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Abstract

This experimental study aims to determine if teaching mathematics while respecting the four stages of the experiential learning cycle (Kolb, 1984) has an effect on grade 7 students' learning of probabilities. More precisely, it is the result of an experimental design pretest/post-test with a control group to better understand the implementation of experiential learning as a pedagogical vision. Two classes of students were split (randomized) into two equal groups, one that received usual didactic instruction and one that received instruction based on the principles of experiential learning. The results of this study seem to indicate that instruction based on the four stages of experiential learning doesn't influence the correctness of students' answers as much as the justifications or the examples that students give to support their reasoning. During the session, the study will be presented and participants will be invited to discuss how experiential learning can be integrated into the classroom. A discussion will also aim to develop a better understanding of the results.

Keywords: experiential learning, mathematics education, probabilities

Conceptual Perspective

While the debate on the performance of Canadian students in international studies in mathematics such as the Program for International Student Assessment (PISA) (OECD, 2003) intensifies in the public eye, sometimes taking the form of an alarm (Alphonso, 2013), researches are slow to help teachers and students find new ways to make sense of mathematics. Various aspects can cause difficulties to students when they try to solve mathematics problems: understanding and interpreting a problem because of language issues (Bélanger, Piché, Riopel, Staub and de Grandpré, 2003; Goulet and Voyer, 2014), choosing a strategy and designing an appropriate mathematical model and using these models, especially when the issue is complex and involves several steps. Students also have difficulty to give true meaning to mathematical content and they lack the ability to make links between the mathematical content and everyday life contexts (Freiman and Savard, 2014). Finally, the motivational, metacognitive and even didactic factors add complexity to the task of teachers wishing to help their students (Freiman and Savard, 2014; Gauthier, 2014). Faced with this complexity and diversity of factors affecting the students' performance, teachers often find themselves short of educational tools to better support their students (Savard et al, 2013).

We decided to turn our attention to experiential learning, a concept firstly developed by Dewey (1897, 1985 and 1997), to see how it could help teachers and students learn mathematics. Dewey, who devoted his research to the notions of inquiry, experience, growth and continuity, greatly influenced Kolb (1984) who later developed the Experiential Learning Theory (ELT) in which he presents the four stages of the experiential learning cycle: 1) Concrete experience; 2) Reflective observation; 3) Abstract conceptualization and 4) Active experimental. For Kolb, each one of these stages is necessary in order for real learning to take place.

For the purpose of this study, we decided to work with the school *La Mosaïque du Nord*, situated in Balmoral, a small village in New Brunswick (Canada). That school has given itself the mission to "renew the teaching-learning process by creating experiences that foster creativity, authenticity of tasks and the construction of meaning" (free translation, Paradis et Lavoie, 2011 p. 4). Moreover, the school has identifies four principles to guide them:

1) Renew the teaching-learning process through innovation
2) Establish "learning cycles"
3) Open learning to the global community
4) Create partnerships with the community

Manifestly, experiential learning is an approach which permits us to join several elements contained in the mission of the school and its four principles.

Conceptual Framework

Experiential Learning

At the turn of the 19th century, Dewey (1897, 1985 and 1997) built his whole pedagogical model from the scientific method. Four key concepts are at the foundation of his pedagogical ideas: inquiry, experience, growth and continuity. These concepts where influenced by the work of the philosopher Hegel whom Dewey studied in his Ph. D. Dewey had a major influence from the American pragmatism movement in philosophy along with C. Pierce, W. James and G. Mead (Westbrook, 1991). Lastly, the findings of the biologist Darwin had a big effect on his ideas of education. All of these influences made him consider that the education that we provide to children has to stop being abstract and detached of the organic way that nature gives itself to the human experience. For the student, as Dewey (1991) puts it: "not till he has grasped the larger scene will many of even the commonest features of his environment become intelligible" (p. 115). The consequences of this is that schools have to be transformed in a way of a laboratory where concrete things, as well as abstract concepts and ideas, are analyzed and synthetized. With his approach, pupils inquire, make theories that will be tested with experiences they create themselves with the help of their teachers. New theories will emerge, forming continuous growth of knowledge and a profound comprehension of the experience he (the student) is engaged in.

> The power to learn from experience means the formation of habits. […] Habits take the form both of habituation, or a general and persistent balance of organic activities with the surroundings, and of active capacities to readjust activity to meet new conditions. The former furnishes the background of growht; the latter contitute growing. Active habits involve thought, invention, and initiative in applying capacities to new aims. They are opposed to routine which marks an arrest of growth (Dewey, 1985, p. 57).

Based on the work of Dewey, Kolb (1984) developed the Experiential Learning Theory (ELT). Experiential learning, as we know it now, is a process by which learners interact with their social and physical environments through different activities to construct their knowledge. In this approach, local issues of the learners' community become great grounds for educational activities. Kolb describes four stages of the experiential learning cycle: 1) Concrete experience; 2) Reflective observation; 3) Abstract conceptualization and 4) Active experimental. The first stage, concrete experience, requires the learner to be actively involved in a task. In the second stage, reflective observation, the learner takes a step back from the task (the concrete experience) in order to analyze what has been done and experienced. At this stage, the presence of others is particularly important, because questions are being asked and therefore answered, and meaning is found in these answers. The third stage, abstract conceptualisation, enables learners to make connections between what they know and the experience they have just lived. Consequently, relationships are made between what we could call the old and the new knowledge. Finally, in the fourth stage, active experimentation, the learner takes what he has just learned and puts it into practice. Hence, he finds himself in the position of a scientist, where he needs to make predictions and see what he could do differently in a similar situation in order to get better results. Although these four stages are crucial for learning to take place, it is important to note that for Kolb, learning can’t be truly meaningful if the learning context is not relevant to the learner.

Methods and Data Sources

In 2014, we conducted a case study (Creswell, 2007) to answer two research questions: 1) How do the management, teachers, parents and students in the school *La Mosaïque du Nord* see experiential learning? and 2) How do teachers exploit the experiential learning cycle of Kolb (1984) in their classroom? After a series of interviews with teachers, students, parents and members of the administration, and subsequent thematic analysis of the data, we found that the first stage of the experiential learning cycle of Kolb (1984) is respected in lesson plans, but teachers are struggling to go beyond this first step in their educational approaches. Therefore, at the end of this case study, we made some recommendations in connection with our results and the work of Dewey (1897, 1985 and 1997) and Kolb on experiential learning, including making more room for reflective observation and active experimentation in the lesson plans in order to further promote learning which respects the four stages of the cycle of experiential learning by Kolb.

In the second phase of our study, we studied the effect of instruction based on the four stages of the experiential learning cycle of Kolb (1984) on the learning of mathematics. More precisely, we aimed to answer two questions: 1) Are students that have experienced a teaching/learning scenario based on experiential learning more apt to transfer their knowledge in new situations over those who have experienced traditional didactic instruction?, and 2) What is the difference between the answers given by students to support their reasoning after having experienced a teaching/learning scenario based on experiential learning or based on traditional didactic instruction?

In order to answer these questions, we compared the degree of learning for a given concept in mathematics between two groups of 7th grade students. More precisely, two combined classes with a total of 34 students were divided (randomized) into two equal groups. Two teaching/learning scenarios on probabilities were developed: one based on traditional didactic instruction and one based on experiential learning. Several differences could be observed in the two scenarios. These differences are highlighted in table 1.

Table 1
Differences between the scenario based on traditional didactic instruction and the scenario based on experiential learning.

DIDACTIC INSTRUCTION	**EXPERIENTIAL LEARNING**
Explicit teaching of concepts followed by students **putting these concepts into practice**	Activities where students **discover** the concepts
Activities done **on paper**	Activities done **with material** (ex: post-its on the wall, clothesline and clothespins)
Experimentation of their games and of the games of their peers Compilation of the results	Experimentation of their games and of the games of their peers, and **comparison of the results** obtained
that their peers obtained at their **(all at once)**game	Compilation of the results that their peers obtained at their game **(one team at a time)**
Changes to the original game and writing of a text to present the game	**Creation of a new game**, writing of a text to present the game, and **presentation of the game to a wider audience** (parents, students from other grades, etc.)

The control group received the traditional didactic instruction, whereas the experimental group received the instruction based on the experiential learning cycle (Kolb, 1984). Before and after delivery (by the same teacher) of the two types of instruction, the students in each group did a pretest and a post-test (the latter different from the pretest) each composed of 5 questions related to probabilities. Two of these questions were true or false questions where students had to explain their answer. In two other questions, a game was described and students had to make suggestions in order for the player to have more chances of winning than losing (or the opposite). One of the questions that students had to answer in the pretest is presented in Figure 1, whereas one of the question of the post-test is presented in Figure 2. Finally, we asked the students what they would say to a person who would tell them a statement that, from a mathematical point of view, does not hold. The statement was given to the students, but it was not specified that this statement was incorrect.

> Mikaela is playing the game described below. How could you change that game in order for Mikaela to have an advantage (to have more chances of winning than of losing)?
>
> Warning! She can't win every time she plays!
>
> Game:
> A deck of cards is presented to Mikaela and she has to draw a card from it. If she draws a red card, she wins. If she draws a black card, she loses.
>
> What is your first suggestion so that Mikaela has more chances to win that to lose?
>
> What is your second suggestion (different from the first one) so that Mikaela has more chances to win that to lose?

Figure 1. Pretest question in which the game must be changed in order for the player to have more chances of winning than of losing.

> Peneloppe is playing the game described below. How could you change that game in order for Peneloppe to have an advantage (to have more chances of winning than losing)?
>
> Warning! She can't win every time she plays!
>
> Game:
> Peneloppe must draw a number from 1 to 10. If she picks a multiple of 3 (3, 6 or 9), she wins. If she picks any other number, she loses.
>
> What is your first suggestion so that Peneloppe has more chances to win that to lose?

What is your second suggestion (different from the first one) so that Peneloppe has more chances to win that to lose?

Figure 2. Post-test question in which the game must be changed in order for the player to have more chances of winning than of losing.

The pre and post-intervention achievement tests measured the degree of learning in the experimental group and in the control group. In order for us to be able to compare the learning between students from both groups, a frequency analysis was done to identify the number of students who had answered each question correctly. Subsequently, a thematic analysis of content was done by two analysts. Each of them independently established codes to represent emerging ideas in students answers. The results were then compared to insure inter-rater reliability.

Results

Knowledge transfer in new contexts

There was no real difference between the pretest and the post-test for the experimental group and the control group. Indeed, both groups performed similarly on both tests; for each questions, the number of students who answered true or false correctly and who provided a correct explanation for their reasoning was almost the same for the two groups, both in the pretest and the post-test. The same thing can be said for the question where the students had to react to a statement that did not hold from a mathematical point of view. It would be interesting to repeat the experiment with various scenarios and with more students to see if any changes would be observed.

Differences between the answers given by students to support their reasoning

Whereas no real difference was seen with the number of right answers given by students from both groups, a difference emerged in the types of justifications given by them, particularly when they had to change the odds of winning or losing a game. Indeed, in the pretest, when students were asked to make a suggestion on how to change a game in order for a player to have more chances of winning than losing (or the opposite) (Figure 1), most students in the experimental group (16) and in the control group (14) that answered correctly suggested to modify the number of cards in the deck by adding red cards or taking away black cards. Hence, they were not changing what you had to do to win (i.e. draw a red card), but rather, they were changing the starting set used in the game (the number of cards of one or both colors). In fact, only one student in each group that answered the question correctly didn't give that type of explanation. Instead, these two students suggested to change what you had to do to win the game. Five students in the control group proposed to cheat ("You could put 12 red cards and she could know the location of these cards, but she would not always take the good cards"). The other students either presented an incorrect answer or made a recommendation which was not clear and didn't permit us to conclude if they had understood or not ("You could take a couple of cards to have more chances").

In the post-test, when the students were presented the question where they had to make a suggestion in order for the player to have more chances of winning than loosing (or the opposite) (Figure 2), we observed a difference between the students from the control group and the students from the experimental group that answered correctly. Indeed, whereas in the pretest most of the students from both groups suggested to change the starting set, in the post-test, twelve students from the experimental group opted to completely change the wining event ("You tell him that he must not draw an ace of spades and he wins if he doesn't draw it") or they added a condition to the winning event to change the odds of winning or losing of the player (for example, instead of winning if multiples of 3 were drawn, students suggested that the player would win if multiples of 3 OR even numbers were drawn). Only four students from the control group made such suggestions. Instead, thirteen of them opted to change the starting set (for example, add multiples of 3 in the set), and therefore used the same type of reasoning than in the pretest. In the experimental group, only five students suggested to change the starting set.

It thus seems that between the pretest and the post-test, reasoning used by the students of the experimental group to change a game was modified. Indeed, they went from changing the starting set (the material used to play) to changing the winning event (the game itself). Could that switch in reasoning be explained by the fact that the students from the experimental group experienced a teaching/learning scenario based on experiential learning? It could be possible that the fact that the students actually got to create a new game in the classroom influenced them. Therefore, they felt they had the “right” to change the initial games presented to them in the post-test, whereas the students from the control group tried to keep the initial game the same and modify subelements of it instead. Essentially, an analogy could be made with the difference between the author and the actor of a play (Lang, 2010). The critical thinker who adopts the perspective of the author understands more deeply the intention since he’s the one creating. He gives himself the right to edit his work as needed, depending on the context. The critical thinker who adopts the perspective of the actor, on the other hand, is trying to understand the meaning, but it is forbidden to modify the text lest it makes sense (which, actually, he ignores) that others wanted to give to the play. In our case, the students from the experimental group adopted the perspective of the author, whereas the students from the control group adopted the perspective of the actor. Although very preliminary, these results are interesting from a pedagogical and didactical standpoint.

Conclusion

Our review of the literature on the topic of experiential learning has revealed that very few scientific studies have examined the effects of this educational vision on learning. In addition, some research, which have addressed the topic, have done their exploration in a postsecondary setting. Therefore, our study is one of the few contributions that provide a look into the effectiveness of experiential education in relation to learning at the primary level (grade 7).

In this research, we aimed to study the way that experiential learning can affect: 1) the ability for students to transfer their knowledge to new situations and, 2) the types of reasoning students use when they are asked questions pertaining to probabilities. Despite the fact that there was no difference between the control group and the experimental group in relation to their ability to transfer their knowledge (both groups had a similar rate of correct and incorrect answers on the pretest and the post-test), we did observe interesting responses from students associated to the types of reasoning they use when they're asked to modify a game in order for the player to have better odds of winning or losing. In reality, the type of reasoning adopted by the majority of the students from the control group didn't change between both tests: they made adjustments to the starting set. Most of the students from the experimental group, for their part, made the transition from one type of reasoning to another: they went from changing the starting set (a subelement of the game) to changing the winning event of the game. It seems that having the chance to create their own game in the classroom (during the teaching/learning scenario) influenced them when they answered the post-test, in the sense that they felt they had the "right" to change the initial game presented to them. Hence, the students form the experimental group went from adopting the perspective of the actor to adopting the perspective of the author. If experiential learning leads students to develop such a way of thinking, we could say that they are not only understanding the mathematical concepts in play, but also developing their critical thinking and creativity.

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