Niches for Constructionism: forging connections for practice and theory.

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Abstract

Can Constructionism afford segregation? Or to put it more positively, what is to be gained if we try to forge connectivities with the academic and the institutional worlds? In this paper I discuss some efforts for connectivity in three different domains. A wide scale Education Ministry digital space for enriched curriculum books, a constructionist kit system built on E-slate which can get students and teachers to create technically sophisticated applications and a process of networking amongst theoretical frameworks and constructs. I argue that such efforts may enable us to include Constructionism as an evolving and in flux realistic epistemology, theory and practice in a world of changing paradigms for education and for using technology.

Keywords

Connectivity, theoretical frameworks, constructionist kits, large scale

Introduction

When Constructionism was coined by Seymour Papert almost half a century ago there was hardly any other theory and practice, let alone impact, on using digital media for added educational value. Papert's concern was to align with constructivism in proposing a sense making human-oriented approach to study learning. It was however also to distinguish from it by challenging Piaget's theory to draw attention to the meanings actually generated by learners rather than to describe their shortcomings in understanding taken-as-ontological meanings at different stages in life. His agenda was further to change the perception that concrete thinking was a 'lesser' kind of cognitive process in relation to abstract thinking by pointing out that proper and rich exposure to the former was pivotal in ever hoping to reach the latter (Ackerman, 1984). Another part of the agenda was to claim that meanings are naturally generated in our social, intellectual and physical environment and that digital technology makes it possible for us to enrich this environment through constructionism so that learners would enjoy more opportunities for the formation of meanings. Papert's work has been an ode to kids' logical-mathematical and creative thinking, he has been provocative in arguing that we have not paid enough attention to how children think and to the nature of meanings they form given the language and tools they use, the activities they engage in and the communicative situations they find themselves in. He also argues that for children, a key to learning is the process of engagement in activity, the ownership of ideas and style of learning and the exposure, i.e. expressing their ideas to others, for reasons of exploration and communication.

So, what happened to constructionist theory since its first articulations? What has the constructionist community learned so far and how has it been put to use in educational practice? Has the theory been developing all these years or is it a well recognized but now rather blunt instrument associated with outdated technologies and ideas of how they can be used for learning? We live at a time of growing connectivity and resource availability, at a time where 'watch and

practice' technologies and administrational infrastructures are popular and politically publicized. We are also in the midst of an era where an important part of youth culture involves the immersion in collective virtual worlds where representations designed for meaning-making are given very low priority by media designers. We live at a time where several theoretical frameworks and constructs in education are in danger of lying in fragmentation each to be used by a community of researchers close to the context from within which they emerged.

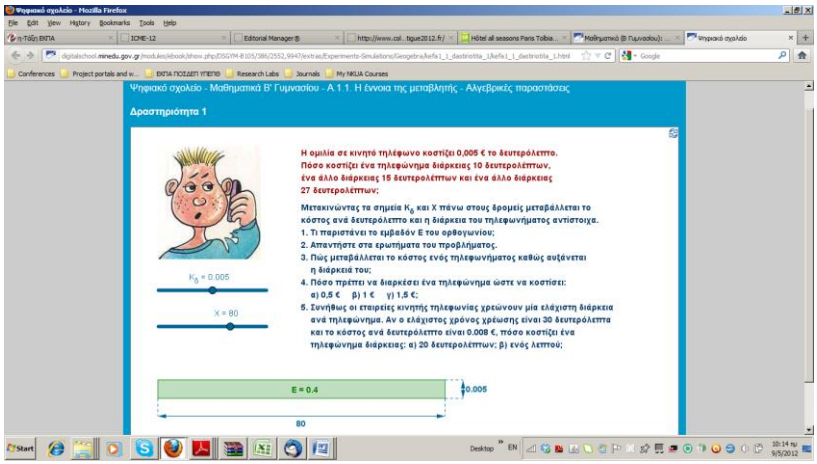
So, is constructionism relevant and useful today and in what capacity? We have seen this kind of learning in practice in many occasions, but we have seen very little in institutionalized life (Kafaii & Resnick, 1996). Does it address only the constructionists and Scratch, NETLOGO, TNG Star Logo and other like-minded communities in relative isolation from institutionalized life? Or can it be meaningfully connected to other theories and compatible practices? Is there some mutual benefit from trying to forge such connections? How can it be useful in the age of jings, blogs, portals and LMS, of reforms delivering tons of instructionist and informative material for free to lower the cost of education? Is there scope for further development of constructionist theory in an era of ever-changing technologies and a wealth of theoretical frameworks and constructs and how can this be justified? In this paper I attempt to contribute to the argument that constructionism is essentially an epistemology creating continual need for an evolving theory of learning in collectives and individually and at the same time a theory of design of new digital media, new kinds of activities facilitating the generation of meanings and techniques and processes for systemic interventions at various levels such as school cultures, resource systems and educational systems. As such, there is scope and interest in finding ways to include Constructionism in wider efforts to promote a culture of networking amongst diverse and fragmented theoretical frameworks and paradigms and top promote an distinct, transcendental and connected role for our community in a changing society which is in a continual flux and under continual challenge.

Changing trends for technologies in education

A particular kind of challenge comes from the changing of trends in what is considered as added value in the uses of digital media in education and in society at large (Papert, 2002). A first wave was the dynamic manipulation and icon-driven technologies which questioned programming as an effective meaning-making activity. Programming (not to mention the use of formal code) were seen as a kind of unnecessary noise to doing interesting things with digital media. A second was the advent of media supporting collaboration when attention was given to collective discussions and argumentation and taken away from constructionist activity as if these two were distinct. A third wave was the advent of social media, portals, LMS and the recently widely advertised 'watch-and-practice' video portals considered as an infrastructure relieving teachers of the need for frontal lecturing. This means that attention is currently given to the use of technology which supports traditional curriculum delivery so that human time and focus can be given to discussing questions and supporting the generation of meaning. So is constructionism going to be considered as an unnecessary noise to content delivery and large 'get togethers'? The problem of shifting paradigms for trendy uses of digital media in education and in society creates a need for constructionists to be able to effectively and clearly forge links and connectivities through which constructionist epistemology, media and uses are described in terms of very different points of view. In this paper however, I'd like to go a little deeper into some experiences with the processes of including constructionism in wider initiatives of networking amongst theoretical frameworks.

Micro-experiments as an avenue to wide scale deployment

This example comes from two otherwise unconnected wide-scale initiatives of the Ministry of Education in Greece. One has to do with training 650 teacher educators to give 96 hour courses on using digital technologies to their colleagues in three subjects, language, mathematics and science. This has involved up till now 14000 teachers who have taken this course. The mathematics teachers amongst them (around 1/4 of the total number) have been centrally exposed to constructionist epistemology, technologies and activity designs[1]. The other initiative is the 'digital school', an LMS - portal containing amongst others a place where the old curriculum books are being 'digitally enhanced', i.e. filled with links to places decided by academic education specialists for each subject[2]. The Ministry's agenda was to provide all students with a free service for them to access the books and to support this move they included the 'enhanced' version to differentiate it from just html files of paper books.



This was a very large scale, raw and visible intervention. It was not the place to try to portray constructionist media assuming that the educational world would just sync into a new norm for learning mathematics. The teacher education course seemed slow and arduous through this lens. So, we decided to propose a construct with constructionist potential and called it a 'micro-experiment'. A micro-experiment is a digital artefact addressing the student through text tasks including open ended questions, aimed at starting mathematical discussion in the classroom and most importantly providing specific things for them to do mainly by means of dynamic manipulation. A crucial feature of these artefacts is that even though they conform to the LMS

[1] In-service teacher training for the utilization of ICT in the classroom, Hellenic Republic, National Strategic Reference Framework, Operational Programme Education and Life-long Learning, MIS codes 217081, 217082 & 217083 (2009 - 2014)

[2] "DIGITAL SCHOOL: Specifying a Digital Educational Platform, Building and Operating an Educational Knowledge Base, Adapting and Annotating Learning Objects with Educational Metadata, Building the Infrastructure to Support Exemplary Teaching Practices and the Use of the Participatory Web", Greek National Strategic Reference Framework (NSRF), No 296441 (2010 -2015)

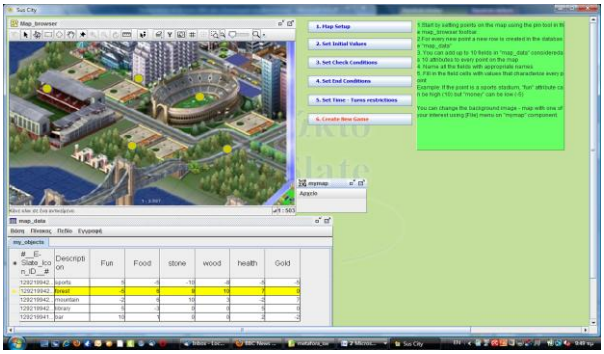
imperatives of immediate web accessibility, they also conform to a constructionist treatment. With a double click, they download as D.G.S. files which can then be changed and dismantled at will. Constructionist activity is thus not pushed aside but instead enabled even in a context where it is not amongst the main issues forming the paradigm. Consider the scale: around 250 of these are being developed for each mathematics year book for the 12 years of compulsory education, they constitute the main type of artefact, and the site has received 3.5M hits in the last year of so in a country of 11M. It's not bona-fide constructionism. But it's a push towards constructionist epistemology, it encourages this kind of activity and this can be done through schooling. Amongst others, Blikstein and Cavallo (2002) have shown what it means to generate change in school cultures and how in any institution, focused change is slow and messy (Papert, 2002). The teacher education program in Greece will take its course in time. The micro-experiments initiative may hopefully make things a little smoother for instance by making the teacher education initiative relevant and connected.

B&W box designs for diverse constructionist activities

Several years ago I discussed the idea of black and white, or semi-transparent box designs as a means to meet students and teachers half way with respect to the quest of generating constructionist cultures and norms (Kynigos, 2004, 2002). B&W box artefacts allow for construction either through programming or in kit-style connection of digital components. The point is that users get to start with building blocks which are much more sophisticated, higher order and specialized than generic primitives. In this way, they can efficiently create artefacts which have sophisticated functionalities in themselves and thus see the point of constructing beyond creating simplistic objects such as Scratch x-mass cards or amateurish games. This is not to say that pure constructionist media should be substituted by kit like media. But I do think they should co-exist. A constructionist culture needs to be able to produce real usable artefacts with professional looking functionalities and interfaces, to see that apart from epistemology and ownership, media useful to others can be developed. In this wake, our long term project to develop E-slate and use it as an authoring system for teachers and students has taken a new twist. In the past two years, we developed the idea of E-slate 'Microworld Kits'. A Kit is a thematically cohesive artefact which operates as a sub-set of E-slate and at the same time as a fully fledged authoring tool itself. A Kit is a template with which microworlds belonging to its theme can be built by teachers or students alike. At the present, on the English 'downloads' link on the ETL site (http://etl.ppp.uoa.gr) three are four such kits. One is recognizable: 'Turtleworlds'. The others are 'Dyna-stage', 'Sus-x' and 'MaStoHF' or 'My Story'. Dyna-stage is a template for Newtonian simulations providing basic tools for the creation of graphical objects and Logo programs to give them properties, behaviours and interactions involving for instance, field forces, collision rules etc. Sus-x stands for 'Sustainable - something'. It is a sim-city like game where everything can be constructed and changed, the map, the fields, the values, the communications to the users, the 'red lines', the places to visit, the consequences of a visit. The components have been connected with the usual combination of plugs and Logo scripts but the Kit is ready for the creation and change of these games. MaStoHF is a Kit connecting geo-coded data with a timeline and allowing for TableTop - like queries and picture matching. Again, all the data can be changed allowing for the creation of investigational artefacts for a wide range of topics.

Mainly Sus-x but also MaStoHF have been used for pedagogical designs and interventions in Environmental Education (EE) where there is a distinct agenda for a shift from an objectivist paradigm of learning about environmental problems to a critical knowledge paradigm where the

complex and multifaceted character of current socio-environmental and sustainability issues is explored and discussed and the underlying socially constructed value-systems, states of mind and practices are revealed and questioned (Kynigos & Daskolia 2011). This agenda can be supported by reifications of such exploration and discussion which can be sus-x games or mastohf explorations in a context where students and teachers tinker with and make changes to their own artefacts discussing the rules and functionalities.



Constructionism with B&W box designs is again not pure constructionism. But it can get outsiders to efficiently get engaged with the idea and to come up with things they can use. we have been using it in our masters courses at the ETL for more than 10 years now with student and in-service teachers of science, mathematics, language, EFL, geography, history, environmental education, ancient Greek. These people engage in constructionism themselves by designing and developing artefacts for realistic constructionist activity by students (see also Healy & Kynigos, 2010).

Constructionism and the networking of theories

Another arena for connectivities is that of theory. Reflections on the place and role of constructionism in amongst theories have emerged as a result of a wider initiative to consider the landscape of theories in the field, to better identify their nature, status and functionalities and to develop strategies for integrations amongst them so that there is a better understanding and communicability of the progress of mathematics education as a field to stakeholders outside academia and educational reformers.

Significant work on bringing constructionism and other theories developed or shaped to study the uses of digital media for learning was done through the work of six European research teams for a period of 6 years (2004-2009, the TELMA European research Team in the Kaleidoscope Network of Excellence and the European Information Society Technologies programme (FP6) titled 'Representing Mathematics with Digital Media' (ReMath)). Mathematics Education theories such as the Anthropological Theory of the Didactique, The Theory of Didactical Situations, Social Semiotics, Semiotic Mediation, Activity Theory, Instrumental Genesis were considered together with Constructionism to be part of the same phenomenon happening more widely in mathematics education, i.e. a fragmentation and polysemy slowing down and diluting the production of knowledge in the field. The teams worked under the initiatives of Michele Artigue (Artigue et al, 2009) to elaborate a process of networking amongst these frameworks initially at

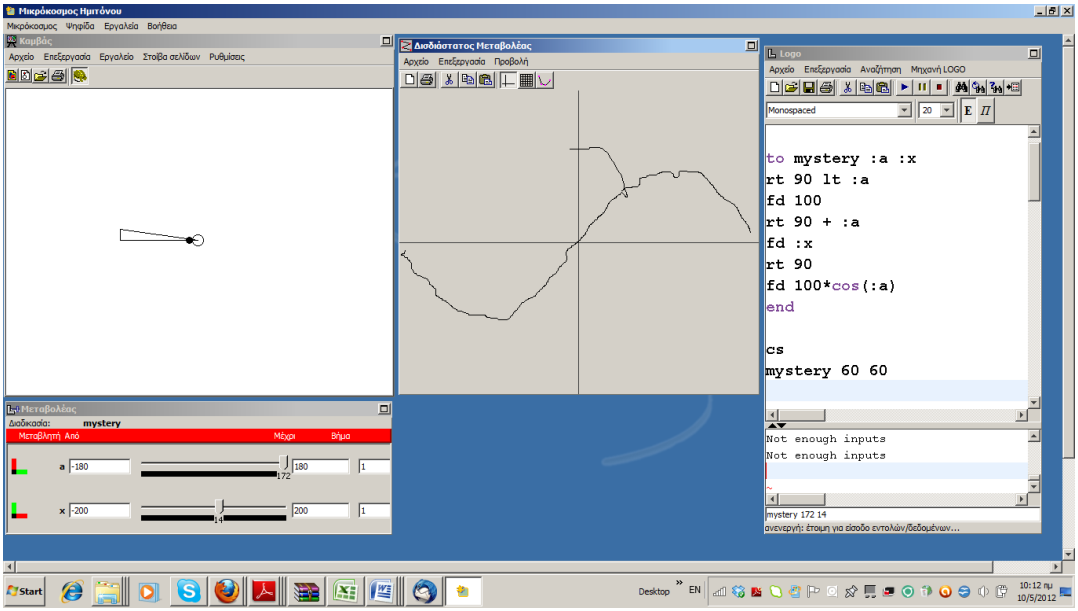
the level of conceptualizing and proposing a networking process and subsequently at the level of operationalizing the process to actively articulate connectivities between frameworks through joint research. The initial framing of the networking process involved an articulation of these theories through the lens of their didactical functionality and the language of concerns. Special attention was give to the aspect of representations of mathematical concepts through digital media (Artigue et al, 2009) and the formative influences of the context of the educational system and the processes of design and development of both media and research interventions (Kynigos and Psycharis, 2010). In the ReMath project, networking involved the whole cycle of designing and developing six original state of the art digital media for learning mathematics, the design of interventions and classroom experiments and the implementations of these analyzing students' meanings in realistic classroom situations. Several networking tools were developed for cross experimentation which operated as boundary objects to identify and articulate connectivities between frames. A key element of the project was the cross-case analysis of these studies, i.e. an integrated meta-analysis or two research studies carried out by two different teams in respectively different contexts involving the use of the same digital artifact.

This section contains three examples each forging connections between constructionism and an alternative theory. The first two are from the ReMath project. The third reflects the discussions around connectivities between Constructionism and Challenge based learning, a new venture connecting Inquiry learning with CSCL for Science Education. What is particular about the enterprise of connecting constructionism with other theories is that as perhaps the oldest theory on this particular issue, it has had enough time to become fragmented largely due to its interpretation as a static theory and in parallel, enough time has passed for it to evolve and develop from a theory focusing on the individual to addressing social and distributed cognition, many types of technologies and representations, new ventures such as for instance the design of activities and interventions and most importantly interventions challenging institutions. This developmental nature has not really been recognized or noticed much outside the constructionist community and yet connectivities with at least some other theories could provide mutual benefit and reveal complementarities useful to elaborate in the future.

Constructionism and Instrumental Genesis

Take for instance the theory of instrumental genesis (Guin & Trouche, 1999). With respect to connectivity, it was originally seen as a tool to explain the instrumentation of CAS-based techniques as discussed earlier within an anthropological framework. There have also been some perceptions of IG providing a more elaborated tool to describe the process of mediation within the framework of Activity Theory. IG has given a lot of attention to instrumentation as a notion to describe what happens when digital artifacts are put to use by denoting the formation of a conceptual schema which users develop about the functionality of the artifact in question, the underlying concepts, the kinds of things is can be used for, the meaning of its representations etc. The process of instrumentation has been seen as incorporating changes made to the medium itself and this aspect has been termed intrumentalization. Instrumentalization was coined to show that the artifact itself is shaped by each individual through its use and that there is a reciprocal relationship between these two processes, i.e. that instrumentation is affected by instrumentalization and vice-versa. Little attention however has been given to instrumentalization itself. Activity theory was not articulated at a time when the medium was susceptible to functional and operational changes as is the case with digital media and therefore gave no detail into the process by which schemes of artifact use were formed through the mediation of artifacts.

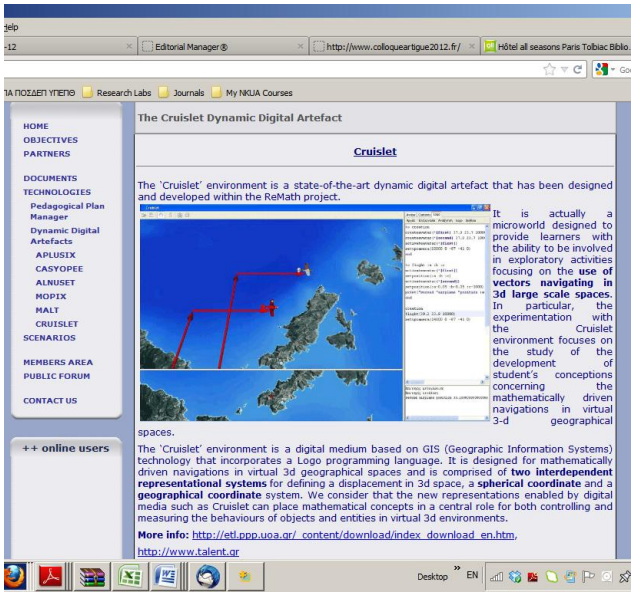
Instrumental theory identifies instrumentalization and situates this process within the context of mediation and schemes of use but does not elaborate on its definition. What is meant by changes to the artifact? What constitutes a change? What constitutes a change which is relevant to instrumentation and are there changes which are less relevant or irrelevant? Is instrumentalization a process which inevitably happens during instrumentation or does it depend on the design and the nature of the activity and on the nature of the artifact. Are there artifacts which invite instrumentalization more than others? What are the issues involving the design for instrumentalization (Kynigos & Psycharis, in press). These ideas are coherent with the notions articulated about a decade earlier by Noss and Hoyles (1996) that a medium shapes the mathematical meanings generated through its use and at the same time is itself shaped by use reciprocally. What is interesting however is that the design element of constructionist theory offers a more elaborate articulation of the process of designing media so that they afford useful and rich kinds of instrumentalization



. A relevant notion here is that of 'half-baked microworlds' developed by Kynigos (see e.g. 2007, 2010), i.e. digital artifacts intentionally designed and given to students as malleable and improvable asking of them to engage in discovering faults and shortcomings and changing them. This process is at the heart of fallibility and bricolage activity and discusses instrumentalization processes through a language of concerns pertaining to design and meaning generation. The figure in this section shows a snapshot of students' work with the 'mystery' procedure which was given to them to find the bug so that it always creates right triangle. The bug is in that angle variable :a is not connected to the second segment which is created by an independent variable :x. The students can use the uni and bi dimensional variation tools to get a feeling of what kind of relationship is required between :a and :x to create a triangle. Dragging became more and more focused, their attention being on how not to 'spoil' the right triangle. This kind of reverse engineering resulted in a periodic relationship which led students to suggest a trigonometrical function and to eventually try out the sinus function. So, the bi-dimensional tool was used to express a relationship kinesthetically through a curve rather than the converse.

Constructionism and the Anthropological Theory

Finally, a comparison between the Anthropological Theory of the Didactique (Chevallard, 1992) and Constructionism may allow for socio-constructivism to play the role of a common basis. A key issue where these two theories are complementary however, is the role and status of control of the didactical process. This may well be attributed to epistemology or simple to the notion of concern. Constructionism takes on board the notion that meanings are in anyway generated to some extent outside the control of a teacher or the sequencing of an activity. In designing educational activities therefore didactical intervention can at most aim to help create an environment rich or dense in opportunities and challenges for meaning generation. There is an element of randomness and uncontrollability in that process which needs to be appreciated if there is learning to be done. Otherwise, intense attempts to control the learners activities may result in disengagement and trying to guess what's in the teacher's head rather than ownership of knowledge. This does not mean that design is 'looser' with respect to activity sequencing, the designed tools to be used or the interactions between teacher and student collectives. It means however that the kinds of interactions are more strategic from the teacher's side, more participatory in a joint enterprise and more allowing for the unexpected. The teacher elicits meanings in formation and mathematics in use and helps students elaborate emergent ideas and generalizations. Also they allow and recognize fallibility, i.e. the status of suggestions, student created artifacts, student solutions etc to be in evolution or in flux rather than that of an expression of thought awaiting a final verdict. In this wake the construct of half-baked microworlds was developed to describe artifacts especially designed to invite changes and improvements and given to the students in that capacity, rendering them engineers (Kynigos, 2007). ATD on the other hand elaborates controlled scenarios and designs where didactical interventions are pre-designed, expectations of activities and understandings are precise and stepwise and teaching sequences are defined in terms of responses to specific pre-defined questions and tasks.



From the identification of fundamental situations expressing the epistemological characteristics of a mathematical concept or theme to the determination of the didactical variables which condition the efficiency of solving strategies or condition students' adidactical interaction with

the milieu, the design of situations reflect an ambition of control and optimization. The importance attached to a priori analysis and to its anticipative dimension also attests this ambition, deeply rooted in the role of *phenomenotechnique*, with the meaning given to this term by Bachelard, devoted to didactical engineering (Artigue, in preparation).

Constructionism and Challenge Based Learning

In the Metafora project, our aim was to support students' reflections on their work as a collaborating group. To look at emerging consciousness of mutual engagement, leadership, task distribution and roles. But to also study the emergence of meanings around the domain or subjects at hand. Some of the student group tasks were clearly constructionist and involved the use of microworlds to explore and generate meanings around challenging tasks. We came up against the need to think about the relationship between Constructionism and Challenge based learning which seems to be a rather recent trend emerging from an integration between inquiry learning and Scardamalia's collective knowledge aggregation learning (Scardmalia and Bereiter, 1994).

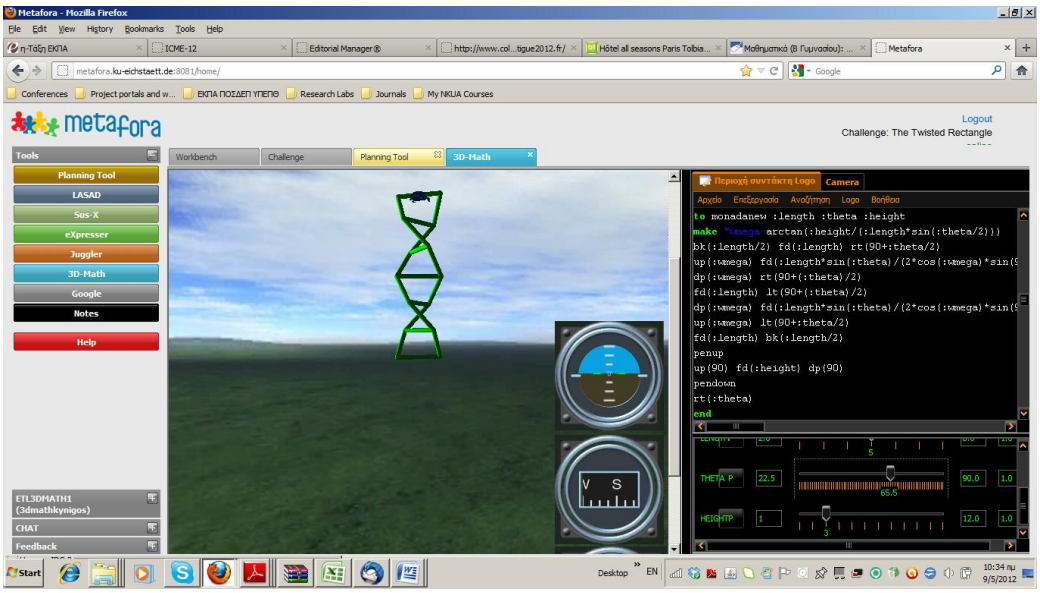
Challenge based learning addresses complex open-ended challenges which we often face in real life. These are challenges where no one knows the answer in advance, there may be multiple approaches and multiple possible solutions. Of course the uncertainty can be emotionally challenging. So, sharing the challenge often reduces the level of anxiety. The best approach maybe to explore or maybe to call a meeting and brain-storm how to go forward. Often creative new solutions and ways forward emerge. In real life there is never a teacher in the background making sure that the challenge is 'well-structured' and within our capacity to solve. Employers complain that a lot of new recruits fresh from school seem unable to cope with this reality. They have been programmed by school to expect neat tasks that they can apply procedures to solve. School-ish challenges need to be well structured so that they are not too difficult as this is found to be de-motivating for the students. So students complain when they are not given clear instructions. They can't cope with the messy ambiguity and ignorance of real world problems and so they are not capable of the creative leaps of innovation that are required. The question for challenge based learning is how can we teach in a way that prepares people to solve real authentic problems? For the Metafora project, this was the challenge of 'learning to learn together' (Wegerif et al, 2012). The focus of this pedagogy is not on a bit of Mathematics or a bit of Science that we have to teach and that they have to learn. The focus is precisely on the discomfort that they feel when faced with a complex challenge. This is what it means to have learnt how to learn - when you know how to carry on with any problem because you can break it down and make a start, explore, brainstorm etc. The theory here is basic to the inquiry based approach. Inquiry based learning should be about pursuing real problems, not about achieving pre set curriculum goals. Whenever we start with 'Maths' or 'Science' we have already failed. Real problems are not bits of a pre-packaged curriculum.

Constructionism can be about real problems but it can also be about interesting problems emerging from exploration and tinkering with digital models of real or abstract phenomena and objects. The focus is on the generation of meaning, on understanding to such depth that you can create or change a model based on the ideas and meanings at hand. Learning to learn together does seem important and challenging to Constructionist collaborations. Constructionist challenges are often complex, open ended and maybe even perceived as unclear in the sense that there can be more than one paths, ideas and constructs considered as 'solutions' etc since the point

is for a collective to reach the generation of socially mediated meanings. Addressing issues of how to work together to tackle the problem, of the responsibilities taken and the communication required and of jumping in and out of meta-levels and between process and content are at the heart of learning to learn together.

So we can think of a constructionist challenge based pedagogy where specific deep ideas and concepts are not considered as artificial and school-ish. The task can be such that the conceptual field around it (to use Vergaud's definition, 1991) is artificially narrowed down so that students - communities will focus and go in depth to generate understandings and meanings related to scientific and mathematical ideas. The agenda here is for them to get an idea of doing science or mathematics themselves. Of engaging in the process of scientific thinking. Of exposing themselves to the beauties of fallibility where any insight or idea is communicated in order for it to be challenged and refuted. I think it's a question granularity. There is complexity and breadth even in clearly defined conceptual fields.

The twisted rectangle - TwR - for example (see figure below) puts together ideas and concepts of mathematics which are never associated or connected in curricula precisely because schooling is so artificial. In a mathematical 'real world' this does not happen. In the TwR trigonometry joins functions, geometry, navigation in 3Dspace, modeling, stereometry (consecutive projections on planes). So, it is designed to counter artificial structure and fragmentation in school. It is also a difficult and 'unknown' task. It is only a real world problem in that once figured out in some user inspired way, models of real world phenomena, objects and relations can be built with it. But here constructionism brings out the idea that building and improving an artifact taking the role of a boundary object can indeed be one of the techniques to get collectives to address learning to learn together aspects of their activity. This can be used both in traditional Scrardamalian contexts and in narrower contexts within designed conceptual fields. In both cases tasks which are designed to be manageable, fragmentation and the artificial nature of schooling is countered.



These are three kinds of connectivity elaborations between constructionism and other theoretical frameworks in mathematics and science education. The process of networking is perceived as essential for the de-contextualization of the theories and a better sense of the richness of theory

building in the field. Constructionism is a theory which studies meaning generation through activities of collective and individual bricolage with expressive artefacts (mostly but not exclusively digital) where meaning is drawn through the use of representations, engagement with discussion and reflections on how to make changes to them and on their behaviors as they change.

Discussion

Constructionism is beautiful and worthwhile and at the same time is becoming segregated and in danger of being forgotten in a fragmented world where networking and connectivity is being recently mobilized to meet such a problem more widely. This networking should include constructionism as a distinct epistemology and paradigm of learning, as a particular kind of media use and as a design and learning theory in a continual flux. There are of course many ways of going about the problem. It is both strategic and scientific. Here, I gave some examples for constructionism to distinctly exist in pluralistic large scale contexts, in teacher education initiatives pushing for teacher as designer reforms and in collective efforts for theory networking. The question however remains: in today's world, what is distinct, relevant and transcendentally useful about constructionism? What more do we need to find out and what else do we need to design and develop? What are we learning about how constructionist communities are learning? What does it mean to be 'a constructionist'? How do we communicate this in a clear way to social and institutional structures? What scope can there be for a constructionist researcher in the next 10 years? I think these questions need to be asked.

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