Using Robotic Technology as a Constructionist Mindtool in Knowledge Construction

Timothy Savage, Inmaculada Arnedillo Sánchez, Fionnuala O'Donnell, and Brendan Tangney
Centre for Research in Information Technology and Education,
Trinity College, Dublin, Ireland.
Tim.Savage@cs.tcd.ie

Abstract

The knowledge society brings its own challenges and demands upon its citizens. Key amongst these is the need to empower people to become lifelong learners, to reflect upon their own learning, to become problem solvers and to appreciate technology. This paper records the experiences of an innovative project using a constructionist Mindtool approach in a module on logic, robotics, and programming for non-technical third level students.

1. The Pedagogy

In 1993 Seymour Papert proposed that the coming period, labelled the *information age*, "could equally be called the age of learning" [1], an age in which he had already identified "the ability to learn" as "the competitive ability" [1]. This poses questions in regards to appropriate learning paradigms and methodologies for utilizing potentially competitive technological tools to promote the ability to learn.

In order to explore paths leading to a technology enhanced ability to learn, the following section will examine Constructionism as a learning paradigm [1, 2], Mindtools [3] as instruments, and learning from dialogue [4-6] as a methodology.

Rooted in Piaget's constructivism, constructionism argues that "the construction that takes place in the head often happens especially felicitously when it is supported by construction of a more public sort in the world" [1], by way of creating a product that "can be shown, discussed, examined, probed and admired" [2]. In effect, "an object to think with" [7].

The constructionist "cycle of internalisation of what is outside, then externalisation of what is inside and so on" [2] encompasses two complementary ways of thinking: the abstract and the concrete. This co-evolution of understanding and artifacts within the individual and social worlds promotes knowledge construction through learning and collaborative knowledge building [5, 6].

This constant duality (abstract-concrete, understanding- artefact, learning-collaborative knowledge building) is further reinforced by a dual manner of thinking proposed by Norman: experiential and reflective [8]. Experiential thinking develops from an individual's experiences with the world when information is perceived and acted upon as a reflexive, automatic action. Reflective thinking requires "mental effort to think of and contrast the various courses of action" and often necessitates external support.

Knowledge representation, external support and reflective thinking are all tenets of Mindtools. The term, coined by Jonassen [3], describes computer-based tools and learning environments that act as extensions of the mind and when engaged in "intellectual partnership" with learners intend to promote critical thinking , creative thinking, and complex thinking [3].

"Developing a discourse is at the heart of developing a culture" [9]. Discourse is understood as the means through which knowledge is formed, criticised and amended [11]. There is a need for a learning environment and context that promotes transformational thought through a knowledge-building discourse that allows for ideas to be conceived, responded to and reframed [6].

2. Design and Implementation

PBL is an instructional strategy that promotes active learning. It is characterized as student centred and occurring in small student groups where the teachers are facilitators or guides. The problems form the organizing focus and stimulus for learning and are a vehicle for the development of problem-solving skills.

The Lego Mindstorms Robotics System (LMRS) enables the learner to design, build, and programme a robot or artefact through a programmable brick that can control motors and sensors. The sensors (light and touch) allow the artefact to interact with its environment in accordance to the programme that has been designed. The programming interface resides on a PC and is downloaded into the brick through an infrared connection. It enables the use and manipulation of all of the basic programming concepts without any knowledge of the syntax.

The course was designed to follow four distinct phases; Introductory, Collaborative Group working, Assignment, and Presentation. All stages except the last

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utilised a PBL approach and all actively encourage reflections on the process and the content.

The learners were adult students on the first year of the Masters in IT in Education at Trinity College, Dublin. There is a strong constructivist/constructionist ethos that is made explicit to the students from the outset and in which they actively engage and contribute to.

3. Reflection on the Module

The highly interactive introductory phase consisted of the presentation of previous years work and whole class PBL with the LMRS. The whole class PBL consisted of the lecturer presenting the programming interface and a robot cart to the class and setting problems. The proposed solutions were tried and the results instantly demonstrated through the cart.

The group-working phase consisted of two problem-based learning sessions. The class was divided into groups of four and assigned a set of tasks of increasing complexity for their robot cart to complete.

The students were set an assignment to build an "object to think with" that interacts with its environment and digitally express your reflections on the process as a learning experience.

The presentations consisted of a demonstration of their robot/artefact and their reflections on the learning experience in terms of the LMRS, programming, and the use of PBL.

3.1 In The Learners Own Words

The comments below are indicative of the reflections of the class as a whole.

On Logic: "I could see that it merged what is traditionally called left-brain and right-brain thinking. The creative aspect as well as the fact that you had to use logic and implement that logic."

On Thinking Skills: "It was a great sense of achievement as others have said when it was finished and it actually worked and I certainly think my logical thinking skills improved and I could hear them being oiled up and the rust beginning to disintegrate."

On Collaboration: "It certainly lent itself to collaborative learning which I personally find very useful."

On Construction: "As it was my very first introduction to programming it was certainly very testing … the reason I am doing this degree is that I love the construction end of it, the building, and it is not just totally theory."

On Programming: "I was wary of it at the start like some other people… It was my first time ever programming so I had to sit down and think what I wanted to do… I thoroughly enjoyed it…"

On Reflection on Learning Process: "… I can see very clearly that there was the implementation of the Kolb cycle of programming, testing, reviewing, copping on to what was wrong having a go off it again"

4. Conclusions

The learning experience described suggests that the combination of constructionism, Mindtools and discourse offers great potential to promote higher-order thinking skills of analysis, synthesis and evaluation. These are key elements to promote the ability to learn that should be ingrained in every single member of the knowledge society.

References

[1] S. Papert, *The Children's Machine: Rethinking School in the Age of the Computer*. New York: Basic Books, 1993.

[2] S. Papert, "Introduction by Seymour Papert," in *Constructionist Learning*, I. Harel, Ed. Boston: MIT Laboratory, 1990.

[3] D. H. Jonassen, *Computers as Mindtools for Schools: Engaging Critical Thinking*, 2nd ed. Upper Saddle River, NJ: Prentice-Hall, inc., 2000.

[4] D. Laurillard, *Rethinking University Teaching. A Framework for the Effective Use of Educational Technology*. London: Routledge, 1993.

[5] M. Lamon, R. Reeve, and M. Scardamalia, *Mapping Learning and the Growth of Knowledge Building Community*: American Educational Research Association Meeting, Seatle, Washington, 2001.

[6] M. Scardamalia and C. Bereiter, "Computer Support for Knowledge-Building Communities," *The Journal of the Learning Science*, vol. 3, pp. 265-283, 1994.

[7] S. Papert, *Mindstorms: Children, Computers and Powerful Ideas*, 2nd ed. Cambridge, MA: Basic Books, 1993.

[8] D. A. Norman, *Things that Make us Smart: Defending Human Attributes in the Age of the Machine*. Readings, MA: Addison-Wesley Publishing Co., 1993.

[9] S. Papert, "Computer Critism vs. Technocentric Thinking," *Educational Research*, vol. 16, 1987.

[10] "School's Out? A Conversation with Semour Papert."

[11] K. Popper, *Conjectures and Refutations*. London: Routledge, 1962.