CONCEPTION OF INQUIRY-BASED ACTIVITY TO FAVOUR HIGH SCHOOL STUDENTS' UNDERSTANDING OF BASIC GEOMETRY

Louis Trudel[*], Abdeljalil Métioui[**]
[*]*Université d'Ottawa, Faculté d'éducation , K1N-6N5, Ottawa, Canada*
[**]*Université du Québec à Montréal, Faculté des sciences de l'éducation, H2X-3R9, Montréal, Canada*

ABSTRACT

In high school, geometrical concepts are a prerequisite for learning most physics concepts: understanding the formation of optical images, finding the center of gravity of objects, etc. However, these concepts are often misunderstood by high school students, mainly because of the way these concepts are taught, often disconnected from their concrete nature. Our exploratory research aims to design and identify the conditions of implementation of an educational approach in which students are encouraged to ask questions about situations involving geometric concepts, to apprehend their properties and to develop a theory to link together the results obtained.

Keywords: *Geometrical concepts, Inquiry strategies, Induction, High school mathematics, Adults' learning*

Introduction

In mathematics as well as science education, understanding the basic concepts of geometry has been linked to subsequent learning of key concepts such as the properties of light and motion (Gal & Chen-Morris, 2013). Moreover, the science of motion elaborated by Galileo, Newton, Descartes, Kepler and others rely on a sound understanding of basic geometry, as well as and also analytical geometry, so that the trajectory of objects in motion, whether it concerns the motion of planets around the sun (ellipses) or projectiles at the surface of the earth (parabolic motion) (Meli, 2006). Although most of mathematical concepts are seen and taught in high school in a purely deductive manner, mostly in a traditional way consisting of lectures, demonstrations, exercises and tests, an increased number of researches points to the inductive nature of mathematical discovery. Indeed, it has been shown elsewhere that inquiry strategy can be used to profit when learning basic geometry (Lewis, 2009).

Drawing from these results, the inquiry strategy, on which the proposed approach is based upon, derive from two assumptions (Joyce, Weil & Calhoun, 2004) : 1) inquiry is a process based on the search for meaning, and the main motivation of the individual in this process is related to the increased complexity of his intellectual structure; 2) this growth of intelligence is made through confrontation with the environment. The resulting data is then interpreted and causes reorganization of knowledge of the individual. According to Desrosiers-Sabbath (1992, p. 1-21), the teacher using inquiry will seek to achieve the following objectives: 1. develop cognitive skills in research and data interpretations as well as acquire logical and causal concepts, that will make every student able to investigate independently and efficiently; 2. provide student a new way of learning that will enable him to build concepts by analysis of concrete events and discovery of relationships between variables; 3. rely on two sources of motivation: the compensatory experience of discovery and excitement or emotion inherent to autonomy in research and data treatment. We will see in the next session how this model can be applied to mathematics learning in the classroom.

Conception of an inquiry strategy of basic geometry

The lesson aims to help junior high school students review their basic concepts of geometry and develop problem-solving strategies in basic geometry. The concepts covered are the following: point, straight lines (intersecting, perpendicular, parallel), ray, line segment, angles (flat, straight, obtuse, acute, convex, concave, vertically opposite, alternate, external, external-alternates, alternate interior, correspondents), triangles (equilateral, isosceles, rectangles, isosceles, scalene) quadrilaterals (parallelograms, diamonds, squares, rectangles, trapezoids). The duration expected is between one and three hours. With respect to the ressources needed, they consist essentially by drawing of geometric figures on sheets 8.5 inches X 11 inches (letter format) arranged in a tabular way on one of the wall of the classroom (fig. 1).

As for the instruction to the teacher, he first chooses one of the geometrical figures of the table (see fig.1) and write its name on a piece of paper making sure that nobody can see it. Students are then divided into teams and choose a name for their team. By questions posed to the teacher, students try to guess the figure chosen. The teacher can only answer yes or no to each of the questions asked by students. Each team is entitled to only ask 7 questions per round, only one question can be asked each round by the same team. When a team thinks they have an hypothesis about the type of geometrical figure chosen, one of its member raises his hand and makes an attempt. Each team is entitled to only 3 attempts per round. After 3 unsuccessful try, the team is temporarily disqualified and must wait for the next round. These restrictions are intended to encourage students to use effective strategies rather than to issue a multitude of questions and go through trial and error. Once the name of the geometrical figure chosen by the teacher has been discovered by a team, the teacher chooses another figure from the wall. The winner is the team that accumulates the most points. That is, one (1) point is granted per correct answer. There are also bonus which consist of one (1) point if the student correctly names the figure and one (1) point if the student correctly describes his approach.

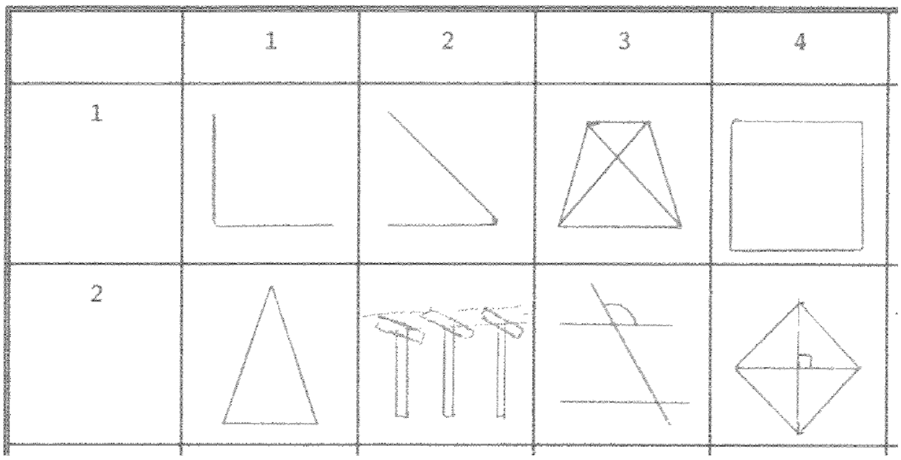

Figure 1. Excerpt of the geometrical figures shown on a wall of the classroom

Methodology

The experimentation took place in an adult learning center during one period of two hours. The subjects of the research were adult learners, from twenty to fifty years old, who followed a high school mathematics course. The mission of this center is to make every effort to ensure that the adult learner develops skills, behaviors and attitudes that will enable him to succeed in his studies and enter the job market. To achieve this, the centre offers personalized monitoring of students in connection with their learning profile, different teaching and learning styles, coaching students and promoting educational success. In this center, students are adults of various ages, making a come back to school. The teaching model is mainly individualized learning, students following their own path.

Each teacher in the Center is responsible for the supervision of a number of students whom he tutors. In this respect, he prescribes activities or a specific learning path according to courses selected by the student. The programs consist of individual books with exercises to do according to student's level. Students' guides include booklets in which are written questions to answer by students and readings in compulsory textbooks available to students according to their level. Despite the support and resources available to students and a sense of higher responsibility of adult students, the school direction found that students were taking much longer than expected to complete their modules and that some accumulate absences and delays. A mixed formula has thus been established to form small groups that follow a similar path led by a teacher specialist of the discipline. The research presented here had been conducted in one of these groups.

To study the implementation of the teaching-learning sequence, the main researcher who was also the teacher held a diary where he recorded his observations on the sequence of events, his reflections about the observed events, and links between his observations and the theoretical framework of the present research (Altrichter & Holly, 2005). The diary kept by the researcher/teacher respectively served two functions: 1) to document the research process in trying to determine the conditions for implementation of the proposed approach in the targeted areas; 2) to document the pedagogical process when the researcher/teacher used as it a reflective tool in planning his own teaching approach.

Presentation and interpretation of results

Any winning educational strategy is based, to some extent, on anticipation of students' reactions. It is through these reactions that teachers can prepare relevant and effective teaching material. The inquiry model was developed for application to the natural sciences. However, we modified it in order to use it to teach geometry. The essential activity focuses on the discovery by students of the figure chosen by the teacher in secret. We presented here idealised examples drawn from our observations while implementing the inquiry strategy. First it is essential at the start to create an environment that enables the students to collect data, formulates hypotheses and put them to the test. The teacher should refrain from being overly prescriptive, among others. The whole process, except for the scenario and occasional support from the teacher, lay mainly upon student's shoulders. Faced with a confusing situation, provided mainly by the training material carefully selected, student asks questions to apprehend the situation (gathers facts, makes observations, etc.), understand by "experimenting" (he may raise questions about a particular geometrical property), to develop a "theory" by linking several propreties together and ultimately verify his hypothesis.

Most of the strategy is based on student's questioning. These questions must be formulated, especially in the early stages when the student gathers information and experiments (in the sense of testing), so as to obtain a yes or no answer from their teacher. The student must ask a minimum number of questions (and a maximum of seven!) to ensure an advantage over other teams. He should also carefully listen to the questions of other teams and answers from the teacher. He has also access to strategies developed by other students. There are many possible strategies and you will probably be surprised by the cunning of some of your students (as I had been). To give an example, one possible strategy would be to first ask general questions and then more specific questions:

- Is it a closed figure?
- Is this a quadrilateral?
- Is it a triangle?

These questions are used to limit the number of possibilities. Other questions, more specific, make it possible to narrow down the field to only a few choices:

- Are there parallel straight lines?
- Are there opposite angles from the top?
- Are there equal angles?

At this stage, the student has an "hypothesis" in his mind and will try to test it by asking questions that will enable him to verify his theory, for example by checking with a question whether the chosen geometrical figure possesses a property others do not. For example, if the student has in mind that it is a square or a diamond, he will compare the properties of the two figures:

A DIAMOND has four equal sides; its opposite angles are equal; its diagonals intersect at right angle in their middle.

A SQUARE has four equal sides; its angles are all equal and right; its diagonals are equal and intersect at right angles in their middle.

To ensure the correct answer, he will ask the following question:

- Are the angles all rights in the figure?

It goes without saying that other strategies are possible and some are more effective than others. The key is that the student seeks to link the concepts together (like straight line, right angle, parallel lines) and associate them with a specific figure. The group of students with whom I had experienced this method told me that this had greatly helped to unravel their geometrical concepts and from the observations I made while experimenting this strategy, students enjoyed the game while revising their concepts of geometry.

Discussion

This paper aims at exploring the concepts of inquiry-based learning as an approach to enhance students' understanding of geometry in high school. In this research, there are many reasons to make us believe that learning geometry through inquiry will allow students to reconceptualise their understanding of geometry in a more meaningful way (Beerer & Bozdin, 2004). Some of these reasons would include : 1) engaging students in activities that allow them to connect geometry to real world; 2) encouraging them to reflect on there learning, and therefore enhance their abilities towards self-directed learning.

To begin with, inquiry method consists of a variety of higher-order learning activities that allow students to postulate hypotheses, design and conduct investigations, collect and analyze data, and apply their newly learned concepts in real life situations. In this regard, Clements (2003) studied students' engagements in inquiry environment while conducting investigation involving geometry. The study concluded that students were engaged when they were given ample time to explore geometrical properties in their own. As per this research, our observations reveal that when students are given opportunities to propose and test hypotheses, they become more aware of of the need to describe shapes of objects available in their natural world using appropriate terminologies. Further, students were able to establish links between popular objects (e.g., diamond) and drawings that are usually used in classrooms to describe geometrical properties (e.g. square). This connection makes students discover their surroundings from a geometrical perspective.

In another line, major part of our observations were focused on students' abilities to work independently by utilizing self-generated questioning technique. As such, questioning technique allows students to work in group setings with minimum guidance. Hence, learning in group settings often make students more comfortable to recall their prior knowledge and discuss it with their group peers. This constructivist approach had been explored by different studies. For example, Costa and Kallick (2004) examined questioning techniques to help students work independently. The study found that students become more willing to accept challenges and problems in order to complete their learning tasks successfully. At the opposite, in traditional teaching of mathematics, students often don't take initiatives to solve challenging problems. Instead, they rather prefer getting their answer directly from the teacher. Thus, one major advantage of the questioning technique initiated by students is the fact students accept doing mistakes as part of their learning processes.

Conclusion

To conclude, the inquiry approach is a very useful strategy in engaging students in a variety of higher-order learning activities. Learning through inquiry is not only limited to teaching and learning science, but also can be implemented in mathematics courses. Learning geometry through inquiry has unique advantages. This type of activities allow students to reconceptualize their understanding of geometry in a more meaningful way. Morevoer, within inquiry activity, students are encourages to discover on their own properties of geometrical figures through drawings of objects around them. However, since the approach advocated here had been experimented with one classroom only, the conclusions drawn here have a somewhat speculative character. More reseach is needed on the use of inquiry in the teaching and learning of mathematics, principally at the crossroad of mathematics and science as exemplified by the approach taken here.

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