

**Evaluating the impact of robotics activities in
Cumbrian schools
Aimhigher Cumbria
(West Cumbria's Thematic Evaluation)**

**Rebecca Marsden
Dr Ann-Marie Houghton**

Lancaster University

REAP: Researching Equity, Access and Participation



Evaluating the impact of robotics activities in Cumbrian schools

Introduction

Context

This pilot evaluation was one of four thematic evaluations undertaken for Aimhigher Cumbria, the South Lakes evaluation focussed on the impact of multiple Aimhigher interventions on pupils' awareness and aspiration, the Barrow in Furness evaluation explored the role and response of parents involved in the year long Aiming4uni in Furness programme, and Carlisle and Eden evaluated the impact of working in partnership to ensure young people's access to information, advice and guidance. The evaluation for West Cumbria was conducted during March to June 2008 and focused on evaluating a curriculum project delivered by an external organisation SETPOINT Cumbria with a special emphasis on robotics activities in primary schools.

Background

Since 2005 there has been increasing co-operation between Aimhigher Cumbria and SETPOINT Cumbria in science and engineering activities in West Cumbria and in other Aimhigher areas. SETPOINT Cumbria is part of STEMNET¹ and it facilitates links between schools and the wider STEM community. There have been a number of events linked to the robotics theme including the Robolab workshops (in individual primary schools) and multi school robotics events discussed in this evaluation.

Robolab workshops are designed to fulfil the Design and Technology element of Key Stages 2 and 3 of the National Curriculum which teachers sometimes struggle to cover adequately with the resources available in any one school. The Robolab workshops use Robolab software² which has been written to be used with Lego Mindstorms kits³. The DfES Curriculum Online product details state that: "The Robolab software is a powerful icon-based diagram-building programming environment. It encompasses a logical linear learning process, quite unlike other programming software that typically requires a large learning curve" (DfES Curriculum Online). Users can program robots built using Lego Mindstorms to perform operations such as moving backwards and forwards and turning. According to Rogers and Portsmore (2004) Robolab software has been used by pupils from age five upwards.

Theoretical basis for use of Lego Mindstorms and Robolab in schools

One of the advantages of Lego Mindstorms kits and Robolab software is that they can be used to produce robots whose programs can quickly be changed as a result of observations of their actions. The experimentation used in the Robolab activities described in this report provides opportunities for two types of learning. Kinaesthetic learning where learning takes place through direct physical experience of problem solving and experiential learning (also known as learning by doing) which "is based on a constructivist theory that purports that learning is an active process in which much of what one learns and understands is

¹ The UK "Science, Technology, Engineering and Mathematics Network" <http://www.stemnet.org.uk/>, accessed July 15th 2008

² Robolab software <http://www.robolabonline.com/>, accessed July 15th 2008

³ Lego Mindstorms <http://mindstorms.lego.com/>, accessed July 15th 2008

constructed by integrating new knowledge with existing knowledge” (Barker and Ansorge, 2007, p.233). The step by step structure of the SETPOINT Cumbria Robolab project is reinforced by Mayer’s (2004) emphasis on the importance of guided discovery in constructivist learning.

Aims and outcomes

The overall purpose of the evaluation was to examine the impact of the Robolab workshops in West Cumbria primary schools and the impact of multi school robotics events (both partially funded by Aimhigher) for primary and secondary school pupils. The evaluation would focus on capturing teachers’ views before, during and after a robotics intervention. This qualitative evidence of impact would complement the standard feedback collected by SETPOINT Cumbria. The outcomes of the evaluation would include:

- a report outlining impact of this approach and identifying areas for future development that Aimhigher Cumbria would share with SETPOINT Cumbria, participating schools and funders
- a leaflet outlining good practice and key findings for Aimhigher Cumbria to promote the project or help encourage other schools to get involved.

Evaluation

As part of their quality assurance and for the purposes of evaluation SETPOINT Cumbria collects and analyses feedback (in the form of teacher and pupil questionnaires) from all robotics events for schools (see appendix 1). For this Aimhigher evaluation the existing post-event feedback forms were modified (see appendix 2) and a pre event questionnaire developed. Questionnaires were not completed by all pupils; the issue of non-return of questionnaires is a recurrent problem for SETPOINT Cumbria when not collected immediately at the end of the event.

Telephone interviews were conducted with:

- Tony Gill (SETPOINT Cumbria) and Sue Donnelly (Area Leader for Aimhigher West Cumbria).
- Three primary teachers before and after a one day multi school robotics event (See appendix 3). These teachers worked in targeted schools who were invited to attend the Sellafield and Cleator Moor events (May 2008) because of the higher number of pupils who met the Aimhigher funding criteria.
- Four teachers who had previously participated in robotics activities organised by SETPOINT Cumbria.

Two non-participant observations were undertaken at a multi school robotics event attended by primary pupils, and at a primary workshop. These included informal participant conversations with teachers who attended the robotics events for primary schools held at Cleator Moor on May 6th 2008. Finally, the evaluation was also informed by reviewing previous evaluation findings from SETPOINT Cumbria and other documentary evidence including a literature review about constructivist educational theories and the use of Robolab in primary school science education

Robotics activities in Cumbria schools

The Robolab project was first piloted in 2006 in a small number of West Cumbrian primary and secondary schools and, after the success of this pilot, was extended to other schools in the area. Sixteen sets of Lego Mindstorms kit (and associated electrical equipment), laptop computers and Robolab software were purchased by SETPOINT Cumbria. Since 2006 SETPOINT Cumbria have organised two types of robotics activities in Cumbria namely:

- individual one day workshops based in primary schools
- larger scale events (at a number of venues including Sellafield, Carlisle racecourse, Barrow Dock Museum and Kendal Museum) which consisted of multi school events for primary and secondary pupils and also events for the general public

The events have benefited from various forms of support including direct funding, use of rooms and the staff time (of apprentices and professional staff) through the Science and Engineering Ambassadors Programme. Between 2006 and 2008 support has been provided by Aimhigher Cumbria, Alstec, BAE Systems, James Fisher Nuclear Ltd, Nexia Solutions, REACT Engineering, Sellafield Sites Ltd, SETPOINT Cumbria, GenII and System Technologies.

Primary Robolab Workshops

A Robolab one day primary school workshop is led by a SETPOINT Cumbria ambassador who brings laptop computers (pre-loaded with Robolab software), pre-built Lego robots (with a Lego RCX brick as the key component) and an infrared device to allow downloading of the computer programs from the laptop to the robot. The day is split into a sequence of challenges which become progressively more difficult. Initially the pupils working in groups of two or three sharing one set of robotics equipment download and run pre-written programs, which involve them in making small changes and then testing these changes. Gradually the programs become more complex and are split into a number of stages. This allows individual pupils within each group to write a stage of the program. As the programs can be quickly changed and downloaded, pupils can see the results of their program changes almost immediately. This process allows experiential learning by encouraging experimentation where pupils can soon learn from any mistakes that they make. In addition facilitators ask questions and prompt pupils to consider how or why their actions have caused the robot to perform a particular movement which ensures the experiential learning is supported by guided discovery as advocated by Mayer (2004).

The duration of primary school workshops is one day and class teachers are invited to attend a local “twilight briefing session” in their area prior to the workshop. In response to requests from teachers, a pre-workshop challenge has been prepared and schools are encouraged to allocate time for pupils to complete this before the workshop.

Multi school robotics events

At the multi school events the pupils again work in small groups (four or five pupils). They use the Lego bricks and Robolab software and undertake similar activities to those offered in primary workshops at individual schools. Sometimes there are audio-visual presentations on robotics and a large robot (Oscar) is often present. Robodance competitions have taken place at some of the multi school events, also Robosoccer tournaments. Multi school Robolab events have been attended by primary and secondary

school pupils. Primary school attendees are generally from years 5 and 6 however pupils from years 3 and 4 have occasionally attended also.

What teachers think of Robolab

Teachers were overwhelmingly pleased with the robotics events and believed them to be beneficial and enjoyable for their pupils providing learning that would motivate, challenge, and enable pupils to cover the national curriculum, improve progression and attainment within school and involve interaction with people from industry. When asked about the overall benefits of the robotics events teachers cited being able to quickly correct and learn from mistakes, working co-operatively as a team, use of investigative skills, exchanging of ideas, the use of computers for a enjoyable activity, independent learning, practical dexterity and communication skills.

Both pupils and teachers were complimentary about the SETPOINT Cumbria staff who led the events. Feedback suggests that teachers appreciated the very practical approach of the Robolab activity which engages pupils in their understanding of control technology. One teacher felt that the event was very motivating and resulted in an immediate and a positive impact *“the children didn’t stop talking about it”* as another explained what seemed to be beneficial was that *“the children ... can actually see their impact ... if I put this in then I can see the robot do this”*. In addition to the motivation teachers also felt that Robolab *“gives central grounding to move out from”* and a base from which they could build future lessons.

One of the reasons that Aimhigher Cumbria chose to fund the Robolab programme was to help fulfil the control aspects of the National Curriculum. Teachers were generally positive although some commented about the difficulty of the existing classroom situation where only two or three pupils can work on a computer based activity at one time. One teacher, who had attended a multi school robotics event, felt that for the robotics event to have had significant impact in this curriculum area the whole class would have had to be involved, rather than a few pupils from one class. Another teacher commented , after a multi school robotics event, that although pupils enjoyed the day some may not have fully understood what they were doing when programming the robots. To ensure pupils felt confident about this learning they felt that further reinforcing work would be needed back at school with existing resources e.g. Roamer robot and computer simulations. Also there were comments about the challenging nature of the tasks at a multi school event and about the key role of Science and Engineering Ambassadors in enabling and empowering the pupils to successfully complete the tasks themselves. The importance of the ambassadors as role models and facilitators of learning is clearly a valuable feature of the robotics activities. A particularly popular element of the multi school events was Oscar whose services should clearly be retained. It is possible that Oscar and the multi school events could become an activity for schools after an in-school event. This would allow a further opportunity for consolidation of knowledge.

There was an impression that pupils who attended the multi school robotics events found the tasks more difficult than when they experienced them in the primary workshops. We did not explore the reasons for this impression but it is possible it may have been because the pupils all arrived with different levels of previous knowledge, were more excited, distracted or overwhelmed by being away from school, and because usually only a small group attend from each school may have not been working with their usual peers. At this point we would wish to note that each experience brought its own advantages and that the teachers all recognised the potential for using both types of event as a stimulus. One

teacher thought that it would have been useful to have had the software in the school to be able to reinforce what had been learned on the day. One teacher who hosted a primary workshop stated that with pre and post school based activities this intervention would fulfil that half term's National Curriculum requirements. They had undertaken prior activities using the school owned robots programmable on the robot itself and in subsequent weeks would consolidate the topic with work on motors.

Generally teachers believed that the robotics interventions would help with the transition from primary to secondary school (particularly for those pupils who would be attending a secondary school with a strong background in engineering and robotics). It was felt to be beneficial that pupils had been challenged with work at a higher level and to give pupils positive expectations of secondary school. The balance of challenging pupils, and achieving appropriate levels of task difficulty, is not easy and the extent to which this is achieved for groups of pupils will vary. It would be useful for schools, Aimhigher Cumbria and SETPOINT Cumbria to consider how school based pre event activities might be used to help ensure pupils are ready for a robotics event.

Robolab was seen as part of a larger package of activities to raise aspirations about life choices after compulsory schooling. Aimhigher Cumbria believes that it would be beneficial if pupils are able to complete some pre-workshop activities in order to introduce pupils to the wider subject of engineering and possible engineering careers. SETPOINT Cumbria produce an activity sheet which asks pupils (working in small groups) to produce posters to explain what engineering is. This activity was not completed by all schools because of time constraints. One teacher noted the small number of suitable websites for primary school pupils that have appropriate content in this subject area and also pointed out that in most classrooms only a few pupils could work on computer based activities at one time. Although the option of setting this as a challenge for homework there is no guarantee that pupils at home will have access to a computer. The level of awareness of post compulsory schooling choices especially amongst primary school teachers is likely to be mixed. This evaluation revealed that some primary school teachers had no knowledge about Aimhigher whereas others who had already participated in Aimhigher funded activities with their pupils had some awareness. Aimhigher Cumbria might wish to develop a short information sheet with links to post compulsory opportunities suitable for primary school teachers to use.

What pupils think of Robolab

Robotics events in Cumbria are popular with primary and secondary school pupils. When asked to select words that described their feelings about the day, pupils from one primary school overwhelmingly chose “enjoyable”, “interesting”, “challenging” and “exciting” as opposed to “confusing”, “too long” and “boring”. Comments (from primary school pupils) after large robotics events:

“I now know a lot about Robots and Technology. I think all things to do with Robots is cool.”

“I would like to meet Oscar again”

In reply to the question “[name] one thing that you enjoyed about the day?” –
“when the robot kept on going wrong and we had to reprogram them”

“I really enjoyed meeting Oscar and seeing how all the robots were programmed. The best part was the history part. Me and Yr 6 of think it was absolutely marvellous”

Feedback collected by SETPOINT Cumbria (after robotics events) shows consistently that pupils perceive that their knowledge about engineering is increased by a robotics event and that they are more likely to consider engineering as a career. Attempts to capture this change using the pre and post activity questionnaires were not as successful as envisaged. Timing and the fact involvement in the evaluation was an 'add on' and voluntary activity did not help. The resources now exist for future use, alternatively the use of student ambassadors or building in focus groups with pupils as part of the process would allow the capture of the anecdotal changes teachers and pupils report.

“Good practice” case studies

St Michael’s Church of England Primary School, Dalston, Carlisle Contact: Mrs J Clarke, 01228 607805

Year 6 pupils attended a one-day out-of-school large Robolab event in early 2008. In spite of a very short period of preparation for the workshop, this school linked the Robolab workshop with Logo and Turtle graphics⁴ which were to be introduced later in the school year. Before the workshop pupils enacted turtle graphics with their bodies e.g. move forwards 10 paces. In written feedback Mrs Clarke explained how the work that evolved from the robotics day included development of: literacy skills (describing Oscar and reporting on the day), discussion and debate (during a discussion about whether robots had rights), artistic and memory skills (in drawing Oscar), use of the internet and technology (when children demonstrated their own toy robots to the other pupils).

St Benedict’s Catholic High School, Whitehaven (a co-educational, comprehensive school with specialist engineering status) Contact: Mr Peter Esslemont, 01946 852680

This school has a strong interest in robotics and the teacher who was interviewed highly recommended Robolab. It is used by GCSE Engineering students and also by an after school club (Young Engineers Club). The teacher would find it beneficial if the school had access to enough sets of equipment and software for whole class use. Links with a feeder primary school had been strengthened by the participation of year 9 pupils at robotics activities at the primary school. This had improved the social skills and self confidence of the older pupils who had been perceived as role models by the younger pupils.

See also appendix 4 Robotics activities in Cumbria newsletter July 2008.

Conclusion and recommendations

Overall the project is regarded positively and teachers expressed interest in making future opportunities available for their pupils. There are several practical considerations and recommendations arising from the feedback obtained these relate to delivery of the National Curriculum, timing of the events, access to resources, pre and post event activity and foci for future evaluation.

- In order to take full advantage of the robotics workshops to teach the National Curriculum, schools should first be offered in-school robotics workshops as this allows all pupils in the class to have the same learning experience which can be consolidated in subsequent lessons.

⁴ Logo Foundation Website <http://el.media.mit.edu/logo-foundation/index.html> , accessed online June 30th 2008

- It would be better if the robotics events were not offered to year 6 pupils directly before the Key Stage 2 national tests in May. The three targeted primary schools were unable to undertake pre-workshop activities because the tests were the week after the robotics event.
- It is preferable for pupils to work in groups of two if space allows as this ensures greater engagement and more hands on opportunities.
- The pre-workshop activity serves a number of purposes. An alternative or additional pre-workshop activity for pupils would be to observe the cycles of a washing machine which is an everyday example of the use of control technology. The homework sheet might include an information box for parents about getting children to help at home as preparation for when they might go to university (see Aimhigher Lancashire Primary School Leaflet)

In addition to ideas already mentioned in this report it is suggested that:

- a post-workshop activity is developed to explore the use of Robolab simulators (accessed through classroom computers) to consolidate the knowledge acquired at the robotics event
- Aimhigher Cumbria promote the findings of this report to primary and secondary schools and explore ways of building collaborative arrangements similar to those established by St Benedict's Catholic High School
- Future evaluation tracks individual children from primary school through secondary school and beyond in order to ascertain the long term impact of the robotics events
- Future evaluation explores the qualities, experiences and contribution of Science and Engineering Ambassadors, together with their training and the benefits to them as well as the pupils as this may provide supportive evidence for employer engagement.

The evidence suggests that Aimhigher Cumbria continue their co-operation with SETPOINT Cumbria to promote STEM activities in Cumbrian schools. The partnership has been mutually beneficial and has led to increased focus on STEM for Aimhigher in West Cumbria.

Acknowledgements

The REAP team would like to thank the staff and pupils who shared their ideas during primary workshops and multi-school robotics events, the teachers who agreed to be interviewed at a busy time of the year. We are grateful to Mrs Clarke and Mr Esslemont for their time in providing images and further details for the case studies. Finally, we would like to thank Tony Gill and Wilma Buckley (SETPOINT Cumbria) and Sue Donnelly and Pamela Mattinson for their involvement and contribution to the evaluation.

References

Aimhigher Lancashire (undated) *Preparing For Further and Higher Education Whilst In Primary School* Aimhigher Lancashire Families
<http://www.lanacs.ac.uk/fass/projects/reap/Documents/Primary%20Leaflet.pdf>, accessed online July 15th 2008

Barker, B.S. and Ansorge, J. (2007) 'Robotics as a means to increase achievement scores in an informal learning environment' *Journal of Research on Technology in Education*, 39 (3), pp 229-243

Department for Education and Skills (undated) *Robolab software product details*
Department for Education and Skills Curriculum online website
<http://www.curriculumonline.gov.uk/include/resource/printproduct.asp?oid=18043>,
accessed online July 16th 2008

Mayer, R.E. (2004) 'Should there be a three-strike rule against pre discovery learning? The case for guided methods of instruction', *American Psychologist*, 59, pp 14-19

Rogers, C. and Portsmore, M. (2004) 'Bringing engineering to elementary school' *Journal of Stem Education*, 5 (3-4), pp 17-28

Appendix 1

Robolab Workshop – Teacher Evaluation

In the final report need to add in the logo from the original forms

Name:

Position:

School:

What did you hope that your pupils would gain from the workshop?

Do you think that the workshop provided activities which helped to achieve this objective?

Did you attend a twilight briefing session? Yes No Not this time

How well did the workshop and twilight briefing session fulfil the following?

	<i>Excellent</i>	<i>Good</i>	<i>Satisfactory</i>	<i>Poor</i>
Provide support for the National Curriculum				
Fun and enjoyment for the pupils				
Provide a useful networking opportunity				

Which area of your work do you think the workshop will impact upon?

- Raising standards of achievement
- Improving pupil motivation and attendance
- Supporting management and leadership in school
- Preparing young people for the world of work including employability
- Raising the aspirations of pupils
- Enhancing the delivery of the National Curriculum
- Supporting the delivery of skills, including creativity and enterprise
- Supporting your personal professional development

Please list other areas of the curriculum that you think SETPOINT may be able to help with.

Please suggest any changes you would have made to the workshop (*continue overleaf if required*):

Signed Date

Form included logos of supporting agencies and uses original layout

Appendix 2

Robolab Workshop - Post event questionnaire

Name of School Class..... Year Group.....

Are you a boy girl ?

Please tick all the words and phrases that describe how you feel about the workshop today:

Enjoyable	Interesting	Confusing	Too short
Challenging	Too long	Boring	Exciting

Name one thing about robotics that you have learned today:

.....
.....

Name one thing about engineering that you have learned today:

.....
.....

Would you like to be an engineer? (please tick one of the boxes)

Yes	No	Don't know
-----	----	------------

How much did you enjoy the workshop? (please tick one of the boxes)

Really enjoyed it	It was OK	Didn't enjoy it
-------------------	-----------	-----------------

Name one thing that you enjoyed about the day:

.....

Thank you very much for your help!

Form included logos of supporting agencies and uses original layout

Appendix 3

Teacher interview schedules

The following questions outline the initial questions which we adapted. We adopted an dialogic approach in the semi-structured telephone interviews this allowed us to follow up emerging issues and ensure that teachers had the opportunity to raise issues not covered within the interview schedule.

Questions to teachers at targeted schools prior to Robolab activity:

Background information about the school and their involvement to date with Aimhigher activities.

Age and year group of pupils attending.

Have you used Robolab before?

Will you be undertaking any activities with your pupils prior to the Sellafield event?

Do you hope that the Robolab activities will fulfil the aspects of the National Curriculum KS2 Design and Technology namely "how mechanisms can be used to make things move in different ways, using a range of equipment including an ICT control program?"

Do you think that the Robolab activities will raise the aspirations of your pupils?

What benefits do you think will arise from the Robolab activities?

Questions to teachers at targeted schools after Robolab activity:

Did the pupils enjoy the Robolab activities?

How easy or difficult was it to use Robolab – for you and for the pupils?

Did the Robolab activities fulfil the aspects of the National Curriculum KS2 Design and Technology namely"? How mechanisms can be used to make things move in different ways, using a range of equipment including an ICT control program?"

Do you think that the Robolab activities will have helped to raise the aspirations of your pupils?

Do you think that this type of activity will help with the transition to secondary school?

What other benefits (if any) have you seen from the Robolab activities?

Did this activity meet your expectation of an Aimhigher activity?

When and how were the evaluation forms filled in?

Appendix 4

Robotics activities in Cumbrian Schools (July 2008)

A copy of this is located on the next page and is available from Aimhigher ... Cumbria.