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Repurposing the Learning Environment: Using Robots to Engage and Support Students in Collaborative Learning through Assessment Design

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Abstract: This paper presents a case study related to the setting up and the implementation of a multi-mode blended learning environment driven by an assessment design. The technological blend comprised access to robots and an online group space. The pedagogical blend included the assessment design and teaching and learning practice informed by current research taking place in the School of Computer Science at the University of Hertfordshire. Learners were provided with access to the research centre and the robotics house to help progress and complete the group based assessment and this was supplemented by class-based learning.

The overall aim was to repurpose the learning environment and shift the emphasis from teacher-centric to learner-centric practices in order to motivate and engage learners in authentic group based assessment. Additionally, emphasis was placed on learners' sharing work on their assessment as it progressed using a mini-project approach. This constructively aligned with the assessment and the subject delivery. In this learner-centric environment learners alongside the teacher administered feedback to students on their work as it progressed. This was intended to provide an opportunity for learners to develop their understanding and skills and take the necessary corrective action.

Learner attitude was captured quantitatively by means of a questionnaire. Qualitative data was obtained using learners' own reflections of their experience. This was provided in the form of students' explanations of their answers to questions posed on the questionnaire. Overall learning was measured using the learner's performance on the assessment. There are some interesting findings including learner views on the assessment design, how access to the robots and the research centre supported their learning and the learners' overall perceptions of learning in the multi-modal blended learning environment.

These findings will add to the debate on how we engage with and support learners who are growing up in a digital world and provides an example of how we can do this by taking a research-informed teaching approach to the practice of learning driven by an assessment design using robots.

Keywords: Robots-in-learning, Research-Informed-Teaching, Research-Informed-Learning, Collaborative Learning, Assessment Design

1. Introduction

The University of Hertfordshire (UH) recognises the importance of Research Informed Teaching as noted in the strategic plan ((UH strategy, 2015). There is a similar picture nationally emphasising the importance of research in underpinning curriculum provision. Between 2006 and 2010 Plymouth University developed a large scale project to link research and teaching activities and its importance is reinforced in the university's strategic plan (UOP, strategy 2020). Bournemouth University have coined the phrase "fusion" to highlight the synergy between research, education and professional practice (BU strategy, 2012). The University of Lancashire has developed a centre specifically devoted to Research Informed Teaching further emphasising its importance nationally in the student learning experience.

This paper presents an example situated in the practice of Research Informed Teaching at the University of Hertfordshire by outlining a module designed to embed research related to robots which is then linked to teaching and learning and the assessment design. Learners were provided with access to the adaptive research group <http://adapsys.stca.herts.ac.uk/> and the robots via the School of Computer Science Research Centre and in scheduled classes. In this study, we were particularly interested in supporting learners studying a Human Computer Interaction module in the completion of their group based assessment to design a user interface for the robots. Part of this process was to

progressively encourage learners to become active inquirers and researchers which was necessary to solve problems for assessment completion. The intention was also to inspire learners to collaboratively develop their work based on authentic research processes within the field of Human Computer Interaction and Human Robotic Interaction in the discipline of Computer Science. This provided opportunities for master students studying the Human Computer Interaction module to access current state of the art research and encourage and support the nexus between research and teaching within the University of Hertfordshire. This approach is supported by Healy's (2005) and Jenkins & Healy (2007) work wherein they present a framework comprising four quadrants emphasising research led, research-oriented, research-tutored and research-based activities to illustrate the links between research and teaching and how research informs teaching. In the example provided in this paper this is as follows:

- *research-led*: whereby students learn and get to use/access the latest research in the field.
- *research-oriented*: helping the students develop a research ethos, understand the research process in its widest sense especially given access to the adaptive systems research group to study the robots and access to the Science and Technology Research Institute to meet with researchers.
- *research tutored*: whereby students are actively engaged in critiquing each other's work through the assessment design informed by research.
- *research-based*: the mode of teaching, the learning and assessment design clearly demonstrates student-centered learning where students participate in a dialogue and showcase work as it progresses with an emphasis on inquiry-based learning.

The use of research-informed teaching in this paper involves a paradigm shift in university teaching where the emphasis is placed on students to socially interact and actively engage in their own learning. Doolan (2013a; 2013b; 2015) describes this social paradigm in the form of the dialogic *shamrock* and views the social and cultural context of learning as crucial and a central tenet of learning itself. It is argued that designs for learning that encourage participation, reciprocity, dialogue and mutual engagements whilst learners are engaged in an active learning experience, generate knowledge that is socially constructed and skills development. In this context the teacher role shifts to one of facilitator and orchestrates learning. In this study this took place through repurposing the learning environment to engage learners in learning through authentic group based assessment in and out of the classroom. Beyond the class based environment learners had access to a group space housed on the institutional managed learning environment intended to support their group based learning, in addition to access to the research undertaken by the adaptive research group, with a specific focus on robots both Human-Robot-Interaction and Human-Computer-Interaction.

Human-Robot-Interaction (HRI) is defined as “a field of study dedicated to understanding, designing, and evaluating robotic systems for use by or with humans. Interaction, by definition, requires communication between robots and humans” (Goodrich, 2007:204).

Human-Computer-Interaction (HCI) is defined as “a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” (Hewitt et al. 2014:5).

3. The Case Study

An exploratory case study design was utilised and commonly used to undertake qualitative and quantitative inquiry (Yin, 2003). The case reported in this paper took place on a Human Computer Interaction module; an elective chosen by postgraduate learners studying a Masters in Computer Science. 23 learners studied the module and were given the opportunity to work in groups of 3 or 4 allocated by the teacher. The students undertaking this were predominately from overseas.

Assessment Design

The overall learning outcome is to apply the tools, techniques, standards and guidelines needed to build and evaluate interactive systems. The module and assessment completion was over one semester. Learners were required to design a user interface for one of the robots under study by the adaptive research group the descriptors are provided below. There was one group based assessment which was supported by a series of mini-projects and a private group space housed on the institutional managed learning environment and intended to be used as a resource to support the group based assessment.

Indeed, its use was necessitated by the fact that learners were required to upload their mini-projects to share in class to obtain feedback on their learning.

The assessment specification was designed to align with the topics delivered on a weekly basis in the lectures, delivered to learners in the first week of the semester and due for submission at the end of the semester. The series of mini-projects was designed to align with the assignment specification. The learning activities within the assessment were a mix of individual and group tasks as outlined below and designed to be authentic based on learner engagement with research and access to the research centre, research group and the robots. At the same time, the assessment was designed to promote reciprocity, dialogue, participation and mutual engagement within and between groups. Within groups this was made possible by designing the activities to be divisible between learners and this required their interdependence. Across groups of learners the mini-project approach necessitated specific components of the assessment be showcased to peers in class as work progressed to obtain feedback from the tutor and peers alike.

The assignment specification comprised a mix of individual and group tasks. The basic features of robots and tasks are described below. Student teams were expected to choose ONE of these and add to the basic functionality based on their own research findings. The overall task was to develop a web based interface to interact with the robot chosen by learners. This necessitated the need for learners to access the robots to help ascertain further requirements, to analyse and evaluate the robots in order to design a user interface to be used by a non-technical person. Learners were required to perform and report suitable user and usage modeling and task analysis. They were not required to program their designs rather a prototype of usable interfaces using storyboards and screenshots and/or sketched drawings of representative and relevant screens clearly explained was expected. The following provides a brief overview of the robots and possible tasks to be chosen by the students.

3.1 Care-O-Bot

A general purpose domestic service robot Care-O-Bot (Website, 2016) has been developed to do a number of useful tasks around the home (Reiser et al. 2013). The robot has a carrying tray fitted, a chest mounted touch sensitive display, speech synthesis available (but not recognition) and could be fitted with a simple expressive head or indicator lights if required. The main tasks it can perform include: general fetching and carrying, following a user, reminding, vacuum cleaning, opening doors, greeting visitors and showing them in (if recognised), greeting delivery people and carrying letters and packages to the user. The robot also has the capability to learn from previous tasks and schedules, so will also make suggestions for tasks at appropriate times.

Task - The robot is WiFi/www enabled, so a web-based interface is required which would be useful for the user to control the robot if it is not present in the room. The web-based user interface should allow regular users/house occupants to control the robot in a natural and user friendly way.

3.2 KASPAR

KASPAR is a small child-sized robot used primarily for providing therapy for children with autism (Dautenhahn et al. 2009). A new model has recently been developed for use by non-robotics specialists including therapist and teachers.

Task - The robot is primarily controlled over WiFi and it is proposed that a suitable web-based user interface is to be developed. The interface is to be accessed through a standard browser and should be usable from a wide range of browser equipped devices (PCs, tablets, mobiles etc.). The functionality of the interface should allow the user to control the position of each of KASPAR's actuators individually: eyes (up/down, left/right), eyelids (up/down), waist (left/right), right and left shoulders (forward/back, up/down), elbows (up/down) and wrists (twist right/left). KASPAR can also speak and play music. Sets

of actuator (joint motor) positions should be able to be learned (stored) as “poses” and learned poses and sounds can then be “played back” in a defined order together to form extended action “sequences”.

3.3 Baxter

The Baxter robot (Baxter Website, 2016) is a light industrial stationary robot which has two compliant manipulator arms. Unlike most other industrial robots, the compliant actuators, and advanced software and control allow it to be used safely in the presence of humans. It is designed to perform various pick and place tasks; either autonomously, or co-operatively with, and in close proximity to human co-workers.

Task - A new board game playing system is being developed and has been prototyped using the Baxter robot. Currently it can play Draughts (Checkers) and Chess on the same board (different pieces). The robot has a manipulator (arm) which is used to make moves on a physical board, with the human opponent(s) either making their own moves, or the robot can sense the current board positions and configuration by means of a camera/vision system. The robot has a small (10”) touch screen display mounted on its chest. The robot can play by itself autonomously, or alternatively there could be a remote human controlling the robot through a web-based interface. A web-based user interface for the remote human player is required, which incorporates the capability for the local and remote human players to both play the game, and also interact socially while doing so.

3.4 CHARLY

CHARLY (Companion Humanoid Autonomous Robot for Living with You) is a robot that can be used as an “avatar” (among other functions) to provide a remote user with a physical presence at an office location which may be located many miles away from the user’s actual location (Walters et al. 2012). The underlying technology has been developed and the following are currently available by typing in commands at a console:

- Ability to autonomously navigate safely around a remote office building location. Each known room or location has a name and it is sufficient to provide the name of a place for CHARLY to navigate to that place. The robot can move safely by itself from room to room, avoiding obstacles and people. It can also send a map image, with its location marked, to the user via an internet connection.
- Can also be moved by the remote user by direct user control. However, pre-emptive collision avoidance behaviour will still be active, so it will not be possible for the user to make the robot collide with people or objects, or to drive down stairs etc.
- A head-mounted wide angle camera is fitted so a streaming video of the robot’s immediate environment can also be sent to the remote user via the internet connection. The direction (pan and tilt) of this camera can also be controlled by the remote user.
- A head display is fitted, where a remote user’s face can be projected onto the robot (via Skype or Webcam). It also has a microphone and loud speaker so that the remote user can participate in conversations with other people at the office location.
- The robot has a number of pre-defined gestures (pointing, waving, etc.) which can be called up by typing the name of the gesture to be performed.

Task - A web based user-interface was now required which would allow any non-technical remote user to control CHARLY in order to move it around an office building to named locations, interact with other people using sound, video and gestures. Also to allow the user to take (limited) direct control over CHARLY as indicated above.

In addition to the development of the human-robot interface by learners, they were required to underpin their work with suitable scholarly research and to make informed and critical choices amongst their research findings in order to help justify and explain their approach to the robotic interface design. This

was in keeping with the research-oriented nature of this practice whereby students engaged in research-informed learning.

4. The Study Findings and Discussion

Quantitative and qualitative data was obtained from a post module questionnaire. Twenty out of a possible twenty three learners completed the questionnaire, which was undertaken in order to measure learners' attitudes and the impact of the teacher role. The questionnaire comprised eight questions, with question 8 in six parts (a to f) and space for open ended comments. Table 1 below provides short details of the questions asked.

The learner responses were provided using Likert scales (Likert, 1932) and each participant rated each question as 5 = "Agree Very" to 1 = "Not Very". Table 1 indicates the Mean, Standard Deviation, Median and Mode average values for the learners for each question. The Mode (N) values are the number of responders' who selected the Mode (most popular) value for each question. The mean, median and mode values are in close agreement, which indicates that the distribution of the responses was relatively normal, given the small sample size, though skewed towards moderate "Agree" with regard to the respective questions. This also may be indicative of "confirmation bias" effect being present in that all positive answers required a high rating and negative responses a low rating.

It can be seen in table 2 that Q2 had the lowest mean rating (3.4), and also one of the highest Mode (N), indicating that 8 of the 20 learners rated Robot Access as relatively poor. The chart in Figure 1 illustrates the relationship between the mode, median and Mode (N) values for each question more clearly.

The qualitative data provides some insight into student dissatisfaction with access to the robots. A learner stated *"Can't take pictures with it"* [sic] and two learners commented that they did not have enough access. This may be due to student absenteeism or a need for the teacher to revisit the information provided to learners. Two of the robots, KASPAR and Care-O-Bot, were housed in the Adaptive Systems research group labs with access by special appointment. These robots were also being used continually by postgraduate students and researchers for their current work, so both these factors probably affected the availability of these robots for access by students.

Positive comments included *"Access to the robots in the robotic laboratory supported my study greatly as it let me have hands on practical experience in robotics"* [sic] and *"It helped me to be more clear and understand how to design"* [sic].

This was deemed a positive outcome especially given 12 out of the 20 learners stated that access to the robots supported their learning. The emphasis on research-informed teaching via access to robots to help learners study, analyse and evaluate in order to capture, clarify and validate the requirements to develop the human robotic interface and complete the group based assessment was paramount. The intention was to provide learners were with access to the research centre and the robotics laboratory to help progress and complete the group based. As explained in the introduction, in this study, we were particularly interested in supporting learners studying a Human Computer Interaction module in the completion of their group based assessment to design a user interface for the robots.

Related to Q.5 in table 1. 16 out of the 20 learners agreed or strongly agreed with the statement "Using Robots was a novel approach to teaching" reasons provided included:

"I totally agree that using robots was one of the best things we have experienced by this module" [sic].

"I really enjoyed the teaching, the teachers made everything very interesting, using the robots was exciting and helped develop the interface" [sic].

A learner's comments related to Q6 included *"Looking at the robots and understanding what it does and how it does it, was the turning point for me to do this module"* [sic].

The learning design was intended to progressively encourage learners to become active enquirers and researchers which was necessary to solve problems for assignment completion. The intention also was to inspire learners to collaboratively develop their work based on authentic research processes within

the field of Human Computer Interaction and Human Robotic Interaction in the discipline of Computer Science. This was to provide opportunities for master students studying the Human Computer Interaction module to access current research to motivate, encourage and support the nexus between research and teaching.

Relating to Q8a a learner comments *“Mini Projects helped me to go that extra way to the main project”* [sic].

Q8b *“Assessment feedback was the best way to improve my weakness”* [sic].

Q8c a learner comments *“By looking at other students work presentation help me understand”* [sic].

Q8d *“Working with a group was the best idea. Learned a lot”* [sic].

Q9e *“Individual task was challenging and intellectually stimulating”* [sic]

Q8f *“Group task was very tough, it made me learn how to tackle a problem with a team”* [sic].

The group based assessment was designed to specifically place the students at the centre of their learning, to empower them to work productively as a group and progressively use a mini-project approach which required groups of learners to present their work to their peers as it progressed in the class based learning environment. Emphasis was placed on students to social interaction and active engagement in their own learning. The authentic learning design embedded an assessment for a learning approach which encouraged learner participation in giving and receiving feedback on their work as it progressed, reciprocal learning was key. Dialogue and stimulating learners through authentic learning tasks were also key as was access to cutting edge research being undertaken in the adaptive research group related to human robotic and human computer interaction. appears. These factors appear to have challenged and engaged learners.

Table 1 Overall Question Averages for all Participants (Agree: 5= Very Much, 1=Not Very

Q_Num	Question	Mean	Std Dev	Median	Mode	Mode(N)
Q1	Robot it motivated me?	3.9	0.8	4	4	11
Q2	Robot access supported me?	3.4	1.1	3	3	9
Q3	Research Centre access supported learning	3.8	1.2	4	4	8
Q4	Module informed by research?	3.9	1.1	4	5	7
Q5	Robots novel for teaching?	4.0	1.1	4	4	8
Q6	Robots kept me interested?	3.8	1.2	4	5	7
Q7	Learned a lot on this module?	3.7	1.2	4	4	6
Q8a	Seeing other students work useful?	3.8	1.1	4	4	7
Q8b	Tutor assessment feedback useful?	4.0	1.1	4	5	8
Q8c	Other students' assessment feedback useful?	3.8	1.0	4	4	8
Q8d	Working in a group?	4.0	0.9	4	4	12
Q8e	Individual tasks useful?	3.7	1.2	4	4	7
Q8f	Group tasks useful?	3.8	1.2	4	4	8
Overall Means:		3.8	1.1	4	4	8

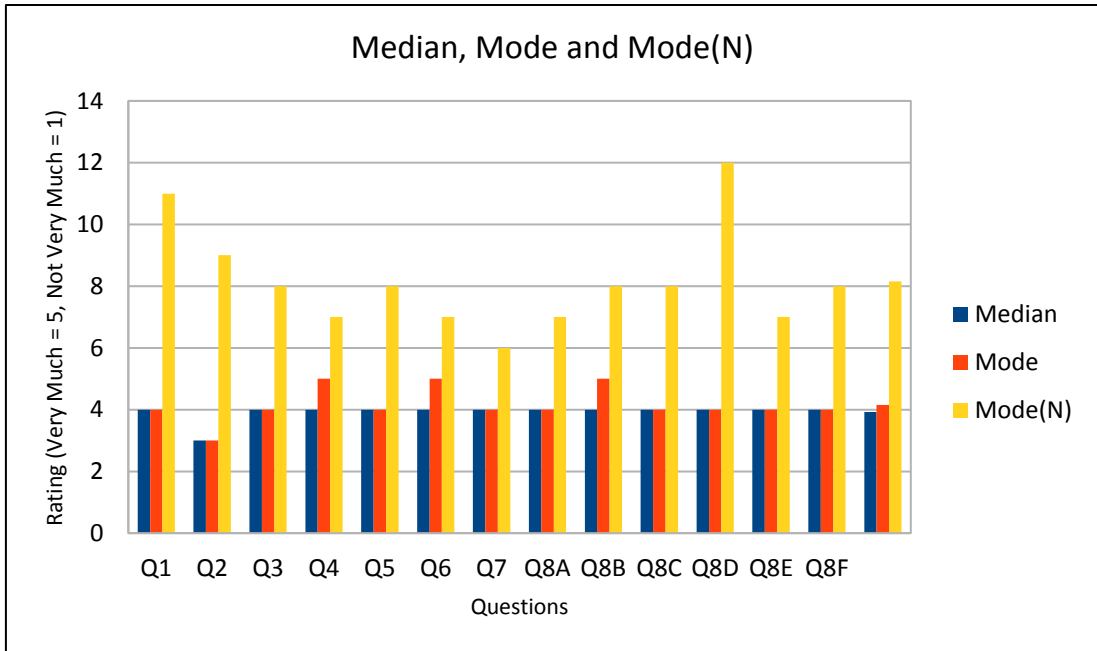


Figure 1: Median, Mode and Mode Frequencies for Question Responses 1 to 8(f). Note

Paired T-tests (generally considered acceptable for ordinal ranked data sets) and Wilcoxon Signed Rank tests (stricter test for ordinal ranked data sets) both indicated that there were no statistically significant differences for individual students regarding their responses to the eight questions, so it can be surmised that as a group they were relatively homogenous. This was reinforced by the results from a series of between question, paired Pearson R Correlation tests which found a number of significant correlation effects between question responses for the group as a whole. See Table 2 for the Pearson R test results, with strong correlations effects highlighted in bold. Note, usually an R value of over 0.35 indicates a relatively strong correlation. It can be seen that there were strong correlations between participants' responses in particular for Q1 and Q2. Those who reported that the Robotics Project was motivating, also found that access to the robots supported their work, and also conversely that lack of access hindered their work. This supports the remarks made by some students (in the Qualitative

Evaluation) that they had found difficulty in accessing the robots. Other correlations to note were between:

- Q3 and Q8 (a to f): Students who rated the Research Centre access useful, also found Tutor and Student Feedback, group working and individual set tasks useful.
- Responses for Q4, Q5, Q6 and Q7 were all positively correlated with each other. In particular Q4 (Module informed by research) was correlated positively with rating (Q5) Robots Novel, (Q6) Interesting, and (Q7) Learning a lot on the module.
- The student responses to Q8 (a to f) were all positively correlated, indicating students generally found group-work combined with teacher and fellow student feedback, was useful.

Table 2 Pearson R Correlations: Pairwise for Individual Participant's Question Responses

Question	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8a	Q8b	Q8c	Q8d	Q8e
Q1	1											
Q2	0.597	1.000										
Q3	0.485	0.588	1.000									
Q4	0.629	0.600	0.200	1.000								
Q5	0.480	0.498	0.144	0.710	1.000							
Q6	0.731	0.651	0.195	0.780	0.657	1.000						
Q7	0.591	0.712	0.186	0.674	0.477	0.771	1.000					
Q8A	0.399	0.243	0.402	0.352	0.121	0.091	-0.008	1.000				
Q8B	0.602	0.411	0.573	0.204	0.129	0.366	0.273	0.425	1.000			
Q8C	0.463	0.535	0.516	0.360	0.242	0.346	0.367	0.761	0.544	1.000		
Q8D	0.655	0.419	0.535	0.303	0.209	0.498	0.586	0.363	0.626	0.603	1.000	
Q8E	0.364	0.426	0.541	0.398	0.151	0.226	0.237	0.722	0.599	0.744	0.488	1.000
Q8F	0.557	0.484	0.799	0.137	0.116	0.325	0.342	0.380	0.782	0.634	0.847	0.576

Note: anything above 0.350 is considered significant (Bold)

Learning was measured using the learner's performance on the assessment. The full range of marks were obtained by learners with the maximum mark of 83 and the minimum of 39. The pass conditions for the module were pass the assessment overall at ≥ 50 marks.

5. Conclusion

In this study, repurposing the learning environment to engage learners in learning through authentic group based assessment in and out of the classroom resulted in a positive learner experience and performance. Overall, both the students' free-form remarks (Qualitative) and Quantitative (Likert scale ratings etc.) results indicate that the learning experience for the learning environment (i.e. group-work with continual student and tutor led feedback, along with the real-research robot task based project approach) has been appreciated by the students. Access to the research undertaken by the Adaptive Systems research group, with a specific focus on robots, including both Human-Robot-Interaction and Human-Computer-Interaction, added value to the learner's experience. Some learners complained that problems in freely accessing the particular robot that was the subject of their project work had adversely affected their experience, and this was tentatively supported by the quantitative analyses findings. However, as no data on the students' Robot Task chosen or project group composition was collected, this result is speculative.

For studies of this type in the future, it is recommended to make some changes to the study procedure and questionnaires in order to allow for a more detailed analyses to include the project task and learner group composition to be examined for effects, and also to refine the range and scope of the statistical analyses This study raises several questions, which are left for future work.

Overall, it has been shown the pedagogical approach used underpinned by Research to Inform Teaching was valued by the learners. The pedagogical blend included the assessment design and the teaching and learning practice was informed by current research taking place in the School of Computer Science at the University of Hertfordshire. Providing learners with access to the Research Centre and the robotics house to study the robots helped learners to progress learning and complete the group based assessment.

This study adds to the debate on Research Informed Teaching providing a pedagogical approach embedded in research to inform teaching practice in order to enhance the student learning experience. As has been shown, Research Informed Teaching is specifically of importance across the United Kingdom at university level.

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