Philosophy for Children Adapted to Mathematics:

A Study of its Impact on the Evolution of Affective Factors

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In teaching mathematics, great importance is placed on the discipline's content. This focus on content in educational programs often prevents teaching staff from investing time in pupils' attitudes toward mathematics. Furthermore, many teachers have a restricted conception of mathematics; far too often, their mathematical and cultural knowledge is limited. This situation leads them to present mathematics in its algorithmic, technical and procedural dimensions. Pupils end up thinking that doing mathematics means memorizing procedures, putting them into application and finding answers. This teaching context does not sufficiently incite pupils to develop their creativity in mathematics, and scarcely stimulates their critical thinking. This approach can lead some pupils to failures which, when repeated, end up discouraging certain of them, undermining their self-esteem and creating fears or uneasiness toward mathematics. In fact, mathematics is a discipline comprising various languages: natural, symbolic and graphic (De Serres and Groleau, 1997). Thus, complex cognitive skills related to translation, in addition to positive attitudes, are necessary in order to make learning mathematics significant. When teachers obscure these two dimensions, some pupils are more likely to experience uneasiness and academic difficulties, which in turn generate negative beliefs or reinforce biases with regard to mathematics itself, to learning the discipline, and to the people that teach it (Lafortune, 1994). These beliefs and biases lead the pupils to enter the mathematics class with an a priori conviction that it will be boring, to consider their achievement in geometry as being of lesser importance than that in arithmetic, to denigrate pupils who are successful, and to think that success is based on the possession of some special or superior talent which they lack.

In a recent research project[1], we studied the evolution of affective factors among pupils within the framework of learning mathematics as they experimented with a pedagogical approach centered on philosophical/mathematical dialogue among peers. In this text, we will define certain components of the affective dimension, among which are anxiety, the concept of self, and attributional beliefs of control. We shall then present methodological elements relating to the research project. Finally, we shall discuss the results.

ANXIETY TOWARD MATHEMATICS

Anxiety is an affective state characterized by worry, uneasiness and fear. Anxiety contributes to inhibiting people's comprehension of the meaning of the problems posed and their thinking process, which aims at finding pertinent hypotheses for solutions and arriving at an appropriate solution. The problem of anxiety toward mathematics as a whole hinges on the negative repercussions of learning this subject. That is, certain pupils experience so much anxiety toward mathematics that they develop an aversion for the subject; anything that has an implicit or explicit relationship to mathematics generates both uneasiness and fear in them. Many youths expressed this through their drawings of mathematics by representing tears, fire, a demon, etc. (Lafortune, Daniel, Pallascio and Schleifer, 1999; Lafortune, Mongeau and Pallascio, 2000). Other manifestations of anxiety were noted when pupils, while solving mathematical problems, applied formulas without first questioning the meaning and validity of these formulas. Their goal was to find an answer rapidly, regardless of its relevance to the problem. Arriving at an answer is a relief for these pupils (Lafortune, 1995). Although some of the other pupils began reflection to search for meaning in the problem and to understand its particulars, they did not pursue the reflexive process, since the reflexive process involves too much uncertainty (and insecurity). All these pupils, according to Tobias (1987), quit mathematics because they believe that they are unable to do mathematics. In fact, the real explanation lies not in their incapacity to do mathematics, but rather in their incapacity to pursue their reflexive process toward a solution because they are overwhelmed by their past negative experiences and fears of failure.

THE CONCEPT OF SELF IN MATHEMATICS

The concept of self corresponds to the overall perceptions and beliefs the pupils have of themselves. It is the personal representation they have of themselves, as well as the attitudes that ensue. Concept of self in mathematics is manifested in the confidence pupils have in their capacity to succeed in mathematics, and in the manner in which they tackle a mathematical task. It can therefore be positive or negative, realistic or unrealistic.

Lafortune (1995) identified four types of negative reactions in those pupils who lack confidence in their capacity for success in mathematics: renunciation, learning through memorization, problem-solving through automatism, and generalization of failure. Some quickly give up the search for a solution. They are convinced of their inability to solve the problem on their own, and so would prefer to search for outside help. Others learn by memorizing all the concepts and procedures, so that they remain incapable of comprehending their meaning, of explaining them, or of working out connections between them. Other pupils still, inhibited by anxiety, solve mathematical problems mechanically. They complete the entire series of exercises they are assigned, but without questioning their comprehension of the problems' meanings, and without bringing into question the results achieved, even though certain answers may make no sense. Finally, there are pupils who believe that their lack of success in mathematics means that they are not good pupils, and that they cannot be successful in other subjects or in other fields. The negative image of their capacity to succeed in mathematics has repercussions on their school and daily experience as a whole.

ATTRIBUTIONAL BELIEFS OF CONTROL

Blouin (1985, 1987) demonstrated that pupils who do succeed in mathematics do not attribute their failures and successes to the same causes as those who experience difficulties in this subject. The latter group seem more often to believe that success, particularly in mathematics, is not a matter of learning, but is somehow innate; in other words, it is solely a matter of a person's talent. Consequently, as they believe they have no hold or control over their school results, they passively accept them and do nothing to improve them (Weiner, 1979; Lafortune and St-Pierre, 1994, 1996, 1998). They therefore have a feeling of «loss of power» over what goes on in class (Bandura, 1977). This notion of the pupils' power or control over their learning is implicit in various theoretical models. We find it under different appellations: feeling of self-efficiency (Bandura, 1977), learned helplessness (Abramson, Seligman and Teasdale, 1978), controllability of attributional beliefs (Harter, 1982) and beliefs of control (Skinner, Chapman and Baltes, 1988).

Various studies have shown that the social/ cultural context in which the child evolves influences the development of attributional beliefs of control (Bouffard and Bordeleau, 1997). School environment, parental values, feedback transmitted to pupils, teaching styles, types of learning activities, these are some of the many factors that have an impact on the development of pupils' beliefs in themselves and the value they give themselves credit for.

A POSSIBLE SOLUTION: PHILOSOPHY FOR CHILDREN ADAPTED TO MATHEMATICS (P4CM)

Since the 1970s, a number of original methods of intervention have been considered to lead pupils toward a meaningful learning experience in mathematics, particularly by developing their affective dimension. These methods generally aim at enabling the pupils to tame mathematics by expressing their feelings and the emotions they experience in connection to this discipline, either through writing (Brandau, 1992; Brown, 1992; Lafortune, Jacob, Hebert, 2000; Talman, 1992), reading (De Serres and Groleau, 1997; Kogelman and Warren, 1978; Tobias, 1987), or verbal exchange (Brookfield and Preskill, 1999; Christensen, 1994; Christensen, Garvin and Sweet, 1994; Greenwald, 1994; Shapiro and Levine, 1999). Unfortunately, these methods are as yet used but infrequently.

To lead pupils to engage in reflection and dialogue concerning mathematical concepts and ideas, adopted attitudes toward the discipline and conveyed beliefs and biases on the subject, we adapted the *Philosophy for Children* approach developed by Lipman, Sharp and Oscanyan (1980). We postulated that adapting the Philosophy for Children approach to mathematics (Daniel, Lafortune, Pallascio and Sykes, 1996a, 1996b, 1996c) could influence the pupils positively, not only in terms of the cognitive dimension, but also in terms of the affective dimension (Daniel, Lafortune, Pallascio et Sykes, 1994). Our intention was to influence pupils' attitudes toward mathematics in a positive manner.

The presumed advantages of the *Philosophy for Children* approach in dealing with the affective dimension have been the subject of numerous publications (Lane and Jones, 1989; Gazzard, 1990; Glaser, 1992; Guin 1994; Lago, 1996; Phillips, 1996; Schleifer and Poirier, 1996). This work of analysis and reflection

on the effects of *Philosophy for Children* enable us to predict a positive influence on pupils' self-esteem from the use of this approach. We reviewed two experimental or quasi-experimental studies in an attempt to ascertain various aspects or of this favourable presumption (Sasseville, 1994; Schleifer, Lebuis and Caron, 1987). In short, the hypothesis that the *Philosophy for Children* approach corresponds to various criteria enabling a positive influence on pupil self-esteem is principally argued from texts that reflect upon the foundations of the P4C approach. However, few empirical results enable us to confirm that this approach truly exercises the influence described over the pupils. This is what prompted us to conduct a research project (SSHRCC 1997-2000) with youngsters aged 9 to 12, to explore and study the influence of the *Philosophy for Children* approach, as adapted to mathematics, on the evolution of pupils' affective reactions, especially with reference to anxiety, the concept of self, and attributional beliefs of control regarding mathematics.

METHOD OF INQUIRY

The experiment was carried out over most of a school year, from the beginning of October to the middle of May. Data were collected from ten class/groups in grades four, five and six (ages 9 to 12) attending French schools in Quebec. In total, 211 pupils aged 9 to 12, divided almost equally in gender (98 boys and 113 girls) participated in the project. The experimentation with philosophical/ mathematical communities of inquiry was conducted in five class/groups totaling 113 pupils (55 boys and 58 girls), whereas five class/groups totaling 98 pupils (43 boys and 55 girls) were used as control groups.

To better understand children's anxiety toward mathematics, we used a questionnaire designed to measure affective reactions (Fennema and Sherman, 1976), focusing in particular on three sub-sets of these reactions (anxiety, pleasure and involvement.) The global alpha coefficient of internal consistency measured for the questionnaire as a whole is 0.88. For the sub-sets respectively, the coefficients are: 0.84 for the anxiety scale; 0.83 for the pleasure scale; and 0.61 for the involvement scale. This questionnaire was completed by all pupils prior to the experiment, and then again after its conclusion.

We used two measures to obtain quantitative evidence of the development of pupil self-esteem. The first is a measure of «concept of self in relation to mathematics, which is an adaptation of the questionnaire developed by Harter (1982). The second measure is obtained by adapting the questionnaire on attributional beliefs of control used by Bouffard-Bouchard, Bordeleau and Dube (1991) to mathematics. These two instruments are not only well known, but are also widely accepted as valid. The internal consistency coefficients, for the versions of the questionnaires adapted to the context of learning mathematics are, respectively, 0.90 for the instrument measuring «concept of self» in connection to mathematics, and 0.86 for the adaptation of the instrument measuring attributional beliefs of control (Lafortune, Mongeau, Daniel and Pallascio, 2000).

To further explore the quantitative data, we also conducted two interviews (pre- and post-experiment) with pupils representing certain «case-types»: five pupils who particularly liked mathematics, five pupils who hated the subject, and five with mixed reactions. The interviews were coded according to the different components of the affective dimension under study in this research project. Pupil case-types were selected from their own drawings illustrating their perceptions of mathematics, which the pupils were asked to produce at the beginning of the school year. The pupils were also asked to explain the meaning of their drawings in one or two sentences.

RESULTS

We present the results of this research project by examining and discussing those results that refer to anxiety toward mathematics. Following this, we move on to those that relate to concept of self and attributional beliefs of control.

Results Relative to Anxiety Toward Mathematics

The first set of results presented relates to the pupils as a whole. As previously explained, to better understand these results, we refer the reader to the previously stated definition of anxiety toward mathematics. We also specify that the pleasure felt when doing mathematics refers to satisfaction, to the contentment a pupil may feel during the realization of a mathematical task. Involvement refers to investment (time, energy, effort), or to the willingness the pupil manifests when doing mathematics.

In studying the pupils as a group, we note that the level of anxiety measured by our instruments did not vary significantly in any of the groups. Examining the results in the other sub-sets, we note that pupils in the control groups experience far less pleasure when doing mathematics, and also feel less involved in the subject, than those in the experimental groups. Furthermore, the results show that pupils in the experimental groups were more anxious than those in the control groups at the start, and remained so[2] throughout.

In an attempt to better understand these results, we examined the results relating to differences between boys and girls. In analyzing the results by gender, we noted that girls, in both the control and experimental groups, had affective reactions that were significantly more negative at the end of the experiment (anxiety, pleasure and involvement), and that the girls in the experimental groups were significantly more anxious than those in the control groups. However, the girls in the control groups were neither more nor less anxious than the boys.

These results led us to examine data on the 15 pupil case-types (eight girls and seven boys) who participated in two semi-directed one-on-one interviews. We carried out a quantitative evaluation of the pre-experiment and post--experiment interviews in order to highlight: those segments in which pupils said they did not feel stress or anxiety toward mathematics; those in which they expressed a bit of stress toward mathematics; those in which they expressed anxiety toward mathematics but in a lesser degree, and finally; those in which they spontaneously expressed significant anxiety toward mathematics. We also took into account the contents of the interviews, since no segment dealt with this dimension.

Overall, the interview analysis does not allow us to state with certainty that there is a difference, when comparing the beginning to the end of the experimentation, in the interviews as a whole. Nevertheless, we note that there is a difference between boys and girls, since boys scarcely expressed any anxiety toward mathematics. We cannot say that girls expressed more anxiety when comparing the beginning to the end of the experiment, but we did observe that they expressed more anxiety than boys did.

Specifically, following is the result of our qualitative analysis of the interviews, conducted using data analysis software *(Atlas-ti.)* During the interviews, the girls seemed somewhat to feel, and to express, an intrinsic anxiety toward mathematics that was linked to an inner distress, the intensity of which varied according to the individual. For example, one pupil mentioned: I *don't really have any patience. [So], I get mad inside, I tell myself that I can't do this problem, it's not fun, I don't like this.* This distress can influence problem-solving in mathematics by causing a pupil to lose control: *I'm going to lose my self-control, I'm going to become nervous, I won't know what to do, where to start.* This can also be expressed by the search for an answer in order to lessen feelings of unease: I *feel so stressed out that I can't do it, I shake all over and I don't even think of math any more, all I do is try to find the answer, the answer, the answer.* The uneasiness or tension can also come from a teacher observing the pupil who is attempting to solve a problem: *I was trying to think of the question, and I couldn't find the answer, and then, I felt nervous, I was thinking, but I couldn't find the answer. Then, on top of that, the teacher was there, waiting for me, I was even more nervous.*

On the other hand, boys often provide external reasons to explain their embarrassment at solving a problem in front of others. When experiencing difficulties, they seem to express them in the form of frustrations: *of course I was «frus».* This frustration sometimes appears to be due to the reactions others might have: if *the others understand, they're going to say that even a baby could do it, then they're going to say I'm not smart enough to do it, and that's when I feel bad.* The judgment of others seems very important for the boys, since, as they state it: *most of the time pupils laugh when we're wrong.* Some are not very worried by this, underlining the fact that, if they have a long series of problems to be solved in a short period of time, they choose not to solve all the problems, or as one pupil stated it: *skip a few.* Reactions range as far as indifference. For example, when a problem requires too much time, a pupil mentioned: I *think I'm wasting my time; [so] I skip to the next number.* Another added: *I'm not the kind* of *person that stresses because* of *problems. I'm not sensitive. If a problem bothers me, I don't do it.* Finally, some youngsters are only stimulated by rewards. As one pupil stated it: I was *mad at myself, [because] my mother told me that if I passed, we would go to the water slides together.*

Discussion: Anxiety Toward Mathematics

Use of the *«Philosophy for Children* adapted to Mathematics» approach in this experiment implies a weekly one-hour session with the pupils. During the 22 weeks of the experimental period, approximately eight weeks were spent reading one chapter from a novel per week and collecting the pupils' questions. Thus approximately 14 sessions were used for philosophical/mathematical activities or for philosophical communities of inquiry in relation to mathematics. Affective reactions refer to attitudes, not to behaviors. In fact, changes in attitudes require time, especially since at ages 10 to 12, pupils have already, in their five years of attending school, developed attitudes relating to mathematics. In a meta-analysis, Ma and Kishor (1997) have shown that, as pupils progress in school, their attitudes toward mathematics deteriorate and become more negative. We can therefore interpret, and in a positive light, the fact that the pupils in the experimental groups did not experience a decrease in pleasure or involvement when doing mathematics, while pupils in the control groups did. Perhaps the *Philosophy for Children* adapted to Mathematics approach had a stabilizing effect. We can postulate that, if this approach were to be integrated into the overall teaching of mathematics, it could have an influence on the development of positive attitudes with regard to the discipline.

Girls in the experimental groups significantly increased their anxiety with regard to mathematics as compared to girls in the control groups. This observation can be explained by the fact that, unlike conventional mathematics teaching, *Philosophy for Children* adapted to Mathematics can be destabilizing for some pupils, since philosophical discussions within a community of inquiry do not provide clear-cut and definite answers, but rather give rise to cognitive dissonance and questionings. This result could concur with Phillips' (1996) remarks in relation to the *Philosophy for Children* approach, which underline that, even if this approach sets certain conditions for the development of affective components, some pupils may become aware that their viewpoints are not always adopted by others, and thus may develop a certain insecurity. Furthermore, since girls express greater anxiety toward mathematics a priori than boys do, a learning situation which is new and different, and indeed contradictory to that usually advocated, may well breed anxiety in the girls. Nonetheless, we can interpret this result in a positive manner if we consider that the increase in anxiety presupposes that they are challenging their beliefs and biases with regard to mathematics; since from a closed-concept discipline, mathematics becomes an open-concept discipline leading to a diversity of solutions. From this perspective, anxiety represents a step toward better comprehension of meaningful mathematical activity.

In the same vein, Fennema, Carpenter, Jacobs, Megan and Levi (1998) cite the works of Gallagher and DeLisi (1994) indicating that girls tend to use strategies close to those taught at school and which are more concrete or, in other words, closer to the reproduction of examples and to counting; that boys tend to use more original and more abstract strategies, showing better conceptual comprehension. In short, if girls are more likely to use conventional strategies, we might think that the philosophical approach to mathematics disturbs their way of thinking when solving mathematical problems, since this approach suggests a different way to conceive of and tackle mathematics. It attempts to counter beliefs and biases regarding this discipline, which may interfere more with the girls' existing perceptions.

We might also think that boys do not wholly express their feelings toward mathematics. For them, expressing a fear of mathematics may seem to imply that they are inadequate for their gender. On the other hand, girls may tend to express the negative emotions they experienced while developing the means to overcome their tension. Another hypothesis could also be explored, that is, that using the philosophical approach to mathematics enabled the girls to become aware of the anxiety they experience in connection with mathematics.

Combined with the results of this research, certain other experimental research results (Fasko and Skidmore, 1999; Lafortune, Mongeau, Daniel and Pallascio, 2002a; McInerney, McInerney and Marsh, 1997) cause us to question whether the influence of anxiety with regard to learning mathematics is strictly negative. Based on the results of their research, McInerney, McInerney and Marsh suggest that anxiety could facilitate learning in some pupils. Because girls seem to experience greater anxiety than boys in learning mathematics (Fasko and Skidmore, 1999; Lafortune, Mongeau, Daniel and Pallascio, 2002a; Marsh, 1988, quoted by Viau, 1995), and because their results turn out to be very similar, we might well wonder whether this anxiety is as prejudicial as long-standing belief assumes.

The discussions we have presented in relation to our research results, combined with the significant increase in the girls' anxiety levels in the experimental group, lead us to consider a hypothesis related to the definition of anxiety toward mathematics. This anxiety could comprise two facets. It could be an affective state characterized by worry, uneasiness and fear, which can prevent a person from doing mathematics significantly. Emotions that are more or less intense can thus hinder concentration and the achievement of performance equal to one's capacities. However, this affective state can also have a positive dimension; it is then characterized by excitement and the search for a challenge, which can lead to a sense of pride and even to pleasure in doing mathematics.

Results Concerning Concept of Self and Attributional Beliefs of Control

A comparison of the experimental groups' results with those of the control groups indicates that neither shows any variation, in the measure of concept of self, between the pre-test and the post-test interviews. However, the experimental group shows a significant increase in the measure of attributional beliefs of control. Thus, in the experimental group, the perception which pupils have regarding their own abilities in mathematics did not fluctuate in a significant manner. On the other hand, pupils' perceptions of their ability to exercise control over their learning did improve during the year. This result allows us to state that philosophical communities of inquiry on mathematics help pupils feel more in control of their learning. Therefore, the results partially confirm the hypothesis stemming from the literature, according to which participating in a community of inquiry would contribute, in the specific context of learning mathematics, to the development of a positive concept of self with regard to mathematics, and could lead to higher attributional beliefs of control with regard to learning mathematics.

In addition to quantitative data, we collected qualitative data to assist with interpretation. In this paper, we analyze qualitative data relating to attributional beliefs of control in order to better comprehend the reasons for significant and positive changes in comparing the beginning to the end of the experimental period. Fifteen pupils (seven boys and eight girls) were especially studied during their participation in two semi-directed individual interviews (pre- and post-experiment).

In the interview, during one of the first stages, the pupils were asked to speak on what they thought of mathematics, of their good and bad experiences, and of what they considered to be easy or difficult. During a second stage, the pupils were placed in a mathematical problem-solving situation. After having solved the problems, they were asked to speak about the affective reactions experienced during this period. No direct questions were asked of the pupils regarding their degree of self-confidence or the control they think they have over their learning.

The pupils' remarks concerning the necessity to make an effort, study, work, concentrate, listen and pay attention were very similar when we compare the beginning and the end of the experiment period. Furthermore, a number of pupils spontaneously spoke of this aspect (11 pupils out of 15) without the question specifically being asked.

At the beginning of the experimental period, certain pupils (E9-El 1-E12-E13[3]) pointed out some specific strategies which they use, and over which they have some control. These strategies were limited to reading and re-reading the statement of a problem, and to highlighting the relevant elements. At the end of the experimental period, certain pupils (E4-E5-E8-E11-E13-E15) expressed their opinions with regard to specific strategies. These strategies were more elaborate and personal. For example, a pupil underlined: *when I do math, I can't be [disturbed], because I have to be concentrated. It's as if everything closed up and then, I don't hear anything around me.* This pupil added: i]'I *really can't, I stop, [..] I start revising. If I still can't find it, I go and eat, then sometimes while I'm eating, I've got it. [...] when I'm hungry, I can't concentrate any more [...] when I eat, it's as if I can concentrate [more].* Having personal and specific strategies places the pupils in a better position to control their learning.

Some pupils indicated that it is necessary to *practice* in order to succeed in mathematics. Many (E3-E6-E7-E8-E9-E10-E13) underlined this at the beginning of the experimental period, whereas very few (E12-E15) spoke of it at the end. Most often, when speaking of practicing mathematics, one refers to mechanical work where one attempts to do exercises or solve problems by applying oneself to reproducing a model. We find it interesting that this idea was not as prevalent at the end of the experimentation. Even if pupils can have some control over the practice or the exercise, it is not necessarily valued from a constructivist perspective, or in the development of critical thinking and pupil autonomy.

At the beginning of the experimental period, a single pupil (E7) suggested, as a means to better solving problems, exercising control over speed, *taking more time to understand the questions better.* At the end, a greater number of pupils underlined this tactic (E3-E8-E11-E14). One pupil specified that it is preferable to make an effort rather than trying to go *fast, fast;* another indicated that he should *go slower,* and that now *[he] takes five minutes to read [the problem].* Studies show that, except during exam periods when time can be limited, pupils are usually granted more time than they think they have. In other words, time is a factor over which they can exercise a certain control, although many pupils believe that after a single reading of a problem, they must immediately begin to solve it, or that the solution must spontaneously appear (see Lafortune, 1993, 1994). If the *Philosophy for Children* adapted to mathematics approach has for some pupils contributed toward teaching them to take some time to read the problem and to search for a relevant solution, then by this simple fact it has contributed to giving them power over their problem-solving process, and to giving them the impression that they have some control over their learning of mathematics. In other words, this approach can have an influence over the attributional beliefs of the children.

Finally, some pupil statements appeared only at the end of the experimental period. Some (E2-E3-E12-El3) mentioned that it is necessary to become involved in the mathematical activity in order to ensure success. For example, one pupil underlined: I *thought to myself, [..] I'm going to have to make an effort, [...I'll have] to rack my brains to try and find [the solution].* Another referred to tiredness to explain her difficulties and lack of concentration: *I was very, very tired, I wasn't feeling good, I was less concentrated in school, (...] I was thinking of all my problems, I was very nervous, I wasn't in the world of mathematics, I was completely outside.* It should be noted that this pupil, instead of simply stating that she isn't good at mathematics, was able to properly identify the source of her difficulties. This contributes to enhancing one's comprehension of self, and to thinking that difficulties can be dispelled. Perseverance represents another factor that was non-explicit at the beginning of the experimentation, and that manifested itself during the final interview. Some pupils (ES-E7-E10-E12) specified that you *mustn't give up.* One pupil

spoke of patience: you *always have to be patient (and...] wait at least five minutes to be able [to solve a problem].* It appears to us that these remarks are important, in that they show the pupils' evolution with regard to the control they can have over the means at their disposal.

Discussion: The Concept of Self and Attributional Beliefs of Control

Contrary to the ideas forwarded by many, particularly Glaser (1992), participating in a community of inquiry does not appear to enable the pupils to develop an improved self-image. According to Phillips (1996), the *Philosophy for Children* approach could even work against the development of self-esteem, if one does not take into account the fact that there may be certain contradictions between promoting the development of self-esteem and promoting intellectual skills such as rigour and intellectual honesty. Thus, according to this author, school would most often favour the «success theory», which is to say that pupils will have a positive self-image insofar as their ideas match those of the majority, and are approved by their teacher and peers. However, Phillips (1996) specifies that if pupils are placed in a school context where the focus is on the development of complex thinking skills, they are necessarily confronted with situations in which their ideas are contradicted, their justifications are challenged, their arguments are undone, etc. To ensure positive development of pupil self-esteem, pupils must therefore consciously link success to surpassing oneself in a co-operative context, rather than surpassing others in a competitive verbal sparring match (Daniel, Lafortune, Pallascio, Schleifer, 1999). From the moment pupils become aware that ideas can evolve and be enriched by peer criticism (Daniel, Lafortune, Pallascio, Schleifer, 2000), they know they can exert a certain control over their ideas: that they can make them more meaningful by basing them on more solid justifications, more reliable criteria, etc.

We can therefore postulate that the *Philosophy for Children* approach adapted to mathematics, insofar as it can influence pupils' attributional beliefs of control, could contribute to stimulating their feelings of competence toward the realization of a task, and thus to developing a more positive concept of self. In order to verify this postulate, it would be necessary to pursue the application of this approach, either for a longer period of time (more than one school year), or with increased frequency (more than one hour per week.)

The research showed that the change between the beginning and the end of the experimental period resides primarily in the feelings of control the pupils developed. Lane and Jones (1989), Gazzard (1990) and Lago (1996) consider that the effectiveness of the approach resides in the development of reasoning skills and in the encouragement of autonomy and self-correction. Development of reasoning skills was confirmed, in particular, by the Lipman and Shipman (1979) study. Indeed, they demonstrated that this approach significantly improved capacities for formal reasoning and creativity, which is to say the capacity to conceive of new ideas, to discover realistic alternatives and to provide reasons. One might think that, if pupils are able to justify their opinions and find reasons for their actions, they will feel they have not only more control over the result of their actions, but also over the choice of their strategies, since they will truly have the impression that they based themselves on valid and organized reasoning. The qualitative results of the interviews point in this direction. At the end of the experiment, pupils provided more strategies, and more elaborate strategies, to explain their success in mathematics.

Moreover, in the absence of a direct impact of the *Philosophy for Children* approach on the pupils' concept of self, and notwithstanding the fact that this approach helps the pupils to connect the various elements presented to them, it appears that it would be preferable, as mentioned by Lane and Jones (1989), to add to the philosophical discussions interventions which are more specifically aimed at the improvement of self- esteem. For instance, adding a counseling approach that is non-evaluative and does not judge the pupils, encourages pupils to speak of their experiences, their behaviors and their emotions in mathematical settings, and encourages them, guides them and answers their queries with an open-minded attitude. Indeed, as the *Philosophy for Children* approach encourages pupils to speak of concepts rather than personal emotions, some may find it difficult to transfer the means suggested to their personal situation.

CONCLUSION

Many young people experience difficulties in mathematics, and some of these are due to negative affective reactions in connection with the discipline. In this research paper, we have attempted to understand how pupils' anxieties toward mathematics, concepts of self and attributional beliefs of control operate when the pupils experiment with a pedagogical approach centered around philosophical/mathematical discussions among peers.

Various factors could explain the development of anxiety toward mathematics. For example, different negative experiences can give rise to anxiety among pupils, and lead them to either indifference or disinterest, to feel obliged to do mathematics, or even to develop an aversion for the discipline.

In order to diminish the influence of negative affective reactions toward mathematics, there are intervention possibilities that could be considered, among which is the *Philosophy for Children* approach adapted to mathematics, which we experimented with among pupils aged 9 to 12 through almost an entire school year. Quantitative and qualitative results indicate that this philosophical approach helps pupils avoid developing more negative attitudes toward mathematics, and has a stabilizing effect on them. Furthermore, girls in the experimental groups developed significantly more anxiety toward mathematics than girls in the control groups did, and the results of the interviews of the case-type pupils show that girls feel and express more anxiety toward mathematics than boys do. Since the *Philosophy for Children* approach adapted to mathematics aims at having the pupils confront their beliefs and biases toward mathematics, one could assume that the girls may have been more disturbed. To help the girls alter their biases toward mathematics in a positive manner, and thus to transform their anxiety into excitement or pleasure at doing mathematics, certain psychological/pedagogical interventions could be associated with this philosophical approach. Thus, with additional tools, teachers could better contribute to the development of pupils' self-esteem.

Other quantitative results show a significant difference in the evolution of pupils' attributional beliefs of control at the end of the school year. After the experiment, pupils felt that they had

better control over their learning, attached greater value to the means available, and had better access to these means. An analysis of qualitative data relating to attributional beliefs enables us to understand this result, since the pupils better described their strategies, attached less importance to using mechanical exercises, were aware of the need for better concentration and for reducing problem-solving speed (speed lost some importance); they better understood the need to be involved in the mathematical activity.

These overall results could lead to a study on the influence of this philosophical approach to mathematics on the content of communities of inquiry concerning mathematics. This content could be studied with respect to the expression of attitudes and beliefs toward mathematics.

NOTES

1. The research project in question was subsidized by the Social Sciences and Humanities Research Council of Canada.

2. For a breakdown of the quantitative results, and for the statistical tables that indicate the thresholds of significance between the control and the experimental groups, between the pre-test and the post-test results, as well as for the comparisons between the control and experimental groups, please consult: Lafortune, Mongeau, Daniel, Pallascio (2002a). Anxiete a l'egard ties mathematiques : ties explications et la mise a l'essai d'une approche philosophique, and Lafortune, Mongeau, Daniel, Pallascio. *(20026).* Philosopher sur les mathematiques : Evolution du concept de soi et ties croyances attributionnelles de controle.

3. The numbers between brackets refer to the specific pupils interviewed. We feel that it is important to specify these codes so as to give an idea of the number of pupils we speak of, and the range of pupils that underlined one or another of the aspects we highlight.

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