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STEM Teachers' Motivation and Engagement in Teacher Professional Development and Career Advancement: A Case Study of Lithuania

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Abstract: The demand for science, technology, engineering, and mathematics (STEM) skills has been consistently increasing due to technological advancements and globalization, making STEM education and teacher training a critical priority. Although many national and international initiatives have been implemented to strengthen STEM education and raise the attractiveness of the teaching profession, a shortage of teachers in general, and STEM teachers in particular, is still evident across Europe. This study aimed to identify factors contributing to attracting existing and potential teachers to careers in STEM education. Qualitative research methods were employed to study teachers' perceived motivation, challenges, and suggestions regarding STEM teachers' careers, competence, and collaboration development. The study revealed that the practical application of competence development initiatives significantly motivates STEM teachers, emphasizing the importance of aligning professional development with classroom implementation. These results emphasize the importance of prioritizing practical, classroom-oriented professional development and fostering a culture of collaboration in educational institutions.

Keywords: STEM education; teacher professional development; shortage of teachers; career advancement; teacher motivation

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Citation: Juškevičienė, A.; Jevsikova, T.; Stupurienė, G.; Vinikienė, L. STEM Teachers' Motivation and Engagement in Teacher Professional Development and Career Advancement: A Case Study of Lithuania. *Educ. Sci.* **2024**, *14*, 780. https://doi.org/10.3390/educsci14070780

Academic Editor: Andrea Nolan

Received: 12 June 2024
Revised: 11 July 2024
Accepted: 12 July 2024
Published: 17 July 2024

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1. Introduction

Science, technology, engineering, and mathematics (STEM) education integrates rigorous academic concepts with real-world applications and real-world challenges from diverse perspectives, fostering creativity and problem-solving skills across science, technology, engineering, and mathematics disciplines [1,2], promoting innovative, inclusive education for social equality and sustainable development. Teachers play the most important role in the successful implementation of STEM education. The professional development of STEM teachers has become a hot topic in educational research. However, according to the Education and Training Monitor's report [3], the widespread issue of teacher shortages, influenced by factors such as demographics, subject specialization, and geographic location, is expected to intensify. Challenges include understaffing in disadvantaged areas, a lack of STEM educators, and a scarcity of male teachers at lower education levels.

In today's world, there is a major challenge in keeping teachers motivated to continually update their teaching skills and methods to better align with current educational needs. This motivation involves feeling empowered and autonomous, avoiding a sense of isolation or stagnation, and being able to recognize one's strengths while also developing new competences to enhance the professional experience. In addition, policy priorities concerning teachers' careers should be addressed by rethinking career structures and guidance, empowering teachers to navigate the career system effectively [3].

To tackle these challenges, an initiative (3C4Life initiative's website, https://icse.eu/international-projects/3c4life/, accessed on 11 July 2024) was started to promote the attractiveness of the STEM teaching profession, and introduce a digital platform designed by the 3C4life consortium to enhance teachers' motivation toward collaboration, competence development, and career progression. This platform stands out with key features such as motivational triggers, multi-directional pathways for teaching careers, and elements supporting cooperation and community building among teachers. The initiative focuses explicitly on the causal link between the motivation of STEM teachers in occupational advancement programs and three innovative features of the digital platform (career, competence, and collaboration). The analysis made by the consortium of this initiative suggests that when STEM teachers are given various motivational cues one after the other, they become more involved in programs to advance their careers. Different ways of looking at progress also help them feel more motivated to shape their teaching paths. Moreover, certain features that help build communities increase the number of teachers who take part in the community of practice.

Therefore, exploring the factors that motivate is crucial, as a deep understanding of what drives individuals will undoubtedly propel progress in teaching, from being merely an occupation to a true profession [4]. By delving into the underlying factors and other influential characteristics that impact the professionalization of teachers, we can provide the necessary support and facilitation. This, in turn, empowers teachers to actively pursue continuous professional development (PD) and fosters an environment that encourages their professional growth.

In addition to exploring factors that motivate teachers toward PD initiatives, it is imperative to recognize the significance of teachers' profiles for tailoring PD programs and support mechanisms. This tailored approach caters to their unique needs and strengths, ultimately enhancing both teacher effectiveness and student achievement. The literature encompasses various components within teachers' profiles, including personal characteristics such as age, socio-economic status, cultural and moral background, along with professional traits like expertise, experiences, commitment, collaboration, role perception, awareness, sensitivity, and satisfaction. Additionally, process-related characteristics like voluntary and effective participation, belief and trust, expectations, and openness to innovation and change are also integral aspects [5]. In the study conducted by Sancar et al. [6], various approaches to teacher PD, such as mentoring, lesson study, and action research, were explored. These investigations underscored the significance of crafting PD initiatives that are not only relevant and engaging but also foster collaboration. Furthermore, incorporating teachers into decision-making processes and offering avenues for leadership and career progression can enhance motivation and job satisfaction.

According to the research by Marín Blanco et al. [7], the main factors were identified as being complex, interrelated, and influential in developing and exacerbating teacher shortages in different educational contexts and were divided into three categories with specific parameters and indicators: (1) education policy (reforms); (2) attractiveness of the teaching profession (de-professionalization; work conditions; status of the profession); (3) the changing landscape of teaching (new perspectives of the teacher; teacher training guidelines; teacher perceptions).

The literature acknowledges the importance of tailoring PD programs to meet the unique needs and strengths of individual teachers. However, there is limited research exploring how to effectively design and implement tailored support mechanisms for diverse teacher profiles. Factors such as age, socio-economic status, cultural background, and professional traits significantly influence teachers' receptiveness to PD initiatives. Further research is needed to identify specific strategies for customizing PD programs based on teachers' personal and professional characteristics, to maximize their effectiveness and promote sustained engagement in STEM education. To address this gap, this study aimed to identify factors contributing to attracting existing and potential teachers to careers in STEM education. Recognizing these success factors can aid in mitigating teacher shortages

by enhancing job satisfaction and teacher legitimacy, potentially drawing former teachers back to the profession.

2. Background and Theoretical Framework

2.1. Context of the Study

In Lithuania, the situation is similar to that of other European countries. The country report [8] referred to a significant shortage of 2000–3000 teachers (from early childhood and care to upper secondary school) in 2025, citing demographic trends, education policies, and the socio-economic situation as determining factors. Both initial teacher education and continuous PD programs were identified as inadequate for equipping teachers with the necessary competences [9]. One of the objectives of the National Progress Plan 2021–2030 [10] is to move towards sustainable economic development based on scientific knowledge, advanced technologies, and innovation and to increase the country's international competitiveness. To increase employment in the tech sector of professionals competent in these fields and to prepare them, it is important to strengthen STEM education in schools and raise the profile of these subjects. The comprehensive approach to STEM education in Lithuania involves national, local, and school-level initiatives, creating a dynamic and collaborative environment for the development of various competences [11].

However, the opportunity to be a competent STEM educator is not enough to make teaching attractive. Teaching is no longer a career choice for many reasons, including low pay and limited career development. It has to be taken into account what challenges teachers face, what their expectations are, and what motivates them to choose the teaching route.

2.2. 3Cs for Teachers—Collaboration, Competence, and Career

As noted above, Europe is experiencing a shortage of teachers, particularly in STEM education [3,12]. A major factor identified for this shortage is that educators no longer see teaching as an attractive career choice [13]. As a result, this trend is leading to higher rates of teacher attrition [14]. To increase the attractiveness of the teaching profession, the following criteria can be outlined: (1) It is crucial to cultivate a favorable perception of the teaching profession among both educators and society [12]; (2) Teaching should be recognized as a lifelong journey of growth involving innovative pedagogical methods [15]; (3) Encouraging collaborative practices and establishing professional learning communities [16].

Teachers need continuous support from the outset and throughout their careers to facilitate their professional development [12,17]. However, significant gaps remain that need to be addressed: (1) Career guidance for teachers is scarce across Europe [12]; (2) Teachers often fail to recognize the importance of developing teamwork skills [18]; (3) Teachers are struggling to implement new instructional strategies [6].

It is important to give teachers information on career options, to encourage reflection on career development, and to support the development of peer networks [19].

Based on the above literature and the experience of the partners in the 3C4life consortium, three main areas were identified to be covered by the designed platform:

1. Collaboration: Promotes collaboration among STEM stakeholders, fostering cooperative efforts among relevant parties within the national educational landscape.
2. Competence: Assists STEM educators in cultivating the necessary skills for success, emphasizing the ongoing enhancement of modern teaching and leadership abilities to ensure educators stay current and equipped with pertinent competences.
3. Career: Offers thorough career counseling for STEM educators, covering both vertical and horizontal career paths and providing comprehensive guidance for their careers.

2.3. Teachers' Motivation and Challenges

As mentioned before, teachers' motivation to learn plays an important role in teachers' professional growth and successful development as educators [20]. Research on teacher motivation has primarily been within the domain of educational psychology, focusing on quantitative assessments and distinguishing teachers' motivation from their professional

learning efforts [21]. Some studies have suggested that teachers' personal and psychological factors, along with their perceptions of school workplace conditions, can significantly impact their motivation to engage in professional learning activities [22].

From the perspective of motivation to learn, Appova and Arbaugh [23] argued that while teachers' active and collective participation in PD is crucial, the depth, meaning, and applicability of new knowledge, as well as teachers' ability to transfer and apply it immediately in their classrooms, are key aspects of the teacher learning process. These authors also identified seven categories for teachers' motivation to learn: (1) to influence students and their learning; (2) to learn with/from other teachers; (3) to become a 'better' teacher; (4) to fulfill PD requirements; (5) to constantly seek and engage in learning as a 'habit'; (6) to gain knowledge about topics of teachers' own interests; (7) to pursue further learning if funds, time, and resources are available.

In a study by Zhang et al. [24], teachers' motivation to participate in continuous PD was related to factors at the personal and school level. Factors such as teachers' prior experience, teaching experience, self-efficacy, beliefs about learning, emotional pressure, and principal leadership had an impact on teachers' motivation toward professional learning. To enhance teachers' motivation to learn, greater emphasis should be placed on their past learning encounters. Professional development initiatives could be meticulously crafted to align with teachers' specific needs, fostering individualized learning paths that may prove more engaging and impactful compared to a one-size-fits-all approach.

On the other hand, it is important to highlight the challenges that teachers face in implementing STEM education. As identified by Hamad et al. [25], the seven main challenges include (1) insufficient competence to teach; (2) insufficient expertise to teach using interdisciplinary methods; (3) lack of guidelines; (4) insufficient resources; (5) overloaded teaching demands; (6) lack of supportive school culture; and (7) limited collaboration between teachers from different related disciplines. In addition, external challenges (such as lack of guidelines) have a greater impact than teachers' competence (in particular, having adequate knowledge and skills to implement STEM education).

In other research by Haesen and Van de Put [1], the authors identified challenges faced by teachers that hinder the effective integration of STEM in classrooms: (1) classrooms become overcrowded and challenging to manage; (2) the substantial nature of science content makes it difficult to adopt the STEM approach due to time constraints; and (3) teachers lack the necessary expertise to instruct using the STEM approach.

2.4. The Aim and Research Questions of the Study

It is important to develop a better understanding of how to improve teachers' motivation toward collaboration, competence development, and career progression. This focus is driven by the existing literature, which underscores the importance of capturing nuanced teacher perspectives to fully grasp the challenges and aspirations associated with the teaching profession. In line with this, this study aimed to investigate teachers' attitudes towards STEM career development, competences, and collaboration by answering the following research questions.

RQ1: What are teachers' perceived motivations, challenges, and suggestions for STEM education across the three different areas: career, competence, and collaboration?

RQ2: How do teachers' perceived motivations, challenges, and suggestions in these three areas vary depending on the teachers' profiles?

3. Methods

The research focused on gaining a broader understanding of teachers' perceptions of career paths, competence development, and peer collaboration in STEM education. A case study was implemented through semi-structured interviews and open-ended questions directed at diverse teachers involved in STEM education. Both qualitative and quantitative data analyses were employed for the collected data. Interview data were processed by

applying a combined deductive and inductive thematic analysis. Descriptive statistics were used for quantitative data derived from qualitative data.

3.1. Instruments

For this study, an instrument consisting of two parts was used:

1. A socio-demographic data questionnaire consisting of 4 short questions (date of birth, gender, name of educational institution) and 11 open-ended questions regarding the teacher's profession, teaching experience, and career path was used.
2. Semi-structured interview questions: 27 preliminary questions, grouped into three sections on career, competence development, and collaboration; 5 questions were related to teachers' general experiences on career development, barriers to competence development, challenges in teacher collaboration, best professional practices, and wishes for collaboration improvements; 3 questions on general experiences with the STEM platform being discussed; 7 questions related to teachers' career pathways; 5 questions related to motivation in competence development; 7 questions on collaboration with peers.

Interview questions were initially designed to gain a better understanding of how the key features of a recently developed online platform for STEM teachers (teach4life) have contributed to improving teachers' motivation and engagement in teacher PD, career advancement, and their willingness to cooperate with peers. The interviews were organized around a discussion about the teachers' experiences on the aforementioned platform. However, the interview questions naturally directed teachers to share their general experiences in STEM education, to better learn what motivates teachers and what their barriers and improvement suggestions are. This was the main focus of our study. Therefore, the interview materials in our study were used to obtain a deeper understanding of the challenges teachers face, what motivates them, and what suggestions they can make based on their experiences in general.

The instruments and interview protocol were designed and validated by an international community representing a multidisciplinary research team: STEM educators, computer scientists, and educationalists from six universities. The translations of the instruments were validated by five experts, including three authors of this paper.

3.2. Participants and Data Collection

This study aimed to showcase both typical developments and extraordinary cases. The selection aimed to capture a range of experiences and perspectives, contributing to the richness of the collected data. Therefore, a group of educators were selected as participants, representing diversity in (1) levels of education; (2) specializations; (3) teaching experience; (4) age; and (5) tendencies in career paths. In total, five participants were selected for the study to represent the case of Lithuania. The interviewed teachers represented different cases in terms of age, teaching experience, and tendencies in career paths (see teachers' profiles in Table 1, where each participant is denoted by the code ID1–ID5). Table 1 summarizes the educators' responses to the socio-demographic data questionnaire described above.

After the five teachers for the individual cases had been selected, the educator's background information (socio-demographic questionnaire) was collected. Participating teachers gave comprehensive insights into the research questions during Spring 2023. Interviews were conducted online using the MS TEAMS platform, and audio and video were recorded. On average, interviews lasted for 48 min (ranging from 35 to 80 min, depending on the particular case). Interviews were performed by Author 1 and Author 2 of this paper. After carrying out the interview, the recordings were carefully transcribed for further analysis.

Table 1. Teachers' profiles (the educators' responses to the socio-demographic data questionnaire).

	ID1	ID2	ID3	ID4	ID5
Current position/specialization	Teacher of informatics	Teacher of informatics and robotics	Teacher of design and technology	Methodologist of a STEM center	Teacher of informatics and math, University lecturer, Ph.D. student
Overall teaching experience (years)	30	>40	16	20	5
Teaching duration in current institution (years)	25	2	16	2	3
Gender	Female	Female	Male	Female	Female
Age	53	60	37	44	41
Other teachers in the family	No	No	Yes	Yes	Yes
Other teachers in the family	No	No	Yes	Yes	Yes
Reported reason for being a teacher	Shortage of teachers in rural areas.	Liked math at school and later programming. She was inspired by teaching children in programming clubs.	In his final year of pedagogical studies, he was invited to join the "I choose to teach!" program. There's a teacher aunt in the family.	She loves children and is also inspired by her brother, who is a teacher.	While working in an IT company, she realized that she could pass on her knowledge to younger people.
Career path and plans for the future	Teaches pupils of ages 11–15. Currently, she works at a lower secondary school as a teacher and part-time as an engineer, teaches robotics in non-formal education, and works in special education programs. No plans for a career change.	Graduated in applied math. Has taught for 2 years at an upper secondary school with special attention to sciences and robotics modules. Involved in managing the e-diary and organizing exams. Plans include working with students interested in programming and robotics.	He has been a teacher at his current school for 16 years. He has also worked in other schools. Apart from being a teacher, he is an event decorator, as well as a print designer and layout designer, as well as a teacher consultant for the "Choose to Teach!" program.	She has worked as a teacher in a primary school, high secondary school, vocational education center, and at the University of the Third Age. Conducts training for teachers. She is a methodologist and consultant at the STEM Centre.	Has been a teacher for 5 years. Her school focuses deeply on children's emotional needs. She previously worked as a teacher in a programming school. As a university lecturer, she teaches PD courses.
Objectives as a teacher	Help students to achieve general education standards by planning and delivering high-quality informatics lessons.	Combine students' new knowledge with what they have already learned and apply what they have learned.	To offer learning opportunities for creativity, noticing details and aesthetics in the environment and life. To be an example of initiative and social action.	Provide students with correct and targeted information.	Give the students knowledge that will be useful in the future.

Table 1. *Cont.*

	ID1	ID2	ID3	ID4	ID5
Teaching principles	Enable the student to develop, acquire, and apply knowledge and develop the patience to implement projects through to completion.	Mutual respect and collaboration.	Honesty, choice, responsibility for one's own attitudes and actions, respect for initiative and creativity.	Not being afraid to make mistakes, search, create and share.	Build a relationship with your students.

3.3. Data Analysis

The interview data underwent thorough qualitative analysis involving coding and categorization. The primary analytical approach to analyzing qualitative data was thematic analysis as a method for identifying, analyzing, and reporting patterns (themes) within qualitative data [26]. The thematic analysis aimed not only to summarize the data but also to identify and interpret key aspects, guided by the research questions of the study [27]. Thematic analysis is valued for its flexibility, capacity for generating insights, ability to identify patterns and trends, data-driven nature, transparency, integration with theory, and practicality [26]. This involved identifying patterns and recurring motifs in the participants' responses. After carefully reading the interview transcripts, a coding process was conducted to identify and categorize recurring themes. The interview data of this study were analyzed using a hybrid approach to thematic analysis, incorporating both top-down (deductive) and bottom-up data-driven (inductive) approaches [28].

First, coding was implemented using a priori themes (career, competence, collaboration) and primary categories (motivation, challenges, suggestions) driven by the aims of our study and research questions. In addition, the predefined categories were enriched with subcategories substantiated by the data, following an inductive process of coding. To ensure robustness and enhance reliability in the data analysis, the coding was conducted utilizing the MAXQDA Analytics Pro ver. 2022 software package.

To deal with the subjectivity of the coding process, several phases of validation were performed. A sample of 40% of the interviews (N = 2) was coded independently by the two coders. Then, an intercoder reliability check was performed (Cohen's Kappa = 0.24, 90% overlapping rate), and the process of peer debriefing employed discussions with colleagues to validate the interpretation and analysis processes. Three experts discussed the interviews coded, including every code and the context of questionable issues, and agreed on the revisions. The overall agreement was K = 0.42 (90% overlapping rate), classified as moderate [29]. Finally, the process of coding was performed with the full interview sample (N = 5). An intercoder reliability check was conducted using the MAXQDA tool for intercoder agreement at a coded segment level.

The focus of our study was on distilling key insights in relation to the factors that influence motivation, the challenges that are faced, and the strategies that are proposed to promote effective collaboration, teachers' competences, and career development.

4. Results

4.1. Predefined and Derived Categories

Based on a hybrid approach to thematic analysis, the data were coded according to the three defined themes, categories, and subcategories derived from the data. Table 2 summarizes the defined subcategories identified from the teachers' answers, frequencies, and percentage of mentions.

Table 2. Teachers' profiles (the defined subcategories identified from teachers' answers, frequencies, and percentage of mentions).

Theme	Category	Subcategory (ID)	Freq	Total	%
Collaboration	Suggestions	Create opportunities for educators to connect (COL_S1)	34	82	16%
		Encourage educators to share their resources and ideas (COL_S2)	19		
		Support educators, especially those who are experimenting with new teaching methods (COL_S3)	9		
		Share resources (COL_S4)	20		
	Motivation	Stay up-to-date on the latest research (COL_M1)	7	38	8%
		Learn something new (COL_M2)	26		
		Reduce stress and burnout/Support (COL_M3)	5		
	Challenge	Time constraints (COL_C1)	8	37	7%
		Communication barriers (COL_C2)	10		
		Trust and respect issues (COL_C3)	11		
		Distance communication (COL_C4)	8		
Competences	Suggestions	Embrace lifelong learning and continuous professional development (COM_S1)	4	32	6%
		Integrate new concepts and approaches into teaching practices (COM_S2)	19		
		Engage in collaborative learning communities (COM_S3)	9		
	Motivation	Contribute to the advancement of STEM education (COM_M1)	1	77	15%
		Gain personal satisfaction and professional growth (COM_M2)	9		
		Spark students' curiosity (COM_M3)	13		
		Get feedback (COM_M4)	8		
		Application for lessons (COM_M5)	24		
		Explanation of the topic (COM_M6)	12		
		Non-standard examples (COM_M7)	6		
		Visual attractiveness (COM_M8)	4		
	Challenge	Ability to adapt (COM_C1)	48	89	18%
		Time limits (COM_C2)	11		
		Need for practical experience (COM_C3)	14		
		Disappointment and burnout (COM_C4)	16		
Career	Suggestions	Provide comprehensive career guidance (CAR_S1)	21	43	9%
		Promote networking and mentorship opportunities (CAR_S2)	4		
		Highlight career development resources (CAR_S3)	18		
	Motivation	Personal satisfaction (CAR_M1)	12	46	9%
		Making a positive impact on students (CAR_M2)	12		
		Continuous learning and professional development (CAR_M3)	13		
		Inspiration (CAR_M4)	9		
	Challenge	Perception of limited career advancement (CAR_C1)	4	53	11%
		Lack of awareness of diverse career trajectories (CAR_C2)	9		
		Limited support for career development (CAR_C3)	15		
		Balancing work–life responsibilities (CAR_C4)	18		
		Need for practical experience (CAR_C5)	7		

4.1.1. Categories and Subcategories Associated with Collaboration

Under the suggestions category within the collaboration theme, the teachers universally emphasized the importance of connecting availability (COL_S1). Four teachers stressed the significance of resource sharing (COL_S4) and encouragement to share (COL_S2). Teachers advocated for various collaborative initiatives such as hackathons and

teacher camps to develop and exchange teaching methods, fostering consistency in content delivery across schools (ID4). They suggested platforms with features like forums, threaded discussions, and "Idea Auctions" to facilitate idea generation and discussion (ID3, ID4). Additionally, teachers expressed a need for real-time communication support, proposing features such as chat functionality or chatbots (ID3), and emphasizing the importance of an easy-to-use platform tailored to teachers' needs, including practical resources and a sense of community (ID3). However, support for teachers (COL_S3) was less frequently mentioned, with only one suggestion regarding international projects as avenues for collaboration and innovation in education (ID2).

Within the motivation category, all respondents highlighted the opportunity to learn (COL_M2) through collaboration. The teachers also provided insights into different aspects of collaboration motivation, including the use of forums and social networks for emotional support (COL_M3) (ID4), and the importance of moral support in integrating innovative teaching methods (COL_M1) (ID1).

In terms of challenges, four respondents mentioned communication barriers (COL_C2), particularly regarding different communication styles and professional jargon (ID5). Additionally, teacher ID5 thought that "cooperation is about sharing experiences and views <. . .> you are limited to your own subject and you don't improve if not sharing <. . .>". Three respondents highlighted issues of trust and respect (COL_C3) in collaboration, including concerns about intellectual property and fairness (ID2, ID1, ID4). The subcategory of time constraints (COL_C1) was mentioned less frequently but consistently emphasized by all participants, who stressed the challenges of allocating time for collaboration amidst daily activities and administrative tasks (ID4–5). Time constraints may also limit opportunities for knowledge exchange, as some teachers prioritize individual experiences over open sharing (ID5).

4.1.2. Categories and Subcategories Associated with Competence

Within the competence theme, the challenge of adaptability (COM_C1) emerged as a key concern for all respondents. Teachers highlighted the constant changes in STEM education, driven by ongoing reforms, which demand continuous adaptation and may lead to feelings of obligation and restriction (ID5, ID2). The multidisciplinary nature of STEM education requires educators to seamlessly integrate various subjects, emphasizing the need for versatility (ID4). Some teachers struggle with integrating technology into their lessons, feeling overwhelmed by time constraints (COM_C2), disappointment, and burnout (COM_C4), due to the pressure to keep up with developments and limited resources. Teachers also expressed difficulty in finding suitable instructional materials for STEM subjects (ID1, ID5).

In terms of motivation for competence development, the desire to find practical applications for the classroom (COM_M5) was highlighted by all respondents. They emphasized the importance of selecting examples from diverse fields to demonstrate real-world applications of concepts (ID5). Half of the mentions for motivation subcategories focused on sparking students' curiosity (COM_M3) through innovative teaching methods and providing relevant real-world contexts (COM_M6), essential for effective teaching and student comprehension. Different interviewees highlighted the importance of varied teaching methods (ID1), engaging students through hands-on activities (ID2), and the challenge of finding relevant and comprehensible resources, especially in areas like engineering (ID3).

The most common suggestion from all participants was the opportunity to integrate new concepts and approaches into teaching practices (COM_S2). Teachers stressed the importance of selecting examples from different areas to demonstrate interdisciplinary applications (ID5) and suggested incorporating current events or forum discussions related to ongoing education reforms to keep content relevant and engaging. Additionally, an "idea auction" was proposed, allowing teachers to share and discuss different approaches to teaching, with an emphasis on providing guidance and resources to support this new approach (ID4).

4.1.3. Categories and Subcategories Associated with Career

Interview results on career development highlighted various elements. Four respondents emphasized the challenge of balancing responsibilities and activities (CAR_C4), stating that "collaboration should occur during relevant working hours" (ID5). The teachers appreciate information about non-traditional career paths within education, such as project leadership or positions in higher education (ID5). Limited support for career development (CAR_C3) was another frequently mentioned subcategory, highlighted by four respondents.

In the motivation category, the teachers stressed the importance of continuous PD and opportunities (CAR_M3) for skill enhancement, appreciating platforms or programs that offer resources for improving teaching methods and expanding knowledge. The need for inspiration (CAR_M4) in their careers was mentioned by four respondents, who provided instances of passionate educators and successful career trajectories.

Four teachers appreciated clear pathways for career progression and guidance (CAR_S1) within the education sector in the suggestion category. They highlighted the role of comprehensive career guidance in facilitating informed decision-making and increasing engagement among educators (ID2–5). The participants emphasized the importance of interactive platforms that provide insights into various career paths, qualifications, and opportunities for PD. Clear explanations of competency levels, qualification requirements, and examples of relevant activities were deemed essential for educators to navigate their career paths effectively (ID2, ID3). They valued structured information and resources (CAR_S3) about career options, qualifications, and advancement opportunities: ". . .material <. . .> structured so that I can see how I'm career oriented and <. . .> (ID2).

4.2. Variations in the Identified Categories According to the Profiles of the Teachers

This section presents results on how the predefined and derived categories varied depending on the teachers' profiles. Figure 1 summarizes the frequencies of the identified segments in every teacher interview.

As mentioned before, a framework by [6] was adopted for profile categorization: professional, personal, and process-related. In our study, personal characteristics included age, gender, personal reasons for being a teacher, professional teaching experience, and process-related characteristics, including career path and plans for the future.

4.2.1. Professional Characteristics: Teaching Experience

The respondents' teaching experience ranged from 5 to over 40 years, indicating varying levels of expertise and seniority. The teachers could be classified into three groups based on experience: veteran teachers, with over 30 years of experience (ID1, ID2); experienced teachers, with 10 to 29 years of experience (ID3, ID4); and novice teachers, with 0 to 9 years of experience (ID5).

All respondents stated student-centered objectives, aiming to help students meet educational standards through well-prepared lessons integrating new information, encourage creativity, attention to detail, and aesthetic appreciation, and providing accurate and relevant information for students' future endeavors. However, only veteran teachers mentioned students' positive impact and sparking curiosity, suggesting their deeper understanding of fostering student motivation.

Regarding collaboration, more experienced teachers tended to discuss motivation and provide advice for fostering collaboration, while novice teachers evenly discussed all aspects. For competence improvement, veteran teachers mentioned challenges and motivating factors, while experienced and novice teachers mentioned all categories almost equally. In career development, all teachers expressed their views with similar frequency.



Figure 1. Frequencies of identified segments per teacher (MAXQDA code matrix).

4.2.2. Personal Characteristics: Age, Gender, and Reason for Being a Teacher/Personal Intentions

The teachers' motivations for entering the profession varied, but all shared a commitment to making a difference in students' lives and contributing to education. For example, ID1, a veteran teacher, was driven by a shortage of teachers in her area. Experienced teachers were inspired by personal experiences or influential individuals, such as family members or mentors (ID3, ID4). Each teacher identified a need or opportunity within education that aligned with their interests or skills, whether it was a passion for IT skills development (ID5) or a love for fostering learning (ID2, ID4). The youngest respondent, ID3, was the only male participant in the survey and emphasized collaboration in his responses, suggesting diverse proposals and opportunities for educators to connect. Interestingly, although he did not mention student influence as a motivator in his interview, he did so in a questionnaire. Notably, ID3 lacks a background in computer science, unlike the other respondents who have taught the subject. It is also unsurprising that the oldest respondents are the most experienced teachers.

4.2.3. Process-Related Characteristics: Career Path and Plans for the Future

Despite potential career changes, all teachers expressed a deep commitment to teaching, emphasizing direct student interaction. In collaborative efforts, teachers (ID1–5) stressed resource sharing and advocated for platforms facilitating idea exchange. Motivation stems from learning opportunities and emotional support, although challenges such as communication barriers and time constraints persist for all teachers; additionally, within competence development, adaptability remains a central concern for all teachers, alongside motivation driven by practical applications and student engagement. Suggestions for improvement, as proposed by ID4 and ID5, included integrating new teaching approaches and interdisciplinary concepts, emphasizing guidance and resource support.

5. Discussion

This study examined teachers' attitudes toward STEM career development, competences, and collaboration and how perceived motivations, challenges, and suggestions in these three areas differed across teacher profiles. The interpretation and elaboration of the main findings through the lens of motivation, challenges, and suggestions are presented first, followed by implications for practice, limitations, and future research directions.

5.1. What Motivates STEM Teachers to Succeed in Their Profession?

Investigating motivating factors is important to understand what drives teachers to perceive their teaching not just as an occupation but as a true profession [4] and to provide implications for practice. Adoption of educational innovations relies on teachers' motivation to develop their professional competences and to transfer this learning into the class [30].

Our study revealed that teachers are motivated by the possibility of practical application of competence development initiatives (this was the most common motivation subcategory in the competences area), which is deeply rooted in the belief that a connection between the classroom and real-world scenarios and applications enhances the learning experience. This closely aligns with the conclusion stated by, e.g., Khasawneh [31] that integrating practical, real-world scenarios into learning environments enhances the learning experience by providing meaningful contexts for skill development and application, as well as the importance of teacher engagement with STEM as both learners and teachers [32]. The applicability of new knowledge and teachers' ability to transfer this to their classrooms are key aspects of the teacher PD process [23].

The findings of this study suggest that teachers are mostly motivated to collaborate by the perceived necessity to stay up-to-date, which can be categorized as an identified motivation according to self-determination theory [33]. Data collection for this study was carried out during the curricular reform period in Lithuania. Since the school year

2023–2024, new curricula have been introduced, and teachers are required to learn and adapt their practices to the policy. Policies and development programs were identified as one of the motivating factors for teacher collaboration in a systematic review by Kolleck [34].

The most experienced teachers in our study saw their motivation in interactions with students, positive impact, and the sparking of students' curiosity. They tended to have a deeper understanding of the significance of fostering motivation in students and creating a supportive and caring classroom environment, which plays a crucial role in enhancing student motivation to learn [35] and their achievements [36]. Interestingly, the literature indicates that job satisfaction increased with experience, e.g., in Latiff et al. [37], and in our study, teachers with extensive teaching experience indicated personal satisfaction as motivation for competence development.

Teachers who prioritize student-centered approaches, as evidenced by their goals of helping students meet educational standards through well-prepared lessons, fostering creativity, and serving as role models for initiative and social engagement, are likely to contribute to the creation of a supportive and caring classroom environment [38], because such teachers focus on individual student's needs and encourage creativity and engagement, leading to positive relationships and mutual respect between teachers and students [5]. This environment, in turn, can enhance student motivation to learn, leading to increased engagement, effort, and persistence in the face of challenges.

5.2. What Challenges Do STEM Teachers Face?

Communication barriers and trust issues hinder educators' collaboration, impeding the sharing of teaching materials and resources [39]. Developing a culture of open communication and mutual respect is crucial for effective collaboration [39]. Collaboration is essential in STEM education but often overlooked by teachers [25]. According to other studies, teachers frequently overlook the significance of developing teamwork skills [12,18]. Teachers benefit from acknowledging the advantages of collaboration, leading to strategies for overcoming challenges [40]. Fostering teacher collaboration and professional development aids in developing diverse teaching practices [41]. Our findings align with the literature regarding the main challenge perceived by teachers in the competence area: the constant need for adaptation. Haesen and Van de Put [1] also found difficulties in adopting the STEM approach, due to time constraints and the substantial nature of science content. This highlights the ongoing struggle educators face in navigating the dynamic field of STEM education and underscores the importance of adaptability for teacher competence development. Additionally, the necessity for support in developing digital competences, especially in the context of STEM education, is evident, as emphasized by Bybee [42]. This convergence between our findings and the existing literature emphasizes the persistent challenges educators encounter in keeping pace with advancements and effectively integrating new concepts. Teaching should be treated as a lifelong journey of growth [12,15]. Teachers stress the importance of time management issues and being adaptable, especially when juggling multiple roles across different schools or areas. They find it tough to balance their work and personal lives, as advancing in their careers often demands more time and effort. Some of our study participants were interested in exploring unconventional/non-traditional career paths within education. Nevertheless, they felt there is not enough support available for their career development, such as mentorship programs. Teachers need continuous support from the outset and throughout their careers to facilitate their PD [12,17].

5.3. What Suggestions Do STEM Teachers Offer?

In terms of collaboration, our study identified variables and important factors for collaboration for professional development similar to the findings in [43], where the authors indicated that collaborative inquiry enhances teachers' knowledge and skills, narrowing achievement gaps in math and science. Effective PD is achieved through sustained, collaborative partnerships that address teachers' needs. Success is further bolstered when

teachers collaboratively set learning objectives, implement new methods, and reflect on their practice. Teacher collaboration and community-building are crucial for impactful PD. Schools supporting productive collaboration see increased instructional consistency and success in addressing practical challenges.

Teachers stressed the importance of structured information and resources about career options, qualifications, and advancement opportunities, emphasizing the need for educators to access such resources as they pursue their career goals. This highlights the critical role of comprehensive career guidance and the availability of career development resources in supporting educators in their professional growth and aspirations within the education sector. Providing teachers with information about career options, fostering reflection on career development, and facilitating the establishment of peer networks are essential endeavors [19].

Teachers are looking for resources that are not only aligned with competency-based learning but also provide guidance on implementing new teaching methods, fostering collaboration, and overcoming the challenges of integrating new concepts into their teaching practice. This aligns with findings of Hamad et al. [25] that also reflect similar concerns, such as insufficient competence, lack of guidelines, and limited collaboration, highlighting the importance of addressing these issues to support effective teaching practices. Additionally, reference [25] suggested that external challenges, like a lack of guidelines, may have a more significant impact than teachers' competence alone, underscoring the complexity of the educational landscape and the importance of comprehensive support mechanisms for educators.

5.4. Implications

The implications derived from this study underscore the fundamental shared values among teachers, regardless of their experience level, subject specializations, or sources of inspiration. These values include a deep commitment to education, a desire for continuous improvement, a belief in the power of collaboration, and a focus on practical application in teaching. Recognizing and nurturing these commonalities can be a foundation for understanding and supporting each teacher's PD journey.

Experienced teachers, drawing from their wealth of experience, are well-positioned to offer valuable insights and guidance to their peers, while novice teachers exhibit enthusiasm and a readiness to learn and evolve in their careers. Therefore, initiatives aimed at PD should cater to both groups, leveraging the expertise of senior educators and fostering a culture of continuous learning for all.

The expressed need for increased collaboration among teachers emphasizes the importance of providing platforms, both online and face-to-face, that facilitate active engagement and communication. By fostering collaboration, educational institutions can cultivate a dynamic and supportive environment, conducive to innovation and growth. Furthermore, future initiatives in PD, including platforms and resources, should prioritize the adaptability and practical applicability of content within the context of the classroom. Policies promoting content-sharing and experience-sharing can foster trust among educators and facilitate collective growth.

Addressing workload management and enhancing support for career advancement are critical priorities for improving the education sector. By alleviating the burden on educators and offering comprehensive support mechanisms, policymakers and educational institutions can empower teachers to thrive in their roles and, ultimately, enhance the quality of education for all stakeholders.

5.5. Limitations and Future Research

There are several limitations to consider in this study. The main limitation is related to the limited number of teachers who were involved in the qualitative research. In addition, the participants represented the case of a single country. Hence, the findings may not fully reflect the range of perspectives and nuances that may be present in a larger and more

diverse population. However, the applied qualitative method allowed us to delve deeper into the participants' experience, perceptions, and attitudes regarding STEM teachers' careers, competence, and collaboration issues. A comparison with the other reported cases, as well as an expansion of the study to include more participants from different countries with similar educational challenges, would enrich the results of future research.

Author Contributions: Conceptualization, A.J., T.J., G.S. and L.V.; Methodology, A.J., T.J. and G.S.; Formal analysis, A.J. and T.J.; Investigation, A.J., T.J. and G.S.; Data curation, A.J. and T.J.; Writing—original draft, A.J., T.J., G.S. and L.V.; Writing—review & editing, A.J., T.J., G.S. and L.V. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by ERASMUS+ grant program of the European Union project "Perspectives for Lifelong STEM Teaching—Career Guidance, Collaborative Practice, and Competence Development". grant number 626 139-EPP.I-2020-2-DE-EPPKA3-PI-POLICY.

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: Original data are available on request. They are not archived in any repository.

Conflicts of Interest: The authors declare no conflicts of interest.

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