users to touch and manipulate an input device such as a keyboard (Zhang & Li 2014), a touch-sensitive surface, or a deformable structure (Warren *et al.* 2013). Throughout this article we will use the term 'gesture' to denote such mid-air movements and poses that can be recognised via computer vision. Gestures can be desirable as an input modality for various applications. Gaming is one of these applications in which using movements with 'prior mappings' to the real world contributes to immersion (Cairns *et al.* 2014). Another application is public interactive systems, as UIs that do not require physical contact are more economical to deploy and maintain, and more hygienic for users. Cooking, gardening, mechanical repairs and surgery (Wen *et al.* 2013) are other domains where contactless UIs can be preferable due to hygiene. Convenient control of smart homes (Tang & Igarashi 2013), interactive art and music, interfaces for manipulating 3D images (Gallo 2013) and spatial medicine (Simmons *et al.* 2013) are further examples of cases where gesture-based UIs can enable novel capabilities. As related technologies progress and mature, we may expect gestural UIs to become increasingly common and novel user experiences to surface.

While developments in gesture-based UIs continuously enable novel computing applications, the possibilities and limitations of gesture-based UIs and what constitutes effective gestural interaction are still topics under study. Currently, compared to UIs that utilise pointing devices, tangible sensors and touch, examples for gesture-based UIs that have reached end-users are few. In parallel, few designers possess insight and experience regarding the nature and usage of gestures in UIs. The coming years will require a growing number of design professionals who can fuel the creative industries with an ability to develop novel products and foster innovation in electronic entertainment technologies (UNCTAD 2010). In line with this requirement, we consider how to educate today's design students who will be expected upon graduation to work in such contexts to be an important problem to investigate. Aspects of this problem include pedagogical approaches, practices and apparatuses for use in design education, preparatory activities and student engagement. Tackling such issues, we believe, requires a practical course that aims to accomplish the following:

- Students should gain an understanding of the nature of gestures and how to use them to add value to UI designs.
- Students should experience and discuss the novelties of using gestures in UIs instead of duplicating previously learned UI concepts such as clicking or tapping.

Briefly, we call this an 'awareness course'. Building on the considerations outlined above, we have constructed a theoretical foundation that investigates the following in order to reveal the nature of an awareness course for designers of gestural interfaces:

1. On which existing educational structures should the course be based?
2. How should the course incorporate existing research on the nature of gestures and gesture-sensing technologies?
3. Based on various models of learning, what are some considerations regarding students' eligibility and the execution of the planned course content?

We designed a 10-day course plan based on the theoretical findings and taught the course to three groups of at least 17 design students. We identified issues and revised the content after each iteration (see Figure 1). At the end of each group's session, students completed final projects, which were analysed by educators and industry professionals. We assigned similar final projects to a control group of students who were characteristically comparable and had received traditional design education, but had not participated in the awareness course we had developed. The projects were similarly evaluated and analysed, and we compared the results to those from the treatment groups. We observed students' progress in this manner, seeking meaningful insights.

Finally, we compared results from observations of the third treatment group and the control group. We discuss the success of the course that we propose based on this comparison and considering student output.

Background

Gesture-related issues for user interfaces

In human–computer interaction, gestures, like all input signals, are performed to obtain some desired result from a system. Current interactive technologies afford these results to be communicated in a variety of ways: in addition to conventional 2D visual outputs (Wexelblat 1995), 3D visual outputs, auditory outputs and system-commands can be produced as responses to gesture inputs. However, merely presenting examples of these experiences to students may not encourage creativity and the exploration of novel solutions. Instead, we provided an environment for students to experience and discover these structures themselves.

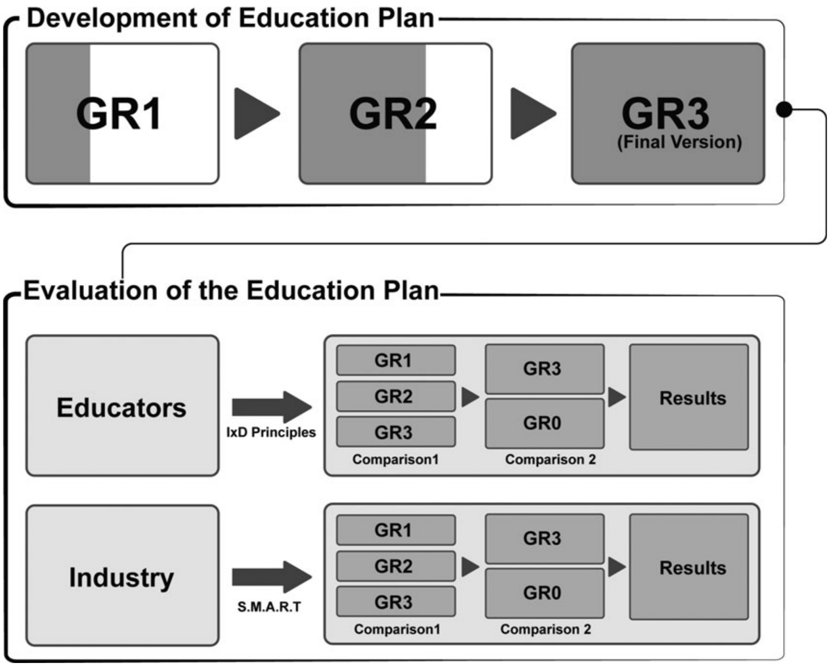

Figure 1. The awareness training programme has been revised through three iterations

When working with gestures, designers should consider attributes such as discoverability, trustworthiness, responsiveness, appropriateness, meaningfulness, smartness, playfulness, and pleasurability (Saffer 2008) to leverage the advantages of gestural interfaces. On the other hand, in current user interfaces, the issues that hinder the usage of gesture-based interfaces are speed, recognition and fatigue (Cabral *et al.* 2005). We prepared exercises that allow students to discover these issues through experience using gestural communication. Most of these issues pertain not to the technical aspects of a gestural interface, but to human factors. These are highlighted in the exercises we propose, where communication between individuals using gestures and the use of gestural interfaces in public or social settings are emphasised.

Furthermore, mapping is an important consideration when designing gestural interfaces (Hunt *et al.* 2003). Gestural mapping is the design of system responses according to gestural input. Taking mapping into account, although vision-based gesture sensing has a distinct nature from touch-based sensing and other technologies, gestures used for different types of UIs may share common attributes. Exercises within the awareness course that we designed aim to highlight both the differences and similarities between different gesture modalities and consider the adaptation of gestures across modalities.

Another important topic for gestural interfaces is issues related to the ergonomics of movement. Bearing this in mind, we designed the awareness course to largely eschew ideating designs on paper, preferring embodied ideation, thereby promoting an understanding of physical and cognitive ergonomics. Students can thereby experience operating gestural interactions in different physical environments and in different user scenarios, familiarising themselves with a variety of narratives and experiencing physical difficulties inherent in using gestural interfaces.

Mime-based creative drama education

An appropriate model on which to base an awareness course for gesture-based UI design comprises creative drama exercises due to the emphasis on bodily and gestural communication in creative drama. In parallel, we especially consider the art of mime – where concepts and/or emotions are expressed purely in body language, without requiring words – to be important in informing gestural interaction design.

Prevalent models where creative drama has been utilised in design education are role-playing (Johnstone 1999; Svanaes & Seland 2004), video sketching (Zimmerman 2005) and participatory drama techniques (Türkmayalı 2008). One field where gestural interfaces are prevalent is pervasive computing. Observations with design students working on pervasive computing projects within an educational context indicate the value of staying away from the computer while designing pervasive interactions (Zimmerman 2005).

In exercises with role-playing and participatory drama, participants who have not been directed by a moderator to employ mime-based techniques have been observed to rely on verbal expression when acting out roles (Gerber & von Wroblewsky 1985). The practices of professional designers who have received training in mime-based drama have not yet been investigated. How the study of non-verbal mime could impact the practice of gesture-based interaction design is a domain that warrants investigation.

Previous research has not directly investigated how mime art and drama can impact design education, with regard to embodied and gesture-based interactivity. However, works that pertain to drama exist within education research, in which aspects of mime art have received attention (Fitzgerald 2007; Kerekes & King 2010; Ozdemir & Cakmak 2008; Wee 2009).

In studies that pioneered the use of role-playing in education, drama is employed to steer students towards developing and reflecting on new ways of seeing and thinking that engender novel problem solving skills rather than enacting a given performance or scenario (Neelands 1992).

In sum, we believe that creative drama and mime art – as tools for expressing concepts or emotions through body movements without verbal communication – may be effective in informing the development of gesture-based UI design practices.

Method

Development of the course

Based on the theoretical underpinnings derived from studies on creative drama, mime art, gestural interaction and learning styles in design education, we developed an awareness course comprising various exercises. This programme was iteratively revised as we conducted exercises with three groups of students and recorded our observations. During the course, students first practised the exercises we designed, and then they completed final projects. Later, educators and an industry expert evaluated the final projects.

Participants

To observe the utility of the awareness course, the exercises were conducted with 52 students in groups of 17 (Group 1), 18 (Group 2) and 17 (Group 3) students respectively. The control group comprised 18 students. In total, 70 participants were involved, 36 of whom were female. The mean age among participants was 22.

Participants were selected from among design students who had completed at least two years of university-level design education, comprising at least two project courses and fundamental notions of design practice. Participants were recruited randomly from submissions to the online announcement.

Procedure

The exercises that make up the awareness course were first given to Group 1. We revised the course for Group 2 according to our observations and data collected from Group1 and applied the same iterative process for Group 3. In the end, observations collected during activities with the third treatment group were compared to observations from experiences with the control group (Group 0).

For the control group, we leveraged the 'design thinking' model pioneered by IDEO (Brown 2008) rather than the awareness course that we designed. This model is often utilised in generalised design education contexts. It is not tailored specifically for gestural UI design and does not include any exercises based on mime art. In order to obtain comparable results, the final projects given to the control and treatment group participants were identical in scope, subject matter and the expected format for the deliverables.

Evaluation

The awareness course we describe was evaluated by incorporating the perspectives of design educators and an industry expert. The perspective of educators and the industry expert was also leveraged to facilitate the iterative evolution of the programme: a criteria-based evaluation of student works was conducted to reveal the contributions of the course; the results from each iteration were compared statistically.

Different evaluation criteria were used by each party, since each field may value design and innovation differently. Educators used evaluation criteria based on the interaction design principles by Blair-Early & Zender (2008), while the industry experts applied the S.M.A.R.T criteria (Doran 1981) which is commonly used for assessing commercial projects. Per their backgrounds, educators could assess the quality of the projects by analysing creativity, usability, gesture ergonomics and visual quality, while the industry experts focused on feasibility and profitability.

The awareness course

The initial version of the awareness course – developed based on previous research – was revised iteratively as it was taught to three groups of students consecutively. The changes implemented in these iterations included improvements to exercises with additional props and items, revisions in terms of implementation, and reordering and replacement of certain exercises with new ones. All changes were made upon comments by students and according to our observations. Figure 2 depicts the iteration process, including additions and replacements.

The final design for the course comprises 8 tiers and 11 exercises in total. All exercises are recorded on video to improve students' understanding and create the possibility of them examining and criticising their own gestures. A full version of the described course plan can be viewed online at the following address: http://bit.ly/gesturetraining

Tier 1: Warm-up

Shadow charades. In this exercise, like a conventional game of charades, students act out a word or phrase through miming, while an audience of their peers tries to guess the word. However, unlike a conventional

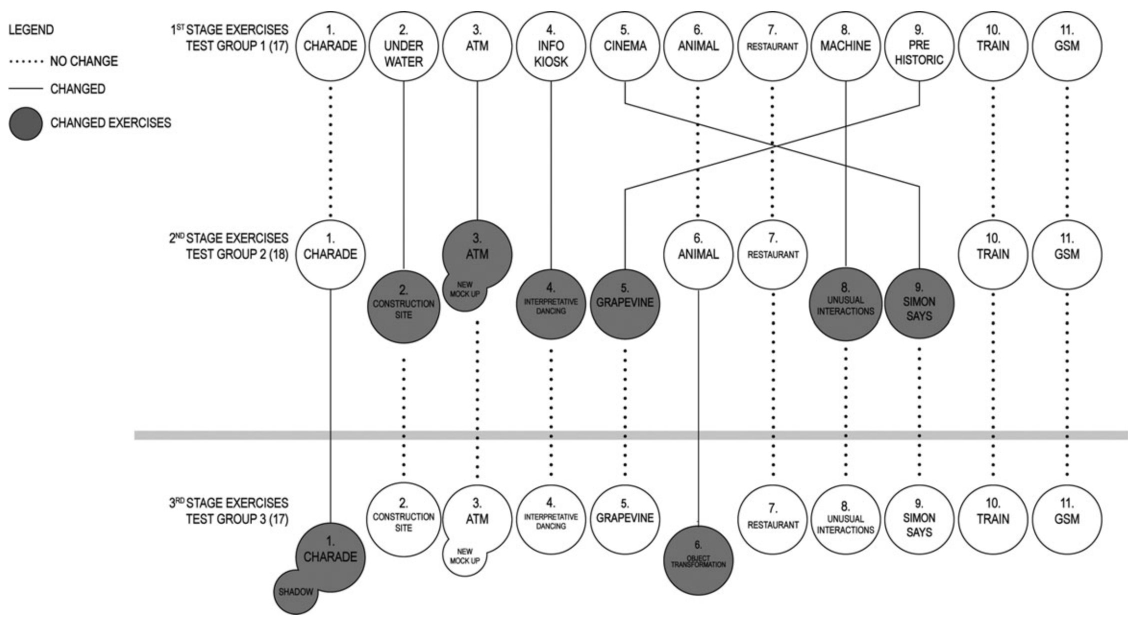

Figure 2. The evolution of the exercises that make up the awareness training programme, following three iterations

game of charades, they use body gestures to manipulate light cast by a projector onto a screen that is viewed by the audience.

The first exercise was designed to highlight the following:

- introduction to nonverbal narration;
- awareness of the challenges introduced by the fusion of 3-dimensional frame of reference for the input modality (body gestures) and 2-dimensional media (projector screen);
- awareness of various performance parameters (speed, timing, consistency . . .) that influence the efficacy and legibility of gestures.
- awareness of interactions involving gestures that may be difficult to prototype and document using conventional UI design tools. Video and storyboarding are workable tools when designing gestural interfaces.

Tier 2: Bodystorming in a disabling environment
This tier of exercises is designed to serve a quartet of aims:

- exploring ideation via embodied experiences;
- venturing into the design space of full-body gestures beyond hand gestures;
- exploring alternative communication channels and creative narration through unusual constraints such as *disabling environments* (Newell & Cairns 1993; Newell & Gregor 1999; Yantaç *et al.* 2011);
- once again, highlighting the occasionally inscrutable and emergent nature of design issues, and the need for designers to experience or simulate them.

The two exercises that make up this tier are as follows:

Construction site. Two students perform a dialogue at a distance and act as if they are on a noisy construction site in which they cannot hear each other. Thus, they need to use body gestures to communicate (see Figure 3).

ATM. Students take turns playing an ATM user who is trying to input an account number and PIN code into the calculator, while the rest of the group forms a crowd behind the user. One of them acts like a 'criminal' who tries to see the user's information (see Figure 4). The exercise aims to highlight the social and physical issues surrounding the use of interactive devices in public spaces and question how privacy, safety and comfort notions can be examined in gesture-based UIs.

Tier 3: Bodystorming
Exercises in this part introduce drama and mime skills and further explore embodied ideation. The exercises also capitalise on the power of metaphor for transferring qualia and concepts between communication modalities such as speech and gesture.

Interpretive dance. Students create a video for a popular song and present its lyrics with gestures synchronously. In the classroom, students (the audience) attempt to guess the song that is being performed without the music. This exercise is meant to facilitate the exploration of metaphorical gesturing and temporal issues related to gestural compositions.

Figure 3. Students partaking in the 'construction' site exercise

Figure 4. Students partaking in the ATM exercise

Grapevine. For this exercise, the well-known children's game of Grapevine is adapted for gestural communication in lieu of speech. A word is given to the first student in line who tries telling the word with gestures to the next person when the others are not looking. This exercise helps to analyse transformation of the word in each turn, detect commonalities between students, gestural narratives, and emphasises the subjective nature of gestural interaction. It also presents an unconventional approach to ideating gesture designs.

Object transformation. This exercise begins with one student describing an object via gestures and throws it to another student, all the while observing the characteristics of the object (size, material, weight, etc.) and adapting their movements to stay true to the object's nature. The student who catches the object 'transforms' it into another by manipulating it with gestures and 'throws' it again (see Figure 5). This exercise, derived from drama techniques, facilitates reasoning about the role of manipulation, metaphor and comprehensibility in gesture designs.

Tier 4: Distorted role-playing

Design scenarios in these exercises are explored via role playing. The scenarios are constructed in ways that abstract, distort and reconstruct aspects of the interactions between the user, the environment and the user interface. Here, we intend to draw attention to the following notions:

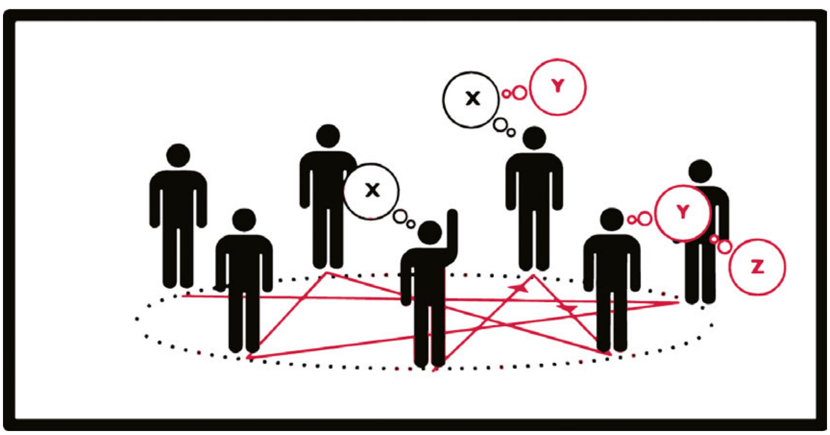

Figure 5. Diagram illustrating the 'object transformation' exercise

- Cognitive and physical ergonomic issues, as well as the interface between them, are important design considerations for gestural interfaces.
- Although nearly all of current gestural interfaces capitalise extensively on hand and arm gestures, the rest of the body retains significant gestural expressive power.

Restaurant. In this exercise, students are divided into two groups to act like waiters and customers at a restaurant who do not know each other's languages. They try to communicate only with gestures and mime techniques. This builds an appreciation for the cognitive ergonomic difficulties of using gestural interfaces for human–computer interaction through experiencing the same difficulties in interpersonal communications.

Unusual interactions. In the second part, students work in groups of four and are asked to create a composition; a bus interior, then expected to implement the composition with the remaining members of the group (see Figure 6). The design scene should be invisible to all the other students. The unusual aspect is that the designer is not allowed to use their hands or arms to perform gestures; they need to use the rest of their body – the legs, the torso and the head. Here, we introduce further ergonomic difficulties that capitalise on the previous exercise. Moreover, we aim to build awareness regarding the expressive power of the body.

Tier 5: Reflexive gestures

Exploring the use of metaphor in gesture designs for interactive systems, and the consequences of both simplicity and complexity in UI design, are the goals of this tier.

Simon says. In this exercise, again adapted from a well-known children's game, students are given a word by the moderator, which they are expected to describe via gestures within a few seconds. The objective of this exercise is to explore gestures assigned reflexively to various concepts. Similarities and differences between gestures elicited from different individuals, and how these considerations may affect user interface designs in practice, are to be discussed after the exercise.

Tier 6: Mime-based gestural communication

A single exercise that facilitates the discovery of natural, everyday gestures through inspiration from mime art makes up this tier.

Train trip. For this exercise, students are split into groups of 4–6, and they each pick a nationality for themselves to emulate in a train trip with a multicultural group in the same compartment. Although this exercise is similar to the Restaurant exercise where students formulate gestural representations to communicate, mainly culture-specific elements are highlighted in this activity. Communicating concepts to a group of people rather than a single person is another salient aspect of this exercise. Gesture designs that are effective in overcoming the interpersonal barriers simulated in this exercise are meant to inform effective gesture designs for human–computer interfaces.

Figure 6. Students participating in the 'unusual interactions' exercise

Tier 7: Gestural shadow mapping

Gestural shadow mapping aims to support students' exploration of how a visual composition can be narrated using gestures and devices, independent of the specifics of any gesture-sensing technology. Students are asked to perform a gesture in front of a projector – the same as the Shadow charades exercise – that represents a photograph which includes both natural and artificial elements and information about the weather, the time of the day and so on. While the narrator describes the photograph via gestures, others attempt to draw it. Then the drawings and the photograph are compared. The aim here is to introduce ideation through developing connections between a visual composition and a gestural one. Additional topics to discuss after the exercise include the expressive power of static gestures versus dynamic movements and which gestures are more appropriate to describe different visual concepts.

Tier 8: Gestural UI design project

After completing the exercises described above, students are given a final project. The projects are to be completed individually, rather than with a group. The project we chose comprised a gesture-based user interface design for a restaurant. Students are to fulfil various functions such as representing the system state, informing the user of available choices or communicating what interactions are possible.

Evaluation of the course

Educators' perspective

Two educators with at least 2 years (each) of experience in teaching interaction design and assessing student work in project-based learning contexts were recruited to support iterative development and verify the programme's contributions. Both hold postgraduate degrees in design. Project materials were available for the two educators to evaluate independently. The educators did not know which group the projects belonged to – projects from all groups were given in one batch. Each project was graded out of 10, based on the criteria described in Table 1. The criteria were formulated in collaboration with the authors and the recruits, based on experience, previous works on interaction design principles (Blair-Early & Zender 2008) and gestural interaction concepts described in the 'Background' section. The criteria were refined through a pilot evaluation conducted by the recruits and the authors, with three similar student projects from outside the course. The two educators' marks were averaged for the analysis.

Table 2 shows a statistically significant difference in terms of the sums of the grades assigned by the educators between the control and final treatment groups [$F(2,49) = 4.761$; $p = 0.13$].

A more granular analysis of the individual criteria reveals the following statistically significant differences between the final treatment group (where the final design for the course was implemented) and the others:

- Cognitive Ergonomics [$F(2,49) = 6.737$; $p = .003$]
- Control [$F(2,49) = 3.475$; $p = .039$]
- Concept [$F(2,49) = 5.306$; $p = .008$]

When the final treatment group is compared to Group 0 (the control group), improvement can be seen in 9 of the 10 criteria (all except 'physical ergonomics'). The most marked improvement pertains to the 'concept' criterion, which assesses the relevance and originality of student works. This is in line with our goals for the course, in which we primarily aimed to support student creativity and concept development. The lack of significant improvement over the 'physical ergonomics' criterion may be explained by the exercises in the course focusing on gestures that utilise the whole body. This increases the effort in performing gestures, causing more exhaustion, which, in the educators' view, negatively affects their assessment of physical ergonomics (see Table 1). While future studies may focus on this criterion for developing exercises and contribute

Table 1. Evaluation criteria constructed by the educators

Innovation	**Innovative Interactions (0.5):** Does the project offer any innovations as to the use of gestures and interacting with a system via gestures?
	Innovative Function (0.5): Does the project embody any innovative design elements?
Gesture Variety	**Diversity (0.5):** Does the project utilise deictic, semaphoric and manipulative gesturing?
	Full-body Interaction (0.5): Does the project utilise full-body movements and poses, proprioception and posture?
Physical Ergonomics	**Compatibility with Motor Skills (0.4):** How easy are the gesture designs to perform?
	Exhaustion (0.3): How tiring are the gestures to perform?
	Accessibility (0.3): Is the project accessible for people with disabilities?
Cognitive Ergonomics	**Memory Strain (0.5):** How easy is it to remember the gesture commands after they are learned?
	Intuitiveness (0.5): Are the gestures intuitive, requiring little training to learn and use?
Consistency	**Gestural Consistency (0.4):** Are gesture commands utilised and mapped to events in a consistent manner?
	Visual Consistency (0.3): Is the use of visual UI elements consistent?
	Mental Model Consistency (0.3): Does the design for the project consider the user's mental model?
Control	**Enabling Control (0.5):** Does the project afford rich interaction via gestures?
	Modelessness (0.5): Does the interface require intermittent re-learning?
Dialogue	**Feedback (0.5):** Do user commands receive appropriate responses?
	Forgiveness (0.5): Does the project accommodate user mistakes?
Social Factors	**Privacy/Fun/Public Use (1):** Depending on the subject matter for the project, does the project afford privacy, fun or undisturbed use in a public environment?
UI Design	**Use of Metaphor (0.5):** Is metaphor utilised appropriately in the UI?
	Direct Manipulation (0.5): Is the direct manipulation of UI elements supported?
Concept	**Relevance (0.5):** Is the design appropriate for the subject matter?
	Originality (0.5): Does the project offer novel solutions, as opposed to recycling existing designs?

Table 2. Breakdown of grades assigned by the evaluating educators to student works

	Group 3	Group 0
Innovation	0.62	0.41
Gesture Variety	0.58	0.48
Physical Ergonomics	0.72	0.86
Cognitive Ergonomics	0.73	0.56
Consistency	0.74	0.62
Control	0.43	0.21
Dialogue	0.59	0.36
Social Factors	0.70	0.48
UI Design	0.58	0.31
Concept	0.70	0.42
Total	6.38	4.7

to favourable physical ergonomics in student works, overall, the contributions of the course are validated by the educators' assessment.

Industry expert's perspective

To contribute to the evolution of the course and verify its efficacy from an industrial perspective, the final projects submitted by students from the four groups were evaluated by an industry expert. The expert was a consultant and project manager from Inventram, a technology and innovation company (Inventram 2014), who had 5 years of prior experience in contributing know-how to technology-, innovation- and design-based startups. Per the expert's recommendation, a rubric based on a modified version of the SMART criteria (Doran 1981), described in Table 3 was used. Each criterion was graded within a range of 0 to 2.5.

Table 3. The modified SMART criteria recommended by the industry expert for evaluating student works, phrased as questions

Specific	Does the project articulate a precise and clear focus? Are coherent goals explicated and pursued systematically?
Measurable	Can the success of the project be measured in some way? Does the project offer a quantifiable improvement over the current world state?
Attainable	Does the project articulate goals that are attainable, and how they are to be attained? If the project adopts a utopian perspective, is the utopian world state broken down into – at least partly – attainable constituents?
Realistic	Are methods and design constituents employed in a relevant manner? Are the means appropriate for the ends?

Table 4. Breakdown of grades assigned by the evaluating industry expert to student works, according to the modified SMART criteria

	Group 3	Group 0
Specific	1.82	1.19
Measurable	1.68	0.78
Attainable	1.59	1
Realistic	1.61	1.33
Total	6.71	4.31

All criteria except 'realistic', along with the sum total of the scores, show statistically significant improvements [$F(1,33) = 20.497$; $p = .000$] (see Table 4). From here we can argue that the course that we propose guides students towards articulating goals (specific), understanding and formulating evaluation criteria (measurable) and aiming for novel visions while being grounded in feasibility (attainable). That the 'realistic' criterion does not show improvement may be attributed to both groups being given demonstrations on relevant gesture-sensing technologies before attempting projects. Thus, students from both treatment and control groups have had opportunities to establish a design space that relates to existing technology. We may even argue that, since the course is designed to support the emergence of novel concepts, the limitations of existing technology may remain meagre. Thus, the significance of the 'realistic' criterion may be disputed. In sum, the industry expert's evaluation presents statistically significant differences that highlight the contributions of our course.

Conclusions

In this article, we tried to discover the formulation for an awareness course that will effectively teach design students to understand the nature of gestures and how to use them for added value in UI design. For this, we employed techniques from mime art and creative drama, and analysed the resulting student works to evaluate the course.

The most important result of our analyses is that encouraging students to

- maximise the utilisation of bodily, non-verbal communication; and,
- employ gestural expressions geared towards narrating abstract concepts and abstract thinking rather than concrete cases

contributes to an awareness that is relevant in terms of both design education and industrial requirements.

Our efforts have resulted in a course that comprises 11 exercises and a final project. The types of gestures utilised by students during the exercises have yielded unconventional relationships between the UI and gestures that may be of use for gestural UIs. These relationships – since they may be either technologically ahead of the times or remain undiscovered by designers since they have not been subjected to an awareness-developing process – may not be sufficiently emphasised in existing applications. However, during educational practice, we argue that experiencing and discussing unconventional aspects yields important outcomes in terms of design education.

Evaluation of the projects turned in by students indicates improvement with regard to 9 of the 10 criteria used by the educators (see the 'Method' section). The only decline was observed in relation to the criterion 'physical ergonomics' of gestures, which we relate to the increasingly exhaustive nature of full-body gestures as concepts become more and more diversified. The most meaningful improvement was observed with regard to the criterion 'concept', which relates to concept development skills. These results, as we stated before, are novel to the literature and warrant further investigation. We believe that the clues we have uncovered will form a foundation for such investigations. Future iterations may also investigate how the same methods can be applied to design for other modalities such as sound, and consider multi-modal designs.

In the industry-perspective evaluation, the 'Specific', 'Measurable' and 'Attainable' criteria show improvement with significant differences. These results indicate that during the design process, students in Group 3 were able to undertake a more systematic approach which aims at more explicit outcomes and have a clearer focus. Moreover, the projects they proposed imply improvements in either user experience or usability which can be evaluated by different measurement criteria in further studies. These projects are also more feasible for implementation either partly or entirely. The industry-perspective evaluation revealed no improvements on the 'realistic' criterion. We think that the aim of creating a novel interface may compromise the immediate practical value of the projects, since some of the designs proposed by students are not within the capabilities of current technologies.

In conclusion, we may say that the awareness course that we have developed will serve as a lodestar for both educators and industrial stakeholders. The value of the course will be more apparent as others adopt and refine it.

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