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2.5. THE REFLECTIONS OF THE TEACHER-RESEARCHER UPON THE CREATIVITY PRINCIPLE

SUMMARY

In this unusual piece of her Teaching-Research diary, Prabhu presents a dual approach to the Creativity Principle, when she explores the creativity of herself as a teacher-researcher working on the facilitation of creativity in her classrooms. She shows through self-reflection the very process through which the creativity principle transforms the habitual teaching practices into teaching-research. She presents her main findings in that process, the concept map of the course, the narrative and the discovery method of teaching. The development of the concept map for the course, which with time acquires the general quality through the dialectical relationship between herself as learner from students, and as their teacher, becomes for her the backbone through which the meaning of mathematics is conveyed. She emphasized the narrative as the medium through which she has appropriated Koestler's triptych for mathematics as the tool with the help of which students are searching for meaning between different concepts. Finally, she describes the process through which the creativity principle enters the discovery-based method of teaching. Discovery based method signifies the classroom instruction proceeding through student inquiry into nature of mathematical concepts, which may lead to discovery of new connections between them.

The teaching-research cycle generates the creativity principle by its repeated iterations. This means that in the iterations, the teacher-researchers, while trying to match diagnosed learning needs with appropriate instructional solutions, have the opportunity to "escape more or less automatized routines of thinking and behaving" (Koestler, 1964), and to begin connecting a "previously unconnected matrix of experiences" allowing "reality to be experienced on several frames at once". Practical examples of how this transformation from habit to originality begins for me, as a teacher-researcher, is in the scrutiny that I must place on the prescribed syllabus I am expected to teach. It has been habitual to teach it the way it has been prescribed. However, when I put the table of contents of the textbook into a concept map, I begin seeing that my own mathematical knowledge begins guiding me to make rearrangements, so that the organization of topics can flow from one to another based on mathematical sense. Making sense of what is taught and making it meaningful is very important in my approach, because I have clearly recognized, as many have before me, that learning is slow at first but catches on and

B. Czarnocha et al. (Eds.), The Creative Enterprise of Mathematics Teaching Research, 127–131.

changes its momentum very quickly; for example, a similar observation is described by Mahavier (1999). In previous reports I described actual instances of students making sense, extrapolating meaning and discovering concepts through inquiry via activities and guided exercises that I facilitated.

The creativity principle aimed at a transformation of the habitual teaching practices of the teacher-researcher plays an essential role. Detailed illustrations of manifestations of the creativity principle are described below.

1. The creativity principle is tangible in the ways in which the materials used in the classroom begin to change; first, the concept map evolves from its original prescribed form (the official syllabus) into a natural progression of beautiful mathematics starting from just 1, and 0, and flowing as seamlessly as possible through the entire list of topics given in the syllabus. For me, the development process of the concept map is directly equivalent to the teaching process itself because one of the main factors in its evolution is the collection of questions asked by the students as well as their expressions of difficulty of certain topics. For example, many students have a difficult time with multiplication tables. To address this challenge, the instructional sequences entitled *Story of Number*, for an arithmetic course, and *Story of Number in Abstract*, for an algebra course, contain the *Prime Number Pyramid* component, a creative tool that aims to enable students to construct multiplication tables on their own.
2. The creativity principle is implicit in teaching; more precisely, the teaching process necessitates learning from students. This occurs by paying careful attention to what students say. For example, when a memorized fact is heard from a student, I ask the student "Why is it so?", and determine whether the student understands the meaning of the idea and how to support it, or is just repeating a memorized claim. This allows me to address the issue on the spot, and, sometimes, to design materials that demonstrate the meaning of the concept in question. *The Fraction Grid* is a good example of a teaching tool, built as a result of such an interaction, to address students' expressed difficulties comprehending sizes of fractions. Shifting focus from traditional one-sided teaching to the bidirectional integration of teaching and learning, the students and I begin developing mutual trust that allows and encourages students to freely express their thoughts; the classroom becomes a safe space where a "thinking partnership" is not just a phrase but is the expected form of classroom discourse.
3. Narrative becomes a useful, interesting and meaning-producing tool in the integrated teaching-learning process. Bruner, in *The Culture of Education* (1996), states that it is through narrative method that one both organizes and constitutes one's experience of the world. In describing narrative as a discourse, Bruner states, "Narrative is discourse and the primary reason for it is that there is a reason for it that distinguishes it from silence" (p. 121). The learner is drawn into a narrative communicating her or his understanding precisely at its current stage allowing further development through continuing discourse. "By using

narrative…as our organizing principle we show new learners…how to make claim of mathematical territories by populating the landscape with fictional things engaged in purposeful activity" (p. 123). Narrative became an aspect of my teaching simply by choosing to name the inquiry-based instructional sequence I was developing *Story of Number*. Shortly after, the concept map, developed through the evolution of the syllabus, was a "story" itself, conveying the natural relation of the mathematical concepts in the teaching sequence to the methods of instruction. However, there still remained the important matter of linking the narrative process to a continuing quest into a deeper learning on the part of the student. This was going to be accomplished by requesting students to write a short one page essay called *Making Sense of Fraction*, after the discussion of fractions was almost completed. This somewhat narrow written exposition led to the end-of-semester essay in which students wrote about how they make sense of numbers, in general, reflecting on how it was taught over the duration of the course, providing specific examples of how they made sense of numbers in daily life. This essay was entitled, *Making Sense of Number*. Between 2010 and 2012, when I co-instructed the course with the college's Vice-President for Student Development and Academic Librarian who has been on the teaching-research team for a long time, regularly observing the evolution of teaching strategies in real-time, our joint insight into the methodology, as teacher-researchers, led to an even broader and deeper learning experience. We found that student engagement was high eliminating any classroom affect concerns allowing me to expand the concepts taught in a typical arithmetic course to a significantly more advanced level. During the same time we found a theoretical match for our classroom discovery,—Arthur Koestler's Act of Creation. This connection suggested another novel way of bringing the creative principle into classroom teaching. Koestler posits that *Humour*, *Discovery* and *Art* are three shades of *Creativity*. Setting the goal of Discovery as the central concept, we began to use Koestler's triptychs to create another gateway into our students' thinking and meaning absorption. Using Koestler's approach of incorporating narrative into the classroom, we created our own triptychs for the purposes of enhancing the teaching-learning process in a way that allows students to take small chunks of course material and examine them deeply, making sense out of them. Students were then asked to write a few sentences about how they perceive the connections between the concepts, allowing me to analyse their understanding. Then the current triptychs were viewed by the whole class along with triptychs created by students from previous semesters providing the current students with an opportunity to rethink their own triptychs. This time the reflection was based on a library of triptychs created by over 60 students allowing the current students to recreate the stories of their own learning of the concepts. Students have continuously found this exercise very interesting and expressed interest in using triptychs in other classes such as anatomy. They claimed that it gave them greater confidence, or, that it made the concepts and

their interconnectedness clearer. Our version of a triptych consists of a central column holding the relevant mathematical concept, corresponding to Koestler's placement of the "discovery" aspect. The left column contains the related instances of "humour" described by Koestler as "the back entry into the inner workshop of originality", and the right column is the contextual interpretation of the "art" aspect of the creativity principle, For Koestler, "art" is the sublimation of "discovery". In the beginning the students are provided with a triptych in with, for example, eight central topics of the course in the "discovery" column. Together, as a class, we complete two of these rows, with the entries in the "humour" and "art" columns supplied by me. However, through class discussion I can assess their grasp of how all three concepts work together within the triptych. Furthermore, having the students write a couple of sentences, using examples, describing their view of the connections, supports the discussion. The association of "simple words" is now taken to a new level illuminating the interconnectedness within a particular triple; the words have meaning linking them pairwise to each other, in addition to the presence of a single thread of meaning underlying all three. Based on the class discussion the connections are already somewhat clearer to the students, so, to contribute a few meaningful written statements, they need to inquire even further into the triptych. In this way, the environment for inquiry and for the facilitation of *bisociation* is created. *Bisociation* is the term coined by Koestler to distinguish it from association, where bisociation is the flash, or a creative leap, of insight that connects previously unrelated frames of reference allowing reality to be experienced on several frames at once. The stage for bisociation is set through the triptychs.

The application of the creativity principle in the classroom is now a useful and usable tool for both the teacher–researcher and the learners. The resulting learning process is a search for meaning and inquiry with the intent of discovery, and provides all of the new instruction aspects that transform the classroom.

A VIABLE TEACHING METHOD

To demonstrate the viability of our respective teaching approaches we must answer the following questions:

1. What are the principles of design?
2. Where do they come from?
3. What are some examples that demonstrate our approach and the application of the principles of design?

The targeted principles of design for my instruction have always been the inquiry or discovery based method of learning. However, the classroom climate had not been conducive to learning via this method, hence, over a period of continual teaching-research experimentation, a way had to be found to transform the remedial

mathematics classroom into one where the discovery method could be successfully implemented. The classroom climate needed to be grounded in simultaneous attention to cognition, directions of problems, meaning of symbols, meaning of problem structures, and the synthesis of all these to achieve the students' goal to "solve a given problem."

Typically, at the end of each problem completed by a student, the instructor carried out a whole class reflection and discussion addressing the following questions:

- What were the rules employed?
  The only rule turns out to be the order of operations.
- What cognitive, or procedural, elements were used?
  The grasp of the meaning of each symbol along with the correct interpretation of the meaning in a given context was the main cognitive requirements.
- How was the structure of the problem taken into consideration?
  A solution to the problem required a careful reading and clear comprehension of the problem, followed by making sense of each symbol correctly and determining which portions of the string of symbols needed to be addressed in what priority.
- Was the solution obtained correctly?
  This consisted of checking what was done, followed by each student's individual silent reflection with the objective of identifying component errors, if any, or addressing more general misconceptions of the meaning of the problem or of the totality of the string of symbols involved.

As students, one by one, completed these problems with the instructor's facilitation, the complaints, negative affect and a general resistance in the room subsided. The following day the topic of radicals was introduced. This topic, based on the instructor's prior experience, is another commonly negatively received mathematics classroom topic. However, this time the climate was strangely different. Students were determined and intense in their thinking, and, when it was time to end the class, those students who complained earlier were continuing to work on more problems. *Discovery had arrived in the remedial algebra classroom!*

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