Is this Constructionism? A case of young children, mathematics and powerful ideas.

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Abstract

In this paper I argue that Constructionism need not only be about computers and programming. In continuation to the themes discussed in Constructionism 2010, this paper argues that if Constructionism is restricted to the use of computers then constructionism cannot be applied in most educational settings around the world and builds on the assumption that schools and teachers should not be ignored but rather supported as to how to design activities that will formally lead children to powerful ideas. The paper describes an example of a learning experience in an early childhood education setting in Cyprus were 25 4-to-5 year olds used objects provided by their teacher to think with about powerful ideas. The learning experience did not involve computers but had all the main ideas of constructionism as expressed by Seymour Papert. It is a learning experience about young children, mathematics and powerful ideas.

Keywords

Young children, mathematics, powerful ideas

Introduction

As supported by Noss and Hoyles (1996), the computer has allowed ‘glimpses to new epistemologies’ and ‘opened new windows on the construction of meanings’. This acknowledgement has always captured for me the origin of Constructionism but I had never though that it implied that in order to create learning experiences in a constructionist way you ought to use computers. I rather believed that it meant that computer-based research showed that provided sufficiently sensitive techniques are employed, learners might gain access to and communicate powerful ideas. Isn’t that what Papert (1993) was talking about after all in ‘*Mindstorms’: Children, Mathematics and Powerful Ideas*’? At least that is what I saw through the window which constructionism opened for me.

If we manage to move away from ‘teaching children mathematics’ to ‘teaching children how to think as mathematicians’ (Papert, 1972) isn’t that learning in a constructionism sense?. If we manage to support children’s learning-by making and thinking-as-constructing (Papert, 1991) and providing children with objects-to-think-with (Papert, 1993) isn’t that what Constructionism is all about? Almost two years after Constructionsim 2010 I still hear voices in my head concerning what Constructionism is (or better say, is not). Should Constructionism be restricted to the use of computers and processes involving programming, or not? In the past, there have been examples of research within the constructionism paradigm that did not involve the use of computers (Papademetri, 2007).

If Constructionism is restricted to computers and programming then it is impossible to apply it to most educational settings around the world. In this paper I would like to describe a learning experience from an early childhood education setting in Cyprus. All public kindergarten classrooms in Cyprus have up to 25 3-to-5 year olds under the responsibility of one teacher.

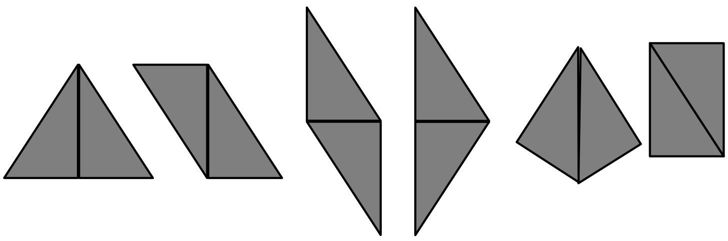
There is one computer in each classroom where the children can play normally during free play. The teachers are rarely and purely educated as to how to use the computer. Besides the restrictions of the setting in which the learning experience described in the following sections of this paper occurred, I would like to argue that this is a learning experience in a constructionist sense.

Methodology

The data presented in this paper originated from the implementation of an activity sequence in a public kindergarten in Cyprus. The activity sequence was implemented by a senior student-teacher in a classroom of 25 4-to-5 year olds in a public school within the children's everyday program. Children's time in public schools in Cyprus is shared between play time and whole classroom activities.

The activity sequence was designed as part, and in support of a much broader research project involving planning, implementing, evaluating and scientifically justifying a joint mathematics and science literacy curriculum for early childhood education, comprising by six common learning axes (experiences, scientific thinking skills, scientific thinking processes, attitudes, conceptual understanding, and epistemological awareness). This three year research project will end in August 2014. The joint curriculum is developed by a mixed group of researchers, content-knowledge specialists and educators, based on a review of existing literature and applications in authentic early childhood settings.

The task sequence was based on the following problem: 'How many different shapes can you make by putting together two congruent scalene, right-angled triangles so that one pair of congruent sides is always shared?' The idea for this problem originated by Claus (1992). In Figure 1 we illustrate all the solutions to the problem.



(a) (b) (c) (d) (e) (f)

Figure 1. The solutions to the problem.

The implementation of the activity sequence was videotaped and then transcribed. The transcript was then analysed in terms of the six learning axes. To be more precise, the effort was to identify among the data the learning outcome of the activity sequence in terms of the experiences the children gained, the scientific thinking skills, attitudes, conceptual understanding and epistemological awareness they developed and the scientific thinking processes involved. For the purposes of this paper we will focus also to those parts of children's learning that can be connected to the constructionism paradigm.

The activity sequence and results from the implementation

In this section we provide a description of the task sequence along with data from the implementation.

<u>Activity One: Introduction to the problem</u>

The student-teacher found an interesting way to get the children engaged in the problem described in the previous section. Besides the word triangle, none of the other mathematical terms of the problem was used to introduce the problem to the children. The children were asked through an interesting story to find how many different shapes they could make by using two given triangles and the problem was explained through an example of an acceptable solution and an example of an unacceptable solution. Through a discussion she had with the children, the student-teacher made sure that the children had understood the elements of the problem.

Activity Two: Experimenting and tracing solutions to the problem

At first the children worked in pairs were they **experimented** with a pair of the two congruent scalene, right-angled triangles while trying to find different solutions to the problem. The children were asked to find a way to remember their solutions so they decided that they had to trace each solution on a piece of paper (Figure 2).

Figure 2. The children are experimenting in order to find the solutions to the problem.

Activity Three: Presenting solutions to the classroom

Then the children presented their solutions to the whole of the classroom and through their drawings they concluded that they had found five different solutions to the problem altogether which they reproduced with the use of pairs of congruent scalene, right-angled triangles (Figure 3). The children did not identify among their drawings the solution illustrated in Figure 1(b).

Figure 3. The five solutions found by the children.

The children along with the student-teacher wondered whether there were more solutions to the problem. The student-teacher told the children that they would try and see if there are more solutions to the problem the next day and took photos of each solution found.

Activity Four: Observing the set of congruent triangles

The following day the children observed the two triangles they had used the previous day and made different observations. They observed that for each side of one triangle they could find the same side in the other triangle. Thus, as concluded by the children, the two shapes were ‘the same’. They also observed that the three sides of each triangle were different between them. When the children were asked to find a way to show which side of one triangle was the same with which side of the other triangle they decided to use a different color marker to mark each set of equal sides. After they marked the two triangles the way they had decided, the teacher showed the children sets of triangles which she had marked earlier using blue, red and green.

Activity Five: Reproducing and observing the solutions to the problem

Then the student-teacher showed the children the photos from the solutions to the problem they had found the previous day and the children recognized that these were indeed their solutions. The children were separated into 5 groups. The student-teacher gave each group a photograph of one of the solutions they had found the previous day and 2 marked triangles. Each group used the triangles to reproduce the solution in their photograph. Then the children observed the 5 solutions found, as these were reproduced using the marked triangles (Figure 4).

Figure 4. The children are observing their solutions as reproduced with marked sets of triangles.

The student-teacher chose the solution illustrated in Figure 1c to start the following discussion with the children:

1 Teacher: *What do you observe about the sides you put together in order to make this shape?(Figure 5a)*

2 Child: *The two sides are open. One is right and one is left.*

3 Teacher: *What do you mean they are open? Explain to me.*

4 Child: *They are like the wings of a bird!*

5 Teacher: *A! The shape you made looks like wings. (Figure 5b)*
What else do you observe about the sides you put together?

6 Child: *They are the small ones.*

7 Teacher: *They are the small ones. What else?*

8 Child: *This shape when you put it the other way round looks like a tear.*

9 Teacher: *But in order to make this shape you put together two sides? The two sides are different?*

10 Child: *Yes. Because this goes straight down and this goes straight up. (The child points out one set of parallel sides of the shape, Figure 5c)*

11 Teacher: *Nice? But I am talking about the sides the children put together. ....Observe their color.*

12 Child: *They are both blue.*

13 Teacher: *So they are ...*

14 Child: *...the same*

15 Teacher: *Do you see another shape which has the two blue sides joined?*

16 Child: *This one. (Figure 5d)*

17 Teacher: *How come we have two shapes with the blue sides joined?*

18 Child: *They were like this…(The child positions her two hands as shown in Figure 5e)*

19 Teacher: *And then …..*

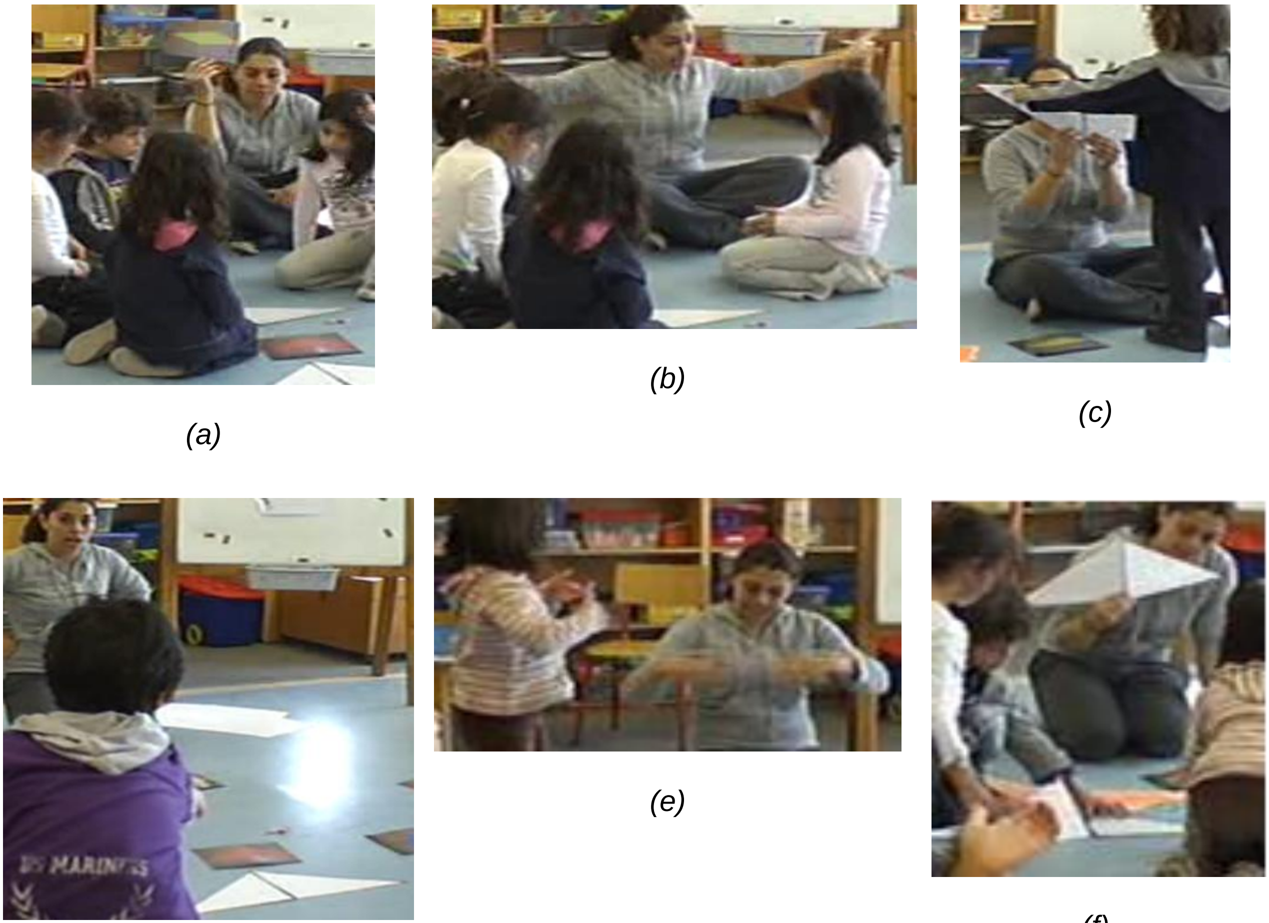
20 Child: *…… the other way round. (The same child as before flips one of her two hands over)*

21 Teacher: *This looks like wings and this looks like a tear. How can we make the wings look like a tear?*

22 Child: *(A child after turning the one of the two triangles around for a while f l i p s it over.) (Figure 5e)*

23 Teacher: *What did you do?*

24 Child: *He turned it upside down.*



(a) (b) (c)

(d) (e) (f)

Figure 5. The children are discussing one of the solutions of the problem.

The student-teacher proceeded the same way with the two shape-solutions where the children put together the sides marked red and the one shape-solution where the children put together the sides marked green.

25 Teacher: *How many times did we join the red sides?*

26 Child: *Two*

27 Teacher: *How many times did we join the blue sides?*

28 Child: *Two*

29 Teacher: *How many times did we join the green sides?*

30 Child: *One*

31 Teacher: *So what do you observe? …… We have two solutions with blue, two solutions with red and one solution with green. Now open your ears because I have a question for you. Do you think we have found all the solutions?*

32 Child: *No*

33 Teacher: *How many more solutions are there?*

…….

34 Child: *There is one more solution.*

35 Teacher: *Why?*

36 Child: *Because …*

37 Teacher: *Let's think. Why is there one more? … How many solutions do we have for each color?*

38 Child: *Two.*

39 Teacher: *Two. Which color doesn't have two solutions?*

40 Child: *The green one.*

41 Teacher: *So, do you think there is one more solution for…*

42 Child: *...for green. Green is also two.*

43 Teacher: *Which is the solution missing? How can I have a different solution with the green?*

Two of the children tried to transform the 5th solution into another shape. Finally they flipped one of the two triangles over thus discovering the missing solution to the problem] (Figure 6)

44 Teacher: *So how many solutions do we have now?*

45 Child: *Six.*

Figure 6: The children are trying to find the missing solution

Findings

In Table 1 we can see the learning outcomes which were identified through the data collected from the implementation of the activity sequence.

Learning Axes	Learning Outcome of the activity	Corresponding

		Activity- Evidence
Experiences	You can make different shapes by combining two other shapes in different ways	Activity Two
	Two shapes might have their corresponding sides equal	Activity Two/Four
	There are triangles which have three unequal sides	Activity Two/Four
	Some problems have a specific number of solutions (there is a reason why the number is specific)	Activity Five
Scientific Thinking Skills	Collection of data	Activity Two
	Collection of observations	Activity Four/Five
	Interpretation of observation	Activity Five
	Formulation of a hypothesis	Activity Five
Scientific Thinking Processes	Problem solving	Activity One-Five
	Mechanistic reasoning	Activity Five
Attitudes	Experimentation	Activity One
	Collaboration	Activity One
	Continuation for the completion of a process	Activity Three-Five
Conceptual Understanding	Congruent triangles	Activity Four
Epistemological Awareness	Mathematical knowledge is based on empirical data and observations	Activity One-Five

Table 1. Tracing the learning outcomes of the activity sequence

In the previous section of this paper, we can see how young children were involved in a problem-solving activity were they had to construct shapes by using two congruent triangles, share and reflect upon their constructions. Reflecting upon constructions is a major issue within Constructionism (Kafai & Resnick, 1996; Papademetri, 2007; Resnick, 2007). Through the process and based on the analysis provided in Table 1, the children gained specific mathematical experiences, developed scientific thinking skills, attitudes, conceptual understanding about congruent shapes and their epistemological awareness and got involved in scientific thinking processes.

As far as experiences are concerned, this is a fundamental learning axis for the education of young children. As pointed out by Richard Noss during the Constructionism 2010 conference as part of the 'Constructionism Under Construction' Panel, 'engaged in constructionist activities makes it easier for teachers to teach difficult ideas later on'. In rephrasing this I would like to support the point of view that experiences are the basis and a prerequisite for conceptual understanding.

The children were involved in processes of flipping and rotating shapes (processes which remind us of Dynamic Geometry) while experimenting in their effort to find different solutions to the problem and in the process of trying to make and interpret their observations. Additionally these processes of observing and interpreting their observations (Activity five, discussion, lines 15-20) which led them to a formulation of a hypothesis ('there is one solution missing' 'because green also has to be two') is a process described by Russ et al (2008) as mechanistic reasoning.

Using a framework derived from the philosophy of science, Russ et al. (2008) developed a coding scheme of 7 major components of mechanistic reasoning that can be used to identify and assess children's use of mechanistic reasoning. Those components include (i) descriptions of the target phenomenon (what we see happening), (ii) identification of the set-up conditions that are necessary for the phenomenon to happen, (iii) identification of entities (conceptual or real objects) that play a particular role in the phenomenon, (iv) identification of the entities' activities that cause changes in the surrounding entities, (v) the entities' properties, (vi) the entity organization (how entities are located, structured or oriented within the phenomenon), and (vii) chaining; that is using knowledge about causal structure to make claims about what has happened prior to a phenomenon and what will happen.

Based on Russ et all's (2008) coding scheme for identifying mechanistic reasoning we can identify the components of mechanistic reasoning in the learning experience described earlier. The children made observations (described what they saw happening) – there are two solutions for the same set of congruent sides (Russ et all's (2008) component i). In order to do that, the children identified the data of the problem (identified the conditions and described the entities which played an important role in the phenomenon) – this phenomenon arose while trying to construct shapes by putting together two congruent scalene triangles so that one pair of congruent sides is completely shared (Russ et all's (2008) component ii-vi). After the children described what they saw happening they became involved in a chaining procedure where they tried to interpret their observation which allowed them to formulate a hypothesis in relation to the missing solutions to the original problem – there are two solutions for each set of congruent sides which result when flipping over one of the two triangles, thus the total number of solutions to the problem must be 6 (Russ et all's component vii). This process of observing something interesting happening and trying to interpret this observation is so familiar when thinking about children playing with computers and observing interesting things happening on the screen within the constructionism research paradigm.

In concluding with the findings, I would like to pinpoint the ways in which the objects provided to the children operated as communicative and meaning construction tools. In Papademetri (2007) through a focused investigation of young children's understandings of squares we concluded that 'in the process of the tasks (designed for the aforementioned research) the children articulated, through the language provided by the setting, rich intuitive understandings about the structure of squares and were, at the same time able to situate their abstractions in the context of construction'. In the study by Papademetri (2007) the children went through a three phase task sequence consisting by a Description Task (the children were involved in classification and shape recognition tasks), a Construction Task (the children were asked to construct squares with the use of sticks) and a Reflection Task (the children were asked to reflect on the construction process). Even though during the Description Task, the children as supported by existing research exhibited limited understanding about squares, through their involvement in the Construction Task, they exhibited much richer intuitive structural understandings. And in the Reflection Task even though the children in a great extent failed to express about the structure of squares in formal ways they expressed about the structure of squares in diverse and inventive ways. As concluded by Papademetri (2007) 'construction became the language the children could 'speak' and the adult (researcher/teacher) could 'hear'. Similarly, in the task sequence described in this paper and through the children's involvement we can see how the objects provided gave the opportunity to the children to think and communicate about powerful ideas without having to use formal language which is strange to young children. If we go back to Activity Four (observing the set of congruent triangles) we can see how the objects provided and the context of the activity allowed the children to think about and communicate their conceptual understanding of congruent shapes and scalene triangles. Similarly in Activity Five in line 10 of the discussion described in this paper we observe how the child refers and expresses his observations about the two parallel/equal sides of the parallelogram (Figure 1c) they constructed with the two congruent triangles. Thus here we have an example of the ways in which construction allows young children to think about, talk about, and reflect on mathematical concepts and phenomena.

Discussion

During the Constructionism 2010 conference as part of the 'Constructionism Under Construction' Panel, Richard Noss pointed out that 'powerful ideas mostly can't be learned by accident' stressing out the need for designing activities which will lead learners to powerful ideas. Furthermore this paper builds on the conviction 'that studies in mathematics education should involve some discussion of mathematical activity, however this is defined' (Hoyles, 2001).

In this paper we have described one such activity sequence and have argued that it is characterized by the main aspects of the constructionist approach. The children were given an-object-to-think-with, developed their scientific thinking skills and thus were taught 'how to think as mathematicians' learned through construction and reflection and gained access to powerful ideas. Based on Celia Hoyles comment in the Constructionism 2010 'Taking Stock' Discussion on assessment I can retrieve a substantial number of educational activities and pieces of research using computers (and claiming to be constructionism) that do not involve learning in a constructionist sense. Thus, the learning experience described in this paper is one example of how Constructionism can reach teachers and schools even in those cases were the conditions are not ideal and learning is not computer-based.

I would like to conclude this discussion with one final comment. According to Resnick (2007) 'Kindergarten is undergoing a dramatic change. For nearly 200 years, since the first kindergarten opened in 1837, kindergarten has been a time for telling stories, building castles, drawing pictures, and learning to share. But that is starting to change. Today, more and more kindergarten children are spending time filling out phonics worksheets and memorizing flashcards. In short, kindergarten is becoming more and more like the rest of the school.' We value Renick's conviction that 'exactly the opposite is needed: instead of making kindergarten like the rest of school, we need to make the rest of school (indeed, the rest of life) more like kindergarten.' Resnick (2007) is inspired by Kindergarten's traditional-authentic approach to learning in trying to formulate a Lifelong Kindergarten education. Because it is indeed a fact that Kindergarten is undergoing a dramatic (and quite sad) change, constructionism can replace kindergarten's lost identity and character. Thus it is time for early childhood education to be inspired (as paradoxical as it sounds) by constructionism.

References

Claus, A. (1992). Exploring Geometry. *Arithmetic Teacher*, 40(1), 14-17.

Hoyles, C. (2001). *From Describing to Designing Mathematical Activity: The Next Step in Developing Social Approach to Research in Mathematics Education?* Educational Studies in Mathematics, 46 (1-3), 273-286.

Kafai, Y. B. & Resnick, M. (1996). *Introduction.* In Y. B. Kafai & M. Resnick (Eds.), Constructionism in

Practice: Designing, Thinking and Learning in a Digital World (1-8). New Jersey: Lawrence Erlbaum Associates.

Noss, R. & Hoyles, C. (1996). *Windows on Mathematical Meanings.* Netherlands: Kluwer Academic Publishers.

Papademetri, C. (2007). *Structural Knowledge about Shapes: A Case Study of Young Children Describing, Constructing and Reflecting on Squares*. PhD Thesis, University of London, Institute of Education, London, U.K.

Papert, S. (1972). Teaching Children to be Mathematicians versus Teaching Children about Mathematics. In A. Floyd (Ed.), *Developing Mathematical Thinking* (235-245). Wokingham Addison – Wesley.

Papert, S. (1991). *Situating Constructionism.* In I. Harel & S. Papert (Eds.), Constructionism (1-12). Norwood: Ablex Publishing Corporation.

Papert, S. (1993). *Mindstorms: Children, Mathematics and Powerful Ideas* (Second Edition). New York: Basic Books.

Russ, R., Scherr, E., R., Hammer, D., & Mikeska, J.(2008) Recognizing mechanistic reasoning in scientific inquiry. Science Education 92(3), 499-525.