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Trends in Research on STEM-Education-Related Areas Research in Europe (2005 – 2019)

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Trends in Research on STEM-Education-Related Areas Research in Europe (2005 – 2019)

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ABSTRACT

The article reviews science education literature from 2005 to 2019, focusing on pedagogical foci in two European publication venues. Using the Didactic Focus Categorization (DFC) method, it analyses research trends in Greece compared to broader European patterns. The study reveals that the most-studied areas are the relationship between students and learning goals, along with the influence of teachers on this relationship. However, certain areas, such as teachers' characteristics and classroom dynamics, remain underexplored. These findings highlight opportunities for further research, particularly in underrepresented areas, which could inspire new research questions and educational improvements. By identifying gaps and trends, this work contributes to a more holistic understanding of science education and encourages a more balanced approach in future studies.

Keywords: Pedagogical foci, STEM education, master's thesis, teacher education, didactic triangle

INTRODUCTION

A comprehensive understanding of educational research holds significance for researchers, educational developers, and individuals mentoring or tutoring pre- and post-graduate students. Attaining this level of knowledge requires years of systematic inquiry across various educational fields. Given the extensive nature of such research, most scholars concentrate on a specific, narrow area to develop expertise. Nevertheless, for the research community as a whole, achieving a broad and holistic comprehension of the field is a more attainable objective. This might seem obvious, but this paper raises the question of whether it truly holds.

A holistic perspective can be interpreted in different ways. It could involve content, such as whether the key concepts and topics in the domain's science are well represented in the research literature (Gul & Sozbilir, 2016). It may also address cross-cutting themes in the education of a particular domain, such as sustainability (Barth & Rieckmann, 2016), argumentation (Erduran et al., 2015), or scaffolding (Lin et al., 2012). Furthermore, it could explore the vertical dimension, which pertains to how the domain is taught across different educational levels, from pre-school to university and teacher training (Tsai et al., 2011). Additionally, it could involve different aspects of the instructional process, including the relevant actors, their interactions, and the activities they engage in. Other viewpoints could examine research conducted in different countries (Tsai & Wen, 2005; Lee et al., 2009; Lin et al., 2014), comparing educational systems and cultures, as well as whether the research investigates single classroom activities, course-level actions, or broader curriculum or national initiatives.

In this paper, the focus is on reviewing science education literature from the perspective of the instructional process. A holistic view of this process is taken by considering the most relevant actors (teachers, students, and learning goals/content) and their relationships within the didactical triangle, referred to as didactic foci. The analysis is enhanced by including perspectives on educational level, contextual scope, and research methodologies used.

Previous analyses of focus areas in science education research (SER) typically employed data-driven methods, where the categorization frameworks emerged from the data itself. Such methods reveal the topics being researched but are limited in that they only reflect what is present in the data. In contrast, this study adopts a theory-driven approach, categorizing based on a theoretical framework of the instructional process, which suggests what could or should be found. A theory-driven approach can expose gaps or neglected areas in the literature, which are often missed in data-driven analyses. Additionally, data-driven methods often group rare findings into "other" categories, treating them as unimportant. Here, it is specifically aimed to highlight these lesser-studied areas, which can lead to the development of new research questions and perspectives on the instructional process.

The methodological framework relies on the didactic triangle (Kansanen, 2003) and has been successfully used to analyse numerous research papers in computing education (Kinnunen et al., 2010), engineering education (Kinnunen & Malmi, 2013), and some areas within science education (Kinnunen et al., 2013; Kinnunen et al., 2014; Lampiselkä et al., 2017). These previous studies show that research in these fields is heavily skewed toward examining the relationship between students and learning goals/content, such as student motivation, prior knowledge, learning practices, and outcomes. Although these are crucial topics, it is concerning that other areas, such as in-service teachers' backgrounds, their relationship with students, or their views on learning and content, receive very little attention. Teachers are arguably the most critical factor in the instructional process, and gaps in this area are troubling.

The aim of this study is to build upon previous SER analyses by identifying the most and least studied didactic foci in two key European publication venues. This work extends the analysis of papers published in the Nordic Studies in Science Education (NorDiNa) journal from 2006 to 2013 (Kinnunen et al., 2016), European Science

Education Research Association conference (ESERA) (Lampiselkä et al., 2019) and Finnish and Turkish Master's theses (Oktay et al., 2024). These earlier studies revealed several intriguing trends regarding the most and least studied areas, prompting us to investigate whether similar patterns exist in Greece. Our primary research questions are as follows: *What are the popular foci of STEM education research in European countries and how do the trends differ between Finland and Greece compared to the general trend in Europe?*

The findings from this study have several potential benefits for the field. For individual researchers, this work can highlight areas with untapped potential for interesting and relevant research. The analysis framework used can also inspire new research questions by focusing on gaps or understudied areas. For instance, Kinnunen et al. (2010) applied this method to categorize research on dropout phenomena in introductory programming courses and found that most studies focused on student-related factors (e.g., student characteristics and behaviours), while neglecting other factors like the role of teachers or curriculum planning. Although this paper does not focus on specific subfields like physics, chemistry, or biology, it can be easily applied to narrower topics to identify gaps in current research and generate new research ideas. Furthermore, the results can inform educational decision-makers by identifying areas of the instructional process that deserve more extensive investigation, which could guide targeted research funding.

FINDINGS FROM THE EARLIER STUDIES

The analysis of science education research (SER) literature has been conducted using various approaches and dimensions. This section reviews relevant studies on focus areas, disciplinary trends, data collection, educational levels, and research methodologies.

Several studies have explored the key topics in SER. Tsai and Wen (2005), Lee et al. (2009), and Lin et al. (2014) examined 2,661 papers published in the International Journal of Science Education (IJSE), Science Education (SE), and Journal of Research in Science Teaching (JRST) from 1998 to 2012. They developed a categorization scheme that included topics such as teacher education, teaching strategies, student learning, curriculum evaluation, and educational technology. Their analysis revealed that the most studied areas were teaching (19%), learning contexts (37%), and student conceptions (15%). Over the 15-year period, there was a notable increase in teaching-related research, while the focus on goals, policy, and social issues declined (Tsai & Wen, 2005; Lee et al., 2009; Lin et al., 2014). Building on this work, Tsai et al. (2011) analyzed 228 papers focused on Asian students, using a modified version of Tsai and Wen's categorization. They found that studies on teaching and student learning were dominant, with no significant decrease in learning conceptions. In addition, they observed that learning contexts continued to be the most frequent focus in SER literature. More recently, O'Toole et al. (2018) reviewed ten years of abstracts from five major journals, identifying five broad categories: scientific literacy (52%), teaching methods (45%), learning focus (42%), teachers (39%), and the relationship between science and education (16%). Despite overlaps with previous studies, they found differences in trends across journals, particularly between the periods 2005–2009 and 2010–2014, likely reflecting changes in editorial policies. Cavas (2015) conducted a smaller-scale study analyzing 126 papers from Science Education International (SEI) and found that the most common topics were teacher education (23%) and student learning (20%), with lower representation for other areas such as educational technology and gender issues. All of these studies suggest that pedagogical strategies and student learning are the most researched areas in SER, whereas topics like educational technology and informal learning remain underexplored (Tsai & Wen, 2005; Cavas, 2015).

In addition to broader analyses of science education, researchers have examined specific disciplines such as chemistry and biology education. Teo et al. (2014) analyzed 650 chemistry education papers published between 2004 and 2013, finding that teaching (20%), student learning (26%), and learning contexts (19%)

were the most popular topics. They noted an increase in studies on teaching and student conceptions, with no significant differences between chemistry education journals and general science education journals. Gul and Sozbilir (2016) studied 1,376 biology education papers from 1997 to 2014. Their findings aligned with those of Teo et al. (2014), showing that learning (21%) and teaching (19%) were the most common topics, followed by studies on student attitudes and computer-aided instruction. Unlike chemistry education, biology education had a greater focus on educational technology and teaching materials. Both studies highlight the predominance of teaching and learning as key focus areas in discipline-specific education research, with educational technology receiving more attention in these fields than in broader SER analyses.

Few studies provide detailed information about the scope of data collection in SER literature. Gul and Sozbilir (2016) reported that the most common sample sizes in biology education research ranged from 30 to 100 participants (23%), with larger studies being rare. Teo et al. (2014) offered limited information on organizational units, such as whether the data came from a single course or a national survey, suggesting a lack of focus on large-scale studies in the literature.

Several studies have examined the educational levels targeted in SER papers. Gul and Sozbilir (2016) found that 34% of biology education research focused on secondary education (ISCED 3), followed by undergraduate studies (23%) and primary education (20%). In contrast, Teo et al. (2014) found that chemistry education research was more focused on higher education, with 54% of studies targeting post-secondary levels (ISCED 6-8). Tsai et al. (2011) reported that 41% of SER studies focusing on Asian students targeted secondary education, with fewer studies on primary or tertiary education. O'Toole et al. (2018) found similar results, noting that 31% of studies focused on secondary education, 18% on post-secondary education, and only 2% on early childhood education. These findings suggest that secondary education remains the primary focus in SER, with higher education receiving more attention in certain fields, such as chemistry.

Research methodologies in SER have been analyzed extensively. Tsai and Wen (2005), Lee et al. (2009), and Lin et al. (2014) found that approximately 90% of papers used empirical methods, with theoretical and review papers making up a small percentage. Gul and Sozbilir (2016) observed that 53% of biology education papers used qualitative designs, often relying on descriptive studies and case studies. Quantitative approaches were used in 43% of papers, with experimental methods accounting for a minority of these studies. Teo et al. (2014) found that mixed methods were used in over half of chemistry education papers, with qualitative and quantitative approaches being used almost equally. O'Toole et al. (2018) also reported that qualitative methods were dominant in science education research, although mixed methods were becoming more prevalent.

In summary, empirical research dominates the SER field, with both qualitative and quantitative methods widely used. However, there is a growing trend toward mixed methods approaches in certain areas, particularly in chemistry education (Teo et al., 2014). The analysis of SER literature reveals a strong focus on teaching strategies and student learning, with secondary education being the most frequently studied level. Although qualitative research dominates the field, there is an increasing use of mixed methods, particularly in chemistry education. Educational technology and informal learning remain under-researched areas, despite their potential significance in science education. Overall, these findings suggest that while certain areas of SER are well-explored, there are notable gaps that warrant further investigation.

MATERIALS AND METHOD

The research data consisted of a total of 265 research articles on physics and chemistry education research published in the Nordic Studies in Science Education (NorDiNa) journal from 2005 to 2013 (89 articles) and in the proceedings of the ESERA 2013 conference (176 articles). The articles covered didactically oriented research on biology, chemistry, and physics education.

The data collection focussed on several aspects, such as the overarching research approach, didactic foci, and educational scope, however this study focuses solely to the didactic foci. The categorization of didactic foci followed the Didactic Focus Categorization (DFC) method (Kinnunen, 2009; Kinnunen et al., 2010; Kinnunen et al., 2016; Lampiselkä et al., 2019). This method is rooted in Herbart's didactic triangle (Kansanen & Meri, 1999), which outlines the relationships between the teacher, the student, and the content to be learned (Figure 1). The DFC method involves eight primary categories derived from the core components of this triad and their interactions. In addition, subcategories are employed within two of the main categories to offer further detail and precision. These eight primary categories and their subcategories are described in detail in Table 1.

Figure 1: a) Herbart's didactic triangle. b) Didactic triangle with coding rubrics

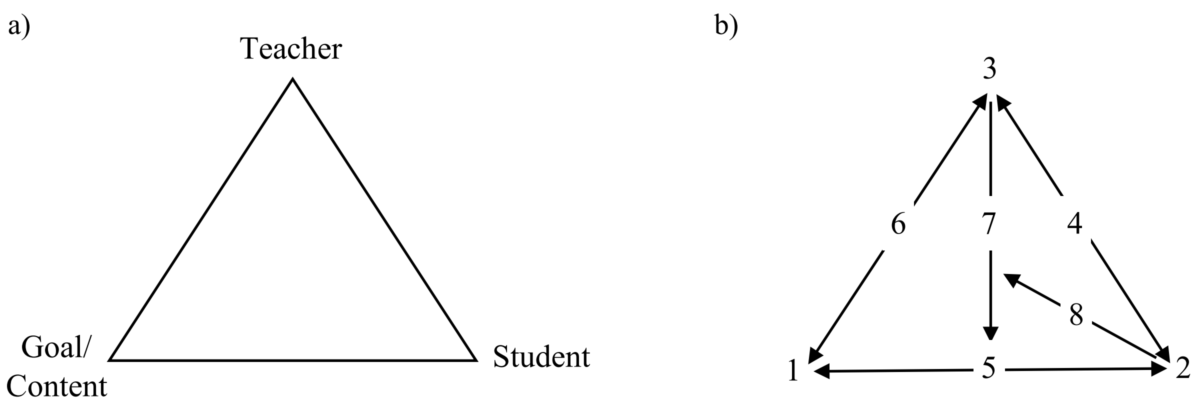

Table 1: The list of didactic foci and their definitions (Kinnunen, 2009; Kinnunen et al., 2016).

Category	Name of the didactic focus	Definition
1	Goals and content	The characteristics of the goals and/or contents of a course, study module of a degree programme. The relationship between the goals and the content in one level (course, degree, general goals of education) or between different levels.
2	Students	The students' characteristics (e.g. gender, level of education, knowledge, or prior learned skills of students). The students' relation to fellow students or the community of students.
3	Teachers	The teachers' characteristics. The interactions between teachers.
4	Relation between student and teacher	How students perceive the teacher (e.g. studies on how competent students think the teacher is) or the teacher perceives the students.
5	Relation between student and goals	The students' actions when they are striving to achieve the goals. How students perceive course goals/contents.
5.1	Students' understanding of and attitude about goals and contents	How students understand a central concept at the course or how interesting students/possible future students find the topic/degree programme/certain occupation.
5.2	The actions (e.g. studying) the students do to achieve the goals	Students' actions include all actions/lack of actions that are in relation to learning and achieving the goals.
5.3	The results of the students' actions	The outcome of the study process, e.g. a study that includes a discussion of the learning outcomes after using a new teaching method.
6	Relation between teachers and goals/	How teachers understand, perceive, or value different aspects of the goals and

	contents	contents.
7	Teachers' didactic actions	Teacher's relation to student's relation to the goals and content of a course.
7.1	Teachers' conceptions of students' understanding of/attitude to goals/ contents.	What teachers think about how students understand goals and content or what students' attitudes are towards goals and content.
7.2	Teachers' conceptions of students' actions towards achieving goals	Teachers' perceptions of students' actions (e.g. studying).
7.3	Teachers' didactic activities	Teachers' didactic actions (e.g. lecturing, providing a learning environment, and assessment methods).
7.4	Teachers' reflections on their own didactic actions	To what degree teachers think the new teaching method was successful.
8	Relation between students and teachers' didactic actions	How the students feel about the teachers' didactic actions (e.g. course feedback)

Each team member conducted a preliminary categorization independently. Following this, the analyses were compared during a pair meeting, where any discrepancies were discussed and resolved by consensus. If consensus was not reached, any discrepancies in categorization were discussed and addressed in collaborative meetings of the entire research group. Once the analyses were completed, the team reviewed the results collectively. This collaborative review process was essential in strengthening the validity and reliability of the coding.

For research papers, the number of didactic foci varied significantly. Some papers included multiple foci, with certain areas being extensively studied, while others contained only a few focal points. The research team reached a consensus to limit the analysis to a maximum of three foci reported in the results section of each paper. This decision ensured that the analysis captured the most significant and relevant themes, allowing for a comprehensive understanding of the key didactic issues addressed. Each selected focus was aligned with the framework of the didactic triangle to maintain a structured and pedagogically coherent analysis. This framework guaranteed that the chosen foci were pedagogically sound and relevant to the research. Studies that did not align with the didactic triangle, such as literature reviews or evaluations focusing solely on the technical aspects of MOOCs without considering pedagogical perspectives, were excluded from the analysis.

RESULTS

The distributions between Greece and ESRA align closely. The most commonly studied aspects were the relationship between students and content/goals (Focus 5) and the influence of teachers on this relationship (Focus 7) (see Table 2).

Table 2: Distribution of research foci in ESERA and NorDiNa compared to the distribution within the Greece data pool

								Focus							
	N (papers)	**1**	**2**	**3**	**4**	**5.1**	**5.2**	**5.3**	**6**	**7.1**	**7.2**	**7.3**	**7.4**	**8**	**Total**
Greece	16	2		1		9	2	8	1			7		2	32
ESERA*	160	11	9	6		67	19	63	18	1		71	6	18	289
NorDiNa	80	24	7	2	3	30	12	17	6	1	1	40	18	10	171
Greece		6 %		3 %		28 %	6 %	25 %	3 %			22 %		6 %	
ESERA		4 %	3 %	2 %		23 %	7 %	22 %	6 %			25 %	2 %	6 %	
NorDiNa		14 %	4 %	1 %	2 %	18 %	7 %	10 %	4 %	1 %	1 %	23 %	11 %	6 %	

*The share of Greek research papers has been subtracted from the total amount of the ESERA data pool.

The data reveals that the distributions of research foci across Greece, ESERA, and NorDiNa differ significantly. In Greece, a large portion of research focuses on the relationship between students and goals (Focus 5, particularly 5.1), accounting for 28% of the total. This is followed by a substantial focus on learning outcomes (Focus 5.3) totaling 25% and teachers' didactic actions (Focus 7, particularly 7.3), comprising 22%.

In contrast, NorDiNa have a more distributed approach across various focuses. ESERA's most prominent area of research is also the relationship between students and goals (Focus 5.1, 23%), but it is slightly more evenly spread across other categories such as teachers' didactic actions (25%) and teachers' reflections and student's feedback (8% altogether). NorDiNa shows a stronger emphasis on goals and content (Focus 1, 14%), and teachers' reflection (Focus 7.4, 11%).

The main differences in the data can be seen in specific areas of focus. Greece places a particularly heavy emphasis on the student-goal relationship (Focus 5.1) at 28%, much higher than the 23% seen in ESERA and the 18% in NorDiNa. Another notable difference is that ESERA focuses more on the relationship between teachers and goals (6%), while this area is far less emphasized in Greece (3%).

Despite these differences, all three groups share strong interest in the student-goal relationship and teachers' didactic actions, although the distribution of attention across categories varies. Greece's research is distinct in its particularly high concentration on students' understanding and attitudes towards course content (Focus 5.1) and on teachers' didactic actions (Focus 7.3). These two areas dominate Greek research far more than in the ESERA and NorDiNa datasets, reflecting a narrower focus compared to the broader scope observed in other groups. Additionally, Greece places less emphasis on topics like goals and content (Focus 1) and teachers' relationship with goals (Focus 6), which are more prominent in the other datasets.

When examining the statistics, it becomes evident that certain topics have generally been under-researched across all three groups—NorDiNa, ESERA, and Greece—while others show more variation in focus between the groups.

In general, topics related to teachers, such as teachers' characteristics (Focus 3) and the relationship between students and teachers (Focus 4), have received little attention in all three datasets. For instance, only one study in Greece (3%) focused on teachers' characteristics, a proportion similar to that in ESERA (2%) and NorDiNa (1%). The relationship between students and teachers has also been understudied, with both ESERA and Greece showing no research in this area (0%), while NorDiNa dedicated only 2% of its studies to this topic.

Another under-researched area is students' actions toward achieving goals (Focus 5.2), which is notably low in both Greece (6%), NorDiNa (7%), and ESERA. This difference suggests that too little emphasis is placed on the processes of student learning compared to the outcomes of student learning.

One of the specific characteristics of the Greek data is the strong focus on students' understanding and attitudes towards goals and content (Focus 5.1), which is significantly emphasized (28%) compared to ESERA (23%) and NorDiNa (18%). This indicates that Greece prioritizes research on students' perceptions and attitudes towards the content they are learning, a notable difference from the other groups.

Teachers' conceptions of students' understanding of contents (Focus 7.1) and teachers' conceptions of students' actions (Focus 7.2) and teachers' reflective didactic actions (Focus 7.4) are topics that have been minimally researched in both Greece and ESERA, whereas NorDiNa gives these areas some attention. This suggests that Nordic countries places more emphasis on teachers' professional development and their reflective approach to teaching, while these themes are less prominent in Greece or Europe in total.

In summary, the least studied topics are teachers' characteristics, the student-teacher relationship, and students' actions towards achieving goals. These themes show similarities across the different countries. However, Greece stands out for its strong emphasis on students' understanding and attitudes towards learning goals, while Nordic countries give more attention to teachers' reflective practices and students' learning processes.

DISCUSSION

The analysis of research focus within the data pool highlights a significant concentration on students' understanding, attitudes, learning outcomes, and the role of teachers in influencing these aspects. However, certain areas remain underexplored, such as teachers' characteristics, classroom dynamics during learning, teachers' perceptions of student actions and attitudes, student feedback to teachers, and teachers' self-reflection. These findings are consistent with previous studies in computing education (Kinnunen et al., 2010), science education (Kinnunen et al., 2013; Tsai et al., 2005), and engineering education research (Malmi et al., 2018).

The observed trend raises the question: why are some topics more extensively studied than others? While no definitive answer emerges from the current data, one plausible explanation is the influence of research policy and funding priorities. National bodies such as the Ministries of Education, National Science Academies, and National Boards of Education play a key role in shaping research agendas. These institutions may favour topics that provide immediate, actionable insights into teaching and learning, thus encouraging researchers to propose studies that align with policy needs. Consequently, less-studied areas may struggle to secure funding, even though they hold potential for further investigation (Kinnunen et al., 2010; O'Toole et al., 2018).

Moreover, it is possible that these under-researched aspects are published in forums focused more broadly on pedagogy, such as the European Conference on Educational Research (ECER). However, this explanation seems unlikely, as the same gaps are evident in both ESERA and NorDiNa publications. Furthermore, O'Toole and colleagues (2018) suggest that shifts in generational research priorities could also be influencing these trends. For instance, studies on pedagogical content knowledge (PCK), constructivism, and public understanding of science appear to be diminishing, while other topics, such as student attitudes and conceptual understanding, are gaining prominence.

These findings suggest there is ample opportunity for further exploration of less studied areas, especially as the digitalization of learning environments is transforming classroom dynamics. As highlighted by Barth and Rieckmann (2016), teachers' PCK and students' study habits are key areas that require more attention, particularly in light of evolving technological and pedagogical contexts. Additionally, research on topics such as teachers' self-reflection and classroom interactions remains sparse, offering fertile ground for future inquiry (Asshoff & Hammann, 2008; Lin et al., 2014).

In conclusion, while much research has focused on student-related aspects and teacher impact, substantial gaps remain in understanding teachers' perceptions, classroom dynamics, and the broader societal implications of educational practices. This presents significant opportunities for future research to contribute to a more holistic understanding of science education, particularly in underexplored areas such as PCK, teacher self-reflection, and large-scale studies that extend beyond the classroom (Erduran et al., 2015; Gul & Sozbilir, 2016).

CONCLUSIONS AND RECOMMENDATIONS

We recommend that authors give greater attention to ensuring internal coherence and clarity in their manuscripts. The didactic foci were not always clearly outlined, even in journal articles. While the theoretical framework might introduce several foci, the results section sometimes reports on only a subset of these, or emphasizes one focus more heavily than others. In several instances, we observed a disconnect between the title, research questions, and the actual content of the results. As a result, classification methods based solely on the title, keywords, abstract, or research questions are prone to misinterpretation. We therefore suggest a more thorough reading of the full text, which, although time-consuming, enhances the quality of the analysis.

The theoretical foundation of the Didactic Focus Classification Model (DFCM) lies in formal school education, and as such, it is most effective for illuminating the relationships between teacher, student, and content within formal educational contexts. Future developments of DFCM should aim to address informal learning contexts as well. Additionally, the resolution of the DFCM could be improved by introducing more subcategories. Currently, certain significant aspects, such as teachers' pedagogical knowledge and evaluation, do not appear in the results to the extent that their importance warrants. The evaluation component, in particular, could be highlighted more prominently.

Based on the findings of this study, it appears that science education research could benefit from being more versatile and comprehensive, as it currently overlooks some key aspects from the perspective of the didactic triangle. The polarization of research into a few select areas may not have been as apparent to the academic community prior to our study.

REFERENCES

Asshoff, R., & Hammann, M. (2008). Content analysis of the ERIDOB proceedings and its comparison to an international journal of science education. *Proceedings of the VIIth Conference of European Researchers in Didactics of Biology (ERIDOB)*, Utrecht University Press.

Barth, M., & Rieckmann, M. (2016). State of the art in research on higher education for sustainable development. In M. Barth, G. Michelsen, M. Rieckmann, & I. Thomas (Eds.), *Routledge handbook of higher education for sustainable development* (pp. 100-113). Routledge.

Cavas, B. (2015). Research trends in science education international: A content analysis for the last five years (2011–2015). *Science Education International*, *26*(4), 573–588.

Elmas, R., Demirdögen, B., & Geban, Ö. (2020). A comparative analysis of chemistry curricula: Turkey, Czech Republic, and Finland. *Journal of Curriculum Studies*, *52*(4), 569–589.

Erduran, S., Ozdem, Y., & Park, J. Y. (2015). Research trends on argumentation in science education: A journal content analysis from 1998–2014. *International Journal of STEM Education*, *2*(5), 1-11. https://doi.org/10.1186/s40594-015-0020-1

Gul, S., & Sozbilir, M. (2016). International trends in biology education research from 1997 to 2014: A content analysis of the papers in selected journals. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(7), 1631–1651. https://doi.org/10.12973/eurasia.2015.1363a

Kansanen, P., & Meri, M. (1999). The didactic relation in the teaching-studying-learning process. In B. Hudson, F. Buchberger, P. Kansanen, & H. Steel (Eds.), *Didaktik/Fachdidaktik as the science(-s) of the teaching profession* (pp. 107-116). Umeå, Sweden: Thematic Network on Teacher Education in Europe.

Kinnunen, P. (2009). Challenges of teaching and studying programming at a university of technology - Viewpoints of students, teachers and the university. Doctoral dissertation, Helsinki University of Technology, Finland, 2009.

Kinnunen, P., Meisalo, V., & Malmi, L. (2010). Have we missed something? Identifying missing types of research in computing education. *Proceedings of the Sixth international workshop on Computing Education Research* (pp. 13-22). https://doi.org/10.1145/1839594.1839598

Kinnunen, P., Lampiselkä, J., Malmi, L., & Meisalo, V. (2013). Pedagogical Aspects in Finnish Science Education Research Publications. In M. Hähkiöniemi, H. Leppäaho, P. Nieminen, and J. Viiri (Eds) *Proceedings of the 2012 Annual Conference of Finnish Mathematics and Science Education Research Association*, 8-9 Nov 2012, Jyväskylä, Finland, 153–164.

Kinnunen, P., & Malmi, L. (2013). Pedagogical Focus of Recent Engineering Education Research Papers. *Proceedins of the SEFI conference*, Leuven, Belgium 16-20 Sep 2013; SEFL, Belgium.

Kinnunen, P., Lampiselkä, J., Malmi, L., & Meisalo, V. (2014). Identifying Missing Types of Nordic Research in Science Education. In C. P. Constantinou, N. Papadouris, A. Hadjigeorgiou (Eds) *Proceedings of the ESERA 2013 Conference: Science Education Research For Evidence-based Teaching and Coherence in Learning*, 2-7 Sep 2013, Nicosia, Cyprus.

Kinnunen, P., Lampiselkä, J., Meisalo, V., & Malmi, L. (2016). Research on teaching and learning in Physics and Chemistry in NorDiNa Papers. NorDiNa, 12, 3 – 20. https://www.journals.uio.no/index.php/nordina/article/view/907

Lampiselkä, J., Kaasinen, A., Kinnunen, P., & Malmi, L. (2017). Research on teaching and learning in biology, chemistry, and physics in ESERA 2013 conference. In O. Finlayson, E. McLoughlin, S. Erduran & P. Child (Eds.) *Research, Practice and Collaboration in Science Education: Proceedings of the 2017 ESERA conference*. Dublin, Ireland: Dublin City University.

Lampiselkä, J., Kaasinen, A., Kinnunen, P., & Malmi, L. (2019). Didactic focus areas in science education research. *Education Sciences*, *9*(4), 294. https://doi.org/10.3390/educsci9040294

Lee, M.-H., Wu, Y.-T., & Tsai, C.-C. (2009). Research trends in science education from 2003 to 2007: A content analysis of publications in selected journals. *International Journal of Science Education*, *31*(15), 1999–2020. https://doi.org/10.1080/09500690802314876

Lin, T.-C., Lin, T.-J., & Tsai, C.-C. (2014). Research trends in science education from 2008 to 2012: A systematic content analysis of publications in selected journals. *International Journal of Science Education*, *36*(8), 1346–1372. https://doi.org/10.1080/09500693.2013.864428

Malmi, L., Adawi, T., Curmi, R., de Graaff, E., Duffy, G., Kautz, C., Kinnunen, P., & Williams, B. (2018). How authors did it – A methodological analysis of recent engineering education research papers in the European Journal of Engineering Education. *European Journal of Engineering Education*, *43*(2), 171-189. https://doi.org/10.1080/03043797.2016.1202905

Oktay, O., Reisoglu, I., Gul, S., Teke, D., Sozbilir, M., Gunes, I., Yildiz, R., Atila, G., Yazar, A., Malmi, L., Kinnunen, P-, Lampiselkä, J. & Kaasinen, A. (2024). A comparative analysis of master's theses in STEM-related disciplines published in Türkiye and Finland. Scandinavian Journal of Educational Research, 1–29. https://doi.org/10.1080/00313831.2024.2360898

O'Toole, J. M., Freestone, M., McKoy, K. S., & Duckworth, B. (2018). Types, topics, and trends: A ten-year review of research journals in science education. *Education Sciences*, *8*(2), 73. https://doi.org/10.3390/educsci8020073

Sözbilir, M., & Gul, S. (2012). Science education in Turkey: An analysis of student understanding and achievement. *Science Education International*, *23*(3), 207-222.

Teo, T. W., Goh, M. T., & Yeo, L. W. (2014). Chemistry education research trends: 2004–2013. *Chemistry Education Research and Practice*, *15*(4), 470-487. https://doi.org/10.1039/c4rp00104d

Tsai, C.-C., & Wen, M. L. (2005). Research and trends in science education from 1998 to 2002: A content analysis of publication in selected journals. *International Journal of Science Education*, *27*(1), 3–14. https://doi.org/10.1080/0950069042000243727