The Evolvement of Constructionism: An Overview of the Literature

Antigoni Parmaxi and Panayiotis Zaphiris

Cyprus Interaction Lab, Department of Multimedia and Graphic Arts,
Cyprus University of Technology, Cyprus
{antigoni.parmaxi,panayiotis.zaphiris}@cut.ac.cy

Abstract. This paper reviews the theory of constructionism from its evolvement in 1980s towards its more recent implementations. By reviewing recent research conducted under the framework of constructionism, we set off in understanding its key ideas and their evolution over time. At the same time this paper acknowledges obstacles, challenges and critiques towards implementing constructionism in the teaching and learning practice. The paper is organized around three sections: constructionism, distributed constructionism and social constructionism. The findings of this study reveal the dynamic progression of constructionism and its potential to be used as a pervasive theoretical framework for instructional technology in various settings.

Keywords: theory of learning, Papert, Logo, microworlds construction, artifact, object-to-think-with, social technologies.

1 Introduction

Whilst educators, practitioners and researchers express high interest in making available technological tools that enable their students to learn through experimentation rather than lecturing, designing and implementing such tools under the appropriate framework is hardly realized [27]. Resnick [27] provides three threads of thought, which need to be taken into consideration whilst designing such tools: firstly, learners' experiences, needs and expectations; secondly understanding of domain knowledge and finally, understanding of computational ideas and paradigms. On the same line, Ruschoff and Ritter [29] raise the need of "a radical change in our approaches to teaching and learning in order to best prepare future generations for living and working in tomorrow's world". From this perspective, constructionism can offer "the guiding principles for curriculum design, materials development, and classroom practice" [29].

The term constructionism originates from Papert [16-20] and captures the concept of construction of knowledge by engaging in the making of concrete and public artifacts. Papert's theory can be summarized in his vision of a new educational environment in which learners build meaningful knowledge artifacts by taking advantage of the ubiquity of new technologies around them. This study reviews the theoretical

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framework of constructionism from its infancy towards its more recent applications and provides support for its privileged status for supporting the use of technological tools in learning.

2 Constructionism

2.1 Constructivism and Constructionism

Constructionism [16-20] builds and expands the Piagetian theory of constructivism [24]. For both constructivism and constructionism, knowledge is built by the learner; instead of being presented and imposed to students by an expert, such as the teacher. As an alternative, they maintain that teachers should enhance students' active learning. Constructionism adds to the constructivist perspective the idea of artifact construction. Where constructivists view the learner as an active builder of knowledge, constructionism places a critical emphasis on having learners engage in artifacts constructions that are external and shared. In contrast to Piaget who focuses on cognitive processes of learning, Papert's constructionism focuses on learning through making and emphasizes on individual learners' interactions with their artifacts that are mostly built through the assistance of digital media and computer based technologies:

Constructionism--the N word as opposed to the V word--shares constructivism's connotation of learning as 'building knowledge structures' irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe [20].

Constructionists argue that learners' engagement with external artifact construction involves a creative and re-creative activity that represents a developmental cycle. Papert has seen the critical role of the cultural surrounding whilst building internal cognitive structures pointing out that surrounding cultures can inform and facilitate constructive Piagetian learning [16]. Papert views the difficulty in understanding certain concepts in the deficiency of education in materials that would make an idea or concept simple and concrete:

All builders need materials to build with. Where I am at variance with Piaget is in the role I attribute to the surrounding cultures as a source of these materials. In some cases the culture supplies them in abundance, thus facilitating constructive Piagetian learning. For example, the fact that so many important things (knives and forks, mothers and fathers, shoes and socks) come in pairs is a "material" for the construction of an intuitive sense of number. But in many cases where Piaget would explain the slower development of a particular concept by its greater complexity or formality, I see the critical factor as the relative poverty of the culture in those materials that would make the concept simple and concrete. In yet other cases the culture may provide materials but block their use [16].

Wilensky [33] took this point further providing a new perspective into our understanding of concrete elucidating that "concreteness is not a property of an object but rather a *property of a person's relationship to an object*. Concepts that were hopelessly abstract at one time can become concrete for us if we get into the "right relationship" with them" [33]. In light of this perspective, any idea, concept or piece of knowledge can become concrete provided that a person develops a set of representations, interactions and connections with the idea, concept or piece of knowledge [33]. The constructionist paradigm offers a fertile ground for promoting concreteness since "when we construct objects in the world, we come into engaged relationship with them and the knowledge needed for their construction. It is especially likely then that we will make this knowledge concrete" [33]. Wilenksy [33] also emphasizes the importance of social relations between people since "it is through people's own idiosyncratically personal ways of connecting to other people that meaningful relationships are established" [33].

2.2 Constructionist Concepts

Constructionism is underpinned by three key ideas [12]: appropriation, knowledge construction and learning cultures. Appropriation emphasizes the importance of having learners seize new knowledge and begin to identify with it [12]. Knowledge construction is closely connected to learning through constructing one's own knowledge whilst engaging in creating meaningful artifacts. Finally, constructionism also values the importance of learning culture. A popular example of a learning community is the samba school, an informal social setting in which people come together for something that involves "social cohesion, a sense of belonging to a group, and a sense of common purpose" [16]. In a setting such as a school of samba, constructionists focus on how the social context fortifies the building of connections to what is being learned. Papert [16] has seen the critical role of the cultural surrounding whilst building internal cognitive structures pointing out that surrounding cultures can inform and facilitate constructive Piagetian learning.

2.3 Potentials and Challenges of Artifact Construction

Digital media and computer based technologies provide a rich teaching instrument, in Papert's words an "object-to-think-with" that can be shared in the world, probed and admired [18]. Constructionism is closely connected with the Logo programming language which is seen by researchers as "a testing bed for engaging students in problems solving and learning to learn" [12]. Logo is a programming language developed at the Massachusetts Institute of Technology in the late 1960s. Logo is renowned for its turtle graphics which provide an "object-to-think-with" [16]. In its early years, the most popular use of Logo involved a "floor turtle" (robot) and with the burst of personal computers in the late 1970s the Logo turtle shifted to its screen version. Both the floor (robot) and screen turtle were controlled through a computer keyboard. The initial commands that were used with Logo to make the turtle move were: forward, back, left, right, pen up, pen down. These commands made the turtle move and draw whatever the user wanted.

For constructionists Logo provides a vehicle and a language for thinking about thinking, an activity that promotes the development of higher levels of thinking and problem-solving performance [1, 3]. Moreover, learners' engagement with the use of computer "offers children the opportunity to become more like adults, indeed like professionals, in their relationship to their intellectual products and themselves" [16]. Advocates of Logo claim that Logo is a developer of creativity, divergent thinking, metacognitive ability, ability to describe direction well [4, 6-7] and an enhancement of students' mathematical understanding [9, 5]. Moreover, research also indicated that Logo can enhance the development of social and emotional development [10, 13] and promote spontaneous social interaction [11].

On the other hand, Logo has received criticism mainly because what it provokes outstrips its actual performance. A growing body of research at the Education's Centre for Children and Technology (CCT) at the Bank Street College failed to identify Logo effects. Pea [22] conducted a longitudinal pre-post study with children who worked with Logo language over a school year. The results showed no cognitive benefits for the children who worked with Logo language. Moreover, two other quantitative studies conducted at the CCT showed that the knowledge acquired within Logo has limited or no potential in transferring easily to any other kind of learning [14, 23]. As an attempt to elucidate these negative results, CCT researchers explored what happens whilst students explore Logo [15]. The study showed that programming experience (as opposed to expertise) does not transfer to other domains which share analogous formal properties. Finally, advocates against Logo also demonstrate that Logo is a limited instructional tool that inhibits other kinds of thinking [2, 8].

Papert entails this criticism as a "poor way to talk about Logo" [17] grounding his argument on his view of technocentrism from Piaget's use of the word egocentrism:

> *Egocentrism for Piaget does not, of course, mean "selfishness"--it means that the child has difficulty understanding anything independently of the self. Technocentrism refers to the tendency to give a similar centrality to a technical object-for example computers or Logo* [17].

Papert [17] points that this technocentric thinking which emphasizes the centrality of the computer as agent that acts directly on thinking and learning, underestimates other significant elements of the learning practice, people and culture:

> *Does wood produce good houses? If I built a house out of wood and it fell down, would this show that wood does not produce good houses? Do hammers and saws produce good furniture? These betray themselves as technocentric questions by ignoring people and the elements only people can introduce: skill, design, aesthetics* [17].

For Papert this tendency has led to questions like "What is THE effect of THE computer on cognitive development?" which position computer or Logo as the most important component of educational situations whereas people and cultures gain a facilitating role. For Papert, human development is situated within its culture and people:

> *In the presence of computers, cultures might change and with them people's ways of learning and thinking. But if you want to understand (or influence) the change, you have to center your attention on the culture-- not on the computer* [17].

2.4 Other Construction Environments

In the years that followed, several new versions of Logo were developed, amongst which MultiLogo, StarLogo, StarLogo 2.0 and the most common commercial version of Logo called Microworlds Logo developed by Logo Computer Systems Inc. MultiLogo is a parallel version of Logo, supporting simultaneous creation and execution of multiple processes with a new programming construct: the "agent" [28]. Each agent can control a computational process, thus by using multiple agents the user can control multiple process at the same time. A new version of Logo, called StarLogo, extends the Logo programming language, used by students to model the behavior of decentralized systems [27]. StarLogo extends Logo in three ways: first it has thousands of turtles who can move at the same time, in parallel; secondly, StarLogo turtles expand the senses of the Logo turtle that could only dray geometrical shapes and thirdly, concretize the turtles' world.

Few decades later, Resnick [26] discusses an advanced construction environment developed at the MIT Media Lab known as LEGO/Logo. LEGO/Logo links the LEGO construction kit with the Logo programming language. Whilst using LEGO/Logo children start by making machines out of Lego pieces, with additional pieces such as gears, motors and sensors. Then children can connect their machine on a computer and through a modified version of Logo to control their machine.

Another construction kit developed at the MIT Media Lab is known as Programmable Brick. Programmable Brick is a large LEGO brick, specially designed for interacting with the world. The Brick can control four motors of light at a time and it can receive inputs from eight sensors [26, 30]. To work and play with the Programmable Brick, children need to write programs on their personal computer and then connect the Programmable Brick with their computer through a cable. Then children can disconnect the cable and take the Brick with them, having the program stored in the Brick.

3 Distributed Constructionism

The theoretical underpinning of distributed constructionism was introduced at the MIT Media Laboratory and draws on research on constructionism and distributed cognition [25]. Distributed constructionism focuses on situations in which learning occurs when a person is interacting with its surrounding environment for designing and sharing meaningful artifacts; thus distributed constructionism develops the constructionist theory towards the direction of distributed construction activities. Resnick [25] focuses on three main categories of activities: discussing constructions, sharing constructions, and collaborating on constructions. Table 1 demonstrates how computer networks can be used in order to support the aforementioned distributed construction activities.

Stemming from Resnick's [25] concept of Distributed Constructionism, Zaphiris et al. [34] explored the implementation of Distributed Constructionism through a Participatory Design methodology for an Online Learning Community. Throughout this study, the learners collaborated in developing the content of an online Modern Greek language course, peer review and publish content contributions, and involve in participatory design teams. In this study the Participatory Design was implemented as a four step process, namely: (a) build bridges with the intended users; (b) define user needs and recommendations to the system; (c) develop a prototype and (d) incorporate feedback and carry on the iteration. Additionally, Distributed Constructionism was employed to enhance the learning experience and community development. The findings revealed that Distributed Constructionism enhanced the learning experience of both the passive users and the Participatory Design team, whose contributions included replying to other students' language enquiries, helping out students to cope with technical problems and helping them explore resources to enhance their learning of the Greek language.

Table 1. Distributed construction activities through computer networks [25]

Category of Distributed Construction Activity	*Clarification*	*Examples*
Discussing constructions	Students use computer networks for discussing, exchanging ideas for their construction	Discussion through email, newsgroups, bulletin boards
Sharing constructions	Students use computer networks for sharing/distributing constructions (text, images, videos) amongst people in the community and make it part of shared knowledge	Create page on the web that displays artifacts
Collaborating on constructions	Students use computer networks to collaborate with fellow-students in real time for the design and development of their construction	Use of MUDs - text-based virtual worlds where participants can work together

4 Social Constructionism

Shaw [31] first launches the term social constructionism emphasizing the importance of the social setting whilst engaging in constructing external and shared outcomes and artifacts. Shaw [31] views social constructionism as a strong tie between Vygotskian sociocultural theory [32] and constructivist leaning processes informed by Piaget [24], since socially constructive activities may provide developmental activity of the individual for constructing an artifact in a social setting. Shaw [31] in his study reports on MUSIC (Multi-User Sessions In Community), a community computer networking system that was designed for enduring constructionist social environments. MUSIC is a neighborhood based community that facilitates sharing of information and organizing programs run by neighborhood residents. The aim of this system is to encourage members in an urban social setting to invest in their relationships in order to make use of each other's services. MUSIC has been successful in organizing and managing neighborhood programs. In total the network facilitated the organization of eleven projects such as, a group trip to Jamaica, a poetry collection, a summer jobs program for neighborhood teenagers, crime watch information updates etc.

Few decades later, the advent of the social web gave a new perspective to social constructionism as Shaw [31] firstly envisioned it. Parmaxi et al. [21] explored how the construction of an online artifact manifests in practice within social technologies, providing its core dimensions that were sorted out in three high-level categories: exploration of ideas, construction of artifact and evaluation of artifact. In this study, various types of social technologies were used, that is wikis, blogs, Facebook Google documents and Dropbox. Learners used the aforementioned technologies for working together and build artifacts throughout a process that included nine actions: orientation, brainstorming, material exploration, outlining, editing material, revising, peer reviewing, instructor reviewing and presenting/publishing. Overall, this study demonstrated the potential of social technologies to act as social constructionist platforms that can enhance learners' thinking and understanding of abstract ideas by relating them to their shared artifact.

5 Discussion

Figure 1 demonstrates the evolvement of constructionism towards distributed and social constructionism. Digital media offer a rich environment of materials that provide a vehicle for promoting the development of higher levels of thinking, problem solving skills, divergent thinking, metacognitive ability and social interaction.

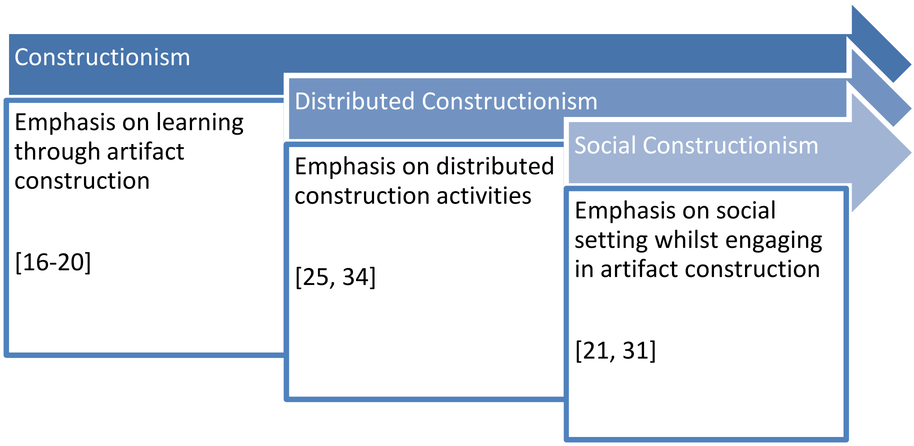

Fig. 1. The evolvement of constructionism

The dynamic progression of constructionism is prevalent not only by its continuous development but also from the various technological tools that evolve as social constructionist tools. A sound mathetic advice in constructionism is "*Look for connections*" which leads to the suggestion of establishing connections between abstract and concrete knowledge by engaging in the making of objects in the world [19]. Through improving the connectivity, we come into engaged relationship both with the artifact and with the knowledge needed for its construction.

6 Conclusion

This study reviewed the theoretical framework of constructionism from its infancy towards its more recent applications. After three decades of theoretical and applied research, constructionism is gaining ground as a comprehensive framework that could ground the use of technology in several settings.

The dynamic progression of constructionism leans towards distributed and social constructionism. This study demonstrated that despite its challenges, constructionism can offer a number of approaches for placing learners as active designers and constructors of knowledge by confronting them with the building of an artifact.

References

1. Battista, M.T., Clements, D.H.: The effects of Logo and CAI problem-solving environments on problem-solving abilities and mathematics achievement. Computers in Human Behavior 2(3), 183–193 (1986)
2. Broughton, J.M.: The surrender of control: Computer literacy as political socialization of the child. In: Sloan, D. (ed.) The Computer in Education: A Critical Perspective, pp. 102–122. Teachers College Press, New York (1985)
3. Clements, D.H.: Effects of Logo and CAI environments on cognition and creativity. Journal of Educational Psychology 78(4), 309 (1986)
4. Clements, D.H.: Longitudinal study of the effects of Logo programming on cognitive abilities and achievement. Journal of Educational Computing Research 3(1), 73–94 (1987)
5. Clements, D.H., Battista, M.T.: The effects of Logo on children's conceptualizations of angle and polygons. Journal for Research in Mathematics Education, 356–371 (1990)
6. Clements, D.: Research on Logo in education: is the turtle slow but steady, or not even in the race? In: Maddux, C.D. (ed.) Computers in the Schools, pp. 55–71. Haworth, New York (1985)
7. Clements, D.H., Gullo, D.F.: Effects of computer programming on young children's cognition. Journal of Educational Psychology 76(6), 1051–1058 (1984)
8. Davy, J.: Mindstorms in the Lamplight. In: Sloan, D. (ed.) The Computer in Education: A Critical Perspective, pp. 11–30. Teachers College, New York (1984)
9. Feurzeig, W.: Algebra slaves and agents in a Logo-based mathematics curriculum. Instructional Science 14(3-4), 229–254 (1986)
10. Fletcher, B.C.: Group and individual learning of junior school children on a microcomputer-based task: social or cognitive facilitation? Educational Review 37(3), 251–261 (1985)
11. Hoyles, C., Sutherland, R.: Logo mathematics in the classroom (revised edition). Routledge, New York (1992)

12. Kafai, Y.B.: Constructionism. In: Sawyer, R.K. (ed.) The Cambridge Handbook of the Learning Sciences, pp. 35–46. Cambridge University Press, New York (2006)
13. Kull, J.A.: Learning and logo. In: Campbell, P., Fein, G. (eds.) Young Children and Microcomputers, pp. 103–130. Prentice Hall, Englewood Cliffs (1986)
14. Kurland, D.M., Pea, R.D.: Children's mental models of recursive LOGO programs. Journal of Educational Computing Research 1(2), 235–243 (1985)
15. Kurland, D.M., Pea, R.D., Clement, C., Mawby, R.: A study of the development of programming ability and thinking skills in high school students. Journal of Educational Computing Research 2(4), 429–458 (1986)
16. Papert, S.: Mindstorms: Children, computers, and powerful ideas. Basic Books, Inc. (1980)
17. Papert, S.: Computer Criticism vs. Technocentric Thinking. Educational Researcher 16(1), 22–30 (1987)
18. Papert, S.: The children's machine: Rethinking school in the age of the computer. Basic Books (1993)
19. Papert, S.: A word for learning. In: Kafai, Y., Resnick, M. (eds.) Constructionism in Practice, pp. 9–24. Lawrence Erlbaum associates Inc., New Jersey (1996)
20. Papert, S., Harel, I.: Situating Constructionism. In: Papert, S., Harel, I. (eds.) Constructionism, pp. 1–11. Ablex Publishing, NJ (1991)
21. Parmaxi, A., Zaphiris, P., Michailidou, E., Papadima-Sophocleous, S., Ioannou, A.: Introducing New Perspectives in the Use of Social Technologies in Learning: Social Constructionism. In: Kotzé, P., Marsden, G., Lindgaard, G., Wesson, J., Winckler, M. (eds.) INTERACT 2013, Part II. LNCS, vol. 8118, pp. 554–570. Springer, Heidelberg (2013)
22. Pea, R.D.: Logo programming and problem solving. In: O'Shea, T., Scanlon, E. (eds.) Technology. Center for Children and Technology, vol. 606(1) (1987), http://eric.ed.gov/ERICWebPortal/recordDetail?accno=ED319371
23. Pea, R.D., Kurland, D.M.: On the cognitive effects of learning computer programming. New Ideas in Psychology 2(2), 137–168 (1984)
24. Piaget, J.: The construction of reality in the child. Ballantine Books, New York (1954)
25. Resnick, M.: Distributed Constructionism. In: Computing, pp. 280–284. International Society of the Learning Sciences (1996)
26. Resnick, M.: Behavior construction kits. Communications of the ACM 36(7), 64–71 (1993)
27. Resnick, M.: New Paradigms for Computing, New Paradigmns for Thinking. In: Kafai, Y., Resnick, M. (eds.) Constructionism in Practice, pp. 255–267. Lawrence Erlbaum Associates Inc., New Jersey (1996)
28. Resnick, M.: MultiLogo: A study of children and concurrent programming. Interactive Learning Environments 1(3), 153–170 (1990)
29. Ruschoff, B., Ritter, M.: Technology-Enhanced Language Learning: Construction of Knowledge and Template-Based Learning in the Foreign Language Classroom. Computer Assisted Language Learning 14(3-4), 219–232 (2001)
30. Sargent, R., Resnick, M., Martin, F., Silverman, B.: Building and learning with programmable bricks. In: Kafai, Y., Resnick, M. (eds.) Constructionism in Practice, pp. 161–173. Lawrence Erlbaum Associates Inc., New Jersey (1996)
31. Shaw, A.: Social constructionism and the inner city: Designing environments for social development and urban renewal. In: Kafai, Y., Resnick, M. (eds.) Constructionism in Practice, pp. 175–206. Lawrence Erlbaum Associates Inc., New Jersey (1996)
32. Vygotsky, L.: Mind in society: The development of higher psychological processes. Harvard University Press, Cambridge (1978)

33. Wilensky, U.: Abstract meditations on the concrete and concrete implications for mathematics education. In: Harel, I., Papert, S. (eds.) Constructionism, pp. 193–203. Ablex Publishing Corporation, Norwood (1991)
34. Zaphiris, P., Zacharia, G., Rajasekaran, M.: Distributed Constructionism through Participatory Design. Group, 164–179 (2003), http://books.google.com/books?hl=en&lr=&id=GaUGjcpjo7AC&oi=fnd&pg=PA164&dq=Distributed+Constructionism+through+Participatory+Design&ots=nr3a7UZes7&sig=Mwum2xiy41oDbi2x4zrRUe-0Z8M (retrieved)