Learning and Experience: Teaching Tangible Interaction & Edutainment
Keyur Sorathia\textsuperscript{a}, Rocco Servidio\textsuperscript{b}

\textsuperscript{a}Department of Design, Indian Institute of Technology, Guwahati, IIT Guwahati, India  
\textsuperscript{b}Department of Linguistics, University of Calabria, Italy

Abstract

This paper shares our learning and teaching experiences carried out during a course of Interactive Communication Project delivered at the Department of Design, IIT Guwahati (India). The course focused on tangible user interaction and edutainment and enrolled diverse mix of undergraduate and graduate students. The course was conducted as a part of academic collaboration between IIT Guwahati, India and University of Calabria, Italy. Although the course was conducted in India, one of the two course instructors conducted lecture and critique sessions from Italy. Parallel sessions of lectures and studio components were conducted during the course. This approach fostered theoretical knowledge and its application through hands-on learning. With a time period of hardly 20 days, students have created novel designs on tangible user interaction and edutainment. We discuss and explain the course details, followed methodology, three student projects, problems and challenges faced delivering the course.

© 2012 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of International Educational Technology Conference

Keywords: Edutainment; tangible user interface (TUI); teaching experiences; documentation; input devices and strategies; interaction styles

1. Introduction

The spread of educational and communication innovation has generated new didactical methodologies and approaches, software and hardware tools. Despite these conceptual and technological advances, however, most of the current electronic educational systems still consist of video-lessons and few interactive functions that stimulate an effective student’s learning. We propose to design and develop innovative learning tools aimed at motivating teachers to use new educational approaches and tools in their didactical activities. Many psychological studies suggest that constructivism promotes the development of a wide spectrum of cognitive functions and skills: communication, creative thinking,
social cooperation, language, etc. In this view, we can affirm that edutainment is an empirical application of constructivism theory (Ozkal, K., et. al., 2009). There has been a growing demand to enhance the edutainment environment for children that supports education and entertainment in a seamless manner, given the context of children learning initiatives (M. Rehm, et. al., 2006, H.S.Horace & K. Belton, 2006, Colace, F., et. al., 2008, Z. Muda & I.S. Basiron, 2005). This type of computer-based instruction tools has been designed and developed to efficiently improve scientific teaching. However they are devoted to variety of students (Alessi, S. M., & Trollip, S. R., 2001, Guillén-Nieto, V., & Aleson-Carbonell, M., 2012). Edutainment systems give the opportunity to the subjects to learn scientific concepts by reducing their conceptual abstraction level. In addition, edutainment system provides a good didactical basis to formulate new and more stimulating teaching approaches. The main idea of these interactive tools is to stimulate subjects to learn from direct experience by exploiting the cognitive potentialities of direct manipulation. Learning is more productive when subjects use tools. The productive dimension result from the fact that subjects pursue goals and these tools represents the cognitive indicator of how subjects learn.

New paradigms in computer interaction have made promising advances in this regard, redefining how physical objects can be used for both play and learning. In last decade, tangible user interaction research has gained visibility within the Human–Computer Interaction (HCI) community, showing promise to support activities such as learning, problem solving, and design (O. Shaer, et. al., 2009).

In this paper, we share our experiences and learning of conducting 20 days course on tangible user interaction and edutainment. The course involved lectures, studio sessions that included cooperative and collaborative work and student projects. This paper is further divided into four sections: introduction to the course, methodology followed to conduct the course, student projects and discussion.

2. Course introduction

The proposed course taken at Department of Design, Indian Institute of Technology – Guwahati (IITG) was named Interactive Communication Project (ICP). ICP was an elective course, offered among 4 undergraduate and 3 post graduate students. 3 graduate students were from varied background of fine arts, fashion technology and electronics engineering. The course was mentored by two faculty members, Keyur Sorathia, Assistant Professor in Design, IITG, India and Rocco Servidio, Assistant Professor in Psychology, University of Calabria, Italy as a part of scientific agreement signed between IITG and University of Calabria for academic and research collaboration. A dedicated lab space, Apple computers and prototyping tools were provided to students to conduct their experiments. Similar to other HCI courses in institutions such as University of Washinton, (Camarata, K., et. al., 2003) and Welleley College (Turbak, F., et. al., 2002) the course was divided among lecture & studio sessions and hands-on learning. They were conducted in parallel introducing appropriate theory based on the stage of the project.

2.1. Edutainment and tangible interaction

Edutainment, similar to infotainment, technotainment, educational electronic games, is a new term coinage (Rapeepisarn, K., et. al., 2006). The idea underlying edutainment is to promote learning by merging educational contents and entertainment activities that increase engagement, emotion, and motivation. According to Buckingham and Scanlon (2005), edutainment is “a hybrid genre that relies heavily on visual material, on narrative or game-like formats computer games-education-implications for game developers, and on more informal, less didactic styles of address. Edutainment is the act of learning heavily through any of various media such as television programs, video games, films, music, multimedia, websites and computer software. On the other side, technological innovations and emergence of research areas such as tangible interaction have opened new exploration possibilities. Edutainment
does not remain restricted to computer based games, but provides opportunity to include multimodal interfaces to interact with educational information. New paradigms in computer interaction have made promising advances in this regard, redefining how physical objects can be used for both play and learning. Tangible user interfaces provide ways of interacting with a computer through real objects that are relevant to the task instead of through the keyboard or mouse (Ishii, H., & Ullmer, B., 1997, Ullmer, B., & Ishii, H., 2000). It introduces physical, tangible objects that augment the real physical world by coupling digital information to everyday objects. The system interprets these devices as part of the interaction language.

There is a need to explore the possibilities of merging edutainment and tangible interaction. There has been good evidence to support the facts through touch, exploring and testing students learn more about the world around them (Strommen, E.F., 2004). Piaget and other developmental psychologists have also emphasized the importance of using physical objects for children cognitive development (Piaget, J., 1962, Ginsburg, H., & Oppen, S., 1979). The importance of instrument-mediated activity through the use of edutainment environments it is consistent with the learning theories derived from Piaget and Vygotskij (1962) works focused on cognitive development. Afterwards, these conceptual frameworks have been revised by Papert, which conceived learning as a student’s active construction. In fact, the constructivism approaches a kind of learning in which the educator does not transfer information, but is rather a facilitator of learning so the learner enhances his/her knowledge through the manipulation and construction of physical objects. We argue that it is important an integration among edutainment, as learning strategies, and tangible user interaction as an interactive way to communicate educational contents.

2.2. Course objective

The objective of ICP course was to train students to design, develop and validate innovative Tangible User Interfaces (TUIs) based on edutainment systems. In particular, students were forced to demonstrate the acquisition of practical and conceptual ways of utilizing advanced technological tools for educational purposes. The project focused on designing and developing an educational system on followings topics: mathematics, chemistry, physics, learning of fruits, colours, history, astronomy, energy conservation, and tourism etc. Students were given freedom to choose any topic. However, the condition was that it had to be in the area of tangible user interaction and edutainment.

2.3. Timeline and deliverable

The courses at Department of Design, IIT Guwahati are divided over a complete semester. During the semester, each course is given a particular time slot to conduct lectures, tutorials and studio. Typically each course is provided one day in a week. In a 4 month semester, most of the courses get around 16-18 days for the course to complete. ICP was also conducted in a 4 months semester period. Total numbers of days allotted to ICP course were 20 days (including official 16 days and 4 days during weekend) during the 4 months’ time period. However students enjoy freedom of working in studio for unlimited period of time, availing the lab facilities. Students were divided in three groups, two students each in two groups and three students in one group. For deliverable, students designed and developed a system for their selected topics. During the course activities, students learnt new interaction techniques, design methods and prototyped them. Students chose educational contents from National Council of Educational Research and Training (NCERT) course structure. Final users must be able to use the developed educational tool for acquiring new concepts aimed at improving their learning process. Day wise course plan is showcased in Table 1.
Table 1. Course structure organization and timeline.

<table>
<thead>
<tr>
<th>Day</th>
<th>Activity</th>
<th>Day</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-03</td>
<td>Project kick-off, literature study and research problem identification</td>
<td>09</td>
<td>Lecture on Creativity Techniques, Brainstorming session continues</td>
</tr>
<tr>
<td>04</td>
<td>Presentation on finalized topic &amp; suggestions</td>
<td>10-14</td>
<td>Concept generation, critique sessions and refinement</td>
</tr>
<tr>
<td>05</td>
<td>Lecture of Cognitive Psychology on: cognitive factors and system design</td>
<td>15</td>
<td>Introduction session on prototyping tools and techniques</td>
</tr>
<tr>
<td>06</td>
<td>Lecture on Tangible User Interfaces-techniques, methods and guidelines</td>
<td>16-18</td>
<td>Prototype development and refinement</td>
</tr>
<tr>
<td>07-08</td>
<td>Brainstorming session</td>
<td>19-20</td>
<td>Presentation and deliverable</td>
</tr>
</tbody>
</table>

3. Methodology

Methodology followed during the course is subdivided into 4 main sections: Self-study assignment, lecture sessions, studio sessions and critique sessions.

3.1. Self-study assignment

As a part of literature study, each group was given research papers to read and review. Two research papers; “Attentive objects: enriching people's natural interaction with everyday objects” (Meas, P., 2005) and “A ubiquitous mobile edutainment application for learning science through play” (Astic, I., et. al., 2011) were given to each student. Additionally, different sets of papers were given to each student to read and review. The papers focused mainly on tangible interactions, edutainment and related projects.

Each group of students presented these research papers. The literature study exercise was conducted among students to learn more about edutainment, tangible interaction, existing design methods, prototyping and paper writing. The project template included several sections, aimed at describing the system and the mentor evaluated students’ acquired skills derived from the self-study assignment. At the end of self-study session students were asked to define a broader area of work. They were given freedom to choose their area of interest to pursue. For example, one group decided to work in the area of chemistry lab experiments. Once the broader area of work is decided, they were asked to refer NCERT books for understanding the exact educational contents and existing methods of teaching those contents. First group of students decided to work in the area of teaching acute angle, obtuse angle and right angle. Second group decided to work on teaching basics of algorithms and third group of students decided to teach Salt Analysis Table of chemistry lab experiments. As a part of self-study, students were also introduced to children behavior of specific age groups. They were explained children’s characteristics and behavior of different age group. The knowledge based was provided through books articles (e.g. Kail, R., 2006, Smith, PK., Cowie, H. & Blades M., 2003). This exercise helped them get an understanding of characteristics, liking-disliking and behavior of their target users.

3.2. Lecture sessions

Lecture sessions were majorly divided into two sessions. The first session explored the relationship between cognitive processing and Human-Computer Interaction applied to the interaction design. More
specifically, cognitive psychology is the scientific study of mental processes, which include attention, perception, memory, learning, thinking and reasoning. Finally, we provided an overview of the main ideas and research methods used to design and evaluate user interfaces. The second lecture was related to Tangible User Interfaces (TUI)-techniques, methods and guidelines. Students were introduced to history & evolution of user interfaces, model of TUI, existing projects, properties of TUI products, tools and methods, framework on tangible interaction-Tangible manipulation, Spatial interaction, Embodied interaction, Expressive representation (Hornecker, E., & Burr, J., 2006), internal abilities, and hands only scenario (Buur, J., et. al., 2004). Tangible interaction guidelines were formulated in a set of questions and given to students to help them design tangible interaction products. For example, is user able to grasp and manipulate the given object? An introductory lecture on creativity techniques was also taken introducing techniques such as storytelling, force fitting tools, random input, brainstorming, brain writing, imagery tool and attribute listing. Students were asked to utilize taught theories and applied them in studio session.

3.3. Studio sessions

Studio session allowed students to practically apply techniques and methods taught to them. Brainstorming activities, concept generation and prototyping were parts of studio session. Brainstorming activities were moderated by mentor to see appropriate use of techniques taught to them. A common task was given to students to share their personal experiences of school learning. Later on it was narrowed down to a specific topic chosen by their group. This exercise helped them to identify their personal emotions, environment, objects and people associated with it. Mock up tools such as clay, wooden blocks, Lego blocks, specific product packages and other workshop facilities were provided. These materials (especially Lego blocks) and workshop facilities helped students to quickly build up their mock up and facilitate them to communicate and share own ideas. Hands-on session also included learning prototyping. Prototyping tools such as Arduino, processing programming language, RFID phidgets, Fiducial markers, sensors-actuators etc. were introduced to students.

3.4. Critique sessions

Learning activities and project progress of students were evaluated and critiqued every week. The aim was to create an environment where ideas can be refined, evaluated and given appropriate future directions. The presentation needs not to be a formal format (e.g. PowerPoint or Adobe Flash), but they were asked to bring their research analysis documents, brainstorming charts, sketches and low fidelity prototypes. Students were asked to digitally report every step of the design process. This report was included in the final presentation, which was formally presented (e.g. PowerPoint or Adobe Flash) by students.

4. Student projects

In this section we carefully describe and explain three student projects designed during the course. In an ideal scenario, all the proposed designs are to be used with teacher’s aide.

4.1. Project I: Drop-on-Top (DOT)

Classroom program teaches the relationship between degree of angle and their relationship with acute, obtuse and right angle through a predefined theory, but do not give experience about angles formed through real life objects. To help students to understand angle formation and their relationship in a more
playful way, Drop on Top (DOT) was designed. The project aimed at teaching main properties of angles to children aged 8-10 years. DOT allows student to learn and understand basic mathematical concepts by manipulating and interacting with real objects. The reproduced educational contents are borrowed from standard curriculum guidelines of NCERT for primary schools.

Table 2. Table showcasing the range and type of angles.

<table>
<thead>
<tr>
<th>Range of angle</th>
<th>Type of angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-89</td>
<td>Acute angle</td>
</tr>
<tr>
<td>90</td>
<td>Right angle</td>
</tr>
<tr>
<td>91-180</td>
<td>Obtuse angle</td>
</tr>
</tbody>
</table>

Basics of geometry are taught from angles. DOT simulates the relation between degree of angles and the relationship with acute, obtuse and right angles through tabletop interaction. The angle details are shown in table 2. The design consists of a smart surface on a table and pencil shaped smart objects. Smart objects are shaped of colourful and shiny markers, so that their use is familiar for children.

As shown in Fig. 1. (a), two different markers are placed on the top of table and extended rays are formed from the markers. The combination of the two rays generates different type of angles, which is displayed through graphical user interface. The rays are of the same colour of the smart objects. The metaphor of rays is: a) related with direction and the figure formed: b) correlated with the shapes formed by markers of the real life objects such as pencils, pens and colour brushes. A working prototype is created using a webcam (mounted on top), projector (underneath the table) and open source software environment Open Computer Vision (CV). Real time image processing is done using Open CV that captures the image frames of placed markers. Each captured image frame is cloned on colour basis generating two main parts: clone-1 and clone-2. Colour line is calculated and drawn from centre location. Slope of line is calculated in their respected frame. The same process is applied for clone-2. When clone-1 and clone-2 are morphed, an angle is calculated and distributed among obtuse, acute and right angle. The type of angle and its degree is shown with customized line colour and font size.

4.2. Project II: Salt Analysis Table

Salt analysis test is a test performed by 8th standard students as a part of their first chemistry lab experiment. In current school scenario, an unknown salt is distributed among students to determine the cation and anion present in given salt. The unknown salts are: Coppers Sulphite[Cu₂SO₃], Ammonium
Carbonate\[(\text{NH}_4)\text{CO}_3\]\ and Lead Nitrite\[\text{Pb(NO}_2\text{)}_2\]. Several tests are performed to identify cation and anion, which helps students to identify the correct salt. Prior of the lab test, students are given experiment manual to learn step-by-step process to perform the test. Most often students do not understand the procedure and just memorize them. Students misplace or waste the salt that leads to incompletion of lab experiment. Considering these conditions, Salt Analysis Table (SAT) is designed. It is a tangible edutainment board game that helps students to learn about salt identification tests. It provides a learning platform where students set up the experiments and their role in determining cation and anion in a given salt. As shown in Fig. 2. (a) SAT board is divided into 3 main sections. 14 reaction boxes are placed at the centre of SAT board, control panel placed on the top (e.g. reset button and chances remaining to identify correct salt) and result section (where identified salt is placed in correct slot). 14 reactions boxes represent a set of reactions to be performed to identify the correct salt. As shown in Fig. 2. (b), reaction details are seen when flap of reaction boxes are opened.

SAT is used along with a teacher or teaching assistant. Student is given an unknown salt (represented by rectangular block). The task is to identify the correct salt by performing a series of reaction experiments placed on SAT board. Based on the placement of unknown salt block in reaction box, LED besides the reaction box lightens up green or red. Sequence of reactions is very important to identify the correct salt. Appropriate sequence of reactions results in positive feedback, leading to increased score. Students are given five chances to identify the right salt, represented through LEDs on control panel. Light sensors, connected to Arduino are placed underneath the reaction boxes. They are used to identify the salt box and correct sequences of reaction.

Fig. 2. (a) Low fidelity prototype of SAT; (b) Reaction details showcased on the flap of reaction box.

4.3. Project III: Fun-In-Flow

A flowchart is a type of diagram that represents an algorithm or process, showing the steps as boxes of various kinds and their appropriate order by connecting these with arrows. Fun-In-Flow project is a tool for learning flow-charts and algorithms for 8th standard children. It is a play-and-learn edutainment kit that allows children to manipulate predefined symbols to write a program. Flowchart learning is divided into four stages: Children are introduced to flowchart symbols and their functioning:

- Children are introduced to flowchart symbols and their functioning
- Examples of washing your hand and boiling water are given to children. These examples are divided into 8 and 10 steps respectively. The predefined symbols are given into Fun-In-Flow kit.
- Children are given three simple problems to translate in a software program. It includes use of each symbol. Three following problems are given: Printing of a particular number, Addition of 2 numbers
and Find the greater number. By manipulation of flow-chart symbols, children learn input/output, start/stop, mathematical operations and decision box functions.

- A complex problem is given to children to test their learning. The problem is to check whether the number is divisible by two or not.

As shown in Fig. 3. (a), the kit is divided into three main areas: learn, practice and result. By pressing the symbol buttons in the learn area, students are introduced to common flow chart functions such as Start/Stop, Input/Output, Processing and Decision. Pressing each symbol, the system provides an audio based learning tutorial. Second, third and fourth stages of learning happen in practice area. Children chooses appropriate symbol and place it on practice area. Green or red light indicates whether chosen symbol is correct or incorrect. Fig. 3. (b) shows the working of Fun-In-Flow. RFID readers and tags are used to prototype Fun-In-Flow. A tag is attached to every symbol. RFID reader is placed below practice section.

![Fig. 3. (a) Overall structure of Fun-In-Flow; (b) Working scheme of Fun-In-Flow.](image)

When the symbol is placed, RFID reader identifies the tag and provides appropriate results. Reader is programmed to identify the sequence of blocks.

5. Discussion

The course was conducted in different sets of constraints, problems and challenges. Due to a week gap between two sessions of the course, maintaining continuity became a big challenge. Theory taught in one session needed a quick recap in next session for better understanding of new contents. Similarly, students needed time to consolidate the learning activities done in the previous session. We found 20 days to be a shorter period of time to conduct a course that demanded lecture, studio sessions such as research, concept generation, prototyping and final deliverable. Although students were always allowed to avail lab facilities but availability of mentors was not fully possible. Students could not get immediate feedback on design process. Mentors had to conduct the didactical sessions on weekend. During the course we had conducted four sessions on Saturdays to fulfil the requirement of the course. It became difficult to find common time availability for mentors and students to conduct weekend sessions.

Availability of equipment and lab facilities provided a platform to build a working prototype. Although shorter time period and simultaneous peer course work pressure restricted students to build high quality high fidelity prototype. Students found the theme very open ended, which resulted in a longer time period to finalize the problem statement. For example, once students chose a broader area of Chemistry
lab experiments, considerable amount of time was spent to choose experiments of salt analysis test. Both mentors used Skype useful to interact, critique and conduct lecture sessions. However, minor technical problems such as invisibility of contents on screen-sharing feature and reduced voice quality of the speaker were found. In these cases, speaker was asked to repeat the contents or notes. English language accent was found to be a challenge at the initial stages of the course. Italian accent of English language was found difficult to understand, but students got accustomed after a period of time. Students’ background influenced the design process. Students of relatively better schools had different perspective on education. For example, one student learnt angle through real life examples of door opening and closing, while others were taught through a predefined theory course. Diverse mix of students and different background (e.g. engineering, design, fashion etc.) opened different perspective on design. For example, engineer students focused on functionality whereas student with fine art background focused on aesthetics.

6. Conclusion

In this paper, we shared our experiences teaching a tightly scheduled course, remote faculty collaboration, parallel lecture-studio approach and highlighted challenges faced to conduct the course. The area of tangible user interaction and edutainment was new to students; however they showed enthusiasm for the course. Each student attended all the lecture and studio sessions. Lecture and studio sessions were conducted in parallel, which provided an opportunity to practically apply theoretical lessons. Course duration was found less, however better lab facilities, availability of equipment and continuous support from mentors provided a platform to make it a successful course. Interdisciplinary backgrounds of students help bringing in different perspective on design approach and ideas. Greater involvement of mentors, continuous feedback and critique sessions were very critical to drive the project in time. We believe that success of the course will attract students from variety of disciplines, thus bringing different perspective, creative approaches and new ideas to edutainment and tangible user interaction. In future, we plan to longer the course duration, tighten the course brief and plan superior lab and workshop facilities.

7. Acknowledgements

We would like to thank all students who participated in this course.

8. References


