SOCIAL CREATIVITY IN DESIGNING CONSTRUCTIONIST E-BOOKS: new mediations for creative mathematical thinking?

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Abstract

The paper discusses strategies for infusing constructionism and creativity in widely recognised media such as e-books. It draws from an on-going project, 'm c squared', where a c-book technology is being developed and tried out by means of collaborative designs by small communities with diverse expertise. Social creativity in such design processes is considered as key for the spreading and democratization of design for constructionism and creativity. Some first examples of social creativity in this process are discussed in the paper showing a realistic mediation of c-book unit and widget instance versions as boundary objects within the community.

Keywords: social creativity, design, constructionism, creative mathematical thinking

Infusing constructionism

Constructionism has been around for many years and constructionist activity has been perceived as inherently creative. In reality however, a large part of children's growing up is still inevitably connected to schooling and today schools are places where even when individual teachers strive to foster creativity it feels like swimming upstream. The constructionist community has and is continually producing media, designs and - mainly out of school - contexts for social creativity to grow. But what about pragmatic school contexts? Is there scope in supporting widespread designs for constructionism beyond the constructionist community? In infusing a constructionist element in wide-scale traditional schooling? This paper is about designs infusing constructionism in e-books.

Designing for students to engage in constructionist activities has not really been democratized. It has of course been seen as a creative activity in itself but mainly by association, not really addressed as such with respect to how it can be inspired, fostered and generated. Designers of constructionist activities have been addressed and perceived mainly as (often idiosyncratic) individuals. Their agendas have been perceived more as if they invite the embracing of constructionism as a whole, the engagement with activity which 'is constructionist'. Very little has been noticed with respect to how existing professionals may infuse a constructionist element in activities addressed to a wider community with broader scope, containing a diversity of perceptions about using digital media and learning. This paper addresses the question: is there scope for investing in the infusion of a constructionist element in *the e-book*, a medium perhaps with the widest recognition along with video (Gardiner & Musto, 2010). E-books have recently been changed from simply electronic versions of paper books to allow for interacting with their content. I-books and CabriLog, two prominent examples contain dynamic experiments, links to video, quiz etc. But these interactions are hardly constructionist.

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In many ways constructionism is perceived by the academic, the educational and the wider community as a distinct, particular kind of learning. Take it or leave it. Try something constructionist, and then do something else. Little effort has been put into understanding constructionism as an inherent property of learning in a variety of contexts and to look for the constructionist element in tools, productions and educational milieus. A long time ago, I argued for the value of bringing together actors with diverse expertise to create a multi-organizational culture for designing microworlds (Kynigos, 2002) only to subsequently find out that fragmentation was being perceived by many others as a general and widespread problem at least in two communities where constructionism was supposed to reign, i.e. the field of digital technologies in education and mathematics education. Kaleidoscope, a huge European Network of Excellence, met the challenge of integrating perspectives, know-how and diverse expertise in designing for the future of learning with digital technologies. Almost in parallel, a group of mathematics educators worked for many years to understand the problem of fragmentation in mathematical learning theories, and to consider strategies and techniques for networking amongst them in order to create a sense-making theoretical landscape visible to the outside world (Artigue & Marioti, 2014). While constructionism gave birth to our thinking of learning (in this case learning mathematics), as a personally meaningful interaction—or „conversation“ —with digital media (Papert, 1980), it did not often feature as one of the theoretical frameworks or approaches in these ventures. There obviously are exceptions to the rule as was the case in the ReMath project, http://remath.cti.gr, ESM special issue, 2014).

In digital media, constructionist ideas are spreading albeit not always as a result of intentional constructionist pedagogical agendas, take for example the case of modding with digital game systems like Kodu. The idea of infusing constructionist affordances in designs affecting wider communities however, has not spread that much, again, I believe, due to fragmentation in communities designing digital media. Here too, there are exceptions however, in some of which I've been involved such as the black and white box design of the E-slate authoring system (Kynigos, 2004), the infusion of constructionist microworlds in a CSCL system (http://metafora-project.org) and the integration of constructionist media in systemic wide-scale portals containing curriculum books with links to digital widgets (Kynigos, 2012, http://ebooks.edu.gr).

In this paper I would like to consider a new arena for the challenge of infusing constructionist activity, that of e-books. E-books appeared in a context which was not related to the questioning of educational paradigms or designing a new kind of interface or expressive medium. They adhered to the rationale behind large portals, to making resources available much more easily, cheaply to all, to making practical, temporal and location issues insignificant with respect to access (Gardineer & Musto, 2010). E-book technologies soon became available widely for the writing and creation of e-books with examples such as the i-book and cabri-log allowing for the inclusion of 'widgets' into the text. Widgets are objects other than text, usually videos but recently with some interactivity such as for example a quiz or a digital experiment simulator. Cabri-log extended the idea of widgets to allow for instances of cabri exercises, games and tasks to be included in amongst the text. It will undoubtedly soon become easy to include any kind of widget in amongst text and make it public as a new kind of book. But how can we think about a *'constructionist book'*, i.e. a kind of e-book where a limitless variety of widget instances inviting social creativity and constructionist engagement are abundant and considered by 'readers' as something natural. How does 'reading' change? What roles do users of such books adopt and how does the way in which a 'reader' is addressed change with respect to the text. Also, how is the meaning of a book going to change when it seems natural to use any 'book' as a resource to shape and change into your own. How can the text address both narrative and the reader as actor? At the time the paper was written, a European project (titled: 'M C Squared') was in its first year, aiming to construct 'the c-book'

(c=creativity) and to try out from the beginning to address how to be creative in designing and writing c-book units which take advantage of the affordances of the technology to engage 'readers' in creative constructionist activity for mathematics thinking. The project involved developing the technology and at the same time engaging a creative group of designers with diverse expertise coming form different communities of proactice to think out of the box about what a constructionist book may look like.

Social creativity to design e-books with a constructionist element

Democratizing design for e-books fostering creativity was both a necessity and an end in itself. I've argued in the past about the importance of integrated designs of microworlds by diverse actors as an activity for creative designs to emerge (Kynigos 2007) and as a teacher professional development enhancer (Kynigos, 2007b). Drawing from this experience in showing the value of collective design by communities consisting of hybrid actors with a diversity of expertise, we put together four groups of designers to try out ideas to design c-book units aimed to foster mathematical creativity in their 'readers'. We were particularly interested in the composition of these groups so that there would be more chance to get creative, and bring forth out of the box but relevant ideas. To help us think and employ this strategy, we found Fischer's 'Communities of Interest' (CoI) to be directly relevant and useful. The emergence of creativity in the design process was perceived as a system involving collectives with tools characterized as cultures of participation (Fischer, 2011). Design creativity was recognised as a multidimensional concept, that can be identified, among others, in the processes or the outcomes of the design activity, or in the context within which such an activity is embedded (Gero, 2010). This is also the case with the design of educational resources (and instructional design in general), which although not overly acknowledged and studied as a design discipline (as compared to software design or architecture), creativity has recently being acknowledged as a 'built-in' dimension (Clinton & Hokanson, 2012). The 'social' component in various collectives of design professionals and its role in enhancing both individuals' creativity and the creative capacity of the group in addressing complex design problems is also a relatively new focus of research. 'Social creativity' actually explores the social and technical environment within which participatory design processes take place (Fischer, 2010; 2011), when specialists from different domains coordinate their efforts to achieve a common design goal. Social creativity arises from the synthesis and synergy of the different perspectives towards a complex design task of shared interest. Designing for digital educational resources for Creative Mathematical Thinking (CMT) can therefore be viewed as a squared creativity challenge, since it requires not only to define mathematical creativity but also to situate the design process itself within a socio-technical environment that can boost educational designers' creative potential. However, both challenges need some paradigm shifts in terms of thinking of, learning and designing pedagogical materials for mathematics (Chevallard, 2012, Daskolia & Kynigos, 2012).

In sum, the first feature of this c-book was meant for its authors, a feature supporting collective design of c-book units. Technically speaking it provides two parallel interfaces for organized discussions, a threaded forum discussion and a mind-map view. Designers can switch from one to the other with a toggle button. They can attach and refer to widget instances which reside in the c-book unit under construction. There are special semantics designed to promote social creativity in the design process. Primary ideas –initiating discussions- are termed as "alternative", and secondary ideas –continuing a discussion thread- are termed as "contributory" and "objecting". So each contributor has to state the nature of the contribution using the following options:

- **Alternative**
    - Expressing opinions, statements, arguments, initiating design process
- **Contributory**

    - Adding, cumulating, building to an existing alternative.
    - Expressed by: questioning, refining, focusing/narrowing, expanding
- **Objecting**
    - Expressing objection to alternative, either by directly contradicting an idea, using disputational style, or by proposing another alternative
- **Off task**
    - Social interactions not associated with the task at hand: greetings, expression of humor, emoticons, phatic elements.
- **Management**
    - Management of the progression of the task itself: planning what is to be discussed, who does what, if a problem is solved or not.

At the time of writing this paper, a workable version of the c-book system was available and the four CoI (Communities of Interest) had had about two months to create their first c-book units. The following section uses some data we analyzed from these discussions and emerging productions from two of the CoI. What we were looking for is to better understand the process of social creativity in collective design and the extent to which this process may both produce c-book units fostering creative mathematical thinking in new ways and at the same time inspire social creativity in itself amongst the CoI members.

CoI discussions and products

The "Windmills" group

The first CoI was given a general theme to write a c-book unit on: 'Windmills'. This was meant by the researchers to be a sparker for social creativity and feeling at ease to think out of the box. The CoI included designers and teachers in Mathematics Education, Computer Science and Engineering/Vocational training. Three of the teachers were also experienced developers. A total of 75 contributions were posted to CoICode (the c-book author collaboration tool) during the initiation phase of the CoI and its first work cycle. A number of these related to technical issues identified and reported by the members (8 posts). Another 8 posts related to organisational issues, such as deadlines, division of work etc. and there are also 4 off-topic contributions. The rest of the posts (55) either started a discussion (initiating – alternative ideas) or continued an existing thread (contributory or objecting ideas). The group had been discussing on how to create a c-book unit on Windmills that would foster mathematical creativity for students. The discussions had taken place in two distinct phases. During the first the CoI members mainly focused on trying out the affordances of the widgets, which could be embedded in the c-book at the time (which were Geogebra and E-Slate Turtleworlds). The CoI members used these widgets as «factories» or «kits» to create 'widget instances' meant for the 'reader', so as to test their initial ideas about the functioning of different shapes of sails for a Windmill. These instances were shared with the rest of the group members through CoICode making them available for comments and modifications by the rest of the CoI participants. During this process the CoI members started posing design issues regarding the instances and the activities proposed.

Two main strands of choices came out as the most dominant ones. The first one started from designing an instance that would offer students an already created shape for representing the sail and its frame. The students would use this shape as a building block for constructing the whole (polar) array of the sails. The other strand related to designing some kind of a more elaborated instance that would call for some kind of "deconstruction". These two strands were reconciled as the CoI members suggested giving students 'half-baked instances' (see Kynigos, 2007) that would invite both for constructions and deconstructions. After proposing a set of ideas for half-baked instances, the CoI members went one step further. They suggested giving students the opportunity

to create their own windmills using the available tools and resources, allowing in this way the fostering of "unexpected" ideas that would surprise even the designers of the instance. The new issue that came around and had not been addressed so far in this discussion was on how to create a "sparker" that wouldn't give away too much, but also provide the available resources for igniting students' mathematical creativity.

A critical episode

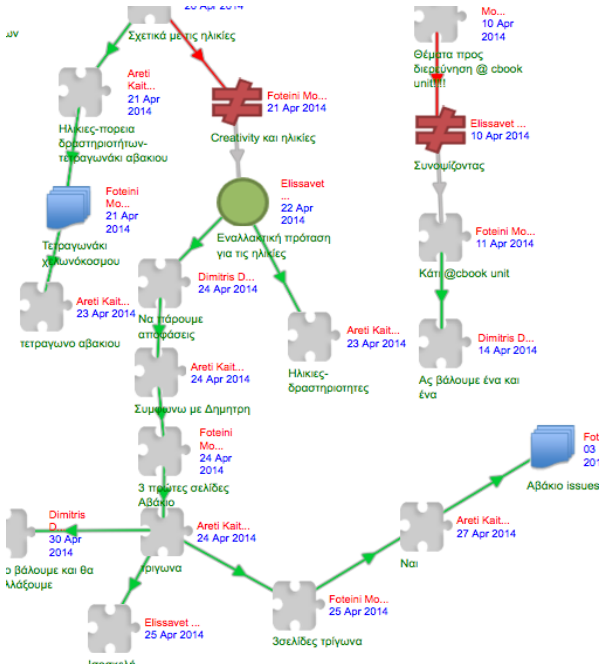

Figure 1: The CoI's discussion thread

The CoI members had been discussing for about a month on the kind of instances to be used in their c-book unit and especially on how include different shapes for the sails of a windmill. Starting from both a mathematical and an engineering point of view, they had created and shared several instances using both with E-Slate Turtleworlds and Geogebra. Some of these instances had been used as "boundary objects", since they had undergone modifications in multiple cycles by different actors of the CoI. A few weeks after this first phase of their discussions, and having already gathered and revised a set of instances, the CoI members seemed to start changing their focus. They expressed the need to start creating versions of a c-book unit, instead of just producing instances. This was a first indication that they viewed the c-book as a whole, as new technology integrating both instances and some kind of activity flow for students to use.

In this new phase of their discussions, the main issues raised concerned: 1) the age of the students to which this c-book unit would be given, 2) the school's official Curriculum and if the c-book's activities should have any connection with it, 3) the order in which the selected instances should appear in the c-book's pages in relation to their affordances, 4) the distribution of mathematical notions among the pages of the c-book unit moving from simpler to more complicated ones and 5) the narrative to be added next to the widgets that would be addressed to the students which will work with the c-book unit. This discussion thread started with Areti posting the "minutes" from a skype discussion among herself, Elissavet and Foteini on how to structure the available instances inside the unit. Elissavet who had also talked to Dimitris and Popi, gathered contributions from all the others and suggested using Turtleworld instances for the first 3 to 4 pages, then Geogebra instances from the 5th or 6th page and Turtleworlds again at the end. Apart from this specific structure, she asked everyone to work towards turning these instances to "didactical scenarios", i.e. to include narrative for the reader. This is the first CoI attempt to relate the instances produced to some kind of text that should accompany them. Elissavet, an experienced math teacher, talking to other (mostly mathematics) teachers in their language, used the word "didactical" to outline what this text should be about. Saying nothing more about the text, Foteini suggested going step by step with the Turtleworlds instances in relation to the mathematics to be embedded in them. Viewing all instances as part of a larger picture, she also proposed having a closing activity for exploration with instances from both Turtleworlds and Geogebra. At that point, the age/grade of the students to work with the c-book unit and their math textbook rationale was made a point of controversy and the CoiCode posts started containing comments in which the c-book unit's structure was intertwined with these matters. Katerina, went back to a previous post in another tree (see fig. 1) and mentioned the idea of

having activities that would be more demanding and complicated as the students moved on along the pages of the c-book unit. That design would ensure having the c-book unit that didn't refer only to specific ages, keeping at the same time a broad windmill theme and having sets of activities with the same characteristics. This discussion closed as Elissavet, with a more pragmatic view, pointed out that integrating the instances in the c-book unit should be the first step and decide the rest afterwards. Adding or removing elements from the design of the activities would do the trick, making the c-book suitable for different ages. Areti agreed with Elissavet and advocated on adding descriptions for each of the instances, which eventually could lead into breaking down an instance to more pages, making it suitable for Junior or High School students. In the same line, Dimitris made explicit that he viewed every activity as an integral part of the c-book unit, not to be formed independently of the rest of the c-book unit. Again this CoI, seemed to view c-book unit as a whole, as something with a specific theme, having sets of activities with common characteristics that could change and transform to be suitable for different ages. Here is an excerpt from a CoICode contribution.

> "Let me go back to this: I think it doesn't matter to precisely decide when we will use Turtleworlds or Geogebra. The instance will change as soon as we start writing the text. I believe the text and the instance is one unit, one c-book unit and not two pieces. The widget can't be alone. So, I think that maybe we shouldn't think of the instance but of the c-book unit a whole thing." (Dimitris, 30.04.2014).

To this end, Areti suggested the first wording of the activities. This was "Build your own windmill" for the last activity of the c-book unit. The last activity was supposed to be the one in which the students would be able to freely create a windmill. This was Katerina's idea, influenced by a comment made earlier in the discussions by Giannis, who noted that the students without an intervention could use their imagination to be more creative.

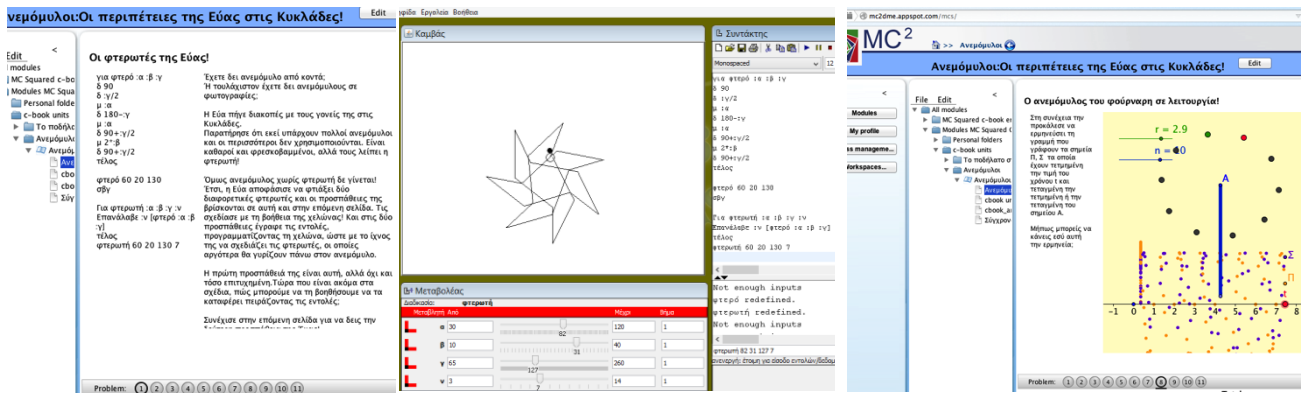

Figure 2: The 1st and the 8th page of the c-book unit – Tutleworlds and Geogebra

So, this CoI was obviously bringing experiences with fragmented technologies to the table, either focusing on standalone instances to be changed and experimented with the students or focusing on the thread of the narrative of the unit and the pacing of the mathematics, the difficulty and the level of openness of the activities. We already witnessed a jolt in their own thinking when their discussions progressively took on more angles to the enterprise. How to include an engineering and a coding element, and integrate them with mathematical concepts? How to allow for and promote unpredictable student activity and personalized creative constructions with the instances, and how to inspire such activity through the accompanying narrative? How to embed diverse mathematical ideas organized in ways not found in standard curricula. However, these issues were only just emerging at the time this data was analysed given that the CoI had just started using the c-book (which did not yet contain the analytics author component). The following sub-section involved a

more diverse CoI and the integration of two more diverse domains, mathematics and environmental issues.

The "Cycling in the city" group

The "Cycling in the city" CoI included people from Mathematics as well as Environmental Education (teachers and researchers), three of which were also experienced developers. The researchers gave them the task to build a unit on "Cycling in the city". A total of 82 contributions had been posted on CoICode in about a month and a half. As with the Windmill CoI, a number of these were related to technical issues identified and reported by the members (12 posts). Another 10 posts were related to organisational issues, such as deadlines, division of work e.t.c. The rest of the posts (60) either started a discussion including initiating or alternative ideas or continued an existing thread with contributory or objecting ideas. During the first month of their work, the group[s?] progressed from an initial phase of brainstorming to more integrative phase of synthesis. The first phase was characterised by experienced members' anxiety to show previous work, i.e., instances they had already developed for other purposes and contexts. The more inexperienced members seemed to be grappling both with a significant cognitive load and with the challenges of using a completely new digital environment as their main working environment. An important tension emerged from the outset between environmental education and mathematics, on the one hand, and secondary and primary education teachers, on the other. This tension became evident in a the vivid discussion of the CoI around their envisioned age group, and in many encounters on the appropriateness of specific mathematical concepts for young pupils. Another output of this phase was the plethora of ideas and supporting materials posted (a total of 8 ideas, supported by 14 instances/digital materials) and the tendency to open new threads just to post new ideas, and not to build on already posted materials. The second phase indicated a progress towards synthesis, as the deadline for the c-book unit delivery was looming. The experienced members now seemed more willing to comment on others' ideas, whilst the more inexperienced members started being more inquisitive and courageous to ask questions and propose synthetic solutions. The analysis of the data revealed several foci of interest while they were collaboratively thinking of, discussing about and co-working over the design of their c-book unit.

A critical Episode

One of the first ideas put forth in the CoI came from a female member, Marianthi, a young developer. She described the idea not in the abstract but by attaching an E-Slate instance she had developed on another occasion. This instance was based on the idea of a GPS and a distance meter device that could be manipulated by students to move a vehicle in the streets of a city. Marianthi suggested an adaptation of this initial idea by replacing the car with a bike. The fact that Marianthi's idea became public and "inspect able" through the posting of her MyGPS instance almost immediately triggered a new idea by Maria R. It was built on Marianthi's but extended it. It originated from an experience Maria R. had with her students who faced difficulties in understanding how to chart an itinerary in more traditional approaches:

> "... Could we have arrow icons, which the children could put on the itinerary they are given, in order to mark it?" Now, I' m sure this is not clear, but I have something in my mind from the first grade school book. My pupils had difficulty understanding this on paper. I' ll find it and post it." (Maria R., 30.3.14)

However, this new idea was received by Marianthi with reservations in practical terms (feasibility) and substantively; 'does it really add something new not covered by the original instance?' (novelty). She went on further buttressing her argument with the attachment of a new version of the instance and by asking Maria R. to try it. The new instance resulted from an adaptation Marianthi had made to the original MyGPS instance to the "bike" theme:

> "I think I get what you mean, but I don't know if this is feasible. Anyway, in this microworld, on the «driving control» utility, they can see with arrows and letters (N, S, E, W) the direction of the bike in space. I' m attaching the same microworld, this time with a bike instead of a car. Try to play with it and tell me if it can be adjusted to the ages we are discussing (primary school)." (Marianthi, 9.4.14)

A second extension of Marianthi's initial idea was suggested by Maria L. This idea introduced different levels of difficulty in succeeding the task, which allowed its use to be adaptable for smaller ages. The idea was further developed in more details with Maria L. to specify particular features to be added in the microworld:

> "Marianthi, I also like this microworld and I think it can be easily adjusted for smaller ages and demotiko. For sixth grade, I would suggest each «destination» to go through three phases: Free navigation, where they just go to the target destination, reaching the target destination with as few movements as possible, as they are recorded on triplogs and finally, they have to program the route for the target destination in Logo, using the existing itinerary example on the Logo component (it could be considered as a «half-baked» microworld)." (Maria L, 10.4.14)

At this point, another CoI member, Eirini, a high school math teacher, intervened. She acted as a "boundary broker" in the CoI, as she was the one who insightfully pinpointed the common threads between different lines of thought within the CoI on a regular basis or proposes creative syntheses of them. On this occasion, Eirini identified the commonalities between an instance suggested by another CoI member (Costas) and one proposed by Maria R who suggested to include a compass for orientation. She proposed this as an extension of Mariathi's initial instance.

> "Maria (R.), have a look at Costas's widget, "Orientation in the city". I think it' s very close to what you' re looking for." (Eirini, 23.4.14)

Eirini's suggestion was taken by a fifth CoI member (Katerina), a primary teacher with a specialization in environmental education, who identified the challenge of combining the two ideas and further developing each idea through the other:

> "Could we achieve a synthesis of "Orientation in the city" Costas made, and the compass idea? So that the children move with a specific orientation?" (Katerina, 23.4.14)

Eirini responded to the challenge actively by creatively designing a new instance with a different widget, Geobebra 4.0, which substantiated the idea of 'compass'. However, although it was approved with much enthusiasm by Maria R., it was finally rejected by Eirini herself as not adding anything really new or different (criterion: novelty) compared to the 'MyGPS' instance:

> "Playing, though, with myGPS again, I don't think I achieved something new with GGB. MyGPS, as Marianthi said, also has a compass, it allows selection of length (with different metric units) and sends players to different destinations which, once reached, players get positive feedback." (Eirini, 28.4.14)

Conclusions

Making it technically possible to infuse a constructionist element in e-books and then orchestrating social creativity in collaborative designs by communities of diverse professionals with an interest in education may place constructionism on the map of wide-scale designs for school resources with a real integrated role. At the same time, it may provide creative designs for e-books changing the role of the 'reader' and the ways in which a book addresses its user. We can imagine a c-book unit containing a variety of instances including Scratch remixes, NETLOGO simulations, e-slate games all designed to generate a coherent theme within which users can read, look for connections, remix dynamic content and turn the unit to something of their own, a live document as Guedet & Trouche,

2012 would say. What we were witnessing when the paper was written was the emergent collaborative design processes of a small community consisting of diverse actors, some from outside mathematics, some of whom were experienced constructionist designers and others experienced teachers in very pragmatic schools. The technology at hand enabled them to base their designs on the idea of classical books and classical dynamic or constructionist widget instances.

The integration of these kinds of media however was something we had only begun to observe. Different levels of creative design processes were recorded within the CoI's activity, addressing among others the design of an instance, pedagogical design in general, the design of a narrative to describe a learning activity, or the design of the overall scenario for the c-book unit. The CoI focused on one or two attributes at a time consecutively moving from one level to the other. For example, in constructing the Windmill unit, their thinking and discussion processes revolved around determining important design parameters such as the core concept it conveys, or more technical characteristics of its design. However, immediately after that they addressed issues such as how to design a scenario that turns the instance into a learning resource. It is only when they formed a clear enough idea over the design of the instance and its pedagogical design that the CoI got involved into the design of the overall scenario running through the c-book unit and how this would be embedded into broader issues of pedagogical design in the teaching of mathematics. It is rather unlikely that the CoI would get into addressing all these different foci and levels of design if it were not necessary to think and work simultaneously along all these lines of thought during the design of the c-book unit. The 'MyGPS' story shows how the social character of any creative process or product in the CoI has to do with the fact that any production, be it an idea or some tangible artefact comes up or further evolves within the CoI. It is actually deployed within the CoI, in the sense that it passes from one CoI member to the other and through this course it is approved or abandoned, it is qualitatively developed, changed or it gives birth to an different one. Moreover, each idea, creative or not, seems to be conceived or built on a pre-existing reference point. Actually, the more pragmatic a reference point is, the more focused the creative ideas emerging out of it as we saw with MyGPS. In the CoI activity the role of a reference point is mainly played by the consecutive versions of the c-book unit. This leads us to consider any idea put forth in the course of the CoI design process of the c-book unit as closely interlinked with consecutive unit versions acting as boundary object resources for the CoI members to scaffold and anchor their creative thinking and design performance (Kynigos & Kalogeria, 2012). Ideas and c-book unit versions seem so interlinked that CoI members could not refer to an idea or suggest any alternative to it without explicitly or implicitly connecting it to a unit version. The borders between any design idea and its reification to a c-book unit are practically blurred. The CoI members seem to use various criteria in approving or rejecting an idea. Prominent among them are the one of appropriateness, be it pedagogical, strategic or domain oriented. Nevertheless, more criteria were employed such as that of newness/ novelty or that of feasibility. In early stages of the CoI's performance, any ideas that were not accompanied by the active attempt of their initiator to put them into action, were usually abandoned. Even when they were, the initiator had to be quite explicit about what they really suggested in order to push forth their idea. This was better accomplished if they try to personally turn their idea into a digital artifact by constructing a new one or by integrating the idea into an already existing one by tinkering it. These were the first considerations of infusing constructionism and creativity into widely recognized educational media inviting the democratization of designing for constructionist e-books.

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