Evaluation Report

Petr Kácovský Habilitation Thesis

"Experiments in Physics Education: Designing Activities & Research"

This evaluation report is split into three main sections, a summary of the presented cumulative thesis and the connected papers, a critical section, and the overall evaluation of the thesis.

Summary

This habilitation thesis delves into the author's extensive involvement in the physics education community and their research in physics education, focusing specifically on experimental activities in teaching and learning. It's structured into two main parts, bound together by a shared introductory theory and a focus on practical work and experiments in physics education.

Chapter 1, titled "Experiments in Physics Education", explores the pivotal role of experimentation in both scientific research and science teaching and learning, invoking a perspective backed by R. P. Feynman, a world-renowned teacher of physics. While the significance of experiments is widely acknowledged, the chapter addresses ongoing debates among scholars and educators regarding the exact role and optimal implementation of experiments in the educational context. Key questions considered include the functionality and effectiveness of science experiments conducted by lecturers versus students, the conditions and methods that enhance or limit the benefits of experimentation, and the potential variance in how different students benefit from experiments. The chapter recognizes the evolving nature of the student body and society, affirming that responses to these questions are temporary and context-dependent. The author endeavours to encapsulate the contemporary viewpoint and related research concerning the varied roles and functionalities of experiments in science education amidst these shifting parameters.

Chapter 2, titled "Designing experiments in the era of technologies: The case of thermal imaging" underscores the transformative impact of modern technology on daily life and its implications for education. While technological advancements pervade every aspect of contemporary life, education is perceived as a sector resistant to change. Critics assert that educational systems, including in the Czech Republic, lag behind in offering content relevant to today's technologically savvy generation. However, the author emphasizes the importance of a certain conservatism in education, which ensures continuity and safeguards against fleeting trends. Still, he advocates for integrating beneficial, real-life technologies into teaching, highlighting how the pandemic-induced shift to distance learning has enhanced educators' tech-pedagogical prowess. In essence, now is the opportune moment to bring everyday technologies into classrooms.

Section 2.1 dives deep into the integration of modern technologies in physics education, detailing the opportunities, barriers, and practical implications of technology adoption. The author provides an insightful blend of empirical evidence, theoretical perspectives, and personal beliefs on the subject. Section 2.2 offers a comprehensive overview of the use of thermal imaging in science education. It effectively combines the historical context with practical applications, making it a valuable resource for educators, students, and anyone interested in the intersection of technology and education. Section 2.3 discusses the use of thermal imaging cameras in physics education, specifically targeting misconceptions related to thermal physics. It provides a comprehensive review of several studies and highlights how these tools might be used to correct or challenge student misconceptions.

The research papers attached to this chapter highlight the author's sustained academic engagement with the topic in question. These documents demonstrate the author's profound connection to the idea of teaching through experiments using contemporary instruments.

Chapter 3, titled "Students' intrinsic motivation towards experiments in physics" delves into the complexities associated with assessing learning gains in specific educational settings, primarily one-off events. It underscores the significance of intrinsic motivation and interest as predictors of potential learning gains, even when direct evaluation is challenging. Section 3.1, titled "Intrinsic motivation through the lens of self-determination theory", provides an in-depth exploration of intrinsic motivation, its historical and theoretical contexts, and how it has been conceptualized within the framework of self-determination theory (SDT). Section 3.2 is primarily focused on the concept of interest and its relation to intrinsic motivation. Key points are interest vs. intrinsic motivation, conceptualization of interest, its relation to intrinsic motivation, development of interest, the four-stage model of Hidi & Reninger, as well as the non-linearity of interest development. Section 3.3 underscores the pivotal role of interest in the educational process in enhancing learning outcomes and knowledge acquisition. It differentiates between individual and situational interests, with the latter being vital in academic contexts. The content emphasizes the reciprocal nature of interest and knowledge acquisition and offers strategies like hands-on experiments and active learning to spark situational interest. The author also delves into their personal research focus on these methods. The piece is well-structured, evidence-backed, and offers a balanced viewpoint, though the addition of real-life examples could enhance its relatability. In essence, the text provides a thorough analysis of the significance of interest in education, giving readers both insights and practical tools. Section 3.4 provides an overview of a research project focused on intrinsic motivation in physics education, situated within the Department of Physics Education at Charles University's Faculty of Mathematics and Physics. The research specifically examines two activities for upper secondary students: Physics Lecture Demonstrations (DEMOs) and an Interactive Physics Laboratory. DEMOs serve as illustrative displays of physics principles, while the Interactive Physics Laboratory allows for hands-on experimentation. Both activities are unique in that they are singular experiences for the students, with limited information about the participants available to the faculty. Section 3.4 sets the research context. The Department of Physics Education at the Faculty of Mathematics and Physics, Charles University, organizes two primary activities aimed at enhancing intrinsic motivation in upper secondary students. These activities are the physics lecture demonstrations, known as DEMOs, and the Interactive Physics Laboratory (IPL). In Section 3.5 the author delves into research findings concerning intrinsic motivation within physics education. The study primarily investigated the Intrinsic Motivation Inventory (IMI) dimensions to understand their influence on motivation, especially about interest and enjoyment. A standout discovery was the significant role of students' perceived value or usefulness of an activity in influencing their motivation. Thus, to foster motivation, educators should emphasize the real-world relevance of physics activities. Other notable findings included the minor negative effect of felt pressure or tension on motivation, while perceived competence, analyzed only in practical work scenarios, had a minor positive influence. Additionally, the effort or importance dimension was found to be vital for motivation. Interestingly, students displayed a heightened effort in practical work, suggesting that these tasks presented an apt level of challenge. In terms of gender disparities, although girls were more critical of physics as a subject, both genders showed analogous perceptions for singular events like the DEMOs or the IPL. However, girls exhibited a lower sense of competence during practical tasks. The research also highlighted that students who viewed themselves as gifted and diligent in physics exhibited stronger motivation, indicating the transformative role a teacher can play in cultivating student confidence and diligence. Looking ahead, the research is expanding its horizons. One avenue is the exploration of a third activity, "Physics Through All Senses", aiming to juxtapose student feedback from this, the DEMOs, and the IPL. Concurrently, a separate research trajectory is examining the DEMOs, probing into the connection between distinct physics displays, intrinsic motivation, and the choices and interactions of the demonstrators.

The selection of co-authored papers gives an insight into the author's strong commitment to empirical research and his main topic, students' intrinsic motivation.

Critical Discussion

The author exhibits a staunch conviction in the principles of physics and an equally strong outlook on physics education. His approach to presenting his arguments is direct and clear. However, there are instances where he could further elaborate on certain details and support his methods with more robust arguments.

A profound educational challenge is to make sure students have a true grasp of the Nature of Science (NOS). Merely teaching scientific facts or methods may fail to impart the complex essence of scientific knowledge and how it has developed over time. Practical work in lab or field settings may act as a conduit for deeper understanding, yet research on the effectiveness of such work remains inconclusive. The text acknowledges the inherent importance of hands-on experimentation in science education and advocates for a strategy that is more purposeful, evolving, and clearly defined to fully harness its potential. There is room for a more expansive discussion on this strategic approach.

Thermal imaging has long been utilized in various industries, including surveillance, wildlife research, and building inspections. Its adoption in educational spheres, particularly in teaching physics, is a recent and growing phenomenon. This surge in interest suggests that educational professionals and innovators are starting to realize the value of thermal imaging as a pedagogical tool. It reflects a possible shift towards optimizing current technologies for educational purposes rather than incessantly seeking out new inventions. The author seems to hint at this, but it is not overtly stated. Misunderstandings in thermodynamics can significantly impede student learning, affecting their comprehension of advanced subjects. The author's reference to his study underscores the ongoing effort to catalogue and address these misconceptions. Consequently, the utilization of thermal imaging cameras in education is particularly promising. Their use in experimental and inquiry-based learning promotes active engagement, allowing students to engage hands-on with the subject matter, thus potentially offering a more effective means of rectifying misconceptions.

Chapter 3 provides insightful analysis into what drives students' intrinsic motivation in physics learning. By situating these insights within the broader academic discourse, the chapter contributes a nuanced understanding of the motivational influences. Its organized presentation and indication of future research paths not only enhance readability but also provide a basis for anticipating new studies in the field.

Turnitin originality check was passed on the document and it is clear that this is original work that only overlaps insignificantly with existing literature.

Overall Evaluation

Despite my critiques in the preceding section, I must commend the author for his perceptive contributions within this habilitation thesis. The duration and depth of the author's commitment to this area of research are impressive, reflecting a shared passion for practical physics education.

Independently and in collaboration with distinguished colleagues, he has developed several pedagogical approaches and initiated compelling experimental opportunities.

The habilitation process culminates in granting the "venia legendi," signifying that a candidate is proficient in covering the entirety of the subject matter and, most importantly, possesses the skills to teach it effectively. From my perspective, Petr Kácovský has exhibited a wide-ranging and in-depth comprehension of physics education and has proven his competency as an educator through his innovative research and ideas. His enthusiasm for the subject is evident and commendable.

Consequently, I wholeheartedly endorse his thesis for approval in his habilitation proceedings. It adheres to the most rigorous academic standards and promises to serve as a lasting reference for interactive teaching methodologies.

I extend my best wishes to Petr Kácovský for the forthcoming phases of his habilitation and his future endeavours in teaching.

Geneva, 05.11.2023

Dr. Sascha Schmeling