Learning Intentions and Educational Robots

Dave Catlin, ***dave@valiant-technology.com*** Valiant Technology Ltd.

Abstract

Some teachers run excellent lessons with educational robots. Others fail. Good teaching practise, is the key to success and prevails despite diverse and difficult challenges. What is good practice? How can we make sure teachers apply it to educational robots? Constructivism underpins the use of robots, but putting theory in to practise has met with difficulties. The increased focus on curriculum and high-stakes testing makes matters worse. Most teachers I meet feel bullied into "teaching to test" and feel forced into abandoning constructivism for more direct teaching methods. Can teachers deliver lessons that meet their curriculum duties and keep the constructivism spirit alive? These practical questions concern the educational robotic community[1]. This paper is one of a series that looks at these issues.

In previous work, I proposed Assessment for Learning (AfL) answered these questions. AfL summarises good practice and provides a way to improve the success of educational robots. In later papers I looked in more detail how AfL (Success Criteria and Peer Assessment) might work with robots. In this paper, I continue this effort by exploring issues to do with educational robots and another AfL strand - Learning Intentions. I review teacher and expert opinion on this topic and develop a definition that works with robots. Finally, I use these ideas with selected Roamer® activities[2] to highlight some of the application issues.

Keywords

Assessment for Learning, AfL, Learning Intentions, Learning Challenges, Learning Objectives Educational Robots, Valiant Technology, Roamer, Turtles, Constructionism, Constructivism.

Figure 1 Muslim girls solving a problem with the Roamer robot. The Learning Objective is, "Students fortify their understanding of arithmetic. The students program the robot to follow a route doing calculations at each step. The Learning Intention is, "Finding out how to get the biggest score". Activity by Stephen Wooley.

[1] I refer to the agenda of RiE (Robots in Education) and TRTWR (Teaching Robotics and Teaching with Robotics). These are annual and bi-annual educational robotic conferences based in Europe.

[2] The activity are published BY-NC-ND Creative Commons Licence. They are available at www.activities.roamer-educational-robot.com. Attribution is Valiant Technology Ltd and the activity authors.

Introduction

The Problem

I started designing Turtle type educational robots in 1983. Over the years, I have noticed some teachers successfully use the technology and others struggle. The problem is not the teacher's technical skills. I have seen teachers who know how to use the robot but manage to deliver sterile lessons. I have also seen the opposite: wonderfully imaginative lessons with children full of enthusiasm, eagerly exploring ideas. The teacher had limited technical knowledge, but excelled in exploiting what they knew. What can we do to make this the norm?

The ERA Principles

As a robot manufacturer, I face a problem: not everyone using the robot is a trained teacher. How can I help all users get success? Mike Blamires and I wrote the ten Educational Robot Application (ERA) Principles (Catlin, D. and Blamires, M., 2010). These explain the value of educational robots. I use them to collate the benefits of robots used in diverse educational scenarios. It helps me compare how the robot aids a 4-year old understand number to how it helps an 18-year-old grasp vector analysis. ERA has another purpose. It provides a "design specification" that guides our creation of educational robots and the way we use them. In this paper I focus on the Curriculum and Assessment Principle which states: *Educational Robots can facilitate teaching, learning and assessment in traditional curriculum areas by supporting good teaching practice.* A key phrase here is "good teaching practice". What is it? If we find that out, how can we apply it to the way we use educational robots? AfL offers a solution.

I also refer to the Engagement Principle: *Through engagement Educational Robots can foster affirmative emotional states and social relationships that promote the creation of positive learning attitudes and environments, which improves the quality and depth of a student's learning experience.* This is a broader idea than "makes learning fun", I will propose that it is an integral part of setting up Learning Intentions.

Introducing AfL – Assessment for Learning

In 1998 Black and Wiliam first published a seminal paper "Inside the Black Box – Raising Standards through Classroom Assessment" (Black & Wiliam, 2006). In this analogy, the classroom is the black box. Conventional testing evaluates what comes out of the classroom. This is Assessment **of** Learning (AoL). AoL benefits others. For example, it helps politicians review whether the school is value for money. It allows parents to compare schools. Assessment **for** Learning (AfL) happens in the lesson. Teachers use AfL methods (Table 1) to check student responses. Do they need extra help with something? Have they discovered something interesting they should explore? AfL helps the teacher manage and improve the learning taking place during the lesson. I believe that AfL captures and codifies good teaching practice. Some of its techniques may appear novel, but, in essence, it summarises what expert teachers do intuitively. Indeed, what they have done for decades.

Table 1 Elements of AfL adapted from Smith (Smith, 2007)

Element	Explanation
Learning Intentions	The student's view on what they are learning.
Success Criteria	How will the student recognise successful learning?
Quality interactions and feedback	Positive, enriching ways for teachers and students to interact during a lesson. Methods a teacher can use instead of grading a pupils work. The aim is not to tell them how well they did, but how they can improve what they did.
Peer Assessment and Self-Assessment	Using what students think of their work and the work of their classmates to improve learning.

Applying AfL to Educational Robotics

The US Department of education classifies teachers according to their experience (US Dept of Education). A Master Teacher is a good educator who models effective teaching practises and shares their skills to other teachers. My studies of master teachers found:

- They used constructivism teaching methods.
- They worked successfully with educational robots.
- They work at the unconscious competence level (Burch, 1970)[3].
- They unconsciously use variations on AfL methods.

I proposed that AfL offered a way of organising activities with educational robots that would help address the basic issues (Catlin D., 2012). I developed the peer and self-assessment ideas (Catlin D., 2014) and proposed using Success Criteria for evaluation (Catlin, Csizmadia, OMeara, & Younie, 2015). In this paper, I look at the details of Learning Intentions and educational robots. I start by analysing diverse teacher opinions. I then look at the views of an AfL expert. I make a distinction between Learning Objectives and Learning Intentions. Finally, I look at applying these ideas to robot activities and some of the issues it raises.

Analysis of Learning Intentions and Objectives

General Views

In an interesting blog, Canadian teacher Joe Bower (Bower, 2011) states: "Stop writing Objectives on the Board". The blog has attracted over 70 comments from various countries. The debate was still active in September 2015 when over 33,000 people read the blog that month. It is a popular topic. The following summarises the debate:

- An analysis of commentators showed 31% favoured making the students aware of the objectives, 58% thought it bad practice and 11% preferred a mix of the two approaches.
- The blog did not present a clear definition of terms. People used various terms interchangeably when clearly they were talking about different things. Few people distinguished between Learning Objectives and Intentions. This included people familiar with AfL ideas.
- Several teachers normally display objectives to satisfy administrators:
    - They do not believe it helped students learn.
    - Lesson evaluators mark them down if they do not display the objectives.
    - Sometimes they must display objectives matching curriculum statements.
- Some comments discussed the students perspective:
    - Teachers recalled knowing the objectives helped them when they were students.
    - Some constructionist teachers proposed students should set the objectives.
    - Some places now require students to copy objectives into their books.
- People suggested:
    - Objectives should focus on process, not outcomes.
    - Establishing objectives using key questions and Bloom's taxonomy.
- Reasons for disliking objectives were:
    - It implies learning is driven by the teacher and not the student.
    - It "gives away the ending" and stops student discovery.
    - It deters pursuit of student inspired lines of inquiry.
    - It is extra work for the teacher without a clear advantage.
- Reasons for liking objectives included:
    - It is usually a good idea for people to know where they're going.
    - It helps the students monitor their progress.

[3] This model states 4 levels of competency. At the bottom, it starts with unconscious incompetence. The next level is conscious incompetence. This gives way to conscious competence and then the final stage of unconscious competence. In this stage, people demonstrate their skills spontaneously.

- It helps students to become responsible for their learning.

Some constructivism practitioners strongly disagree to setting objectives. “How dare you tell me what I am going to learn”; “How can you call 'learning' something you predetermined?”

Dylan Wiliam on Learning Intentions

AfL expert Professor Wiliam (Wiliam, 2011; 2012) made several observations:

- Assessment becomes ‘formative’ when teachers use the evidence to adapt their teaching to meet student learning needs.
- Teachers lead formative assessment, but it is something students do.
- A narrow Learning Intention is not always enough to direct student learning.
- Creating a good Learning Intention is more craft than science.
- You need to make sure writing Learning Intentions does not become a dull routine.
- Sometimes
  - Giving a Learning Intention takes out the mystery of a lesson.
  - The Learning Intention leads to one answer (maths).
  - The Learning Intention leads to various answers (Literary Criticism).
  - You can have a whole horizon of goals and it's ok if kids go in different directions.
  - Setting up a good Learning Intention leads to inspiring lessons.
  - You want to focus on process.
  - You cannot always write a Learning Intention for a lesson.
  - A better way of starting a lesson is with a question that grabs their attention.

The Mayflower Lesson

Bower’s blog starts with a clip of educator Alfie Kohn (Kohn, 2011) discussing a lesson where a teacher introduced the idea of non-standard measurements to students. The lesson epitomised constructivism in practice. When pupils arrived they found the outline of the Mayflower on the floor. A student, Zeb, appeared dressed as a royal herald and read from a scroll. The decree told the class they could board the Mayflower if they could tell the King how long the ship was. What followed was a lesson which showed the children’s creativity and engagement as they explored the ideas of measurement.

Misunderstanding Constructivism

The Mayflower lesson challenges those blog commentators who think students must set the objectives, or that you could not set an objective because you did not know what was going to happen. Misconceptions like these bolster opponents of constructivism (Cox & Dyson, 1971; Price, 2009). The ‘Mayflower’ teacher had a **clear plan and objective that met curriculum needs**. Few plans ever work out without management. Student inspirations may take them away from the objective. Teachers need to use their professional judgement to manage the lesson: does the detour benefit the student learning or should they bring them back on task?

AfL helps organise activities in a way that lets the teacher connect to the curriculum, but still allow the freedom associated with constructivism. The role of Learning Intentions is to start the lesson in a way that helps achieve these aims. Often schools use educational robots in special events or after-school clubs. The ERA Curriculum and Assessment Principle says their proper place is supporting normal schoolwork. Learning Intentions help set up lessons using the robot.

Learning Intentions versus Lesson Objectives

I find it useful to distinguish between Learning Intentions and Lesson Objectives. A Learning Intention focuses on what the student thinks they are learning. A Lesson Objective connects the work to the curriculum. The Lesson Objectives of the Mayflower example might say, “Students will learn about standard and non-standard units of measurement”. To most students this is gobbledegook. Compare it with what children might say, “We are finding out how to measure the ship”. Educators claim you should negotiate Learning Intentions with students, but it seems

to me this rarely happens. Often, the teacher creates the Learning Intention and the "negotiation" turns into an explanation. Nothing the students say contributes to what the teacher writes on the blackboard. Setting up Learning Intentions should aim to engage students and help them to take ownership of their learning. This has nothing to do with "telling students what to do". The Mayflower teacher had no idea what the students would do. She was ready to help and guide, but not direct. Although she did not make it explicit, she did set up a Learning Intention by engaging the students with their learning.

A lesson rarely achieves an objective like, "Students will learn about standard and non-standard units of measurement". As Vygotsky makes clear, knowledge gradually emerges from many different experiences. The Learning Intention "We are **finding out** how to measure the ship", contributes to the Learning Objective in an achievable way which you can measure. Note "finding out" highlights learning.

Engagement

Engagement is a characteristic of the Mayflower example. Getting students to buy-in to a task is a key part of setting up Learning Intentions. Trevor Thomson is a teacher who helped me understand how to put constructivism theory into practice (Catlin, Thompson, & Year 6 Students, Fleet School, Class of 1998, 2014). The Design Technology (D&T) Exhibition invited his school to show their work in their 1998 exhibit. At the time making fairground rides was a favourite D&T project. The pupils chose to make various automata for a circus. When I said it was lucky they had chosen this richer theme, Trevor replied, "I knew they would". He used a strategy straight out of Dale Carnegie's How to Win Friends and Influence People (Carnegie, 2006): If you want people to do something, get them to think it is their idea. Student buy-in is critical.

Examples

These examples do not explain anything about robots or how we use them in the classroom. That is beyond the scope and editorial limits of this paper. You can find this information elsewhere[4]. The examples look at setting up Learning Intentions for robot activities.

Number Grab

The playing area of this game (Fig 1) has several targets labelled with a score. The students write a program that will move the robot from target to target. They score points for each target the robot lands on within in a 2-minute session. Only points the robot gets back home count. You vary the activity by changing numbers, for example, to mixed fractions. You can add more targets and change numbers for operators. Students work in pairs. The pairs come together to test their programs. While one team is running a test, the others act as referees (peer review). They check whether the robot landed on the target and the score is correct.

Figure 2 Number Grab Target Area. Authors Dave Catlin and Alan Coode.

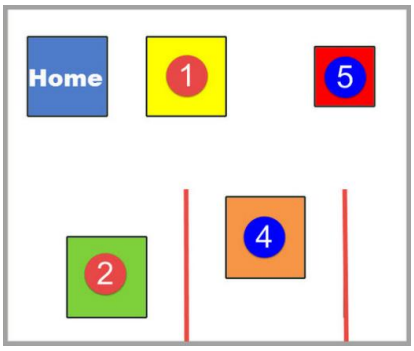


Table 2 A Possible Way of Finding the Best Answer

	Roamer moves forward 1 and back 1.	Score 1	Distance moved 2	Score Distance 1:2
	Roamer moves forward 1 then forward 3. Then it moves back 3 and back 1.	Score 7	Distance moved 8	Score Distance 7:8

[4] Check out the Roamer website www.roamer-educational-robot.com.

The task offers students the chance to improve their computational fluency in a problem-solving context. They get to practise estimation and coding. The activity has hidden depths (table 2). Students might also think about trying to work out the speed. So if the robot travels 1 unit in 1-second, the students can repeat the program 120/9 - fifteen times.

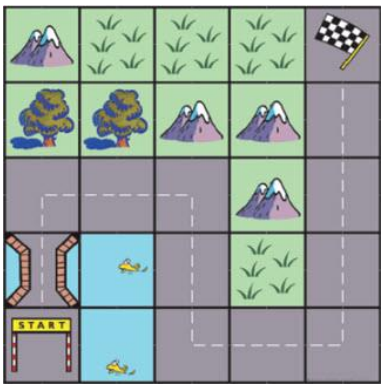
In tasks like this, you start by explaining the game followed by a question: "How are you going to do this?" Students will make statements like, "I'll go lots of times to the nearest number?" The aim is to get the students discussing the problem and potential solutions. This brings out an important adjunct to AfL – effective questioning. Students can surprise you with their thoughts, but in the words of Oscar Wilde – spontaneity is a meticulously prepared art. You can prepare questions (Wragg & Brown, 2001; Pope, 2013). "Do you think you can get a bigger score?" "Will you run out of time?" "What would happen if you went for the big numbers?" You should not force the students to discover the hidden mathematics mentioned above. However, asking questions in a discussion will prompt them to think more deeply about the problem.

At the end of a discussion, you can talk to the students about what they think they're learning. Instead, of them regurgitating something you wrote on the blackboard, they will express their thoughts. You can guide them, but recording their words helps them own their learning. A Learning Objective "developing computational fluency and mathematical thinking" becomes a Learning Intention, "Finding out how to get the biggest score" or "Thinking about how to win".

Robot Rally Race

The robot runs at different speeds over the various topographies. The task is to program the robot to get from the start to the finish in the fastest time. The first job is to do speed trials over the terrains. Pupils use that data in their programs. The teacher gathers the data from each team, which the class reviews using statistics.

Figure 3 Robot Rally Race by Dave Catlin and Alan Coode.



You will normally find it easy to engage students in games like this. The activity is split into different parts. Each part needs a different Learning Intention. The first phase of this work is gathering and using data. The students get to reinforce some calculation skills, run experiments and use mathematics to solve problems. In the second phase students start to analyse the collected data.

Sindbad's Treasure Hunt

Sinbad and his crew have to make a long journey in a hot desert[5]. Before they set off they need to make a tent. Students split into 3 teams of 2. One team use their Roamer and measure some "tent poles". Another team uses Roamer to measure "the tent covering" (paper). The final team use their Roamer and measure the "guy ropes". When they bring the materials together they find a problem – each Roamer has a different unit of movement so the parts will not come together to make a tent. This is an example where starting with a Learning Intention (Learning Objective: exploring the need for standard units of measure) will not work. You need to set up the Learning Intention when the students realise the problem. A set of effective questions aimed at guiding the student discussion on how to resolve the problem is valuable. The aim of the discussion is to help the students discover why we have standard units and that the choice of units is arbitrary.

Spacecraft Rescue

You can see details of this activity[6] in (Catlin D. 2012) and in the doctoral thesis (Holmquist, 2014). A spacecraft has crash-landed in a deep ravine. Your team needs to bid to recover it.

[5] Authors: Dave Catlin, Kate Hudson and Alan Coode.
[6] Author: Dave Catlin

You need to build a crane to lift the spacecraft out of the ravine, use the robot to move the crane to the crash site and bring the craft back to base. All the materials and manufacturing processes have a cost. The robot movement has a cost. Your challenge is to complete the task for a minimal cost. Holmquist did this activity in an elementary school. I did the project with a Grade 12 Gifted group. With the younger students, the project broke down into several subtasks. Each of these had a different Learning Intention, mostly targeting learning of subject matter. The older students also dealt with the content, but the Learning Intention-focused on higher levels of Bloom's taxonomy and the development of life skills. This suggests the same activity can require different Learning Intentions for different students.

Delivering Letters

A preschool activity[7] asks students to program Roamer to deliver letters to some house in a street. What is the quickest way of delivering the mail? The Learning Objective aims to "Develop an understanding of ordinal numbers". One teacher told me that when she asked a pupil, "How did you know that", the child replied, "Magic". Early Years teachers spend a lot of time helping students understand what and how they are learning. You may need to remind students of the Learning Intention several times.

Conclusions

This paper develops further the notion that AfL methods can support the effective use educational robots. The following summarises key points about Learning Intentions:

- I define Learning Intention as what the child thinks they are learning.
    - It should reflect their understanding and language.
- In contrast, a Learning Objective links student work to curriculum objectives.
- Learning Intentions set up constructivist learning environments.
- Setting up a Learning Intention involves engaging students in the tasks and helping them to take responsibility for their learning.
- Learning Intentions focus on student learning, not what-to-do instructions.
- Involving students in discussions and using effective questioning is a good way of setting up Learning Intentions.
- As a rule, teachers should set up Learning Intentions at the start of a lesson, but this is not always desirable.
- It is not always possible to set up a Learning Intention.
- Some activities require multiple Learning Intentions.
- You might use different Learning Intentions if you use an activity with different age groups or different cultural settings.
- You might need to remind students of the Learning Intention during in the lesson.
- You can change the Learning Intention in a lesson if it improves a student learning.

Gathering data on the value of this approach is ongoing under the e-Robot Project (Catlin & Blamires, 2010a). This is an online project where teachers provide data on their use of the Roamer activities. I will publish these results in the future.

References

Black, P., & Wiliam, D. (2006). *Inside the Box: v. 1: Raising Standards Through Classroom.* NFER Nelson.

Bower, J. (2011, October 27th). *Stop writing the objectives on the board*. Retrieved December 1st, 2015, from For the Love of Learning: http://goo.gl/865VHm

[7] Author: Chrissie Dale

Burch, N. (1970). *The conscious competence ladder*. Retrieved December 1st, 2015, from Mind Tools: https://www.mindtools.com/pages/article/newISS_96.htm

Carnegie, D. (2006). *How to Win Friends and Influence People.* London: Vermilion.

Catlin, D., Thompson, T., & Year 6 Students, Fleet School, Class of 1998. (2014). *Fleet School Circus Project*. (Valiant Technology Ltd) Retrieved April 11th, 2014, from Roamer Podcast Site: http://podcast.roamer-educational-robot.com/other-projects

Catlin, D. and Blamires, M. (2010). The Principles of Educational Robotics Applications (ERA): A framework for understanding and developing educational robots and their activities. *Constructionism 2010.* Paris: Proceedings of Constructionism 2010.

Catlin, D., & Blamires, M. (2010a). The e-Robot Project: A Longitudinal On-line Research Collaboration to Investigate the ERA Principles. *TRTWR 2010 Conference, part of SIMPAR 2010.* Darmstadt, Germany.

Catlin, D. (2012). Maximising the Effectiveness of Educational Robotics through the Use of Assessment for Learning Methodologies. *3rd International Conference on Teaching Robotics, Teaching with Robotics.* Riva La Garda, Italy.

Catlin, D. (2012). *Spacecraft Rescue*. Retrieved December 1st, 2015, from Roamer Tumblr: http://roamerrobot.tumblr.com/post/27181743875/spacecraft-rescue

Catlin, D. (2014). Using Peer Assessment with Educational Robots, Peer Review. *Peer Review, Peer Assessment and Self-Assessment in Education, ist International Workshop, collated with the 13th International Conference on Web-based Learning ICW.* Tallinn, Estonia: Springer Verlag.

Catlin, D., Csizmadia, A. P., OMeara, J. G., & Younie, S. (2015). Using Educational Robotics Research to Transform the Classroom. *RiE 2015: 6th International Conference on Robotics in Education.* Yverdon-les-Bains.

Cox, C. B., & Dyson, A. E. (1971). *The Black Papers.* (C. B. Cox, & A. E. Dyson, Eds.) London: Davis-Poynter.

Holmquist, S. (2014). *A multi-case study of student interactions with educational robots and impact on Science, Technology, Engineering, and Math (STEM) learning atitudes.* University of South Florida. Tampa Bay: University of South Florida.

Kohn, A. (2011, October 24th). *Alfie Kohn Math*. Retrieved December 1st, 2015, from YouTube: https://www.youtube.com/watch?v=9gkplk3uEW4&feature=youtu.be

Pope, G. (2013). *Questioning Technique Pocketbook.* Alresford, England: Teachers' Pocketbooks.

Price, B. D. (2009). *The Con in Constructivism*. Retrieved December 1st, 2015, from Improve Education: http://www.improve-education.org/id55.html

Smith, I. (2007). *Assessment and Learning: Pocketbook.* Alresford, Hampshire: Teachers' Pocketbooks.

US Dept of Education. (n.d.). *Section IX—Appendix: Sample Teacher Role Structure.* Retrieved January 26th, 2015, from The Respect Project Vision Statement: The RESPECT Project: Envisioning a Teaching Profession for the 21st Century: http://goo.gl/DIok2t

Wiliam, D. (2011). *Embedded Formative Assessment.* Bloomington: Solution Tree Press.

Wiliam, D. (2012, December 12th). *Unpacking Formative Assessment*. (N. W. (NWEA), Producer) Retrieved December 1st, 2015, from YouTube: https://goo.gl/btXsAz

Wragg, E. C., & Brown, G. A. (2001). *Questioning in the Primary School.* London and New York: Routledge.