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AN EVALUATION OF LEARNING RESOURCES IN SUPPORT OF INTEGRATED INTERACTION AND ELECTRONIC PRODUCT DESIGN

Tom PAGE and Kevin BADNI
Loughborough University, UK

ABSTRACT
Over the last two years we have seen an increased interest from our students in integrating electronic product design with interaction design in their final year major project work. Furthermore, this has been coupled by increasing interest in the use of Arduino (www.arduino.cc) as a prototyping environment for electronic product design. Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and a freely downloadable development environment; it is intended for designers, hobbyists, and those interested in creating interactive objects or environments. Adobe Flash is used in interaction design as a platform for graphical interaction. Using Arduino and Adobe Flash, students are able to build fully working prototypes in their projects, rather than creating non-interactive mock-ups. The worked outlined here comprised the evaluation of learning resources to enhance students' learning in Arduino and Adobe Flash.
The work reported here considers an action research project around the use and evaluation of learning resources in Arduino and Flash which were developed to support final year major product design projects. These resources were developed by the authors and a learning technologist at Loughborough University funded by the Centre of Excellence and Teaching in Engineering (Eng-CETL). The resources were evaluated by the authors and this evaluation forms the basis of this paper. A Grounded Theory approach to this evaluation was employed, whereby each subsequent study was designed using the knowledge and insight gained from the previous study. Moreover, the students observed gave a reflective commentary on their learning experience due to the controlled nature of their final year projects.

Keywords: Interaction design, electronic product design, flash, Arduino

1 INTRODUCTION
The Department of Design and Technology at Loughborough University provides two undergraduate design courses namely Industrial Design and Technology (BA) and Product Design and Technology (BSc). This paper addresses quality enhancement of learning provision in support of the final year major project, common to both courses, where students undertake research, design, prototyping and evaluation of a product. The BA students currently feel unable to produce technical working models of their designs to the same high standards as the BSc students. Furthermore, this paper attempts to bridge the disciplines of interaction design and electronic product design with the aim of allowing both BA and BSc students to create physical interactive products.
The authors have identified a means of bringing together interaction design and electronics product design through the development of an integrated suite of learning resources using Adobe Flash and Arduino. These resources have been designed in an open and accessible way such that students can use them in their own time and at their own pace inside or outside the university setting. The work aimed to provide a pedagogical evaluation of the implementation of the integrated learning resources in the final year major design project. This work was partly funded by the Centre of Excellence for Teaching and Learning in Engineering (Eng-CETL) at Loughborough University.

1.1 Project aim

The aim of this project was to achieve a pedagogical evaluation of learning resources in Interaction and Electronic Product Design in support of the final year project the Department of Design and Technology, Loughborough University. In essence, the overall project attempted to answer the question 'Do such integrated learning resources provide an effective approach to Interaction and Electronic Product Design Education?' In order to fulfil this aim the objectives (section 1.2) were identified. Furthermore, this work aimed to enhance the student learning experience through the promotion and sharing good practice in learning and teaching in interaction and electronic product design. The authors undertook a qualitative investigation of current student learning experience through the provision of learning resources and tutoring on the use of Arduino and Flash creating on-line resources and evaluate their pedagogical impact. The overall student experience during their most important degree module of both courses was reviewed and analysed.

1.2 Objectives and milestones

The following objectives and milestones were used to direct and measure the progress of the project.

1. Identified a methodology for data collection and analysis based on qualitative data collection and analysis to enable evaluation of integrated learning resources.
2. Implemented integrated learning resources and undertook qualitative data collection and analysis from the implementation.
3. Identified pedagogical issues relating to the evaluation of such problem-based learning (PBL) resources in Interaction and Electronic Product Design.
4. Published conference and journal papers on evaluation of PBL as an approach to Interaction and Electronic Product Design Education.

2 METHODOLOGY

This work applied grounded theory as a strategy for developing new theory 'grounded' in observation or in other terms, generated theory from the data collected during the investigation [5]. Grounded theory derives new theories rather than testing the validity of existing theories [5], 'supporting claims with credible evidence' [6]. This strategy is particularly useful in emerging areas of pedagogic research where there is little theory and concepts to describe [5]. The approach is suited for use in aiming to capture the actions, interactions and processes of the learners [5]. Typically in a grounded theory approach, the data is collected 'in the field', by conducting interviews, and the data is immediately analysed to develop initial categories, interpretations and theories [7]. In doing so, it is possible to identify issues (relevant to the area being investigated) that emerge and target potential interviewees who might prove useful in expanding, modifying or refuting evolving conceptualisations [6].

For the work proposed here, a grounded theory approach was adopted as an established means of developing new understanding of the effectiveness in learning these resources [9]. Due to the breadth, variety of applications of interaction and electronic product design, it was necessary to develop relevant resources along with authentic assessment schemes. To develop hypotheses based on the little knowledge documented previously may be seen as presumptuous. Therefore, the grounded theory approach was employed, whereby each subsequent study was been designed using the knowledge and insight gained from the previous study. The limitation of grounded theory is that it is difficult in practice to decide when the theory is sufficiently developed and when data categories are saturated. Moreover, the students observed gave a reflective comment on their learning experience due to the controlled nature of their final year projects. This formed part of a student centred evaluation of these resources [6].

2.1 Timetable

The project implemented and evaluated the learning resources and supportive materials in the context of across the final year major project module. The following tasks were realised within the timeline of this project.

1. Pilot resources in support of major design project were developed and implemented
2. Observations, interviews and focus group activities were undertaken.
3. An analysis of the results of stage 2 was conducted.
4. A discussion of pilot approach was achieved.

5. The data gathering methodology was further refined.
6. Deeper research using the refined data gathering methodology was undertaken.
7. The results were analysed fully.
8. A final report was prepared and published.

3 LEARNING RESOURCES

There were 4 main components that were needed in order that Arduino could communicate with Flash:

1. Bespoke code was written to run on the Arduino. This sends data through the USB virtual serial port.
2. A Serial to Socket Server (e.g. serproxy) was employed. This takes data from the serial port and sends it over a network socket (designed to be used with any client software (Flash etc) and any microcontroller).
3. A Flash Socket Library (e.g. as3Glue) was used. This is ActionScript code in Flash that accepts and interprets the data coming in from the network socket.
4. Flash Code (the custom ActionScript code that does something interesting with the data).

The communication between Flash and Arduino is bi-directional i.e. Flash can tell Arduino what to do and Arduino can tell Flash what to do. Figure 1 illustrates a screen from a Flash-Arduino interface which was trialled as part of these resources. It comprises a series of digital, analogue and pulse-width modulated pin configurations and facilitated two way communications between Arduino and Flash.

Students were provided with a step-by-step guide on how to set up the required software and hardware elements. To accompany the guide, the specially written Flash application was developed that demonstrated a number of control options between Flash and Arduino and Arduino to Flash. These included:

Controlling Arduino with Flash:

- Digital on/off switches.
- Digital on/off for flashing LEDs.
- Analogue input values to control analogue devices such as buzzers.
- Analogue scroll bars for controlling the brightness of LEDs.

Controlling Flash with Arduino:

- Digital on/off switches which changed a colour in Flash.
- Analogue input using a variable potentiometer (rotary switch) to move a movie clip graphic along the Flash stage.

4 RESULTS

With the help of information technology we can develop environments that present complex problem situations while providing students with a rich variety of tools, which effectively support their attempts to control the complex relationships of learning tasks. [3], [4], [8] and [10]. The support material produced sits favourably within the four building blocks for an ideal learning environment identified by [1]. The students seemed to like the idea of the Arduino board being developed for people unfamiliar with microcontrollers. They also liked the flexibility of the Arduino boards and all the extra components or shields that are available at relatively low prices, considering the functionality. Some preferred to program the Arduino directly rather than using Flash as they did not require a graphical interface. There are a large number of pre-programmed example ‘sketches’ as they are called, available in the development environment and in the large community ‘playground’. For example, to make a few LEDs flash it was a relatively simple task using one of the existing sketches. However, to actually create the type of bespoke interactions that the students needed for their major projects required a much larger learning curve. The main Arduino programming language is C, which the vast majority of students had had no experience of. This lack of knowledge and experience meant that actually implementing small changes was not as straight forward as they had hoped. The support offered by the Arduino community is very good, however as our students come from a design background, and not a computer programming background, the language differences between these two disciplines became a difficult barrier to overcome.

With the introduction of the new learning resources, the issue relating to learning C was removed. The learning resources use Adobe’s action script 3.0 language. ActionScript 3.0 is a powerful, object-oriented programming language that eases the development to facilitate object-oriented, reusable code bases. The language is much easier than C for students to be able to read and write programs without constantly consulting a reference manual.

To aid the students in the understanding of ActionScript 3, each line of code was commented, describing the function of each piece of code. This was seen very positively by the students giving them extra confidence to try out different variables and achieve different results. The advantages of these learning resources may be summarised below:

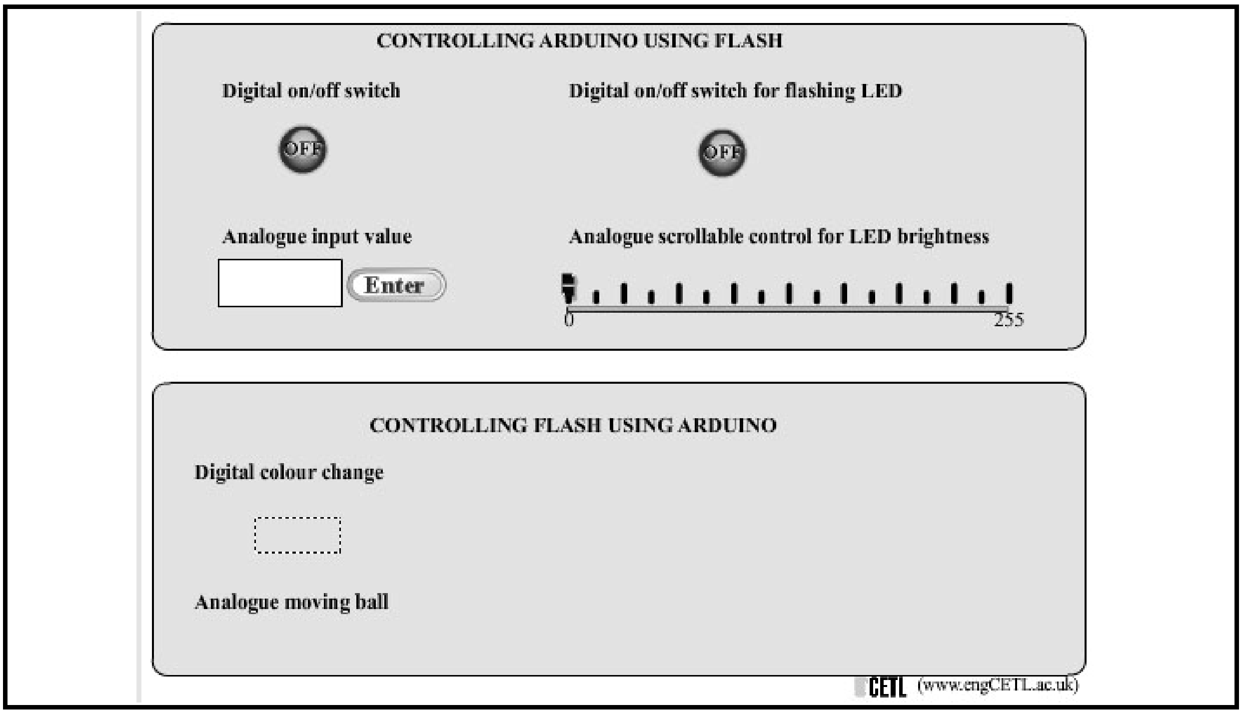

Figure 1. Arduino-Flash interface

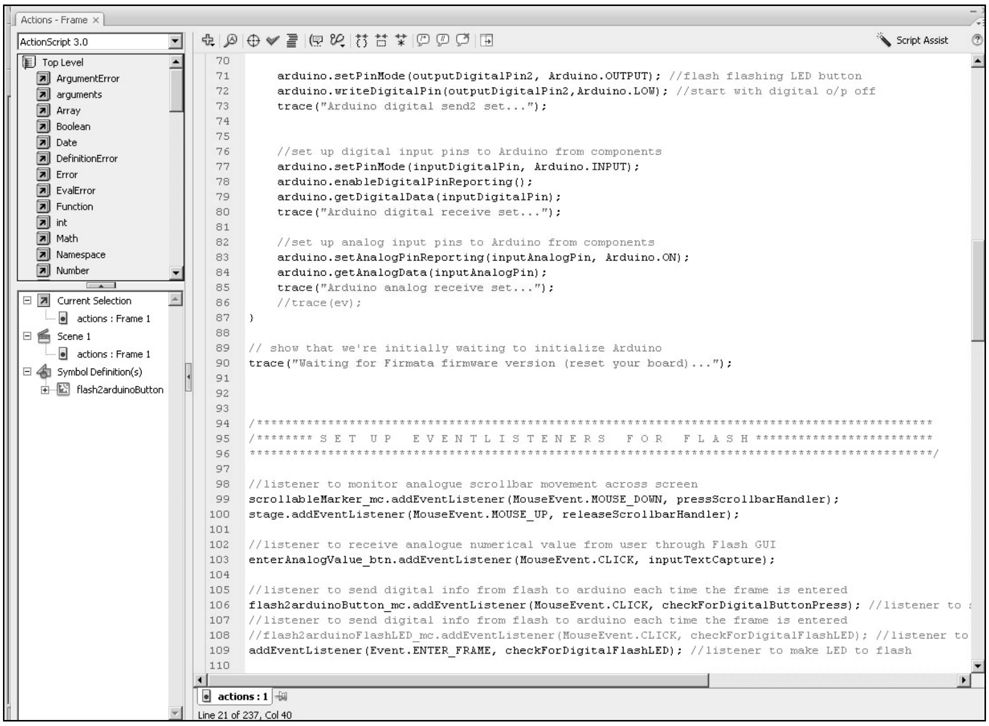

Figure 2. Flash Action Script interface

- Content – The learning resources provided tacit and heuristic knowledge.

- Situated learning – The learning resources teach knowledge and skills in contexts that reflect the way the knowledge will be useful in the major project module.
- Modelling and explaining - The learning resources show how a process unfolds and give reasons why it happens that way.
- Exploration – The learning resources encourage students to try out different strategies and hypotheses and observe their effects within the Flash/Arduino environment.
- Sequencing - The learning resources present instruction in an order, from simple to complex, with later Flash elements increasing in task diversity.
- The specially written Flash demonstrator application was used by all students as a base from which they built their own systems.

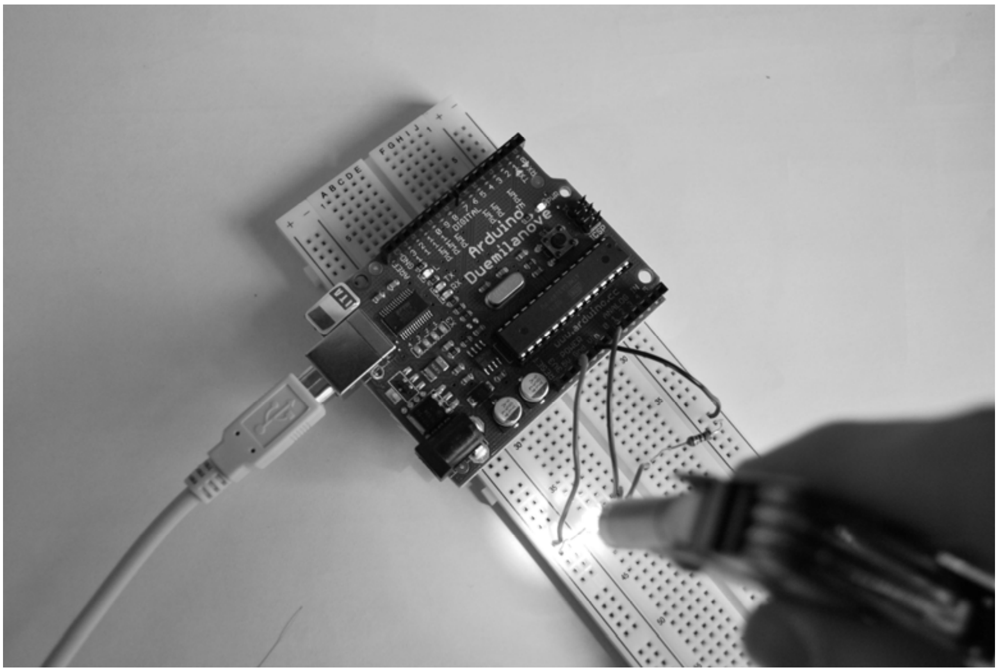

Figure 3. Arduino-Flash being used to test digital I/O

Figure 4. Example Arduino-Flash being used in a final year major project

5 OUTCOMES

This project offers unique contributions, from an interdisciplinary perspective, to beneficiaries involved in current discussions and strategies on the Interaction and Electronic Product Design education agenda. The findings will be of particular interest to practitioners in the field of design education, interaction design and electronic product design. The benefits gained from this work relate to the provision of evidence of the effectiveness of integrated learning resources to emerging interdisciplinary subject areas.

Significantly, this project centred on effective approaches to Interaction and Electronic Product Design Education. It therefore provides a unique opportunity to reveal the pedagogical underpinnings which have not previously been recognised as significant, and will be of interest to practitioners working in design education beyond the focus on Interaction and Electronic Product Design.

6 CONCLUSIONS

A pedagogical evaluation of learning resources in Interaction and Electronic Product Design in support of the final year project the Department of Design and Technology, Loughborough University was achieved in this work. In essence, the overall project answered the question ‘Do such integrated learning resources provide an effective approach to Interaction and Electronic Product Design Education?’. This work enhanced the student learning experience through the promotion and sharing good practice in learning and teaching in Interaction and Electronic Product Design and enabling the BA finalist students to produce technical interactive working models of their designs to the same high standards as the BSc students.

The authors undertook a qualitative investigation of current student learning experience through the provision of learning resources and tutoring on the use of Arduino and Flash creating on-line resources and evaluating their pedagogical impact. The overall student experience during their most important degree module of both courses was reviewed and analysed through a grounded theory approach.

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