

Final Report for IATL Project Reference 11-12/PI/Russ

Pedagogic Intervention grant: *A personal introduction to linear algebra.*

(July 2012, lead applicant: Steve Russ, Computer Science)

Background

The internal title of the project was *Empirical Modelling Interactive Learning Environment* (EMILE).

This project was a hybrid project with a slightly complicated history. It began with the award from IATL in November 2010 of an Academic Fellowship *Constructivist Computing for a Mathematics Learning Environment* with a start date of January 2011. The original aim of this project was ill-conceived as detailed in separate 'Reflections' from myself and co-investigator Meurig Beynon in February 2012.

By that time we realised that much of the learning experience we sought for in our environment would not be 'using a product', but rather be a *constructing experience* using suitably prepared resources (software artefacts and interfaces). Following discussions with Paul Taylor the project was re-oriented towards working directly with students. It then became a Pedagogic Intervention grant entitled *A personal introduction to linear algebra.*

This report, which combines a progress report with a final report, should be read in conjunction with the web page at:

<http://www2.warwick.ac.uk/fac/sci/dcs/research/em/EMILE/>

This web page was set up before the project began and was developed and maintained by Meurig Beynon who also maintained the pages linked from the final paragraph - being notes for a project report and notes for a research publication. The main web page contains images, links to artefacts made during the project, and details of practical procedures, schedules, exercises and tools used during the project.

Note that the URL links on the pages should be active though access to some of the directories mentioned on the webpage requires access to machines in Computer Science. Any documents referred to there can readily be made available through email on request.

There is an Appendix to the report on Feedback and Finance.

Overview

We recruited 8 of our CS students who worked for two weeks full-time in July 2012. A photograph and names of the team are on the webpage. Their task was to construct for themselves the artefacts needed for the learning intended (the domain was linear algebra). This required reflection on their own learning and the identification of suitable 'stages', or intermediate learning goals, around which concepts and methods were clustered. The analogy of a journey – traversing and charting a new territory – was useful, as was the analogy of a 'plot' in a drama in which the learners were like actors (not audience) and the action was separated into scenes. Naturally the 'clusters' of material (textual and software artefacts) made by different students had many similarities, but like any learner's notes they were also personal and provisional. The project demonstrated the possibility of such personal constructions, and that constructions by different authors could be merged. This demonstrated the potential for collaborative working and for construction experiences lending themselves to different learning styles. Another feature of the tools used for the construction is their preserving a record of the entire history of interaction – and therefore of the thought processes involved. We did not exploit this on the project but it is pedagogically and personally significant.

The students worked as individuals and in pairs or triples. Initially we were organised as a learning team (six 1st years who had recently taken a module CS131 which included a large section on linear algebra) and a technical team (two senior students with good experience of our tools and my colleague Meurig Beynon). I was in the role of co-ordinator. The broad idea was for the learning team to construct (with help from the technical team) artefacts to embody or illustrate the concepts and methods of each of their learning 'clusters'. The boundaries between teams and groups became quite fluid as the first year students started to use the tools themselves. The learning team had been recruited in March 2012 and they had had four (unpaid) sessions of preparation before July about our approach and tools.

The internal working title for the project, EMILE (Empirical Modelling Interactive Learning Environment), was a reference to Rousseau's novel of that title in which the theme of 'ingeniously guided discovery' is prominent.

Assessment and Outcomes

The decision to work directly with students was a good one for the investigators and good also (judging by written and oral feedback) for the students. Everyone seemed to find the experience generally enjoyable and itself a learning experience. The feedback showed that more time in preparation would have helped students appreciate why we were adopting our approach and tools. The timing of the project meant that examinations limited the scope for such preparation.

Although the goal of the project was clear enough we had little idea of how far we could get with the tools available within two weeks. We achieved less than I expected in terms of models or artefacts built. The technical, performative challenges presented by the use of our tools were greater than I expected, though the perseverance and goodwill from the students was also greater than I expected. The basic conceptual principles of our approach to learning of beginning with simple concrete construals and elaborating these through personal construction with observables and dependencies became clearer to me through the work we did. The overall experience of the project left me more confident of the potential and power of our approach, but also more aware of the practical challenges still to be overcome in making the tools widely accessible.

An interesting (though predictable) theme over the project was the disparity, and the relationship, between the concern of lecturers for 'understanding' and the concern of students for 'performance'.

The outcomes can be summarised as follows:

- Some artefacts which embody 'samples' from the learning domain – such as vector addition, subspaces, matrices, and eigenvectors
- Some examples of the merging of models and a 'merging tool'
- An outline, with some key issues and questions, for a research publication arising from our work. This would benefit from further progress with practical examples – there are some enthusiastic collaborators in Thailand who we hope will help to take this forward.
- On final day or two of the project we developed a vision for a very 'rich' kind of module Notes for students, to be read in a browser. Such Notes could include extra 'commentary' windows, examples, images, web links, small interactive models, videos etc. In discussion students emphasised the value of short videos (undoubtedly right, and easily exploited). We demonstrated practically that videos can be included in a JS-EDEN script.
- Impetus and motivation for improved versions of our new tool JS-EDEN. (This has already happened and is on-going – with practical benefits to students to our MSc/MEng module last term in Autumn 2012.)
- Web page with further links and details as above
- Development of a 'cloud' of supporters who would like to see this work progressing with improved tools and examples of artefacts and resources. The project has been sufficiently positive to encourage this and future work on the main goal.