On the Nature of Students' Digital Mathematical Performances

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In my doctoral research I investigated the nature of students' digital mathematical performances (DMPs) available at the *Math + Science Performance Festival*. I analyzed all the twenty-two elementary school students' DMPs (from grade 4 to grade 6) in the first year of the Festival, which was in 2008 (Scucuglia & Gadanidis, 2011).

My investigative focus was on the ways students communicated mathematical ideas in their DMPs and I highlighted the role of the arts and the technologies in shaping students' mathematical thinking and reasoning (Scucuglia, Gadanidis & Borba, 2011b). I initially conducted a descriptive analysis of each DMP using a performance arts lens based on Boorstin's (1990) categories of what makes good films (Gadanidis & Borba, 2008). I also conducted a cross-case analysis of the DMPs, pointing out similarities between the DMPs. Besides a performance art lens (Boorstin, 1990), I used the mathematical processes and strands of Ontario Curriculum (Ontario Ministry of Education, 2005) as analytic lenses (Scucuglia, 2012b).

Boorstin (1990) states that good movies offer three pleasures to the audience: voyeuristic, vicarious, and visceral. The voyeur eye is the rational eye, the sense-making of the story. Surprise is a fundamental voyeuristic element to capture the attention and the interest of the audience to understand the story. The vicarious eye refers to emotions, when the audience feels what the actors are feeling. Close-ups on actors' facial expressions enhance the vicarious pleasure. The visceral eye involves direct experiences, when the audience feels its own feelings through scenes of action, suspense, thriller, and others. Similarly to Gadanidis and Borba (2008), I adapted Boorstin's categories to mathematics education in the following ways:

- *Voyeur – new/wonderful/surprising*: Good DMPs offer ways of seeing the new and wonderful in mathematics. They explore *big mathematical ideas* in order to surprise the audience and show the joy of mathematics (Scucuglia, 2011; Scucuglia, 2012a).
- *Voyeur – sense-making*: Both the story and the mathematical ideas explored in a DMP have to make sense to the audience. Students' mathematical reasoning and thinking in a DMP must be structured in such a way that the audience can understand the mathematical idea within the context of the digital narrative. Connections between representations and ideas are key aspects of the two dimensions of the voyeuristic eye – surprising and sense-making (Scucuglia, Gadanidis & Borba, 2011b).
- *Vicarious emotions*: Good DMPs connect mathematical ideas to dramatic events. The emotions and feeling portrayed in the play must be related to the mathematical concepts explored in the DMP (Scucuglia, 2012a).
- *Visceral sensations*: Good DMPs offer direct experiences through the use of concrete materials, for instance. The use of songs, the emphasis on a-ha! moments, hands-on activities, and the exploration of a sense of mathematical fit and aesthetics (e.g., patterns) are also characteristics of mathematical visceral sensations in a DMP (Sinclair, 2004).

First of all it is important to highlight that the multimodal nature of DMP is one of its most significant pedagogic strengths. Mathematics is traditionally communicated through print-based texts (Ernest, 2004), but DMP is an alternative that engages students in producing multimodal narratives (Scucuglia, 2012b). When students perform arts in the classroom, and record their performances to make them available online at the Festival, they are communicating ideas to a wide audience, beyond the classroom-based settings. They are constructing identities as

performance mathematicians and sharing their ideas to the world (Gadanidis & Geiger, 2010; Gadanidis, Hughes, & Borba, 2008). DMP may offer ways to students to represent ideas collaboratively, with creativity and imagination. Students-with-DMPs form thinking and feeling collectives (Borba & Villarreal, 2005; Scucuglia, Borba & Gadanidis, 2010).

Students' DMPs offer surprises, sense-making, emotions, and sensations to the audience. However, some of the surprises are not conceptual mathematical surprises or the idea explored does not offer ways of seeing the new and wonderful in mathematics. That is, when students only reproduce some of the typical ideas explored in classrooms (e.g., textbook definitions), they are not exploring big mathematical ideas, which is a fundamental aspect of the voyeuristic eye.

In a DMP, it is crucial the investment on the conceptuality of the mathematical idea. The exploration of big mathematical ideas is a necessary condition to create a conceptual DMP. "Students can add artwork to 'decorate' procedural knowledge, thus adding a layer of sugar-coating to otherwise dry mathematical ideas, but mathematical art, like art in general, requires a deeper engagement and understanding" (Gadanidis, Hughes & Cord, 2011, p. 424). Although the use of the arts and the digital technology offer ways for multimodal communication and connections of multiple representations, it does not guarantee the conceptuality of the mathematical idea. In terms of sense-making, it is also important to recognize that DMPs are short (2-3 minutes long) and it has an impact in terms of the ways students provide understanding to the audience. DMPs, as mathematical narratives (Doxiadis, 2003), deal with the approximation and synthesis between the subjectivity of the arts and the objectivity of the mathematical reasoning.

The focus on drama offer vicarious emotions to the audience. For instance, when students play roles as geometric in a skit, "thinking-and-performing-as-polygons," most of the emotions that the characters feel are mathematical emotions, that is, dramatic events connected to mathematical properties or concepts offer mathematical vicarious emotions. But, like on the voyeuristic eye, we need more modules or examples of DMPs that explore big mathematical ideas and deep connections between emotions and mathematics.

In terms of visceral sensations, students use songs in many DMPs, they explore a-ha moments, they use concrete materials and they explore senses of mathematical fit such as patterns, symmetry, and relations between properties of polygons. Connections between representations of mathematical objects and everyday objects or phenomena also involve visceral sensations. Mathematical modeling usually refers to big mathematical ideas and shows the beauty of mathematics (Borba & Scucuglia, 2009).

Although I analyzed only students' DMP in the first year of the Festival, it is important to highlight that there is a great variety of good DMPs along the years of the Festival that convers a rich diversity of big mathematical ideas and strands, schools levels, and artistic approaches. I believe that my doctoral study contributes to the field of mathematics education by (a) presenting an interpretative discussion on the nature of students' DMPs in the Festival and (b) showing a range of possibilities on how mathematics can be communicated through multiple modes, considering the use of the arts and digital technology. It is important to disrupt stereotypes of learning mathematics as an authoritative process, highlighting the pleasure of experiencing mathematical ideas within the genre of the performance arts (Gadanidis & Scucuglia, 2010). The Festival offers ways to do that and my thesis offers some orientation about the pedagogic components of conceptual DMPs, considering the processes and strands of the Ontario Curriculum at the elementary school level.

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