Anthrobotics: Science-by-Doing in Higher Education

Mike Reddy, Neil Hughes, Naomi Turnbull
Centre for Astronomy and Science Education
School of Applied Sciences, University of Glamorgan,
Trefforest, Pontypridd, RCT. CF37 1DL Wales, UK
+44 (0)1443 482 240
mreddy@glam.ac.uk

ABSTRACT

This work-in-progress report gives a short account of the development of a final year science degree module, called Anthrobotics, which incorporates both a "hands-on" approach to understanding science and technology, and reflective practice on educational theory. The module is based upon Activity Theory (AT) and Participatory Design (PD), where the learning community is crucial and the traditional lecturer-student power relationship is deliberately eroded. Students engage in peer-supported, challenge based learning (ChBL) and peer-negotiated assessment. The use of new technologies adds to the innovative nature of the module by improving a range of ICT skills, such as digital video editing, multimedia, and web design, as well as computing and engineering skills, with no prior experience. Students also reflect on their learning experiences, and set personal learning objectives by means of a learning log. The module is time intensive, but is cost effective in contrast with traditional science and engineering courses, requiring fewer resources than traditional lab based modules. Previous students have volunteered to work as tutors, supporting community participation by learners in the design process. This has resulted in changes to the structure and content of other modules taught in the School of Applied Sciences at the University of Glamorgan.

Categories and Subject Descriptors

K.3.1 [**Computer Uses in Education**]: Collaborative learning.

Keywords

Anthrobotics, participatory design, activity, technology enhancement, challenge-based learning.

1. INTRODUCTION

The episodes described in this paper are concerned with the last two years of teaching the Anthrobotics module. The setting is the Centre for Astronomy and Science Education (CASE), based in the School of Applied Science at the University of Glamorgan. CASE is an innovative centre with staff from a range of educational backgrounds, but all committed to supporting access to science for non-traditional students, and fulfilling the widening access agenda common in new universities in the UK [1]. The CASE BSc awards in Science and Science Fiction, Astronomy and Space, and Science Communications have been widely recognised as being innovative in both content and delivery [2].

In PDC-04 Proceedings of the Participatory Design Conference, Vol 2, Toronto, Canada, July 27-31, 2004, under a Creative Commons license. CPSR, P.O. Box 717, Palo Alto, CA 94302. http://www.cpsr.org ISBN 0-9667818-3-X

Therefore, using traditional teaching practices would have been inappropriate, given the scope of the module content. In order to expand the range of transferable skills, students were exposed to multimedia and ICT, but the more unusual aspects of the module – multimedia portfolios, collaborative group work, and peer assessment at level III, contributing directly to the final degree classification of students – revealed tensions with the institutional administration. The use of PD was, therefore, applied to aid students to reflect on their own participation in active learning, and to see "how particular university procedures and policies affect issues of concern to the teaching staff (... the teaching and assessment of courses) so as to understand the concerns of different actors and jointly to agree improvements." [3].

1.1 Integrating Robotics with Educational Theory: A Brief History

The first instance of using a situated space simulation with a robotics-based problem solving activity was for the Glamorgan Space School, a 5 day residential workshop for 17 year olds from a variety of educational backgrounds. This was followed by a five week long series of one day workshops for year 5-6 primary school students, based at the Pontypridd Museum. A revised and extended version of this activity was repeated this year with students ranging from year 3-6, which has proved an interesting challenge in itself, due to the spread of educational and psycho-motor skills across the students. Application to younger audiences was also a factor with the collaboration on the BBC Family Robots Workshops, where the youngest participant was 3 years old! The range of activities involved has expanded from the use of iBook computers to provide basic programs for controlling the robots, to use of web browsers for research, filming and editing of digital video, and the creation of multimedia to present group progress reports and materials for final assessment. Figure 1 summarizes the range of transferable skills taught, and often self-taught or supported by student peers, in the Anthrobotics Module.

Figure 1: Transferable Skills in Anthrobotics

Specific Skills	Communication Skills	General ICT Skills
Programming, Electronics, Material Science and Design Engineering	Oral and Written Presentation, Desk-top Publishing and Digital Video	Web browsing & Internet searching, Web page authoring with HTML, Computer graphics and Computer animation

2. ANTHROBOTICS: SCIENCE BY DOING

The first delivery of the module was the subject of both informal and formal review by the lead tutor and the independent external examiner. Student feedback was extensive, consisting of learning

logs and overviews, which were part of the assessment. Students were given up to a total of 20% of the final subject mark for submission, rather than evaluation, of these learning logs, in order to encourage this element. Even at level III, final year students find it challenging to provide an honest and reflective account of their learning experiences, and while support was given to improve their logs, the quality of entries was not used as a summative assessment. The second delivery of the module was also the subject of a student-led evaluation, conducted by three students from within the cohort. Although this is only the second year that the module has been run, there have been substantial changes made in its content and delivery, and more are planned for next year. These revisions have been student-led, based on continual feedback, as well as inspired by the lead tutor's continued research and educational development. This has involved personal observations by the lead tutor, volunteer past participants acting as tutors, and the students themselves. The students concerned with the longitudinal study of their colleagues interviewed staff and students, and designed a questionnaire to determine student attitudes to a range of factors in the course: the effectiveness of the learning logs; appropriateness of the challenges; and, attitudes to the community spirit of the module.

2.1 The Lead Tutor's Tale

Mike has been working with educational applications of robotics for nearly six years, with most early efforts being underfunded and in addition to his regular duties. These activities have grown in scale and are now a mainstream part of his job, and Mike has been seconded for two years to an Objective 1 project that includes development of innovative uses of technology to aid scientific understanding of adult learners. However, he faced opposition from within the college to plans to extend the scope of outreach activities initial aimed at primary and secondary schools to be applied at university level before the module was recognised as a potentially ground breaking educational experiment and validated as part of the Astronomy and Space BSc. This has been recently supported with a £5000 grant from the University's Learning and Teaching Office, with match funding from the School of Applied Sciences. A key aim in setting up the module was strong support for the participatory development of a student-centred, collaborative community within the module. This is not to say that such an anarchistic environment has not proved challenging for Mike, as the traditional hierarchical power structure, where the lecturer sets assessments, and marking schemes, interprets them liberally and returns a student mark with little input from the students, aside from their attempts to satisfy often vague assignment criteria. Due to the level playing field, Mike has had to work hard to assert his dual role as part of the community, and an assessor of the individual effort. This has caused some interesting internal conflicts, but has also encouraged students to be far more actively involved in their own educational process. This has fostered renewed understanding of both the student and staff role in the HE environment, which has been beneficial to all. For example, during the first delivery of the module, the lead tutor's role as local expert on several aspects of the course were impossible to maintain, due to the student set challenges not being clearly and obviously solvable with the time and resources available. These were not trivial activities where everyone knew that the lecturer knew all the answers. Therefore, the initial level of student stress was quite high as assignments had an unknown quantity, common in "real life" but rare in university teaching. The experimental nature of the module as led Mike to seek out contributions from colleagues in the educational arena, yo invite guest lecturers and to take the students to educational and robotic conferences and workshops. Above all, Mike has learned to view the students, many of whom are mature students with extremely pertinent lifeskills, as a valuable and often overlooked resource. He has encouraged learners to help each other develop their skills and offer their views, readily acknowledging their input by rewarding mentoring in the assessment: students with a skill already are expected to share it, not just show they have it; students who make relative progress are judged by the improvement, more than the level of attainment. These skills are taught as and when students identify their resource needs, with co-mentoring from fellow students when skills can be shared. These mentoring activities are encouraged and rewarded in the marking scheme. These approaches encourage active learning and recognise that teaching others both grounds personal understanding and improves communications skills, which are hard to exercise in other, more competitive environments. More importantly, student feedback has served to challenge and influence the future delivery of the module. These activities have grown in scale, with funding from the Royal Society, the European Social Fund, and Setpoint Wales. Several invited papers on the subject have been presented at educational technology conferences and workshops, including RoboFesta, TechnoScience, the Campaign for Learning, and at the Open University.

2.2 Integrating the module community with HE needs

The content of challenges was less of an issue in the second year, because there was a precedent from the previous year. While students were again given the opportunity to decide the content of the challenges, it was the range of peer-negotiated marking schemes, with an emphasis on dedication, attendance and communication, which was explored. Some of the original challenges were revisited – the flying aerobot challenge being the most successful, which resulted in the lead tutor receiving a grant from the Royal Society to run a version, called "The Robotarium", with a local secondary school – but with a wide variation between the manner in which different teams were assessed on each challenge. This caused some difficulty and 'hand wringing' by the lead tutor, as some of the proposed marking schemes were difficult to implement in a way that was a fair reflection of the individual student abilities and contributions. Often the spirit rather than the letter of the marking scheme had to be adopted, because students were occasionally disadvantaged; one student spent a great deal of time working on documenting the other team members with video, excellently shot and edited, only to be given a total contribution of 5% for the video in his final mark.

3. PROVIDING CONTINUITY

3.1 The Volunteer's Tale

Neil is a graduate in combined studies and was taught on the Anthrobotics module in its first year of delivery. He has begun a PGCE in Further/Higher Education and volunteered as co-tutor on Anthrobotics this year, in order to accrue hours of teaching experience to satisfy the experiential component of his course.

Due to the student oriented agreement of challenges, and assessments, there is little opportunity to plan in advance, Neil has used his own experience of the module in order to develop and teach basic skills to give more pragmatic than theoretical support to the students. Having been introduced to PD while studying on the module in its first year, Neil has encouraged the active participation of learners in course development, mainly through discussions with individual groups about their final deliverables and marking schemes. However, several more focused sessions on specific skills, such as computer programming, were organised in response to requests from learners. Neil is now working on the second year of his PGCE and his role in CASE is being extended to include other science communication and outreach activities.

3.2 Integrating the module community with HE needs

HE in the UK has a strong tradition of focusing on measuring the individual by threshold assessment, rather than encouraging the collaborative support of peers that is a requirement of good business and community work environments; an example of this is the traditional attitude to plagiarism, collusion, and the insecurity felt about assessing the individual engaged in group activities. This means that most traditional HE courses offer little scope for extending the individual's responsibilities beyond their own personal requirements. However, there has been a growing need to situate educational activities in a wider context than the learners' personal experience, and to make them equally relevant to future employer/collaborators. Transferable skills, particularly communication skills are developed through a flexible requirement to disseminate the results of complex problem solving tasks through a range of different media; it should be noted that many students find it difficult to present in the traditional sense, where posters, videos and multimedia, with some more informal questioning can be just as lucrative as forcing them to engage in 'powerpointitis'. This is more creative, and fun for both students and staff, but has required assessment to be carefully matched to the official learning outcomes of the module, as defined by formal validation, accreditation and reporting structures necessary in the HE sector.

One means through which this mapping takes place is the individual Learning Log, where the student is encouraged to summarise educational experiences, set personal learning objectives and plan and review achievement of their progress and requirements during the course of the module. The log is an ongoing activity, with feedback and suggestions by the tutor that begins with the initial setting of 4-5 personal objectives, which may or may not map to the official learning outcomes of the module. Subsequent versions of the log are intended to review progress toward the long-term objectives, and were achieved to propose new or revised goals for the next few weeks. The log is also expected to constitute collaborative evidence for later summative assessment of the individual student, in order to support the distinction between members in a group activity. For example, a student may mention support from a mentor in a particular task, which would improve the assessed grade for the mentoring student. Furthermore, in cases where there is group conflict, the honesty, or at least the subjective opinion of a personal dialogue has allowed the tutor to intervene to improve group dynamics. These factors are especially useful in combating several common complaints against the use of group work in modules that contribute to a student's final grade.

At 6-10 weekly intervals, the students submit their logs for evaluation. These periods have matched roughly to the length of challenges, as well as the university calendar (e.g. end of term). This log of the learner's activities and achievements is expected to be updated at the end of each teaching session, but evaulation by the students themselves have sometimes questioned both the honesty and regularity of these revisions. Therefore, feedback leads us to believe that more regular submission and review, such as every fortnight, might be beneficial. The students are expected to develop their skills in writing the learning log, with no externally imposed formal structure, to encourage students to feel ownership and familiarity with their own writing style. This has led to some interesting developments buth in the students' literacy and personal empowerment, with some logs reading like a travel guide through their minds, and some reading like a professional executive summary document. Used in moderation at HE level, the learning log serves as a boundary object [2] that provides a useful communication conduit, both for the on-going tutor-student relationship and the formal requirements of the external examiner assessment of the module, such as for monitoring and discussion, and quality assurance.

This system of direct, but asynchronous, personal communication between the students and tutors around a mediating artefact has allowed more meaningful participation by the students in their own learning and in shaping the learning environment. They have provided a useful facility to 'let off steam' about the everyday activities, like teamwork, as well as the overall strategic goals of the module. The deliberate attempt by both tutors to encourage a flattened hierarchy has improved the community spirit of the module, and on occasion changed the nature of the learning experience quite radically. One such example being discussions on what challenges should be covered by the course, or what specific skills would require a formal training activity to be developed. The most prominent instance of this would be the voicing of concern over the relevance and theoretical underpinning of the module by one student's learning log, which led to a completely revised challenge to undergo an anthropological assessment of the module community by, with and for those students.

One future factor in the continued development of the Anthrobotics module is the extension of the module from a level III compulsory course, to being a shared level II and III module, with students being taught in tandem. At the final year, the module will be optional – the alternative being a double project, which might be more suitable for some students than the practical 'hands on' nature of Anthrobotics – but with the expectation that the more experienced final year students should provide continuity, and experienced mentoring for the second year newcomers. This will help improve the co-mentoring and peer-supported activities, so necessary for fostering a community spirit of collaboration. Another factor in development, supported by the Learning and Teaching Office grant, is the participatory development a shared archive of student achievements via a bespoke web site. This will server to highlight best practice, showcase the creative and innovative materials, often mutually developed by the students and staff. These co-created artefacts [3] can often blur the distinction between student 'test pieces' made to satisfy a learning requirement or assessment, and staff

'exemplars' intended to show an important process or level of acceptable skill. During the course of the Anthrobotics module, most student artefacts have, in fact, had quite a tutorial element; one such example was a seminar on the value of learning logs as a developmental technique, given by one of the students who had worked for many years as both a mental health nurse and social worker. While the tutors have used learning logs in an educational setting, learning about their benefits in the caring services was potentially more useful for them than the students. The student's 20 minute presentation was videoed by fellow students, and will provide a useful resource to next year's cohort. Other tangible artefacts, such as teaching resources, web tutorials, and examples of previous group presentations, are an on-going resource, which may help future students to leapfrog towards greater achievements.

This is not to say that PD isn't something of a culture shock to final year students, who are not used to being asked for input to course design. For both years of delivering Anthrobotics, initial student contributions were relatively low, but steadily increased as the explicit use of PD techniques became established: the most prominent of these in the first year was the nature of the challenges, many coming from students' aspirations in their learning logs. The flying aerobot challenge arose because one of the students had been a professional blimp designer in his former career and 'fancied running a challenge' as part of his personal development; the lead tutor accommodated this request and let the student lead many aspects of the challenge, including the provision of expert help and access to resources, such as specialist books, plans and materials. However, there were some infeasible suggestions from students, due to time or resource restrictions, so it was not always possible to implement a request; one student was interested in 3D stereo vision, another wanted to build a human size bipedal walking robot, but in most other respects student requests were achieved to some extent.

The content of challenges was less of an issue in the second year, because there was a precedent from the previous year. While students were again given the opportunity to decide the content of the challenges, it was the range of peer-negotiated marking schemes, with an emphasis on dedication, attendance and communication, which was explored. Some of the original challenges were revisited – the flying aerobot challenge being the most successful, which resulted in the lead tutor receiving a grant from the Royal Society to run a version, called "The Robotarium", with a local secondary school – but with a wide variation between the manner in which different teams were assessed on each challenge. This caused some difficulty and 'hand wringing' by the lead tutor, as some of the proposed marking schemes were difficult to implement in a way that was a fair reflection of the individual student abilities and contributions. Often the spirit rather than the letter of the marking scheme had to be adopted, because students were occasionally disadvantaged; one student spent a great deal of time working on documenting the other team members with video, excellently shot and edited, only to be given a total contribution of 5% for the video in his final mark.

4. DISCUSSION

The innovative nature of the module, and its unusual remit of encouraging the students to take an active role in their learning, and to provide real cases for transferable skills to be employed, has required a PD approach to the curriculum design. This has served as a fertile spawning ground for new approaches to the design of teaching and learning at university level, where innovation is rare, and difficult to implement in the face of institutional bureaucracy. So, it is possible that Anthrobotics has had as much success as a "catalyst... that expands the possibilities for organizational realignment and empowerment" [4], as an innovative experience with a strong emphasis on student key skills. In particular, possibilities for participating in course design, assessment development, resource management, and reflection on the personal learning experience in a group/community setting are rare at university level.

5. ACKNOWLEDGMENTS

The authors would like to thank the University of Glamorgan students of Anthrobotics for their friendship, assistance and support, and past students and volunteers who have assisted in ways too numerous to mention, specifically Steve Harris, Neil Hughes, Bruce Etherington and Adam Eppendahl.

6. REFERENCES

[1] Griffiths M. and Brake M. (2001) A Multidisciplinary Approach to Teaching Science. *The 32nd SFRA conference.* New York

[2] Saunders D., Brake M., Griffiths M., Thornton R. (2004) Access, astronomy and science fiction: a case study in curriculum design. *Active Learning in higher education.* Vol. 5(1), 27-42

[3] Wright S. (2003) *Enhancing the Quality of Teaching in Universities: Through Coersive Mangerialism or Organisational Democracy.* LTSN Generic Centre. Feb. 2003

[4] Clement A. (1994) Computing at Work: Empowering Action by 'Low-level Users'. *Communications of the ACM.* 37, 53-63.

[5] Star S. L. (1989) The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving. *Distributed Artificial Intelligence* (eds. Gasser L. and Huhns M.N.), Vol. 2, pp. 37-54. Pitman, London.

[6] Blomberg J., Suchman L. A., and Trigg R. H. (1996) Reflections on a Work-Oriented Design Project. *Human Computer Interaction.* 11, 237-265. cited in [5].

[7] Harris S. (2002) PD in Ponty: Design-by-Doing in Adult Basic Education. *PDC 02 Proceedings of the Participatory Design Conference.* Binder T., Gregory J., Wagner I. (Eds.) Malmö, Sweden, 23-25 June 2002. CPSR, Palo Alto, ISBN 0-9967818-2-1. Pages 278-283.