Examining Concurrent Representation Choices in University Modeling Instruction

Daryl MCPADDEN

Michigan State University, Department of Physics and Astronomy, 567 Wilson Rd. Rm. 1310, East Lansing, Michigan, 48824, United States

Eric BREWE

Drexel University, Department of Physics and School of Education, 32 S. 32nd St. Rm. 918, Philadelphia, Pennsylvania, 19104

Abstract. In this talk, we use network analysis to examine the concurrent representation choices that students make in the Modeling Instruction – Electricity and Magnetism (MI-EM) in course. We find that on mechanics questions, MI-EM students repeatedly use a common set of representations, whereas in EM they have a wider variety in their concurrent representations across the problems. We also show that in both mechanics and EM contexts, pictures play a critical role in connecting the different representations in physics. Ultimately, these results have implications for instruction and future research directions.

1 Introduction and Study Context

Representation use and coordination are critical skills in physics to communicate, visualize, and construct knowledge in science [1, 2]. Particularly in physics, multiple representations serve as powerful tools for both problem solving and constructing understanding about physical phenomena [1, 3]. Rather than focusing on how students use any one representation, this talk focuses on what representations students choose concurrently during problem solving and introduces network analysis as a method for examining these choices. We situate this study in the University Modeling Instruction (MI) classroom context because the MI curricula spends explicit class time devoted to generating, understanding, interpreting, and using multiple representations as part of the model building process [4]. MI is a two-course introductory physics sequence, with the first covering introductory mechanics (MI-Mech) and the second covering introductory electricity and magnetism (MI-EM).

2 Research Question and Methods

In this paper, we address the question of how students' concurrent representation choices are different between the mechanics and EM contexts. To answer this question, 121 students from two sections of MI-EM in Spring 2016 were given a survey of 25 physics problem statements at the end of the semester, covering both Mechanics and EM content [5]. Rather than asking students to solve every problem, they were asked to simply list which representations they would use. Using students' responses to this survey, we created a network where the nodes of the network were the representations that students picked and the edges and edge weight show which representations students chose together on any given question. By combining the responses from the whole class, we constructed two separate networks for the mechanics and EM questions. As these networks were fully dense, we filtered these networks using a disparity filter to determine the ``backbone'' or most important connections in these networks [6]. We also calculated the edge-betweenness of each node in the network to determine which representations serve as more central in the network [7]. This allowed us to compare the mechanics and EM filtered networks to determine what representations students frequently rely on together in each context, what representations feed into others, and what representations serve as "connectors" between the various representations (shown in Figure 1).

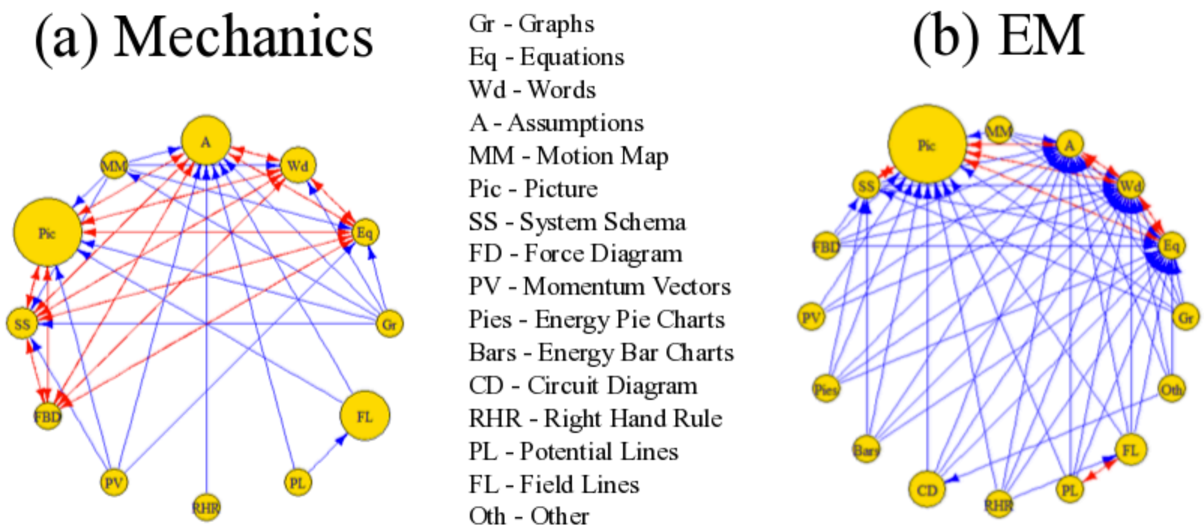

Fig. 1 This figure shows the filtered networks for the MI-EM post survey in the Spring 2016 semester. (a) shows the filtered network for the mechanics questions only. (b) shows the filtered network for the EM questions only. Between the two networks is the list of representation abbreviations used in both networks.

3 Results and Conclusions

We find that on mechanics questions, MI-EM students repeatedly use a common set of representations as evidenced by the many red-bidirectional arrows, whereas in EM they have a wider variety in their concurrent representations across the problems (fewer red-bidirectional arrows, with more blue-unidirectional arrows). Finally, we show that in both mechanics and EM contexts, pictures play a critical role in connecting different representations. Ultimately, these results have implications for further curriculum development and open up many future directions for study.

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