Πανελλήνιο Συνέδριο της Διδακτικής των Φυσικών Επιστημών και Νέων Τεχνολογιών στην Εκπαίδευση

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Trends in STEM Education Research in Europe in 2005-2019

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TRENDS IN STEM EDUCATION RESEARCH IN EUROPE IN 2005 – 2019

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ABSTRACT

Finnish STEM education research experts critically examined the focus of STEM education research, particularly in physics, chemistry, and biology, using the didactic triangle framework. Analyzing numerous research papers and master's theses from forums like NorDiNa and ESERA, three pivotal articles were highlighted. These articles revealed dominant research trends like the student-content relationship, underscored areas lacking attention, such as educators' insights into students' perceptions, and advocated for a broader, more holistic approach in future STEM education research endeavors.

Keywords: Pedagogical foci, trends in STEM education; teacher training; didactic triangle

SYNOPSIS

Over a series of articles, a team of Finnish researchers from the University of Helsinki and the University of Aalto examined the focus of academic studies on teaching and learning in science disciplines, with specific emphasis on physics, chemistry, and biology. Using the didactic triangle, a theoretical framework, they analyzed a significant number of research papers and master's theses published in various forums, including NorDiNa and the European Science Education Research Association (ESERA). Several studies have been conducted and this presentation captures the core insights from three pivotal research articles that provide a multifaceted perspective on the thematic orientations of the studies.

The first article (Kinnunen, Lampiselkä, Meisalo & Malmi, 2016), delved into teaching and learning processes in physics and chemistry education, analyzing journal articles published in NorDiNa from 2005 to 2013. Utilizing the didactic triangle as a guiding theoretical framework, the study developed a typology that led to the categorization of 89 research papers from primary, secondary, and tertiary educational levels. Predominantly, students' characteristic features, their understanding of content, and learning outcomes emerged as focal areas of educational research. However, there was a noticeable research deficiency surrounding science educators. A majority of the analyzed papers centered on studies conducted at the teaching organization level, supplemented by course and society-level investigations. Strikingly, there was a lack of studies with an international concern.

Shifting the spotlight to the second article (Lampiselkä, Kaasinen, Kinnunen & Malmi 2019), the study unfolded the didactic focus areas in educational research encompassing biology, chemistry, and physics. By employing the Didactic Focus-Based Categorization Analysis Method (DFCM)—a revision of the didactic triangle—the research parsed through 250 papers published in both NorDiNa and the European Science Education Research Association (ESERA) 2013 proceedings. Central to the findings was the observation that teachers' pedagogical interventions and the student-content interplay were the epicenters of research interest. In stark contrast, aspects like teachers' reflections on students' perceptions and their understanding of students'

proactive measures toward goal attainment remained under-explored. Despite the venue of publication, the thematic distributions were consistent, leading to a call for a more encompassing dialogue on the breadth and depth of science education research.

Lastly, the third article (Lampiselkä, Malmi, Kaasinen, Kinnunen, Gülc, Oktay, Reisoğlu, Teke, Sözbilir, Atila, Yazar, Yildiz, & Gunes, submitted 2023), provided an intriguing comparative analysis of master's theses related to STEM disciplines from Finland and Turkey during 2015-2019. The master's thesis, a pivotal academic milestone, surprisingly often fades into obscurity post-publication. The study scrutinized 765 such theses and discerned that Finnish research prominently pivoted toward enhancement, development, or empowerment. While both nations demonstrated a strong affinity for studying the student-content relationship, Finland uniquely exhibited a heightened interest in teachers' pedagogical maneuvers. Across both nations, there was an obvious absence of research on educators' insights into students' perceptions and their interpretation of students' endeavors to achieve educational objectives.

In summation, while science education research has examined diverse thematic terrains, it remains necessary to extend the global, reflective, and diversified dimensions of such investigations to ensure a holistic and comprehensive understanding of evolving educational paradigms.

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Appendix 1

Didactic focus-based categorization method (DFCM)

The categorization of didactic foci of a study is based on the Didactic Focus Categorization Method. The method draws its foundation from the didactic triangle, a conceptual model originally introduced in the 19th century by Johan Herbard (see Peterssen, 1989). The didactic triangle serves as a representation of the relationships among content, students, and teachers (refer to Figure 1). The DFCM builds upon the work of Kansanen and Meri (1999), Kansanen (2003), as well as later extensions by Kinnunen (2009) and Lampiselkä et al. (2019).

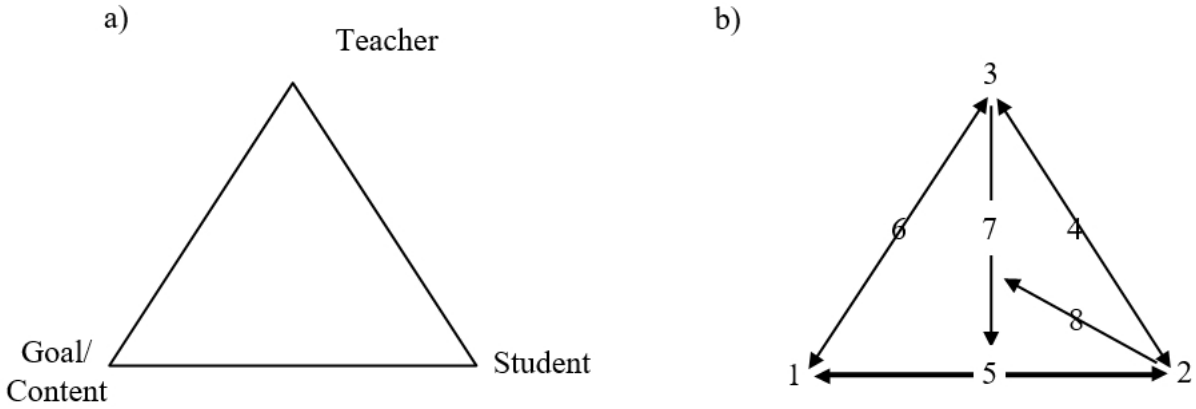

Figure 1. a) Herbart's didactic triangle (Peterssen, 1989). b) The analysis units in DFCM are described as foci and comprise the main actors of the instructional process (1 = content/goal, 2 = student, 3 = teacher) and the interactions between them (4–8).

The extended didactic triangle based on educational scope (Figure 2). The concept of 'educational scope' is determined by the context in which the research took place. This scope can be categorized into four attributes: course, organization, society, and international levels. A 'course' scope refers to research conducted within one or a few classes at a single educational institution. An 'organization' scope involves studies spanning multiple classes across various institutions. The 'society' scope encompasses studies spread across multiple regions within a country, while the 'international' scope pertains to research involving multiple countries.

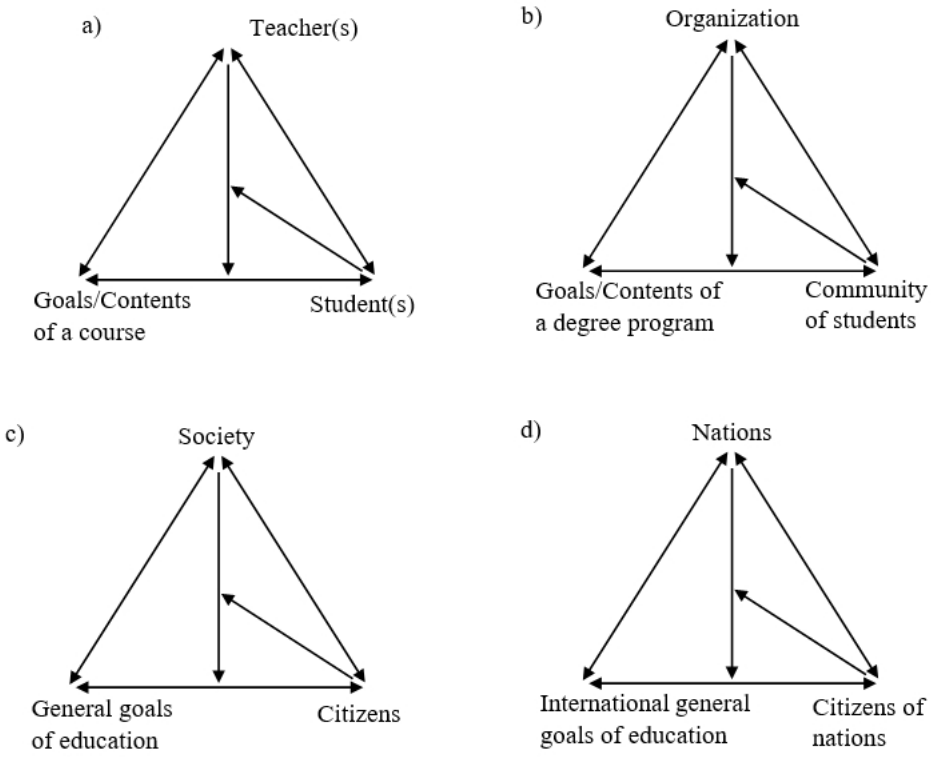

Figure 2. Extended didactic triangle based on educational scope. a) teacher/course level, b) teaching organizational level, c) society level, and d) international level.

However, it is important to note that some educational phenomena become apparent only when examined with a sufficiently broad lens. For instance, discerning trends in educational policy and their effects on national science curricula necessitates a view beyond just individual courses.

Appendix 2

Didactic foci and their definitions

The DFCM methodology identifies eight primary categories, with several subcategories within each (Table 1). The triangle's nodes yield three categories: goals and contents (category 1), students (category 2), and teachers (category 3). Five categories stem from the triangle's connecting arrows: the relationships between students and teachers (category 4), students and goals and contents (category 5), teachers and goals and contents (category 6), teachers' didactic actions (category 7), and between students and teachers' didactic actions (category 8). The categories 5 and 7 are split into subcategories to distinguish the various ways these relationships can manifest. All categories function at different levels: course, organization, society, and international.

Table 1: List of categories and their definitions. The number of the categories corresponds to the numbers of the nodes/arrows in Appendix 1. Each category operates at four levels: course, teaching organization, society, and international levels.

Category name	Definition
1. Goals and Contents	The objectives and content of a course, study module, degree program objectives, societal education goals, or international educational standards
2. Student	The attributes (such as gender, and educational level) of individualstudents, student groups, citizens, or populations from multiple countries
3. Teacher	The attributes of teachers, educational institutions, societal education structures, or international educational entities.
4. Relationship between student and teacher	Studies examining how students perceive their teachers, especiallyregarding a teacher's competence, are categorized here. Similarly, research focusing on how teachers perceive their students also belongs to this category.
5.1 Student's understanding of and attitude about goals and contents	Studies exploring students' comprehension of a key concept within a course, or their interest in a specific topic, degree program, or profession are considered in this category.
5.2 Actions (e.g. studying) student do to achieve goals	Students' actions encompass all behaviors, or the absence thereof, related to learning and attaining objectives.
5.3 Results of student's actions	The results of the educational process. For example, research examining learning outcomes from implementing a new teaching technique would fall into this category.
6. Relation between goals/contents and teacher	How teachers interpret, perceive, or value various facets of the objectives and content.
7.1 Teacher's conceptions of student's understanding of/attitude to goals/contents	How teachers perceive students' views and attitudes towards objectives and content. For instance, research examining teachers' awareness of students' comprehension of key concepts or processes.
7.2 Teacher's conceptions of students' actions toward achieving goals	Teachers' views on student behaviors, such as studying.
7.3 Teacher's didactic activities	Teachers' didactical actions, such as lecturing, creating learning environments, and assessment techniques.
7.4 Teacher's reflections on his/her own didactic actions	For example, how successful the teacher believes the new teaching method was.
8. Relation between student and teacher's didactic actions to enhance learning	Students' perceptions of the teachers' didactical actions, such asfeedback from the course.