Newton's Laws — a Theory of motion or force

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Abstract. Regular disciplinary instruction of introductory physics at high school often misses a holistic perspective of the subject matter, its structure and hierarchy. We have considered the domain of mechanics and provided such a perspective in a summative lecture by framing mechanics contents in discipline-culture framework. In the experimental teaching, we focused on Newton's laws of motion as the nucleus of classical mechanics. Considering mechanics as a culture, that is, addressing the debate with periphery conceptions, caused students to appreciate the fact that mechanics is about theory of motion, while forces present only a certain conception to account for it.

1. Introduction

In the process of learning science, constructing meaningful knowledge and holistic understanding of the subject matter remains in the focus of research effort. Science traditionally seeks establishing structural knowledge, a theory, with a hierarchical and relationship arrangement of its components. The progress in science presents restructuring of the previous theories in the conceptual dialogue. A common disciplinary course presents scientific products univocally while researchers argue for the conceptual variation, creation learning space for the goal concept to be understood [1]. The recently introduced discipline-culture (DC) structure of a theory [2] preserves such variation by peripheral knowledge in contrast with the clearly identified nucleus (fundamental concepts of the theory). Such knowledge was labeled as cultural content knowledge (CCK) [3]. This approach in the form of summary lecture was first applied as a delay organizer with regard in optics instruction at high school [4]. This study made the same with respect to teaching mechanics at high school.

2. Method

In the first stage of the study, we prepared a summary lecture emphasizing the nucleus of mechanics in the school course of mechanics. The sample included a regular class of 11^{th} grade and a group of preservice science teachers. The experiment comprised a lecture of 90 minutes, pre and post questionnaire, class discussion and a few clinical interviews. The open-question format helped in collection data about the impact of the novel instruction. The lecture touched on such aspects as theory-nature relationship, area of theory validity, the status of principles, models, and laws in physics drawing on valid resources.

2.1 Lecture contents

The lecture put in focus Newton's laws of motion – from the nucleus – contrasted with the ideas from Aristotelian and medieval conceptions of motion, from the periphery, as prescribed by the DC structure of the theory of classical mechanics. The nucleus also included the model of point masses, the definition of inertial mass and force concepts, absolute and mutually independent space and time, the state of natural motion, the instant velocity and acceleration, rest-motion equivalence. In contrast with regular teaching [5], a hierarchical structure of the theory of mechanics was emphasized and the First Law was presented as the central law of mechanics, rather than a special case of the Second Law [6]. The complementarity of the three laws was refined. Furthermore, the concept of energy was affiliated to the body of knowledge as being derived drawing on the principles of the nucleus. The debate on the state of motion along the history (Hellenic and medieval conceptions) significantly enlarged the space of learning about the classical account of motion. Inertial mass replaced the "resistance to motion" and natural state included uniform motion leading to Galilean principle of equivalence.

3. FINDINGS

The analysis of the rich data collected testified for a positive impact of the teaching in several aspects. Those included understanding of relationship among concepts and their status, appreciation of knowledge structure and the knowledge of alternative accounts of motion (periphery), triggering students' curiosity and interest. We were evident to the affective influence of the lecture, increasing of self-confidence and intention to continue learning physics. To all these aspects, we have received qualitative and quantitative support.

4. DISCUSSION AND CONCLUSION

This study demonstrated the need of change in the approach to curriculum design, adopting DC structure. It encourages construction of holistic perspective on the disciplinary knowledge promoting appreciation of the hierarchical organization and conceptual meaning of physics taught at high school level. Summary lecture acts as a delay organizer of knowledge and presents a feasible way to reach meaningful learning of physics. The experiment had an impact on the common misconceptions of force-motion relationship. We also observed that students perceived Newton's Laws as theory of force rather than motion. Though the latter conception may not influence problem solving, it may indicate missing general understanding of mechanics important in further studies of other theories of physics, such as quantum mechanics. Students obtained a chance to grasp the features of scientific knowledge rarely discussed in physics class: the theory based knowledge, modelling, laws, principles, validity area of any theory in physics, the status of being proved in science, and the idea of conceptual genesis of knowledge. We consider this change being significant evidence for the ongoing debate on the nature of scientific knowledge and its representation in education [7] seeking normative contents to adopt in science education.

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