CULTURAL AND SOCIAL PERSPECTIVES ON SIMULATION MODELING IN SCIENTIFIC EDUCATION

Iftikhor Kamolov
Prof. Head of the Department of Arts, Karshi state university
Firuza Davronova
3rd year PhD student, Karshi State University

Introduction

Some studies in the literature have focused on the social and cultural aspects of modeling within scientific education. For example, Danish and Enyedy (2015) proposed that actor-network theory offers a valuable analytical framework to explore the social interactions of students in science classrooms. Similarly, Pierson et al. (2020) showed that existing social interaction patterns can serve as resources to participate flexibly with computational tools as active participants in the learning process. In another research, Lauca and Zacharia (2012) examined the social and epistemological contributions of models-based learning (MBL) to scientific education. In similar lines, Southerland et al. (2016) found that the participation of teachers in research experiences influenced both their instructional practices and professional beliefs. Schademan (2015) emphasized even more that modeling in scientific education can establish significant connections with the cultural practices of African-American communities. Although Jones and Hite (2020) did not observe statistically significant differences in the perceptions of the students or representations of scientific models to continue based on school or gender, their findings showed that the students generally perceived scientists who were looking for intellectual objectives that seemed difficult to achieve and saw themselves as low desirability. In contrast, Teig et al. (2018) found that the

socioeconomic state of students had no impact on the strength of the relationship between research based on academic and performance.

Review and theoretical studies on modeling in scientific education

A review of the literature on the scientific education model reveals that some studies take the form of theoretical or conceptual analysis. For example, Gonsalves et al. (2011) reviewed the work of Schademan (2015) entitled "What do the letters with science have to do? A look rich in resources to young African Americans", in which two central concepts, hybridism and resources are explored. The study proposes an alternative approach to scientific education that defies the prevailing narratives based on the deficit that surrounds this demographic group by analyzing how these concepts are applied in educational contexts. In another research based on the review, Clark and Senguta (2020) conducted a critical analysis of a wide range of research articles to evaluate the potential to integrate modeling in games based on the curriculum, particularly from the perspectives of computational thinking and science as a practice. In addition, Fuchs (2015) established a connection between modeling, particularly through simulation, and story narration, arguing that formal scientific models are closely intertwined with narrative structures that are often found in these worlds of stories.

Discussion

The purpose of this systematic review is to synthesize findings and provide conclusions highlighting the importance and influence of modeling in science education over the journal from 2011 to 2022.

However, in contrast to these positive results, Mierdel and Bogner (2019) reported that modeling did not have a positive or negative impact on cognitive performance, which it suggests that its effectiveness can vary according to the context or other influential factors. The research has specifically highlighted that students tend to understand certain issues more effectively when the concepts are visually presented, as through diagrams or

tangible objects such as blocks or balls that symbolize molecules and atoms. In addition, several studies have shown that the use of models during instruction not only supports the acquisition of immediate knowledge but also contributes to better long-term retention compared to traditional teaching methods that depend solely on conferences and reading materials without visual aids (Demir and Namdar, 2021; Fulmer, 2015; Lucas, 2021; Or-Bach and Brewegg, 2013; Rates et al., 2016).

Given the findings, educators are strongly recommended to incorporate modeling approaches into the planning of their lessons as long as appropriate opportunities arise, since it has been shown that the modeling improves the understanding of students in a wide range of scientific disciplines. In addition, teachers must take into account that the effectiveness of the different types of representations of models, such as physical models versus visual diagrams, varies according to the nature of the concept taught. Selecting the most appropriate way of representation for each topic can lead to more effective instruction. In conclusion, the implementation of model-based learning strategies (MBL) presents a valuable opportunity to improve educational results in science classrooms. Therefore, its continuous use and additional research are justified, considering the growing body of evidence that supports its positive impact.

Importantly, findings emphasize that modeling is not merely a supplementary instructional tool, but rather an essential component of inquiry-based and constructivist learning approaches. The positive impact of modeling was consistent across diverse geographical regions, suggesting its universal pedagogical value. However, special attention must be given to the socio-cultural context in which modeling practices are implemented, as cultural factors significantly mediate their effectiveness. Considering the broader European educational landscape, where competency-based and active learning approaches are increasingly prioritized, modeling-based learning aligns closely

with current educational reforms. Thus, the integration of various types of modeling into science curricula across Europe and beyond holds considerable promise for improving both cognitive and motivational learning outcomes. Future research should continue to explore how different types of modeling (e.g., computational, conceptual, and physical modeling) can be effectively adapted to varied educational contexts and how teacher training programs can be better prepare educators to implement model-based instruction.

REFERENCES

1. Gonsalves, A. J., Seiler, G. and Salter, D. E. (2011) Rethinking resources and hybridity. *Cultural Studies of Science Education* 6, pp. 389–399. Available at: https://doi.org/10.1007/s11422-010-9295-1.

2. Hand, B., Shelley, M. C., Laugerman, M., Fostvedt, L. and Therrien, W. (2018) Improving critical thinking growth for disadvantaged groups within elementary school science: A randomized controlled trial using the science writing heuristic approach. *Science Education* 102(4), pp. 693–710. Available at: https://doi.org/10.1002/sce.21341.

3. Hofstein, A. and Lunetta, V. N. (2004) The laboratory in science education: Foundations for the twenty-first century. *Science Education* 88(1), pp. 28–54. Available at: https://doi.org/10.1002/sce.10106.

4. Huber, R. A. and Moore, C. J. (2001) A model for extending hands on science to be inquiry based. *School Science and Mathematics* 101(1), pp. 32–42. Available at: https://doi.org/10.1111/j.1949-8594.2001.tb18187.x.

5. Mierdel, J. and Bogner, F. X. (2019) Is creativity, hands-on modeling and cognitive learning gender dependent? *Thinking Skills and Creativity* 31, pp. 91–102. Available at: https://doi.org/10.1016/j.tsc.2018.11.001.

6. Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A. and PRISMA-P Group (2015) Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-

P) 2015 statement. *Systematic Reviews* 4, p. 1. Available at: https://doi.org/10.1186/2046-4053-4-1.

7. Morgan, P. L., Farkas, G., Hillemeier, M. M. and Maczuga, S. (2016) Science achievement gaps begin very early, persist, and are largely explained by modifiable factors. *Educational Researcher* 45(1), pp. 18–35. Available at: https://doi.org/10.3102/0013189X16633182.

8. Or-Bach, R. and Bredeweg, B. (2013) Support options provided and required for modeling with DynaLearn: A case study. *Education and Information Technologies* 18, pp. 621–639. Available at: https://doi.org/10.1007/s10639-012-9194-z.

9. Roth, T., Scharfenberg, F. J., Mierdel, J. and Bogner, F. X. (2020) Self-evaluative scientific modeling in an outreach gene technology laboratory. *Journal of Science Education and Technology* 29(6), pp. 725–739. Available at: https://doi.org/10.1007/s10956-020-09848-2.

10. Saba, J., Hel-Or, H. and Levy, S. T. (2021) Much.Matter.in.Motion: Learning by modeling systems in chemistry and physics with a universal programming platform. *Interactive Learning Environments.* Available at: https://doi.org/10.1080/10494820.2021.1919905.

11. Sackes, M., Trudle, K. C. and Bell, R. L. (2013) Science learning experiences in kindergarten and children's growth in science performance in elementary grades. *Education and Science* 38(167), pp. 114–127.