Community of Inquiry in Mathematics for Higher Education

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Currently, we are completing an experiment in Philosophy for children in which students in elementary schools use philosophy to think and talk about mathematics. Reflections on this experiment have led us to wonder if the fields of teaching philosophy and mathematics at the college level could benefit from the results of this experiment. If so, which components could be transferred to teaching and learning practices in higher education?

In this article, we will try to answer other questions relating to our experiment: Which philosophico-mathematical concepts could be more fully *examined in the context of higher education? What could students gain from philosophical communities of inquiry in their mathematical learning experiences? What would be the predictable reactions of teachers? What would the students' reactions be? How could we integrate communities of inquiry into teaching mathematics at the college level?*

Currently, at the college level' in Quebec, the teaching of both philosophy and mathematics gives rise to many questions. Even if these questions are brought up for different reasons, the relevance of the teaching given in philosophy classes has been challenged. Also, the fact that many students fail and quit mathematics has provoked the emergence of new pedagogical approaches favoring learning mathematics. Also, many mathematics teachers want to demythify mathematics and integrate affectivity in the learning of mathematics but they do not feel they have the training to do so and they think they need more models and pedagogical materials to give them ideas. (Lafortune, 1992)

In mathematics, an approach that would modify teaching habits, favor interdisciplinarity and lead students to be critical towards this discipline, too often perceived as neutral and objective, may interest many students. By presenting mathematics differently and by using a pedagogical approach centered on philosophical reflexion, teachers could help students who succeed well to broaden their understanding of mathematics and better integrate what they have learned. Students with learning problems in mathematics could be stimulated in their curiosity and motivated to have a more positive view of mathematics.

We have implemented an experiment based on these thoughts with students at the primary level. This experiment has led us to think that we could transfer it to the college level. We will briefly present this project. In order to show how such an experiment could be carried out at the college level, we specify in this paper the contribution of the philosophical approach to learning mathematics. Considering that this approach seeks to demythicize mathematics, we will explain the relation of myths to mathematics and their impact on learning mathematics. Two examples of myths will be discussed. While considerably relying on the methodology of Philosophy for children of Lipman and Sharp, we will propose a few adjustments. We will discuss certain difficulties relating to a philosophicomathematical approach while identifying the advantages of this approach in teaching and learning mathematics.

THE PROJECT: YOUNGSTERS PHILOSOPHIZE ON MATHEMATICS

A CIRADE team of researchers favoring the socioconstructivist perspective, in collaboration with the College Andre-Laurendeau, is conducting an interdisciplinary experiment that is part of a project integrating the methodology of Philosophy for children. This project holds a particular view on learning mathematics: it takes into account the affective dimension of learning mathematics and the myths related to mathematics (Daniel et al., 1994).

The project has been carried out in two elementary schools (St-Andre-Apotre School, Montreal and Les Petits Castors School, Longueuil). It rests on two main questions: Can youngsters at the elementary school level philosophize? Can they philosophize on mathematics? Experiments in Philosophy for children conducted in Quebec for the past ten years, lead us to answer affirmatively to the first question. But the second question remains to be answered. Indeed, as demonstrated by a few recent studies (Daniel, 1994; 1992; Lafortune, 1994, 1992, 1990a, 1990b; Lafortune and Saint-Pierre, 1994; Lafortune and Kayler, 1992; Pallascio, 1992a, 1992b), philosophy and mathematics are permeated with myths such as “boys succeed better than girls”, “students need a special talent to succeed” and “mathematics are neutral and objective”. These myths are generally sustained by the dogmatism and elitism of traditional pedagogy in its often excessively formal material.

According to the pragmatist and socioconstructivist perspectives, education is a process in which youngsters learn with the help of peers, to construct their own understanding of problems and to formulate their own hypotheses to solutions of problems. In continuity with this perspective, we think that the objective of philosophical and mathematical education is not to impose learning and beliefs but to favor the emergence of meaning by inviting youngsters to enter a process of research and reflection.

Even though Philosophy for children and other various approaches to learning mathematics have led to many studies, the creation of philosophical material aimed at having elementary school youngsters philosophize on mathematics remains a novelty. In order to invite youngsters to philosophize on mathematics, we have written two philosophical novels adapted to students completing the latter part of elementary school and to students beginning high school. These novels encompass mathematical notions contained in the regular school program. They also contain biographical notes on men and women of the science and in mathematics fields. A teacher’s manual has also been produced to help teachers conduct class communities of inquiry. This manual proposes discussion plans, exercises and activities on themes contained in the novels.

It is while completing the manual that we have realized that this approach could be adapted to higher education. We have come to think that many discussion plans, exercises and activities could be used in the teaching of philosophy and mathematics at the college level. We will therefore show the relevance of using this philosophical approach in a mathematics class at this level.

PHILOSOPHICAL REFLECTION IN THE COMMUNITY OF INQUIRY AND ITS CONTRIBUTION TO LEARNING MATHEMATICS

The experiments conducted at Saint-Andre-Apotre and Les Petits Castors allow thorough investigation of certain mathematical concepts (infinite, abstract, zero, geometry, measure, cube, sphere, definition, proof, existence, discovery) without seeking definite answers to questions on these concepts. This approach is rather a means to involve most students in a discussion, even those who have difficulties. It is a means that favors the use of superior skills to reflect on mathematics before using problem solving skills in mathematics exercises. Like Smith (1995) wrote, philosophy is content, method and process. It offers to the students a research method and makes them practice inductive, deductive and inferential thinking skills.

Philosophical reflection on mathematics is also used to counter certain preconceived ideas on mathematics. The community of inquiry becomes a means to view mathematics as an evolving human construction and to perceive it as less rigid and nearer to emotions than is generally believed. It is a means to perceive those who teach mathematics, less as infallible experts whose lives are centered on what they teach and more as persons who like thinking and talking about mathematics. It is also a means to recognize that success in mathematics does not solely belong to those that supposedly possess a knack for mathematics but belongs also and more so to those who work hard at mathematics using judicious work methods. Hitchcock (1992, cited by Smith, 1995: 45) sustains that the students must learn to become conscious of the human part of mathematics: “competition, lust, pride, ambition, self-delusion, fear of the unknown, courage, endurance, the cry of victory, the vanity and vitality”. Hitchcock suggests that the students must be involved in an interactive dialogue.

Before presenting examples of discussion plans and activities prepared for elementary school students, we will focus on certain elements related to the mythicizing of mathematics.

LEARNING *MATHEMATICS* AND MYTHS’

Students at the elementary and high school levels carry myths and prejudices towards mathematics and learning mathematics. It is by consulting some of these students (Lafortune, 1993) that we have come to know more precisely their preconceived ideas about mathematics and that we were able to use their language and expressions to convey myths. We believe that many students keep those preconceptions even at the college level.

These myths about mathematics are not innate in youngsters. They originate from different sources such as school, family, media and society at large. Whether it be myths, prejudices or stereotypes, preconceived ideas that result in opinions and a priori judgments hinder the learning process. Youngsters' preconceived ideas about mathematics have an influence on their learning of mathematics. In mathematics, preconceived ideas have a greater influence on learning because this subject-matter is compulsory and is perceived as being abstract and difficult to understand. Lafortune (1994) describes this influence on learning and we add to this description our reflections as to how Philosophy for children can help counter myths about mathematics.

1. Certain students develop negative attitudes towards mathematics. They come to class convinced that they will have no fun. Negative attitudes bring students to experience their mathematics classes as a burden. Therefore, they do not listen in class and do not succeed well or do not succeed at all (Lafortune, 1994).

While reflecting on mathematics in a community of inquiry, students can think about their ideas towards this discipline so as to reduce negative attitudes towards mathematics. In a community of inquiry, mathematics appear more accessible. There is not only one good answer to problems. Students reflect 'and share opinions. They build answers that are significant to the group. In so doing, students feel they are an essential part of the community of inquiry on mathematics and their sense of personal worth benefits from the whole process of inquiry. Mathematics can thus become less burdensome and more fun to do.

2. Certain students are convinced they cannot succeed in mathematics. They believe that success in mathematics is due to a special talent or due to having a knack for mathematics. This serves as a pretext to justify their failure or to convince themselves that any effort to succeed is useless (Lafortune, 1994).

One of the characteristics of the philosophical community of inquiry is to help students develop good judgment which in turn boosts self-esteem (Lago-Bernstein, 1990). In participing in a community of inquiry, students are stimulated to submit their ideas to the group; group work motivates students to develop solid argumentation which requires effort; students who have difficulties in mathematics can discover their ability to make an effort. In discussing different conceptions and definitions of failure and success, students perceive success in a more realistic manner.

3. Some students nourish false beliefs on mathematics and contribute to sustain false beliefs in other students. For example, they may think that "mathematics are like magic". Therefore they cannot perceive problem solving as requiring time, reflection and effort. (Lafortune, 1994)

While thinking about myths concerning mathematics in a community of inquiry, students come to perceive learning mathematics as it is: a task that requires effort, organization, intuition and creativity. While thinking about mathematics, its history and its evolution, students come to understand that mathematics is not magic. Discussions in communities of inquiry lead students to question the infallibility of mathematics teachers. Teachers are no longer perceived as mathematics magicians who spontaneously solve problems without prior reflection. In communities of inquiry, teachers think and search with students. They become models for students and contribute to counter the myth of the "magic of mathematics".

Preconceived ideas about mathematics held by some students cannot be sustained because other students develop critical thinking and reduce the effect of preconceived ideas on their learning of mathematics.

In a study carried out with students of the elementary and the beginning of the high school levels (Lafortune, 1993), three types of myths were identified on which it is possible to intervene with student.

1. Certain myths concern mathematics: "Mathematics are useless"; "doing mathematics amounts to doing calculations"; "geometry is not mathematics"...
2. Other myths concern learning mathematics: "Math brains are dull and nerds"; "those who have difficulties in math can't think logically"...
3. Other myths concern the person who teaches math: "Math teachers are serious people who lack emotions"; "math teachers' lives are focused on math"...

The two first types of myths were more spontaneously expressed by students and for this reason we choose to discuss two myths of the two first types.

"Mathematics are useless"

Mathematics are often presented as very abstract. This often leads students to think that mathematics are useless because they do not notice they use mathematics in daily situations. Yet while solving everyday problems, students use deductive and inferential means of reasoning, i.e. procedures they have learned or practiced in their mathematics classes.

An important source of motivation for students lies in knowing the usefulness of a notion or a process. By limiting the usefulness of mathematics to the acquisition of notions in arithmetic, youngsters are not stimulated to learn and to thoroughly inquire about abstract notions. Without motivation, students who do not want to make any effort or students who fail will say: "Maths are useless, they exist just to annoy us". Teachers who reduce the usefulness of mathematics to doing arithmetic contribute to reinforce the myth that mathematics are useless.

If mathematics and the processes used to work with this subject-matter are integrated to students' daily experiences and to other subject-matters, it becomes easier for students to assimilate what is learned in mathematics. They learn to establish analogies and to use the transfer principle between mathematics and other life situations including other subject-matters. Mathematics no longer appear to students as something isolated in a sealed box but as something meaningful and useful in daily experiences. Beyond arithmetic, mathematics make more sense. Students who recognize the usefulness of mathematics often perceive the mental processes and liabilities they develop in mathematics and transfer them to other subject-matters. Creativity and transfer processes are improved (Lafortune, St-Pierre, 1994).

In order to stimulate philosophical reflection towards the myth "Mathematics are useless", the following questions may serve to begin and sustain a discussion:

- *When is an act useful?*
- *Do we only do useful things in life? Why? - Can we say that mathematics are useful? In which way?*
- *Could we imagine a world without mathematics? What would this world be like?*

"A special talent is needed to succeed in mathematics"

Students who succeed in mathematics generally devote more time and make more efforts than what appearances lead to believe. The efforts they make are usually sustained and backed by good work methods. These students solve problems outside the classroom and have an open mind towards the unexpected. Their relation to mathematics is akin to that of a poet searching for poem verses while walking or to that of a cinematographer to a film scenario she completes while jogging.

Students often explain success in mathematics by the "knack for mathematics" that only gifted students have. Those who believe they have no talent for mathematics often rely on their memory to solve mathematics problems. This strategy may allow for good results at the primary school level, but as students get older they often attribute their difficulties to a lack of talent rather than inadequate work methods.

In order to stimulate philosophical reflection towards the myth "A special talent is needed to succeed in mathematics", the following questions may serve to begin and sustain a discussion:

- *What does "to succeed in mathematics" mean?*
- *Does "success", have the same meaning for everyone? Why?*
- *Does "succeeding in mathematics" have the same meaning for everyone? Why?*

These myths and others are addressed in different ways in the philosophico-mathematical novels we wrote for students of the end of the primary school level and the beginning of the high school level. Once the students have read an episode of the novel and have chosen their questions to be discussed in a community of inquiry, our manual enables teachers to choose discussion plans and mathematical activities they can propose to students. We will now present a way to initiate a community of inquiry on mathematics that could well be used in a higher education setting.

METHODOLOGICAL STAGES OF THE PHILOSOPHICAL APPROACH TO MATHEMATICS

The basic methodological stages to a reflexive experience in a community of inquiry on mathematics are inspired by Lipman and Sharp and the Philosophy for children program. We have added steps proposed by Clark (1994) who has used communities of inquiry for teaching biology at the university level. We have completed the methodology following our experiments in the project we are currently completing with students of the primary school level.

First stage: Reading

In the Philosophy for children program, students begin a thinking process by reading an episode of a philosophical novel designed for youngsters. Clark (1994) has adapted this procedure by proposing to her students to read short papers or abstracts addressing current biological problems (e.g., cloning human embryos) and the questions they raise. At the college level we could use short texts that all college students can understand, such as articles from pedagogical periodicals on mathematics. These short texts of a few pages could refer to the history of mathematics, myths carried through mathematics, teacher reflections on learning mathematics, mathematical notions, recent discoveries, etc.

Second stage: Students' questions

Students gather the questions that arise form their reading of the text. This may be carried out individually or with fellow students. At the college level as in Philosophy for children, these questions would be shared with the class group and students would choose which questions they wish to investigate in a community of inquiry.

Third stage: Individual reflection prior to discussion

As Clark suggests, it is preferable to first let students reflect upon and answer individually the questions they have chosen to discuss. This allows a preparation time for students to develop an opinion and to elaborate arguments that can support their points of view regarding the chosen questions. It also helps students build motivation to participate in the group discussion. We find

Clark's preparation idea interesting and think it could well be applied in math discussion.

Fourth stage: Philosophical community of inquiry on mathematics

The community of inquiry is probably the most innovative aspect of the Lipman and Sharp approach. It is founded in Socratic pedagogy and is caractarized by philosophical dialog. For Lipman and Sharp and for pragmatists, to dialog is not the same as to talk or to converse. To dialog is understood in the Greek dia-logos sense of the term. The community of inquiry dialog becomes a means of "authentic communication" where student are invited to participate at reconstructing together social and personal discourse. In other words, to dialog supposes a search of significant exchanges among peers (and not a search of rhetorical arguments) that values pluralism and intersubjectivity.

Let us note here that pluralism which constitutes the essence of dialog in a philosophical community of inquiry, is not to be confused with any form of relativism. Indeed, the objective of philosophical dialog is the development of autonomous, critical and responsible reflection by younsters in addition to building meaning through questions addressed by younsters. Philosophical dialog helps students verify the validity and relevance of traditions, norms and social values and from a personal point of view, to verify the validity and relevance of prejudices, opinions and beliefs. The objective here becomes personal and social improvement.

Also, it is not any random grouping of persons that constitutes a community of inquiry. A community of inquiry is formed when persons authentically communicate together: persons recognize that intersubjectivity is preferable to subjectivity and the parts are important to the success of the whole (Daniel, 1992). According to the accounts of many teachers who regularly animate communities of inquiry in their classrooms, many qualities such as self-esteem, courage, humility, tolerance and openness to differences are gradually developed through the regular practice of community of inquiry discussions.

To instigate discussions in philosophical communities of inquiry, we propose three kinds of activities (these activities may be carried out in another order than the one proposed here). The first kind which is mostly philosophical, is initiated by philosophical discussion plans. The second one comprises philosophico-mathematical exercises and activities. Certain activities refer mostly to mathematical notions that are part of the curriculum. Others give rise to reflections on myths related to mathematics. Still others refer to affective aspects that influence learning mathematics. The third kind of activities are mathematico-philosophical; they use interdisciplinary relations that can enhance the meaning given to concepts and to representations used in mathematics and in philosophy. We will give an example of contents for each of these three kinds of activities.

First kind of activity: Discussion plan

The following discussion plan may be applied to a community of inquiry seeking to investigate what is, for example, "to take up a challenge" in mathematics such that the students involve themselves in a dialogue. According to Watson (1989, cited by Smith, 1995: 47), "dialogue is essential for the development of mathematical thought, for visualisation of patterns and their interactions. In denying learners opportunities to work towards making mathematical meanings through dialogue we are denying them the opportunity to appropriate those genres of text which incorporate mathematical meanings". Cartwright et al. (1985, cited by Smith, 1995: 48) specify that "the act of participating in discussions forces students to communicate mathematically both veralising their own (often partially formed) ideas, and reconstructing in their own words ideas that other people have proposed. By discussing problems among themselves, students often sort out each others' misunderstandings... By pooling their ideas, the group will often be able to find solutions to problems that no individual member of the group could solve, with the result that each student will participate in solving more problems, and will see a greater variety of approaches to each problem than he could possibly do on his own... It increases their confidence in facing unfamiliar situations".

- *Does "to take up a challenge" mean the same thing as " I challenge you "? What is the meaning of each expression?*
- *Will a student who allows him or herself to take up challenges in mathematics, be more able to take up challenges in sports? Why?*
- *What are the necessary qualities required to take up challenges in sports? What are they in mathematics?*
- *What are the differences and similarities between challenges in sports and challenges in mathematics?*

Second kind of activity: Philosophico-mathematical activity

In pragmatism or in socioconstructivism, experience constitutes the beginning of learning. It motivates students, provokes cognitive conflicts and encourages the construction of a personnal understanding system. In that sense, we propose using exercises of the following type. The objective of the example is to better reflect on the concept of geometrical figure.

When we talk about geometrical figures, our first idea is to refer to geometry and mathematics. We rarely think of an art work. Yet many artists use geometrical figures to produce works of **art.** We will use this premise to present the following exercise.

Each student produces a drawing comprised of geometrical figures. The drawings are hung on a wall. The teacher hangs a white sheet of paper below each drawing. Students walk by each drawing and write on the this sheet what they see in other students' drawings.

Philosophico-mathematical exercises are used to introduce or stimulate the philosophical discussion. So, this part of the exercise can be followed by questions like:

- *What type of geometrical figures have you discovered in others' drawings?*
- *Can we produce a drawing without using geometrical figures? Why?*
- *Can we produce geometrical figures without making a drawing? Explain your answer.*
- *What purposes do geometrical figures serve in a drawing?*

All students can participate in these types of exercises. It is possible that students who succeed well in mathematics will say: "This is not mathematics. We want to do mathematics. This type of discussion is a waste of time". Those who have difficulties in mathematics will tend to be valorized by this type of discussion because their opinions are as good as that of other students.

Philosophical reflection on mathematics represents an intellectual challenge similar to that found in problem solving. It is not always easy to manage a philosophical discussion in a mathematics class because it is often difficult to offset students' preconceptions and ready-made opinions as to what a mathematics class should be. But when we succeed, students realize that mathematics do not boil down to applying formulas, learning theories and theorems, solving problems and searching for the good answer. The theories, the formulas and the answers found can be criticized, discussed and improved on by the community of inquiry and the philosophical dialogue.

Third kind of activity: Mathematico-philosophical activity

To thoroughly investigate a question like "Why do certain persons work hard to succeed and others don't?", we can suggest to students to use a modelization based on cartesian coordonates. Each students is invited to position the percentage of effort (X axis) and success (y axis) related to solving a mathematics problem.

Then a discussion is initiated in order for students to establish relationships between using the same model to represent solving mathematics problems and to represent ideas that are not necessarily mathematical in nature. This discussion may be pursued on topics such as perseverance, self-confidence, the sense of organisation or any other aspect choose by the students as factors contributing to success in mathematics.

Fifth stage: Individual reflection following the philosophical discussion

Clark proposes an additional stage in which she invites students to write down their impressions and commentaries on class discussions to further make their own what they have discovered or developed during the community of inquiry. This allows student to assess, to synthesize and to give priority to various elements investigated during discussions in the communities of inquiry. It is a way to give the students the occasion to construct their own understanding and knowing.

We believe that this stage is a logical consequence of any well conducted community of inquiry. Since part of the objectives of the community of inquiry is to instigate significant questioning by students, to stimulate their curiosity and to motivate them to pursue the search process initiated in class, we recommend that teachers involve all students in completing this last step. By this step, students will be able to "think mathematically" (Daniel et al., 1994): this means that mathematics will become alive in their mind.

It is important to note that philosophical reflection on mathematics in a community of inquiry does not replace traditional mathematics material. It is a complement to help students transfer their mathematical learnings, to favor significative learning and to stimulate the learners' reflection and creativity to the learners.

THE DIFFICULTIES OF THIS INTERDISCIPLINARY APPROACH

The advantages of an interdisciplinary approach to learning are numerous: students can establish relationships and transfer what they have learned from one subject to another; they can better integrate what they learn; they can recognize the usefulness of what they learn. However, it is not always easy to initiate an interdisciplinary approach at the college level. Subject-matters are often partitioned and even with a global approach used actually in Quebec colleges it is difficult to integrate what is learned in one subject-matter to another.

We may also wonder if the training of teachers allows them to conduct communities of inquiry on mathematics at the college level. Generally, teachers have been trained to teach only one subject-matter. Can mathematics teachers bring students to philosophize on mathematics? Can philosophy teachers integrate communities of inquiry on mathematics? We think that mathematics teachers as well as philosophy teachers can use this philosophical approach in their classes. We do not suggest here the integration of philosophy of mathematics in classes of mathematics, but rather the use of an approach that encourages students to philosophize on mathematics. By philosophizing on mathematics, students reflect in a critical and argumentative way on this subject-matter. They search for criteria, justifications, arguments, and criticisms in a systematic way.

With this philosophical approach, our goal is to develop students' critical thinking on mathematics. This goal can be met in a concrete way through two objectives: to develop critical thinking and to demythicize mathematics. Teachers will have a tendancy to aim for one or the other specific objective (and generally not both) according to their subject-matter training or their teaching and learning conceptions. It is probable that mathematics teachers as well as philosophy teachers lack the training to integrate all aspects of this type of community of inquiry in their classes. What we think is important is that each teacher recognize his or her limits, bear an open mind to this new approach and seek training to acquire experience. One way of training for this approach is to experience communities of inquiry on mathematics with philosophy and mathematics teachers. To further the training it could be useful to experience communities of inquiry in classes with students in philosophy and mathematics courses in a team teaching situation (mathematics et philosophy teachers together).

CONTRIBUTIONS OF THIS REFLEXIVE APPROACH TO COLLEGE TEACHING

Where would teaching philosophy in college be now if all students had reflected on different notions in communities of inquiry? To what point would students would have refined their reflection and metareflection liabilities if they had participated in philosophical communities of inquiry?

We believe that teaching philosophy could benefit from a philosophical approach used in different subject-matters at the college level. Students could establish relationships between personal, social and school experiences and on what they learn in different classes. Students could also develop their argumentative habilities by practicing authentic communication in different contexts.

Different disciplines including mathematics, would benefit from the integration of elements of a philosophical approach and from the organisation of communities of inquiry in classes. This would lead students to reflect more critically on notions taught and on their apprenticeships.

IN CONCLUSION

This philosophical approach based on communities of inquiry could be organized and integrated in contexts where college programs and subject-matters would be less partitioned than they are now. We should think about integrating innovative pedagogical approaches where students work at projects or problems they have themselves elaborated and to take inspiration to the "Learning by problems" approach.

Even though there are difficulties related to implanting such approaches, we believe it is possible to start using elements of a philosophical approach for teaching mathematics and thus contribute to the evolution of college teaching.

NOTES:

1. In Quebec, college level corresponds to the twelfth and thirteenth years of schooling and is a bridge between high school and university. Also, at this level, all the students take philosophy courses and a lot of them take math courses.
2. The content of this section is for the most part based on LaFortune, Louise (1994), *Les maths au-deli des mythes,* Montreal: CECM.

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