Discussing digital artefacts under design as a process aiming towards the centre of TPaCK

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The study addresses the illumination of TPaCK knowledge of postgraduate mathematics education students and their progression towards the TPaCK centre by means of a threaded forum discussion concerning their on-going designs of digital artefacts for pupil meaning-making. We perceived those digital artefacts as living documents under change and studied both students' constructions and their written exchanges to identify how their initial ideas were placed in the TPaCK model and how these could progress. We studied the exchanges between them and their instructors as a boundary crossing process considering the artefacts as boundary objects. Our preliminary results show that the process was effective in helping us with our understanding of both how the students started and how they were challenged to progress towards TPaCK intersections and centre.

Keywords: Professional development, instrumental approach, boundary crossing, turtle geometry.

Theoretical Framework

This study addresses how to understand and support the process by which mathematics majors, studying mathematics education, jointly design, construct and discuss over half-baked digital artefacts (Kynigos, 2007) aimed at generating constructionist learning in their prospective students Kynigos, 2012). We use the term 'half-baked' digital artefact to discuss an artefact didactically engineered to be faulty or incomplete and mediated as such to the students. Typically the students are required to identify its properties and in particular those requiring change, make those changes and come up with a mathematically sound model. After doing so, the students are encouraged to build a construction of their own using the correct model as a building block. So, our Masters' students were acting as teachers designing such artefacts. We employed TPaCK (Mishra & Koehler, 2006), Documentational Instrumentalization (Guedet & Trouche, 2009, Kynigos & Psycharis, 2013) and Boundary Crossing (Kynigos & Kolovou, in press) in an integrated way in order to focus both on illuminating the 'placement' of our students' thinking on the TPaCK model (Technological, Pedagogical and Content Knowledge of a math teacher as circles having overlaps in a Venn Diagram) and on ways in which they can be supported to progress towards the centre of the model. That is, we identified the students' arguments to be situated mostly at the T and C parts of the Venn diagrams of TPaCK and intervened during their discussion to support the inclusion of P and their progression to the two-way intersections en route to the centre. So far, not so much attention has been paid to the instrumentalization process in the Documentational approach (Pepin,Gueudet&Trouche 2013, Guin,Ruthven&Trouche, 2005)., i.e. how a living document - in the form of digital artefact - involves the reciprocal shaping of the TPaCK and the document (in this case the half-baked artefact), affordances. In our work with our students we wanted to understand

the process by which the changing affordances became the focus over which ideas were expressed and developed towards the centre of TPaCK. The on-going study involved twelve mathematics teachers and two researchers. Most of the teachers had recently graduated from Mathematics Departments in Universities in Greece. Very few of them had experience in teaching mathematics in a classroom, they had mostly acted as private tutors with high-school and junior high-school students preparing candidates for University entry exams. The study took place during the "Pedagogical Utilization of Digital Media in Mathematics" course, which was given as a part of the University's postgraduate studies in Mathematics Education. The two researchers operated in the capacity of giving the course, the senior (academic) researcher in the role of course instructor and the junior PhD candidate and acting teacher in the role of supporting tutor. It is important to say that the latter had previously followed the same course and had hence gained further experience in the design and the use of these media in classroom. As an assignment of the course, teachers in pairs had to jointly design a digital model (artefact) for teaching mathematics, post it in a threaded discussion forum, where only the members of the class had access, and then engage in a critical friend style discussion of each others' artefacts. As a result, there should be the final versions of six artefacts, therefore six parallel threaded discussions. Teachers were also supposed to make comments on each threaded discussion. The two researchers also took the role of critical friend who assist the students with their posts in the thread discussion. During the semester, three such assignments were to take place; each one consisted of another phase of the study. In this paper, we are presenting some early results of the study's first phase. The first assignment for the teachers' pairs was to design a half-baked representation of the capital letter "N" in MaLT2. MaLT2 is a web-based Turtle Geometry environment that affords programmable Logo-based Turtle Geometry in 3D space (hence the avatar is now a 'sparrow' instead of 'a turtle') uniquely integrated with dynamic manipulation of variable values by means of a uni and a bi dimensional variation tool (see Kynigos, 2012). We chose "N", because of the plentiful mathematical concepts that can be integrated in several versions of its construction (Psycharis & Kynigos, 2009).Teachers should design and post the relative Logo program along with a text, as an exercise, asking students what to do with it and explain in a separate text, around what kind of mathematical concepts were their prospective students expected to make meanings during their effort to fix the bug of the specific "N" which each pair half-baked.

Results and discussion

The first phase of the study lasted three weeks. During the first week, most of the groups posted their Logo programs. The discussion started at the end of the first week. By the end of the third week, 77 posts were totally submitted. The most commented object had 24 posts, while the less commented had 8 posts. In this paper we focus on a turn of the discussion under a certain thread.Theextractthat follows is a discussion between a teacher (T1) and one of the researchers (R, the school teacher). The discussion was about the half-baked "N" of T1's group. When running the Logo program, which used a variable "x", the bird forms an ill-constructed N. The bird moved executing sequentially the commands: forward x, right 150 degrees, forward x/cos(150), left 30 and forward x, for a certain value of x. The purpose, according to T1 was to find out that the amount of turn and the argument of cosine must be supplementary angles, in order the N to be well-shaped.

R: If a student fixes the bug, through trial and error, without using the property of supplementary angle or trigonometric numbers, should it be accepted?

T1: But we want to realize it, through the use of Geometry, not trials.I would ask "If the turn changes from 150 to 145 what would be the argument of cosine?"

R: Is it possible that a student, will answer "it will change from 30 to 35, so what?

T1: I think you are right. In this case we should add an extra activity, asking the student to construct "N" by using sine instead of cosine.

The idea of replacing cosine with sine sparked off a succession of posts. A version of the same program were posted by R having"forward (x/sin(30))/a" instead of "forward x/cos(150)", where "a" is a variable. The second extract is a discussion between a teacher (T2) and the researcher R.

T2: We could ask the students: "If there is a reason that you should not use cosine, but only sine is there a way to change the relationship?" To avoid trial and error, you should use the new variable "a" and ask the students: "Can you find out what the value of "a" depends on, in order to make a proper N?" […]

R: What if a student says: ""a" depends on my mood, since I can manipulate its value, using the slider! And, using sine instead of cosine makes the diagonal of "N" very long and ugly! It's a mess!"

T2: This reaction of the student made me mad, already! There are most important things than maths, you should explain to this student;mostly about behavior!

R: This might be a little tactless, but the student stresses that, in his/her point of view that "a" is not depended on anything. Is it wrong?

T2: Totallywrong! It must depend on something. You could be driven to formula's exploration by putting the right questions!

In the first extract, T1 stated that "the student should use Geometry, not trial and error" and he tried to reformulate his/her hypothetical question to the students. In the second extract, T2 described hypothetical student's attitude, as inappropriate, construing the answer "depends on my mood" more as arude reaction which had no relation with the activity in MaLT2, than related with the context of the activity, which may have no personal meaning for the student. The T1's and T2's first reactions may show that they both used CK than PK. In that case R, acting as a critical friend, that assist teachers to develop TPaCK tried to cross the boundary, by using the half-baked construction; he/she made a hypothetical scenario of a student's reactions that branched off the initial plan of T1 and T2. However, the reaction of T1 and T2 was not the same. T1 reflected on his/her initial design, used the program as a tool, changing its functionalities (sine instead of cosine) and then proposing this change as an alternative activity for the students, a reaction that could be seen as instrumentalization. On the other hand, T2 did not changed his/her position. She insisted that the reaction of the student was wrong. Through this analysis we do not assume that T1 extended his/her development of PK, PCK or TPaCK. Our effort was to find technics and theoretical tools to see in more detail what happened, during a course of TPD. We suggest that the use of threaded discussion as an extra resource during the resource design process could give a potential of a more distinct understanding the TPD's mechanism. We found the process of critically discussing the affordances digital artefacts under design and the potential student meanings in using them both illuminating and a rich context for student progression to the TPaCK centre. The artefacts themselves as 'documents under change' were particularly useful as boundary objects between the

researchers-instructors and the students playing an important role in the development of a more articulate language to discuss TPaCK issues. The T, P and C knowledge in our students became effectively apparent and a generative starting point to negotiate and progress towards two-way intersections and the centre of TPaCK.

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