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Shapes recognition in early school: How to develop the dimensional deconstruction?

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In primary school there is, in geometry, an important rupture between primary (age 4 to 12) and secondary school. Some activities are already proposed for students from 8 to 12 years old to help to prepare for this rupture. Our research has the same aims, but for students from 4 to 6 years old by developing some pre-geometrical activities around shape recognition using dimensional deconstruction.

Keywords: Shape recognition, visualization, dimensional deconstruction, way of thinking.

Context

In all French speaking Switzerland we have a common program for all compulsory education. For the geometry curriculum, in the elementary division (from 4 to 8 years old), students use a physical space where «the shape is linked to the visual perception of the object»¹. Then, from 8 years old, they use a conceptual space where objects are associated with figures as «unchangeable and ideal». These figures are independent of their graphical representation. We consider that there is an important gap between these two divisions, and we need to help students to overcome it.

Theoretical framework

Some researches like Berthelot and Salin (1993-1994), Houdement and Kuzniak (2000), Parzysz (2003), Braconne-Michoux (2008) show a rupture, in geometry teaching, between primary and secondary school where the focus is put on reasoning and deduction. Without reaching the theoretical level of the geometric objects and therefore of their properties, an intermediate work on the elements which compose the forms is possible and constitutes the heart of this research with students of cycle 1 and beginning of cycle 2. As Duval (1994) says, one of the aims of geometry in primary school is to emerge the operative apprehension of a figure parallel to the one, first and naturel, more perceptive. Therefore, to help, it “presupposes the dimensional deconstruction of the visual representations”² (Duval & Godin, 2005, p.11). The first visualization is global; the perception is centered on the closed contours of the shape. This visualization is called two dimensional visualization (2D element), which is referred to by Duval (2005) as the iconic way of seeing. The dimensional deconstruction considers the elements of the shape like the sides and the lines, which are one dimensional elements (1D element) and the vertices and the points, the zero dimensional elements (0D elements). This is what Duval (2005) distinguishes as the non-iconic way of seeing. The decomposition of shapes into figural unities is an essential stage prior to building the non-iconic visualization.

1 Our translation from the French speaking Switzerland curriculum « Plan d'études romand » (<https://www.plandetudes.ch/per>) : « la forme est liée à la perception d'ordre visuel d'un objet ».

2 Our translation.

Having as objective to evolve the students' visualization of geometrical shapes, we rely on the work of the Lille group (Duval (1994), Duval, Godin & Perrin-Glorian (2004), Duval & Godin (2005), Keskessa, Perrin-Glorian, Delplace (2007), Godin & Perrin (2009), Perrin-Glorian, Mathé & Leclercq (2013), Perrin-Glorian, Godin (2014), Perrin-Glorian (2015), Bulf & Celi (2016)) which consider the transition between the recognition of a form by global perception and the deduction from its axioms as the "identification of properties that are verified or produced with instruments"³ (Houdement and Godin, 2014, p.28). Most of those researchers propose tasks of reproduction of figures in particular the reproduction problems called "restoration of figures (define by Perrin-Glorian and Godin (2009)). In our case, we work on tasks of forms recognition. To prepare students to the rupture pointed out between primary and secondary school, we introduce two new levels between the global perception and the non-iconic way of seeing. We call them the "hybrid thinking" and "thinking by characteristics". Below, we associate each thinking according to the ways of seeing of Duval. We give an example based on the following shape:



	Iconic visualization	Towards dimensional deconstruction		Non-iconic visualization
Way of thinking	Perceptive thinking	Hybrid thinking	Thinking by characteristics	
Associated vision				
Associated language ⁴	« It looks like a fish »	« It looks like a fish with a flat nose and a curved body »	« It is a shape with holes (the convex character). It as rounds and straights (straight and curved edges) »	

Table 1: Levels of the different visions of the shapes

Those levels focus 1) on a global vision of the shape (2D) 2) on a hybrid vision of the shape (using the global vision and some characteristics of the shape (0-1-2D) 3) on the vision of only some localised areas of the global form (as the types of lines (straight or not, etc.)) considering therefore some of the characteristics of the shape (0-1D). This third level corresponds to pre-geometrical work. The last level "non-iconic visualization" relates to the definition of the properties of geometric figures. So, to think by the characteristics is more than a perceptive vision but does not yet correspond to the geometric properties. As for the hybrid thinking, it mobilizes in the same time the global vision of the shape, through its surface, and a more expert vision from its elements.

This table shows a wider process of dimensional deconstruction than usual. Thus, our goal, in this research, is to develop some pre-geometrical activities around shape recognition using these two new levels to provide students with a more harmonious transition in order to overcome the gap between primary and secondary school.

³ Our translation.

⁴ In the next steep of our research we will also consider the "associated action".

The developed material

In order to help 4 to 6-year-old students to pass from the perception of the shapes as they are worked in primary school to what is expected in secondary school, we propose to work on shapes recognition tasks with a collection of 36 shapes. Very often, the most common use of characteristics concerns the number of sides of the shape. However, students at this age are precisely building the concept of number which is therefore "fragile". Other characteristics of shapes are nevertheless affordable and interesting from Cycle 1. For example, the presence of straight or curved edges, symmetries, parallel opposite sides or the convex or concave character of the shape. Of course, students are not expected to use the correct mathematical terms. What is important is that they identify these characteristics, whatever the vocabulary used. The collection of 36 shapes takes into account the different characteristics cited. Figure 1 presents the collection of the 36 shapes. All the different tasks are built around this collection (tasks of classifications, associations and housing).

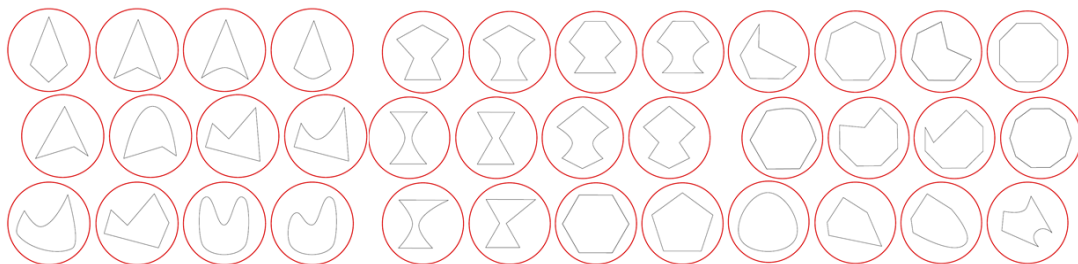


Figure 1: The collection of the 36 shapes

The chosen shapes are not nameable, at least not using "classical" shape names such as triangles, squares, rectangles, circles. To identify them, students have to focus on other aspects than their name. Either students recognize, in the shape, a resemblance to a well-known object (for example the fish mentioned above), or they are obliged to refer to its characteristics. This last point promotes dimensional deconstruction with the components of shapes.

Thus, the main objective aimed through the developed activities is that the student constructs a thinking of the objects based on their characteristics. This does not mean that it is necessary to replace the global thinking, but to supplement it. The joint use of the hybrid thinking and the thinking by characteristics is therefore also necessary. For example, in many activities, students can first classify the shape by global perception (we put together shapes perceptually close), and then only need to distinguish them through their characteristics.



Below is an example of strategy to find a shape in a collection of eight shapes :

Starting Collection	Reduced collection	Identified shape in the reduced collection
I observe and manipulate the assortment of forms	I extract all "bow ties" (or "vases") of the assortment.	I then focus on the characteristics "it is the one that is not regular (=symmetrical) and with rounds (=curved edges)". I select then the corresponding shape.

Table 2

The choice of the selected shapes is essential because it can directly influence the way of thinking that the students will mobilize.

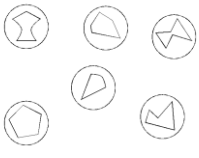
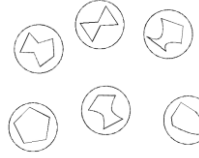

Perceptive thinking	Hybrid thinking	Thinking by characteristics
		

Table 3

Thus, if the selected shapes are perceptively distant, the overall vision is promoted. Conversely, if the shapes are perceptively close, an entry through the characteristics is necessary. These shapes are cut out from "translucent" Plexiglas. The choice of a circle does not favour any particular orientation. With this material, we can work on the shape using the edging by the exterior or the interior of the shape. Depending on the activity, we may choose to present one or both of these supports (or both). The interest of this material is that it can be embedded providing direct feedback for students.



The inside form



the empty circular part

With this collection of shapes we then create activities working on shape recognition with different kinds of tasks, classifications, associations and housing.

Methodology

For one school year we have worked with six classes including four classes in a downtown Geneva school, a class in the Geneva countryside and a class in neighbouring France. This diversity makes it possible to confront our material and our activities in different contexts (without pretending any generalization). In total there were 112 students aged from 4 to 6. At the beginning and the end of the year all the students took a test. We do not develop the results of the tests in this article. The students worked in small groups with the researchers from 2 to 4 periods in total. Each period lasts 45 minutes. In every class, except one, we realized, among the proposed periods, a session with big shapes in the "meso-space".



Photo 1: Work with big shapes

In each class we have: 1) One individual pretest at the beginning of our research in which we use the activity « families to build ». This test has been passed by the teachers and was not filmed. 2) Many activities using the developed material. Each session was filmed by one or even two cameras.

3) One activity with big forms. 4) One « concluding activity » at the end of the year. 5) One post-test at the end of the school year (exactly the same as the pretest). 6) One pretest at the beginning of the following year (exactly the same as the previous ones). This test was filmed and students were systematically asked about their production.

We thus have many hours of observations that allow us to verify if students of this age can mobilize the characteristics of the shapes.

Presentation of an activity for 4 to 6 year old students: Families to build⁵

The activity is done in groups of 2 to 5 students. The teacher selects an assortment of 8 to 16 pieces from the collection (the inside form or the empty circular part). Below is an example of an assortment that has been frequently used in classrooms with students.

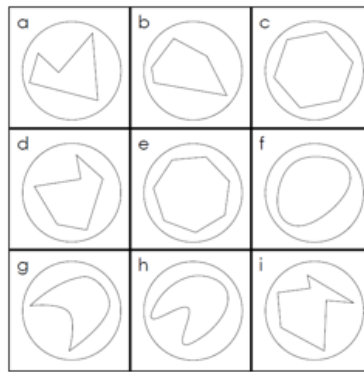


Figure 2: An assortment frequently used in classrooms

In this activity students must build families (with a number of families imposed or not). The pieces are scattered on a table. Students must create families by putting the pieces "that fit well together". Students must agree and be able to explain their choice, possibly giving a name to the families created. Various objectives can be identified for this activity: 1) classification of shapes based on characteristics 2) emergence of a common lexicon that can be reinvested in other activities 3) peer collaboration with the need to agree and to argue. Thus, according to the assortment of selected pieces, students can use global or hybrid thinking or thinking by characteristics. The choice of perceptively close shapes or not is therefore an important didactic variable for this activity as well as the number of families (imposed or free).

In the pooling phase the teacher can introduce new pieces to check the solidity of students' family choices. Either they manage to integrate the new pieces within the existing families, or they need to question their classification criteria and maybe modify them.

⁵ For more activities see Coutat & Vendeira (2015).



Photo 2: An example of three families built by a group of students: 1) "the mountains" 2) "the pebbles" 3) "the fish" (vision according to the resemblance of the shapes to well-known objects)

Some results

In this section we look at the productions of three students which reveal three different ways of thinking that the students mobilize about the shapes following our interventions in class. These are outcomes from the activity "families to build" carried out during the pretest (done at the beginning of our research) and the same test realized a year later.

Concerning the case of Luce, almost no change is noticeable between the two productions at one year interval. During the first run, it is found that very perceptively similar objects are associated in order to create three families. A year later, the student explained that he had formed a family of *mountains*, *trumpets*, *teapots* and *lamps* and could not say more. It is possible to relate these objects to some of their characteristics as the sharp peaks for the mountains, the symmetry for the lamps or the asymmetrical spout for the teapot. However, this remains implicit and the primarily mobilized vision is, in this case, global.

	Luce					
Activity in 2016						
Activity in 2017						
	Mountains		Lamp	Teapot	Trumpets	

Table 4: the two productions of Luce at one year interval

Lea's productions at the same task are identical to those of Luce for the first test. Her vision is essentially global. On the other hand, the two families created the following year are quite distinct. She chose only two families by mobilizing hybrid thinking. Indeed, the global perception is partially used with the second family where Lea recognizes *thunder* thanks to their "peaks in". As for the first family, it only possesses "rounded in" and does not belong to the family of the thunders.

Léa	
Activity in 2016	
Activity in 2017	

Table 5: the two productions of Léa at one year interval

The first production of David is distinct from those of these two classmates. However, without a trace of his activity, it is difficult to understand how this student proceeded. It is conceivable (1) that devolution has not taken place; (2) that David mobilizes hybrid thinking but it is impossible for us to interpret. This is why we focus directly on the second production made the following year. The first family of David is justified according to two characteristics common to the three forms, namely "rounded and sharp". As for the second family, the forms are "all sharp", but have no rounding. This student thus mobilizes some characteristics of the forms.

David	
Activity in 2016	
Activity in 2017	

Table 6: the two productions of David at one year interval

Conclusion

The task "build families" is very interesting for the researcher because it gives a lot of information about the student's perception of the shape such as the visualization to build the families (global or not), the use of characteristics to build the families, the use of a pertinent language for oral interactions.

The various tasks created with the developed material and experimented in classrooms allow a progressive change of the visualization of geometrical shapes. It is important to note that students do not replace their perceptual way of thinking with a new way of thinking by the characteristics of the forms. Indeed, these ways of thinking must coexist and intertwine, sometimes giving rise to a hybrid way. It remains to be defined 1) whether the work undertaken allows all students to change their eyesight and 2) whether they are able to mobilize the appropriate thinking according to the situation.

Currently we are experimenting with new tasks with students from 6 to 8 years old and still analyzing the data collected with students from 4 to 6 years old. In addition, the developed material is currently tested in five schools. We look forward to the feedback from the teachers.

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