Mathematical Knowledge Forum Communities: A Proposed Study in Geometric Learning, Concreteness Fading and Graphical Literacy.

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Abstract: This paper will explore how Knowledge Forum (Scardamalia et al. 2012) can address Graphical Literacy in order to assist elementary students in understanding Mathematical Geometry. Students will problem solving, to expand their geometrical understanding through the use of Graphical representations. This theoretical thought experiment is to be the starting focal point of a future pilot study to be conducted. The position of this paper is that graphical literacy in conjunction with Knowledge Building pedagogy will enhance "Concreteness Fading "(Fyfe et al, 2012), in order to assist student's abstract geometrical mathematical understanding.

Introduction

Images can convey meaning that may be difficult for students to communicate with words alone. Having students describe their mathematical thinking through words alone can be difficult, especially if students are not exposed to mathematical terminology. Mathematical communication involves "adaptive reasoning" (Kilpatrick et al. 2001, p. 170) and argumentation (Andriessen 2006), which give students opportunities to think mathematically. However, when students are interpreting mathematics they are not interpreting words alone. Mathematics consists of various symbols in which students are interpreting images, they are understanding symbols, and semantically analyzing what an image represents or signifies.

Mathematical data that a student can encounter, analyzes, or investigates can be demonstrate through various plots, graphs and charts. However, it can also be portrayed through two or three-dimensional shapes, and prisms, within the field of Geometry. Students need to explore data in multiple ways, in order to make sense of the information presented to them. Students can also ascribe meaning, and make connections based on this bimodal form of words and images to fit with their own understanding. By giving student multiple representations, students can ask more questions and better interpret the data, to formulate more conclusions.

Solloway (2017) found that within the elementary classroom, students spend 90% of their time with text based materials, and only 10% with imaged based materials, yet outside of the classroom, today's youth instead have an opposite effect, in which youth spend 90% of their time with image-based materials and only 10% of the time with text-based materials. Solloway depicted this phenomenon as "picting." (2017). While students have access to pictorial representation of media for their social needs, could this medium also be more successful in students understanding academic material? Graphical literacy should be used in conjunction with text based materials in order to assist in student's decode through a bimodal understanding of material. Could graphical literacy lead to acquiring and learning mathematical concepts within and outside of the classroom? How can we best integrate 'picting' as a mathematical task ascribe to better understanding geometry?

Graphical Literacy

Frye (1981), interpreted graphical literacy within the field of mathematics to be defined through the use of words, numbers or symbols but a major portion of the information communicated must be by line, image or area. Krane and Dyson (1981) defined the importance of graphical as, "Drawing should not be seen only as a piece of artwork but as an aid to understanding communication, ideation and problem-solving processes. Drawing can act as a vehicle for the development and communication of thinking, but particularly when thinking uses symbols and images rather than words. Drawings then become a most direct and economical translation" (p. 23). Students must be able to decode these drawings to convey their ideas across. Ideally these are to be used in conjunction with text. Zhang at al (2010) researched graphical literacy in conjunction with Knowledge building framework. Results demonstrated graphical literacy to be an extension of textual representations in regard to support science, and history Studies. Moreover, the study suggested that students exceed expectations within graphical, textual, digital and scientific literacy. Students can remain resilient when contributing, to also combat misunderstandings throughout the study.

Geometry and Graphical Literacy

In regard to Knowledge Forum (Scardamalia et al. 2012), recent recommendations from Costa (2017) explored Math Talk within Knowledge Building pedagogy, and found that students would benefit from incorporating graphics

and visualizations as a part of their postings in order to better represent and display their understanding of the material they are learning.

Costa (2017), found that within her exploratory research, students in a grade two classroom had inquiries amongst their own graphical literacy. The study incorporated student's hand drawn geometric images. Students were asked to draw what they believed to be a shape. Students did not draw the conventional two-dimensional shapes, they learned such as a circle, rectangle or square. Instead students guided their drawings by the definition given to them by the teacher of what a shape is. The teacher defined the shape as follows: it must be a closed figure, made up or lines or curves. Once the students understood this task, the students drew their interpretations. The researcher then individually uploaded each student's image to have a canvas filled with their work to be visually viewable and comparable all at once. When the researcher demonstrated this to the classroom, students began to make comparisons regarding their imagery and how they understood the shapes they drew. Students began to notice misconceptions and drew shapes that some believed not to follow their collective understanding of their agreed upon definition of a shape. Thus student began to discuss again why their shapes did or did not fit the category.

By using adjectives, and mathematically prescribed descriptive language, students began to negotiate their understandings of shapes, geometry, symmetry, lines, curves and the ability to incorporate graphics to match their understandings. As well this imagery assisted students in interpreting and identifying their misunderstandings. While the study did not focus on Graphical literacy, the recommendations of future work was heavily requested by the author, and this study hopes to propose that. There is a need to develop pedagogical mechanisms in mathematics classrooms and for assessment to allow students to facilitate their communication, and have a record of such accounts. Future recommended work should also explore how children's drawings can be utilized in the mathematical learning process and how the physical act of drawing allows geometric understanding to emerge in the community setting. By incorporating more tactile designs into student learning, student understanding of Mathematical Talk and comprehension may be demonstrated through the Knowledge Building Framework. (Scardamalia et al. 2012)

Through the development of Data literacy, students can analyze data to ask meaningful questions and deifier if patterns exist. Dimmel and Herbst (2015) concluded in their study that "As it becomes standard to use dynamic geometry software and other digital means of representation in mathematical classrooms, it becomes all the more important that students develop a sensibility for crafting and reading diagrams and other visuals (p 158). In their analysis of the semiotic structure of geometric diagrams the authors concluded that this study validates the use of geometry software due to the growing standard of digital representation (or diagrams) within this day and age. By teaching students through a software, students can develop their sense of reading complex digital diagrams.

Proposed Study

Kesan and Sevdane (2013) found that computer programs, especially for slow learning students, provide a more positive mathematical educational environment. Students were found to perceive as they were not being rushed, and enjoyed receiving feedback from various students as opposed to solely the instructor. As well, students felt to be in a less pressure environment. Moreover, the study demonstrated that geometric sketching led to student's better interpretation and retention of shapes, and understanding of geometric properties.

Through an upcoming Pilot study, the goal is to expand upon the literature to conduct a thought experiment, and gather some preliminary data in order to create a full study. This would begin by experimenting how Knowledge building pedagogy can be enhanced by Graphical Literacy, in regard to Geometric Learning. By students having access to Knowledge Forum version with the integration of Google Documents, students would have access to a suite of tools that would be available to draw and create mathematical diagrams and shapes. While Knowledge Forum has always had a drawing, tool incorporated within its technology, it had limited abilities, in which did not extend into supporting of mathematical properties. Nason & Woodruff (2002) noted the need for Knowledge Forum to provide symbolic math representations to enhance the discourse space. The most recent version of Knowledge Forum allows use of symbols and graphical representation of math ideas.; students work more productively with other software environments. Currently, with the integration of google documents, we can now insert the following Mathematical Graphics: equations, multiple graph styles (bar, line, pie, column), tables, and Geometric Shapes in two and three dimensions. Furthermore, students can now take photos on mobile devices as reference points, and can upload to the Knowledge Forum space and can annotate on top of these images.

The proposed pilot study would take the Ministry of Ontario's Mathematics Geometry curriculum (Ontario Ministry of Education 2005) in order to define what the mathematical process consists of. The Steps are as follows: "problem solving, reasoning, reflection, computational strategies, connection, representing and communication" (pg. 2). The Ontario Mathematics Curriculum defines the Big Ideas for geometry as "intuition about the characteristics of two and three-dimensional shapes and the effects and changes of shapes in relation to spatial sense. To recognize basic

shapes and figures, to distinguish between the attributes of an object, while understanding and appreciating the geometric aspects of our world." (Ontario Ministry of Education, 2005: pg. 9).

By utilizing knowledge forum, students will create graphical representations of the shapes they are learning about. Moreover, students will also create collaborative tables and graphs of geometrical properties they have discovered. Students would also post notes regarding difficult math issues they are encountering throughout this process, by sharing these concerns openly within the community. This should result in collaborative investigation on how to tackle the problem, or to clarify misconceptions. The classroom community should continually evaluate and revise their geometric theories of their own construction, especially with regard to: the definition of a shape, the properties of shapes, and two-dimensional vs three-dimensional properties of shapes. Students would also be engaging in "Concreteness Fading" (Fyfe et al 2012) through physical representations of the shape, in block form, as well as examples found in other environments in order to understand abstract theories. Fyfe et al (2012), composed the concept of "Concreteness Fading". This methodology consists of three main forms.

- "the enactive stage – using a physical concrete model to represent the concept:
- the iconic stage - perceptual features unrelated to the concept are taken away and there are introductions of symbols and linkage of concrete and abstract objects.
- the symbolic stage – essentially an abstract model of the concept."

Fyfe et al (2012) utilized this methodology in relation to teaching mathematics. With an instructor issuing a concrete object than slowing transition to students were found to not only achieve better marks, but also were found to perform and understand better than other students whom received a different method of instruction.

Students will then collect this information creating data. The data will be displayed in a chart form, and collaboratively the Knowledge building community will then use charts to mark differences they find in the various shapes they encounter, for example vertices, lines, points, and dimensions. Once this activity is completed, students will assess if there are patterning, differences and create theories in relation to mathematical theorems.
Once this second part of the project is complete, students will then go into their daily lives and find objects in which are three and two dimensional as reference points, take a picture and again assess their own conceptions and see if their beliefs and mathematical understandings are proven outside of the classroom.

These activities will be beneficial as they utilize graphical literacy in order to make sense of organizing multiple information as well as building a collective class repertoire of their learning of Geometry in an "pictorial" as well as text form. Once students have incorporated their graphics, students can then communication their findings to capture their sequence of data analysis and present their findings, understandings, misunderstandings and overall investigations to teach the rest of the class and formulate a hypothesis. By documenting their processes and observations students alongside their teachers can see their misconceptions as well as track their thinking over time.

Conclusion

Knowledge Building competence will allow students to enhance their Graphical reasoning by providing a reflective community setting. Students learning about geometrical fluency, through text and graphical literacy pilot is in hopes to achieve results which will allow students ways to reason and become reflective. We hope this proposed study can initiate new ways to incorporate strong math discourse, and have students remain resilient, in a collaborative setting to understand shapes.

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