

ESRC End of Award Report

For awards ending on or after 1 November 2009

This End of Award Report should be completed and submitted using the **grant reference** as the email subject, to <u>reportsofficer@esrc.ac.uk</u> on or before the due date.

The final instalment of the grant will not be paid until an End of Award Report is completed in full and accepted by ESRC.

Grant holders whose End of Award Report is overdue or incomplete will not be eligible for further ESRC funding until the Report is accepted. We reserve the right to recover a sum of the expenditure incurred on the grant if the End of Award Report is overdue. (Please see the ESRC Research Funding Guide for details.)

Grant Reference	RES-139-25-0400					
Grant Title	Synergynet: supporting collaborative learning in an immersive					
	environment					
Grant Start Date	1 st Oct 2008	Т	otal Amount		£1,291,817.68	
Grant End Date	31 st Dec 2012	E>	kpended:			
Grant holding	Durham University					
Institution						
Grant Holder	Prof E L Burd					
Grant Holder's Contact	Address Email					
Details	Durham University	Durham University		Liz.Burd@dur.ac.uk		
	South Rd, Durham			Telephone		
	DHI 3LE			0191 3341719		
Co-Investigators (as per project application):		:	Institution			
D A Hatch			Durham University			
Dr J Adams			Durham University			
Prof S Higgins			Durham University			
Prof J Elliott			Durham University			
Dr S Smith			Durham University			
Prof M Munro			Durham University			

Please refer to the Guidance notes when completing this End of Award Report.

I. Non-technical summary

Please provide below a project summary written in non-technical language. The summary may be used by us to publicise your work and should explain the aims and findings of the project. [Max 250 words]

This research has resulted in the development of:

1. A new IT rich classroom of networked multi-touch tables, a teacher control and a set of 58 pedagogic applications for use within the environment that can be easily adapted by teachers to teach a broad range of curriculum topics. 25 classes have been taught within the environment impacting over 300 students.

2. A new integrated pedagogy which, by enabling easy transfer between teacher-centric and pupil-centric activity, and between independent and collaborative activity, demonstrated positive impacts on learning (Mercier, Higgins, Burd & Joyce-Gibbons, 2012; Mercier & Higgins, 2013).

An open-source research data-capture system which enables researchers to automatically capture video and audio data, simultaneously record user-interactions with multi-touch technology and enable simultaneous review of any number of data-streams from cameras and tables etc. This software has been downloaded by 237 external researcher/developers.
A data repository of classroom activity in which we recorded pupils' and teachers' collaborative exchanges (verbal and non-verbal) as they used SynergyNet. We captured 4.77 terabytes of data and used this to inform the evaluation, evolution and demonstration of our research.

2. Project overview

a) Objectives

Please state the aims and objectives of your project as outlined in your proposal to us. [Max 200 words]

Aims

I To create a radically new technology-rich learning environment that integrates traditional classroom layouts and collective activities.

2 To design and implement a new form of user interface for educational multi-touch systems.

3 To formulate a new pedagogy that eases transition and movement between teachercentric and pupil-centric interaction.

4 To analyse pupils' learning strategies to inform fundamental research by capturing data as pupils use the *SynergyNet* environment.

b) Project Changes

Please describe any changes made to the original aims and objectives, and confirm that these were agreed with us. Please also detail any changes to the grant holder's institutional affiliation, project staffing or funding. [Max 200 words]

There were no changes.

c) Methodology

Please describe the methodology that you employed in the project. Please also note any ethical issues that arose during the course of the work, the effects of this and any action taken. [Max 500 words]

This research project included a substantive element of computer engineering. At the time of the project commencing multi-touch tables were not available for purchase; to ensure the tables worked efficiently we worked with two companies to design and build them. NUI supported the development of the multi-touch hardware while NESS ensured that the build matched the needs of multi-touch and was robust for school use. The software was co-developed alongside the hardware, as was the data collection software and associated data collection infrastructure (camera etc.). Research outcomes associated with technologies used within the software design, technical solutions identified and specific optimizations were collected during the developmental phase and disseminated as appropriate.

The initial education research focused on whether using multi-touch technology influenced the learning or collaboration processes for groups of students. Using a within- and between-subjects design, groups of students completed tasks on multi-touch tables and paper. Video data was collected and analyzed using emergent and pre-existing coding schemes to determine whether there were differences in the interaction and reasoning processes across condition. Later studies, which focused on the development of the classroom required a design research approach to allow for the iterative design and testing of the learning opportunities (Cobb et al, 2003; Shavelson, et al, 2003). These studies used a combination of designs, including experimental design, comparing students using the multi-touch classroom with students working on traditional activities in their own classroom, observational studies and video-analysis of groups learning in the multi-touch classroom and prior experiences with collaborative work.

During the education data collection, ethical issues arose when only some students from a class could be brought out to experience using the multi-touch tables. This was addressed by inviting the rest of the students to visit the multi-touch classroom on another day.

The psychology team used a within-subjects experimental design to explore differences in the way groups of students worked when they completed tasks on a multi-touch table, paper and traditional desktop. Participants were also tested prior to the study, and grouped according to measures of working memory, to allow for the comparison of processes in groups with all high, all low, or mixed levels of working memory.

d) Project Findings

Please summarise the findings of the project, referring where appropriate to outputs recorded on the ESRC website. Any future research plans should also be identified. [Max 500 words]

Education/collaborative learning findings:

- Using multi-touch tables supports joint attention and the development of a joint problem space for group problem solving; they are associated with higher levels of interactive statements (e.g. elaborating and negotiating) (Higgins et al, 2012).
- Multi-touch tables in a classroom setting can be used to support learning between groups of students, as well as within group collaboration, leading to increased fluency and flexibility with mathematics (Mercier & Higgins, 2013).
- Projecting the content of the student tables to the interactive whiteboard allows for whole class discussion about the task. This results in an increase in the level of reasoning that occurs within the groups when they return to complete the task (Mercier, Higgins, Burd & Joyce-Gibbons, 2012).
- A range of tools are necessary for teachers to successfully orchestrate learning in the multi-touch classroom; these classroom orchestration tools may be of use in other environments (Mercier, McNaughton, Higgins & Burd, 2012).
- The emergence of leadership in student groups appears to be systemically distributed among students, with some students taking on organizational leadership, while others take on intellectual leadership. Leadership roles change across content areas (Mercier, Higgins & da Costa, 2011; Mercier, Higgins & Da Costa, under review).
- Changing the orientation of the tables within the classroom (facing the whiteboard in a traditional manner, or inwards in a circular manner) influences the way the students act. Higher rates of problem solving are seen in the traditional classroom, while higher levels of collaborative interaction are seen in the circular classroom (Mercier & Higgins, 2012).

Computing findings:

- The design of the classroom identified new challenges and solutions regarding Human Computer Interaction and specifically orientation, reach, shared work spaces and connectivity (Smith, Burd, Ma, Alagha, and Hatch, 2011; Alagha, Hatch, Ma, Burd, 2010).
- The development created the first networked multi-touch environment allowing interactivity between tables and whiteboard (Alagha, Burd, Higgins, & Mercier, 2011).
- Real time capability was built into the environment to ensure the correct functioning of some apps requiring this capability such as music (Richardson, Burd and Smith, forthcoming).

Future Plans:

- Analysis of the use of the classroom by two teachers and their students for two days to understand how the teachers used the orchestration tools, how collaborative practices developed with multiple use of the tables.
- Analysis of the use of NumberNet by classroom teachers, specifically to understand the development of mathematical discourse during the final stage of the activity.
- Publication of findings that indicate tables can be used to create a shared representation of the group process.
- Creation of an above table gesture set for the manipulation of 3D objects.

e) Contributions to wider ESRC initiatives (eg Research Programmes or Networks)

If your project was part of a wider ESRC initiative, please describe your contributions to the initiative's objectives and activities and note any effect on your project resulting from participation. [Max. 200 words]

Members of the group have participated in 9 TLRP TEL meetings. In addition, the Durham team hosted a two-day Show and TEL for other members of the TLRP and selected TEL researchers.

The TLRP community developed small special interest networks to facilitate collaborative activity. In this regard, on the 14th May 2009 and July 20th 2010, two meetings with Echoes2 were held to discuss the effective use of technologies common to the projects.

A small amount of funding was made available to contract a researcher to support some specific research on the benefit of SynergyNet to early year students. This was led by a member of the TLRP Steering Committee, Lydia Plowman. This led to close collaboration between Durham and Stirling.

In total 9 PhD researchers have completed their study within our research group, and 3 are due to submit within the next two months. In addition, 2 research masters students and 8 undergraduate students have completed their study using the SynergyNet environment. A small number of students will continue to research in this area. These students participated within a number of TLRP events and particularly the junior researcher forums held in Oxford.

3. Early and anticipated impacts

a) Summary of Impacts to date

Please summarise any impacts of the project to date, referring where appropriate to associated outputs recorded on the Research Outcomes System (ROS). This should include both scientific impacts (relevant to the academic community) and economic and societal impacts (relevant to broader society). The impact can be relevant to any organisation, community or individual. *[Max. 400 words]*

These include:

Academic impact: 16 academic publications and over 25 scholarly seminars, presentations and keynotes. Including The World Technology Summit (2012); Teacher's College, Columbia University (2012); Stellar Surface-Learning Workshop (2012); SRI International (2012); Toronto University (2012), Stanford University (2012); Finnish Education Research Association Conference (2011); Interactive Mobile and Computer Aided Learning, Jordan (2009)

Our open-source software has been used by other researchers, including by a team from the University of Oslo. Our table software has been downloaded by researchers / developers 77 times and our data capture software 237 times.

Industrial enterprise: We have worked collaboratively with the furniture manufacturer NESS to design and manufacture the tables we use in our classroom. This relationship was strengthened by a grant of $\pounds 15k$ from OneNorthEast. Our work with NESS evolved into a very productive relationship where both parties received genuine benefit. NESS' contributions allowed us to conduct our experimental work with tables meeting the health and safety requirements of schools several years before commercial availability. In turn, their involvement has enabled them to bid for capital funding to support business-use of multi-touch.

A further grant of £15k from OneNorthEast was received to make Timemaps software compatible and marketable with our infrastructure.

Visits from Promethian, Smart and Pearson resulted in benefit to all parties including Promethian donating one of their first multi-touch boards for us to use and evaluate its usability.

Society: Our infrastructure and sets of the 58 pedagogic applications have been used to teach 25 classes impacting over 400 students. We have received in excess of 100 visitors including those from the US, China and Australia.

Media interest: 26 news stories about the classroom in Autumn 2008 including The Times, Guardian and BBC which included a special report on Newsround.

Media uptake of Learning and Instruction online publication in November 2012 (June 2013 print date), resulted in over 60 news-sites internationally developing the story, including BBC, The Times, Reuters, and Wired.

Social media interest: Considerable interest has been raised throughout social media outlets. This includes: 48.5k YouTube and 21.5 blog hits and annually approximately 4.5k hits to our web site. Recently over 9000 views resulted from the YouTube video from the November 2012 media campaign.

Higher Education: our research and classroom have been used to provide short-courses for Durham University Engineering and Computing Sciences undergraduate programme 'Technology for the Modern World' and the Education postgraduate programme '21C technology'.

b) Anticipated/Potential Future Impacts

Please outline any anticipated or potential impacts (scientific or economic and societal) that you believe your project might have in future. [Max. 200 words]

Both Promethian and Pearson have been to visit close to the end of the project and expressed a desire to learn from our research and to take them on board. They are exploring ways in which we can continue this collaboration.

Since the start of this project it is clear that hardware providers have changed the direction of their business model away from individual surfaces to networked solutions. At the start of the SynergyNet project both stated they intended only to market individual surfaces; now both are following our networked classroom concept. It is, however, very difficult to assess to what extent SynergyNet resulted on their business model changes.

You will be asked to complete an ESRC Impact Report 12 months after the end date of your award. The Impact Report will ask for details of any impacts that have arisen since the completion of the End of Award Report.

To cite this output: Burd, L, *et al* (2013) SynergyNet: Supporting Collaborative Learning in an Immersive Environment ESRC End of Award Report, RES-139-25-0400. Swindon: ESRC.

4. Declarations

Please ensure that sections A, B and C below are completed and signed by the appropriate individuals. The End of Award Report will not be accepted unless all sections are signed. Please note hard copies are **not** required; electronic signatures are accepted and should be used.

A: To be completed by Grant Holder

Please read the following statements. Tick **one** statement under ii) and iii), then sign with an electronic signature at the end of the section (this should be an image of your actual signature).

i) The Project

This Report is an accurate overview of the project, its findings and impacts. All co- X investigators named in the proposal to ESRC or appointed subsequently have seen and approved the Report.

ii) Submissions to the Research Outcomes System (ROS)

Output and impact information has been submitted to the Research Outcomes	Χ
System. Details of any future outputs and impacts will be submitted as soon as they	
become available.	
or	
This grant has not yet produced any outputs or impacts. Details of any future	

This grant has not yet produced any outputs or impacts. Details of any future outputs and impacts will be submitted to the Research Outcomes System as soon as they become available.

iii) Submission of Data

Data arising from this grant have been offered for deposit with the UK Data Service.	X
or Data that were anticipated in the grant proposal have not been produced and the UK Data Service has been notified.	
or No datasets were proposed or produced from this grant.	