Interdisciplinarity of science, mathematics and technology in a context of scientific investigation in elementary school using a virtual manipulative.

Takam Djambong & Viktor Freiman, Université de Moncton

Context, background, and objectives: Today's elementary science education evolves as students are confronted with the analysis or resolution of more complex problems through the integration of knowledge, know-how and interpersonal skills resulting from interaction of different disciplines (science, mathematics and technology in particular). The analysis and resolution of complex problems increasingly involves the manipulation of computational models (virtual simulators) of scientific phenomena. As part of the projects carried out within the CompéTICA network, which between 2015 and 2018 conducted several case studies of innovative practices (Freiman et al, 2017).

This article presents one of these studies, which aimed to: (1) identify the different modes of symbolic representation mobilized by elementary school students from an interdisciplinary perspective; (2) bring out the different thought processes used by the students during the scientific investigation activity on Archimedes' thrust using a virtual simulator; (3) explain the articulation between the mobilization of different modes of symbolic representation, the mobilization of different thought processes and the interdisciplinarity of science, mathematics and technology.

Conceptual framework: The investigative approach in science (inquiry process) is a favorable context for the emergence of pedagogical practices aimed at integrating knowledge through interdisciplinary learning activities (Kelley & Knowles, 2016; Hasni, Lenoir and Froelich, 2015; Walker et al., 2018). On the other hand, the potential of computational modeling to improve students' understanding of science and mathematics has been documented by a number of authors (Repenning et al., 2010; Wilensky et al., 2014). For Wing (2014), computational thinking is the driving force of scientific research that has potential for cognitive development and conceptual change in students when they are engaged in relational thinking through the construction of links between the scientific method (Landriscina, 2013) and mathematical thinking (Savard et al., 2013). Beaufils (2000) highlighted the advantages of involving students in the manipulation of computational models of scientific concepts and phenomena. This allows them to articulate and match different registers of symbolic representation in order to examine different facets of the same phenomenon. This was supported by Gauthier (2014) with students building and exploring models using dynamic algebra software.

Method & Data source: A qualitative study was conducted in with grade 7 & 8 students in two French schools in New Brunswick, Canada. Students accomplished additional science tasks through independent study of (1) relationships between density and buoyancy; (2) the factors likely to influence buoyancy; and (3) force(s) that keep a piece of cork afloat in a liquid. Students had to make predictions, conduct virtual experiments and explain the results. Multiple data collection tools were used to track student learning journeys, including video recording of students working in pairs, written notes and digital student traces, and interviews.

Results: With regard to the first objective, the students in a context of scientific investigation of the of buoyancy (Archimedes principle) using a virtual simulator had to articulate the development

of a mathematical model of the Archimedes principle, the manipulation affordances of the computational model of Archimedes' principle as well as the verbal modeling of buoyancy in order to analyze the phenomenon explored.
Regarding the second objective, the data collected during the study shows that the students used mathematical thinking, some traces of computational thinking and the scientific method process in exploring buoyancy.
Finally, for the third objective, the data suggest some disciplinary interactions between science, mathematics, and technology concepts, as a potential vector for the science, technology and mathematics (STM) knowledge integration in a context of science learning in elementary school. Theses STM interactions are mainly manifested by the ability of students to handle and articulate different modes of symbolic representations and different approaches to thinking in order to analyze and apprehend a scientific concept (the principle of Archimedes) under different facets.
.
Scholarly Significance: Our results help to highlight the importance of technologically rich learning environments in a context of scientific inquiry as vectors for the integration of science, technology and mathematics in an interdisciplinary perspective in elementary school. They also bring out the importance of bringing together different types of modeling (mathematical, computer and verbal) in an interdisciplinary perspective of integrating knowledge from science, mathematics and technology in elementary school.

Références

Beaufils, D. (2000). Les logiciels de simulation comme supports de registres de représentation pour les apprentissages en physique. *Journées Internationales d'Orsay sur les Sciences Cognitives*.

Freiman, V., Godin, J., Larose, F., Léger, M. T., Chiasson, M., Volkanova, V. et Goulet, M. J. (2017). Towards the life-long continuum of digital competences: exploring combination of soft skills and digital skills development (p. 9518-9527). INTED2017 Proceedings, IATED.

Gauthier, M. (2014). Perceptions des élèves du secondaire par rapport à la résolution de problèmes en algèbre à l'aide d'un logiciel dynamique et la stratégie Prédire – investiguer – expliquer. Éducation et francophonie, 42(2), 190-214. doi:10.7202/1027913ar

Hasni, A., Lenoir, Y., & Alessandra, F. (2015). Mandated Interdisciplinarity in Secondary School: The Case of Science, Technology, and Mathematics Teachers in Quebec. *Issues in Interdisciplinary Studies*, *33*, 144-180.

Jona, K., Wilensky, U., Trouille, L., Horn, M. S., Orton, K., Weintrop, D. , & Beheshti, E. (2014). Intégration de la pensée computationnelle dans les sciences, la technologie, l'ingénierie et les mathématiques (CT-STEM). Dans *les orientations futures de l'enseignement de l'informatique, réunion au sommet, Orlando, FL.*

Landriscina, F. (2013). *Simulation et apprentissage. Une approche centrée sur le modèle*. Springer Science+Business Media, New York. Doi 10.1007/978-1-4614-1954-9.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM education*, *3*(1), 1-11.

Repenning, A., Webb, D., & Ioannidou, A. (2010). Conception de jeux évolutifs et développement d'une liste de contrôle pour introduire la pensée computationnelle dans les écoles publiques. Dans *Actes du 41e symposium technique de l'ACM sur l'enseignement de l'informatique* (pp. 265-269). ACM.

Savard, A., Freiman, V., Larose, F., & Theis, L. (2013). Discuter des outils virtuels qui simulent la probabilité: quelles sont les préoccupations des enseignants du collège? *McGill Journal of Education / Revue des sciences de l'éducation de McGill*, 48(2). Consulté le 30 novembre 2013 sur http://mje.mcgill.ca/article/view/9019/6882

Walker, W., Moore, T., Guzey, S., & Sorge, B. (2018). Frameworks to develop integrated STEM curricula. *K-12 STEM Education*, *4*(2), 331-339.

Wilensky, U., & Papert, S. (2010). Restructurations : Reformulations des disciplines du savoir à travers de nouvelles formes de représentation. *Constructionnisme*. Repéré le 17 mai 2018 à l'adresse https://pdfs.semanticscholar.org/a684/d3149266ce9e55dc366b8acbbc6e905f8c80.pdf

Wing, J. (2006). Pensée computationnelle. *Communications de l'ACM*. 49(3). p. 33 à 35. Repéré le 12 janvier 2016 à l'adresse https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf