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MASTER'S DEGREE DISSERTATION

Identifying career aspirations of STEM Chemistry Teachers

7M01502 - Chemistry

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CONTENTS

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Introduction

STEM is an integrated educational concept that combines the fields of Science (Science), Technology (Technology), Engineering (Engineering) and Mathematics (Mathematics). The term was first widely used in the 2000s in the United States for the purpose of reforming the education sector, and later became one of the areas of Education recognized at the global level. The STEM educational model differs from traditional subject teaching in that it organizes the educational process in a complex, interdisciplinary way, that is, it is based on teaching, combining several disciplines in solving real-life problems. Its significance lies not only in preparing individuals for specialized careers but also in cultivating a broader set of skills essential for navigating the challenges of the modern world.There are several reasons why STEM education is important. First, it prepares students for careers in STEM-related fields, which are growing rapidly and offer good job prospects. Second, it helps students develop skills that are valuable in all fields of work, such as creativity, innovation, and adaptability. Third, it promotes scientific literacy and understanding of important scientific issues. Despite its many benefits, STEM education faces several challenges. One challenge is the lack of qualified STEM teachers.

This study is **significant** as it provides insights into the motivations and barriers affecting STEM chemistry teachers' career trajectories. The findings can guide educational institutions in enhancing teacher development programs, ensuring a sustainable and motivated teaching workforce.

The primary **aim** is to identify the career aspirations, motivational factors, and challenges faced by STEM Chemistry teachers. Specific **objectives** include:

•Exploring teachers' long-term career goals.
•Examining factors influencing career aspirations.
•Identifying challenges faced during career path.

Research questions:

1.What are the primary career aspirations of STEM chemistry teachers?

2.What factors influence their career choices and professional growth?

3.What kind of challenges STEM Chemistry teachers face?

1.1. STEM education is currently one of the main strategic priorities in global education systems. This is primarily due to globalization, technological progress and the changing demands of the labor market. The importance of STEM education is explained by several key aspects.

First of all, STEM training is aimed at developing the skills of the XXI century – critical thinking, creativity, teamwork, digital literacy and solving complex problems. These skills are the basis for a successful life and professional success in modern society .

Secondly, STEM industries are directly related to the most demanded and promising professions in the modern labor market. The demand for engineers, programmers, scientific researchers and technology professionals is growing every year. Therefore, attracting students to STEM areas at an early age is an important way to build future personnel potential.

Third, STEM is the main mechanism for increasing innovation potential. People who master science and technology can contribute to the economic and social development of society, create new products and technologies, and increase the global competitiveness of their country.

Fourth, STEM education must comply with the principles of social equality and inclusion. The involvement of girls and socially vulnerable groups in the STEM sphere plays an important role in ensuring gender and social equality .

Thus, STEM is not only an educational model, but also part of the national development strategy. With the correct implementation of its substantive and methodological aspects, the education system will be able to prepare students in accordance with the global requirements of the XXI century.Chemistry stands as a cornerstone of scientific inquiry, its principles permeating various disciplines within the realm of Science, Technology, Engineering, and Mathematics (STEM). At the forefront of disseminating these fundamental principles lie chemistry teachers, whose role extends beyond mere instruction to that of sculptors shaping the future scientific landscape.

Chemistry teachers serve as catalysts for nurturing the next generation of STEM professionals, laying the groundwork for scientific literacy and innovation. As champions of inquiry-based learning, they spark curiosity, encouraging students to delve into the mysteries of matter and its interactions. Through hands-on experimentation and theoretical exploration, students under their guidance not only grasp foundational concepts but also develop critical thinking skills essential for navigating the complexities of modern scientific inquiry (Bencze & Hodson, 1999). In the contemporary educational landscape, the role of chemistry teachers extends beyond traditional classroom boundaries. They serve as mentors, guiding students through

research endeavors and interdisciplinary projects that bridge the chasm between theoretical knowledge and real-world applications. By fostering collaboration and interdisciplinary thinking, they instill in students a holistic understanding of science and its interconnectedness with other STEM domains (NGSS Lead States, 2013).

Furthermore, chemistry teachers play a crucial role in addressing the pressing challenges of the 21st century, from environmental sustainability to healthcare innovation. By contextualizing scientific concepts within real-world issues, they empower students to become agents of change, equipped with the knowledge and skills to tackle global problems (Tran et al., 2016).

Above all, chemistry teachers serve as catalysts for inspiration, igniting the flames of passion that fuel the next generation of scientific innovators. Through their enthusiasm and dedication, they instill in students a love for learning and a curiosity about the world around them (Jimenez-Aleixandre & Federico-Agraso, 2012). By sharing their own experiences and expertise, they mentor aspiring scientists, guiding them along the path to discovery and success (Bencze & Hodson, 1999).

Chemistry teachers are well-positioned to play a key role in promoting STEM education for several reasons. First, they have specialized knowledge and expertise in chemistry, which allows them to teach complex chemical concepts and principles. Second, they are trained in teaching methods and strategies that can be applied to STEM education. Third, they can collaborate with other STEM teachers to create integrated lessons and projects that span multiple disciplines.

One way that chemistry teachers can promote STEM education is by designing and implementing lessons that integrate STEM concepts. For example, a lesson on chemical reactions can be expanded to include engineering aspects such as designing apparatuses for specific reactions or technology applications like using simulations to visualize reaction mechanisms. This type of lesson not only teaches chemistry concepts but also promotes problem-solving skills, critical thinking, and collaboration.

Another way that chemistry teachers can promote STEM education is by serving as mentors and guides for students. They can encourage students to explore STEM topics in more depth, provide feedback and support on STEM projects, and help students develop their own ideas and solutions to STEM problems. This type of guidance can be especially valuable for students who are interested in pursuing STEM careers.

A study conducted by Brown et al. (2020) revealed that integrating hands-on laboratory activities into chemistry lessons significantly enhanced students' understanding of scientific concepts and their interest in STEM careers. The authors emphasize that when students study abstract scientific concepts through real experience, their understanding at the cognitive level increases significantly.

This statement echoes the basic principles of STEM education. Experience-based learning-makes the student an active subject of learning. That is, students not only receive ready-made information, but also independently experiment, analyze the results and draw conclusions, "building"knowledge on the basis of their own experience. Such a method develops such important skills of students as analytical thinking, problem solving, the use of scientific methodology. In addition, laboratory work plays an important role in increasing interest in future professions in STEM fields. As noted in the course of the study, students who participated in real experiments showed great interest in the subject of chemistry and scientific research in general. This increases their motivation to enter higher education institutions in the STEM direction in the future, as well as to choose a path of professional development in this area. In this regard, there was a significant increase in affective factors, such as motivation, interest, and self-efficacy. The effectiveness of laboratory work in STEM learning is not limited to students. Such approaches also characterize the professional role of teachers in a new way. The STEM teacher is considered not only as an educator, but also as a guide, researcher, and motivating person for students. This directly affects the professional aspirations of STEM teachers. They strive to use innovative approaches to teaching the discipline, improve the quality of education and build relationships with students in a new form. Another study by Davis et al. (2018) explored the impact of project-based learning in chemistry classes and found that it not only improved students' academic performance but also fostered their creativity and teamwork skills. These studies highlight the importance of innovative teaching methods in promoting STEM literacy among students.

Additionally, research by Green et al. (2017) investigated the influence of professional development programs for chemistry teachers on their ability to implement STEM-focused curricula. The study clearly shows that the professional development of teachers plays a crucial role in the effective implementation of STEM-oriented curricula. This study, studying the impact of professional development programs for chemistry teachers, showed that teachers had a significant impact on mastering the content of education in

STEM fields, effective application of pedagogical methods and increasing confidence in the learning process as a whole.The results of the study showed that teachers who participated in professional development programs felt much more confident and competent in teaching STEM subjects. This means that the ability to build interdisciplinary connections inherent in STEM disciplines, organize research-based learning, and apply innovative pedagogical approaches has increased. In addition, teachers ' personal interest in the STEM field and the desire for professional growth have also increased.This finding suggests that updating the curriculum alone is not enough to improve STEM education. The development of professional competence of teachers is one of the main prerequisites for quality STEM education. Such professional development programs not only deepen the subject and methodological knowledge of teachers, but also increase their teaching self-efficacy (teacher self-efficacy), pedagogical flexibility and susceptibility to innovation (Green et al., 2017).In the STEM-oriented educational process, the role of teachers is seen not only as information providers, but as facilitators that engage students in research, discovery, and critical thinking. In this regard, systematic support aimed at the professional development of teachers increases their motivation in teaching, professional confidence and influence on the quality of students ' knowledge.

Furthermore, a study by Williams et al. (2016) examined the effects of collaborative teaching between chemistry and other STEM disciplines on student engagement and learning outcomes. It was found that such collaborations enriched the learning experience and motivated students to delve deeper into STEM topics. Interdisciplinary collaboration is another critical dimension of the chemistry teacher’s role in STEM education. Williams et al. (2016) demonstrated that collaborative teaching between chemistry and other STEM disciplines enriched the learning experience and motivated students to engage more deeply with complex scientific topics. Chemistry teachers who work in tandem with colleagues from mathematics, physics, or technology fields help students see the interconnectedness of scientific knowledge and its real-world applications, thereby enhancing their overall STEM engagement and outcomes.Taken together, these studies illustrate that chemistry teachers are not only content experts but also key agents in fostering STEM literacy, critical thinking, and future-oriented learning. Their ability to implement innovative teaching methods, collaborate across disciplines, and continuously develop professionally positions them at the forefront of quality STEM education. As such, understanding and supporting the career aspirations and development of chemistry teachers is vital for the sustainability and advancement of

STEM learning in schools. As evident from the literature, the role of chemistry teachers in STEM education extends beyond mere content delivery. It encompasses fostering holistic learning, promoting skill development, inspiring passion for STEM, and ensuring relevance through continuous professional growth.Finally, chemistry teachers must stay updated with advancements in STEM fields to effectively incorporate them into their teaching practices. This requires continuous professional development, attending workshops, conferences, and engaging in collaborative projects with professionals in related fields. Such initiatives enhance the teacher's capacity to provide relevant and up-to-date education, thereby preparing students for the dynamic nature of STEM careers.

1.2.The development of STEM (Science, Technology, Engineering, and Mathematics) Chemistry teacher careers has garnered significant attention in recent years, as the importance of STEM education has grown in response to increasing global demand for skilled professionals in these fields. Teachers of STEM subjects, especially chemistry, play a crucial role in shaping the next generation of scientists, researchers, and engineers, making the development of their careers a critical area of study. The STEM education system meets the requirements of modern scientific and technological progress, provides for the formation of students ' functional literacy and interdisciplinary thinking. The subject of chemistry occupies an important place in this system, as it allows students to understand processes in nature, master scientific methods and develop laboratory skills. The successful implementation of the STEM approach largely directly depends on the professional competence, methodological skill and pedagogical approach of teachers. The professional development of a chemistry teacher is a continuous process that involves not only deepening subject knowledge, but also mastering innovative teaching methods, developing qualifications for the use of information and communication technologies and the ability to establish interdisciplinary connections. In STEM education, the teacher acts as not only a provider of information, but also a facilitator who engages the student in cognitive activity, directs him to conduct scientific research, encourages critical thinking. In the modern educational space, several important areas of professional development are distinguished for STEM chemistry teachers:

- The development of interdisciplinary competence , that is, teaching chemistry in connection with Physics, Biology, Mathematics and technology, which contributes to the expansion of students ' worldview and the combination of knowledge with life.
- Mastering research-based teaching methods-increasing the student's scientific and cognitive activity through the use of experimental work, project tasks, problem-based learning.
- The use of digital technologies is to improve the quality of teaching through the effective use of virtual laboratories, simulations, interactive platforms and distance learning tools.
- Professional cooperation and mutual exchange of experience – creating conditions for professional growth through coaching, mentoring, joint classes and work in methodological communities among teachers.
- Self – improvement and reflection is the teacher's constant differentiation of his experience and adaptation to changes in education.

A teacher who can work effectively in the field of STEM is not only a specialist with subject knowledge, but also a creative, flexible, innovative, highly professional aspirant. Such teachers stimulate students ' interest in science and motivate them to choose a professional path in the future in the direction of STEM. Thus, supporting the professional development of STEM chemistry teachers is one of the key mechanisms for high-quality education and education of a generation with high scientific potential. This development should be systematic, purposeful and based on the professional self-knowledge of the teacher.

Chemistry teachers in STEM fields often experience unique career trajectories that are influenced by the dynamic nature of both the education sector and the broader STEM industry. Early-career STEM teachers frequently face challenges related to classroom management, curriculum design, and adapting to new educational technologies. The professional path of a teacher is a complex and important process based on continuous development and accumulation of experience. Chemistry teachers working in the STEM direction, over time, not only develop their pedagogical competencies, but also move forward along the professional career ladder. At the initial stage, teachers try to adapt to the learning process and master the curriculum and characteristics of students. Over time, they begin to gain professional experience and acquire deep knowledge and methodological skills in their field.

Experienced teachers often strive for leadership roles. This is reflected in such areas as participation in the development strategy of an educational organization, mentoring young specialists, leading the work of a department or methodological Association, improving curricula. Turning to such leadership roles is a logical continuation of the professional development of teachers and increases their influence in the education system. As noted by Hargreaves and Fullan (2012), teachers develop expertise and may seek leadership roles, such as department heads, curriculum developers, or mentors for new teachers. Because this direction requires interdisciplinary communication, research activities and technological literacy. As a STEM chemistry teacher gains professional experience, he will be able to manage a wide range of projects at the school level, organize STEM clubs, develop innovative lesson models, and provide methodological support to his colleagues. In addition, such teachers can further advance their careers by participating in educational policy, participating in educational forums and conferences at the regional or national level. Career development is closely related to the teacher's internal motivation, professional reflection and desire for continuous learning. STEM teachers often need to adapt to changing technological and scientific environments. For this reason, their career development should not be limited to formal professional courses, but also be accompanied by the exchange of experience, training on the basis of experience, research activities and creative search. In addition, one of the most important factors affecting the career development of teachers is the desire for continuous professional growth. Many teachers, in order to improve their knowledge, take additional advanced training courses, receive certificates confirming the level of pedagogical skills, or strive for new professional roles, such as teaching at higher educational institutions (Richter et al., 2011). These actions have a positive impact not only on their personal development, but also on the quality of the education system. Such processes contribute to the modernization of pedagogical methods, active involvement of the teacher in research work and increasing his authority in the professional community. Even for STEM-oriented chemistry teachers, updating professional knowledge and skills is a constant necessity. This is because the pace of development of Science and technology in the field of STEM is very high, which requires teachers to master new sources of knowledge, use modern digital tools and master effective teaching strategies. Therefore, teachers who aim for professional growth are constantly improving their career paths, and this is one of the main mechanisms for improving the quality of STEM education.

Professional development is a cornerstone of career advancement for STEM Chemistry teachers. Research shows that participation in deep-content and long-term professional development programs not only increases the effectiveness of teachers, but also has a positive effect on their professional satisfaction. Such activities include formal education programs at the graduate level, short-term courses, nonformal learning in professional communities, methodological seminars, and mentoring practices (Borko, 2004; Darling-Hammond et al., 2009). For STEM chemistry teachers, such professional development opportunities are useful in several areas. First, they will have the opportunity to improve their pedagogical skills and modernize teaching methods. Secondly, they will be able to get acquainted with the latest developments in the field of science and technology and teach their subject in a modern context. Third, they master effective innovative approaches to teaching – for example, research – based learning, problem-based learning, or the use of digital tools. It plays a key role in increasing the cognitive interest of teachers in students, shaping scientific thinking, and stimulating interest in the STEM field. In addition, professional development increases the teacher's confidence in their role, making them seek creativity, research and leadership. Especially for successful work in the field of STEM, the teacher needs not only to master the subject well, but also to constantly update his knowledge and be inclined to introduce modern methods into his practice. Another point is support systems, especially collaborative collaboration and mentoring programs, are important in increasing teachers ' satisfaction with their work and long-term professional life (Ingersoll & Strong, 2011). Such support systems reduce the professional isolation of teachers and create conditions for improving pedagogical skills through the exchange of experience. Especially for young professionals, the guidance, methodological support and moral support of experienced teachers contribute to their self-confidence, professional stability and commitment to their profession. For chemistry teachers working in the STEM direction, partnership support mechanisms are especially important. This is because the renewal of the content of training, the rapid change of technological tools and the expansion of interdisciplinary communication in this area require constant methodological innovation. In this case, joint planning with colleagues, analysis of lesson models, conducting open lessons or working together within professional associations will give impetus to the professional development of the teacher. In addition, through the mentoring system, experienced professionals strengthen the methodological culture throughout the school by guiding colleagues who are just mastering STEM methods. Thus, the availability of support systems is recognized as an important factor in the professional path of STEM chemistry teachers, increasing their perseverance and creativity in educational activities.

The career aspirations of STEM chemistry teachers are formed by a combination of various internal and external motivational factors. An important role as intrinsic motivation is played by their sincere interest in the subject of chemistry and their desire to educate future generations. For such teachers, the development of students ' scientific thinking, the formation of research skills and the awakening of interest in science is the main driving force of professional life. In addition, external factors also have a significant impact on career goals. These include mechanisms of material incentives such as workplace stability, social status, professional recognition, and wages (Friedrichsen et al., 2013). These aspects contribute to the fact that teachers maintain commitment to the profession, build a long-term career in their field, and strive for leadership roles. The complexity and constant updating of the STEM field requires teachers not only subject knowledge, but also professional adaptability and readiness for continuous development. In this regard, teachers with clear career aspirations, high internal motivation, as well as effective use of external incentives can build a long-term, meaningful career in the field of STEM chemistry. According to a study by Baran and Can (2018), teachers with high intrinsic motivation tend to seek roles with high Professional Responsibility. They see contributing to the curriculum, mentoring colleagues, or participating in intra-school reforms as an important part of their career development and personal professional satisfaction. Such roles allow teachers to spread their experience, increase their authority in the professional environment, and make a real difference in the educational process. These aspirations, formed under the influence of intrinsic motivation, strengthen teachers ' commitment to their profession, help relieve professional stress, and increase their tendency to work long-term in the education system. For STEM chemistry teachers, these factors are of particular importance, because their experience and innovative ideas play a key role in improving the quality of the educational process. Teachers who are especially active in such areas as the development of Interdisciplinary STEM projects, the improvement of teaching methods and the development of research skills of students have the opportunity to reach a new level of professional development. In addition, the direction of teachers on their professional path is significantly influenced by the personal and professional support they receive from colleagues, school administration and the educational community in general (Teemant & Cahnmann-Taylor, 2013). The presence of such support allows teachers to feel like a valuable member of the professional community, openly present their ideas and implement their pedagogical initiatives. Administrative support-methodological freedom, opportunities for professional development, methodological assistance and improvement of working conditions – increases the teacher's confidence

in his work and stimulates the desire for career growth. In addition, continuous communication with colleagues, exchange of experience and joint projects create conditions for professional improvement and creative development of the STEM chemistry teacher. The formation of such a supportive environment in the education system is an important factor contributing to the extension of the professional life of teachers, reducing their emotional stress and improving the quality of education in general. For teachers working in the STEM field, this support is especially important, as they work with constantly updated content and high methodological requirements. However, despite the presence of supporting factors, there are also significant obstacles to the career development of STEM chemistry teachers. One of the main issues limiting the professional freedom and creative potential of teachers is the standardized assessment requirements and specific curricular restrictions introduced at the national and regional levels (Lauermann & Karabenick, 2013). Too much attention to the results of external assessment of educational achievements forces teachers to abandon the use of deep and meaningful approaches to teaching, focusing the educational process only on memorizing test tasks. In such a situation, the teacher does not find the opportunity to present his subject in an interesting and innovative way and is distracted from professional growth and creative initiatives. This leads to the limitation of research-based and interdisciplinary learning methods specific to the STEM field. In addition, this situation can negatively affect the teacher's motivation for work and prevent him from drawing up a long-term career plan. Consequently, in addition to supporting the professional development of teachers, maintaining their professional freedom and the ability to implement pedagogical initiatives is one of the main prerequisites for improving the effectiveness of STEM education. One additional difficulty is that many teachers find it difficult to balance their professional responsibilities and personal lives, which in turn leads to high levels of stress and professional stress issues or burnout, especially in schools that are not financially secured or have limited resources (Guarino et al., 2006). Such a situation can reduce teachers ' interest in work and weaken their confidence in their professional life. Financial deficits and lack of resources cannot adequately provide teachers with the necessary equipment, teaching materials and professional development opportunities to provide quality education. This increases the level of stress and does not allow teachers to maintain a full-fledged balance both in working hours and in their personal lives. Such stressful situations, if they continue for a long time, negatively affect the psycho-emotional state of teachers, hindering their career growth and pedagogical effectiveness. For STEM chemistry teachers, this issue is especially relevant. This is because the subject of chemistry is complex and requires

experimental teaching methods, and this requires special equipment and laboratory materials. If teachers do not have access to these tools, it becomes difficult to develop students ' scientific thinking and develop research skills. Understanding how these barriers impact STEM teachers' career trajectories is essential for designing policies and interventions that can foster more sustainable and rewarding career paths. The career development of STEM Chemistry teachers is a multifaceted issue that requires a deep understanding of both personal aspirations and external factors such as professional development, institutional support, and societal expectations. Research indicates that while there are significant challenges in the field, there are also numerous opportunities for career progression and professional growth, especially for those who engage in continuous learning and seek out supportive environments. A comprehensive approach to career development, addressing both the personal and professional dimensions of teaching, is essential for cultivating a resilient and effective STEM teaching workforce. Certain studies have shown that there is a decrease in the choice of profession in chemistry in the period from high school to higher educational institutions. This trend is more pronounced in the field of chemistry than in other disciplines in the STEM direction. It is interesting that women choose Chemistry more often than men, this trend is observed both at the high school level and at the university level. In addition, although minorities are more interested in chemistry in high school, their interest in chemistry decreases when it comes to higher education, which is evident in the differences between groups (Avargil, S., Kohen, Z., & Dori, Y. J., 2020). These data show that STEM is one of the most important social factors affecting the career development of chemistry teachers. Differences in the level of choice and interest in relation to the field of chemistry also reflect gender inequality in the pedagogical field. The decline in the interest of women and minorities in chemistry in higher education, especially because of the technical and research nature of this profession, highlights the importance of equal opportunities and support systems in the STEM field. This situation can affect the professional life of chemistry teachers and hinder their future career growth.

High school serves as a critical period for developing or shaping students' interests and career aspirations, particularly in STEM fields. Effective STEM education in high school emphasizes the relevance of STEM concepts to students' lives and future careers. By showcasing how STEM knowledge and skills are applied in various fields, educators can help students understand the practical significance of these subjects, making them more inclined to pursue further studies in STEM. Science teachers play a pivotal role in shaping students' academic performance and their decisions to major in STEM fields. Supportive environments, encompassing emotional backing and career guidance, have a

constructive relationship with students' expectations for their career outcomes and their belief in their own capabilities. For instance, exposure to science from an early age can shape students' interest in pursuing STEM careers, bolstering their confidence in their abilities and their aspirations for future success.

The significance of fostering individuals' development within the field of chemistry, as well as in STEM disciplines more broadly, is profoundly rooted in the foundation laid during their school education. Research consistently reveals that many professionals in chemistry-related fields attribute their career choice to the captivating experiences they had during their chemistry education at school. These formative educational experiences not only cultivate a fascination for the subject matter but also instill essential skills, knowledge, and a passion for scientific inquiry. Thus, investing in high-quality chemistry education at the school level not only nurtures future scientists and professionals but also serves as a crucial catalyst for innovation and advancement within the broader realm of chemistry and STEM disciplines.Career knowledge entails understanding a specific STEM occupation, such as chemistry, including its prerequisites and anticipated responsibilities. While crucial, STEM career knowledge has not received extensive examination, yet it warrants increased attention. The depth of knowledge about professions in the field of STEM significantly affects the motivation of a person to choose a professional path in the direction of STEM. In principle, the higher the level of information about STEM professions, the more likely a person will perceive them as a real professional path. And if students do not have enough information about professions in the field of STEM, they may ignore this direction as a field that has opportunities for their future (Shwartz, G., Shav-Artza, O., & Dori, Y. J, 2021).
This indicator raises one important issue related to the system of education and professional development in the field of STEM: it is necessary to interest students in STEM areas and provide them with effective information and practical opportunities to familiarize them with a wide range of these areas. Such measures can increase students ' interest in the field and contribute to the choice of STEM professions in the future.

Teacher training programs in STEM education commonly employ several methodological strategies, including project-based learning, problem-based learning, collaborative learning, ODR approach (observation/discussion/reflection), and design-based learning. Among these strategies, design-based learning emerges as particularly suitable for disciplinary integration. In STEM education programs, the two most important competencies that pay special attention to when training teachers are design thinking and

computational thinking. These competencies are considered transversal, that is, they are relevant in different aspects of the educational process (Rodríguez, C. M. A., González-Reyes, R. A., Ballen, A. B., Merchán, M. A. M., & Barrera, E. A. L., 2024). Design thinking and computational thinking are the basis for the introduction of new approaches and methods in teaching STEM disciplines. The competence of design thinking encourages students to make creative decisions, solve problems in innovative ways. And the competence of computational thinking allows students to use logical and analytical methods to solve complex problems. The development of these competencies plays an important role, especially in terms of updating and improving the effectiveness of pedagogical methods of STEM chemistry teachers.

Interest in STEM careers and the development of one's career begin at school. A survey was conducted in Kazakhstan among CIS countries, examining factors such as gender and students' positive attitudes toward STEM fields. This study examines the factors influencing middle and high school students' interest in pursuing STEM careers in the future. The findings are particularly relevant to Kazakhstan, where STEM education has been studied only minimally. The researchers aimed to explore a wide range of factors that could impact students' interest in STEM careers, and the results align with similar studies conducted in other countries. Overall, students displayed a positive attitude towards STEM careers. Notably, both boys and girls showed similar levels of interest across various STEM-CIS sub-scales. Additionally, students from rural areas expressed a strong interest in STEM careers, while those from private urban schools showed the least interest. The study also found no significant correlation between students' STEM career interests and factors such as family size, parents' education, or their occupations (Japashov et al., 2024). In recent years, Kazakh STEM graduates have begun to focus on improving their professional and educational skills after first receiving their education in order to obtain their diplomas (Francesco, A. L., Minazheva, G. S., Sadyrova, M. S., & Shakhmatova, N. V., 2020). This trend reflects the need for STEM professionals not only to have theoretical knowledge, but also to improve practical skills, to master new technologies and methodologies. This change will optimize the adaptation of STEM graduates to the labor market and contribute to their formation as highly qualified professionals. In addition, this approach, aimed at improving professional skills, has a significant impact on their career development and professional success. Such aspirations of young people interested in STEM specialties are a contribution to the modernization of the education system of Kazakhstan and scientific and technological progress. According to data from the STEM labor market of Kazakhstan, companies and organizations are

reducing the recruitment of graduates with appropriate STEM qualifications in special specialties. According to surveys conducted by universities in Kazakhstan, STEM graduates are often interested in (a) gaining experience outside the STEM field, (b) further improving their education, or (C) doing business. To understand why STEM graduates often prefer to gain experience in sectors that are not related to the STEM industry, sociological surveys conducted among companies hiring university graduates in Kazakhstan were analyzed. These studies have made it possible to determine, in particular, the requirements that employers impose on STEM graduates and their expectations regarding employment. In addition, this trend contributes to the explanation of the decline in interest in employment in their field and the desire to build a career in other areas of young professionals who have received STEM education. As a result of research conducted in 2020, the lack of practical skills required in STEM work and the largely theoretical nature of students ' knowledge were found to be the main reasons for this change. As a result, graduates faced difficulties in demonstrating the necessary professional qualifications to employers and applying for high-level positions in accordance with their field of Education (Kuzhabekova, A., Dmitrienko, A., & Daurbay, Z., 2021). This trend prevents STEM graduates from being competitive in the job market, increasing their difficulty in getting a job. The insufficient attention of higher education programs to practical skills makes it difficult for these graduates to adapt to real working conditions. Thus, improving the education system in the field of STEM, including the equal development of theory and practice, improving professional skills, is an important step to support the career development of graduates.

1.3. The teaching profession holds a special place in society, nurturing the minds of future generations and shaping the trajectory of scientific advancement. Within the realm of Science, Technology, Engineering, and Mathematics (STEM), chemistry teachers play an important role in fostering scientific literacy and inspiring the next generation of innovators. Understanding the career aspirations of these educators is essential for enhancing professional development opportunities and creating a supportive work environment conducive to their growth and success. STEM chemistry teachers are often distinguished by a deep inner interest in their subject and the learning process. Many teachers choose this profession sincerely under the influence of a love of chemistry and a desire to share their enthusiasm for this subject with students (Barman et al., 2010). Such intrinsic motivation (intrusive motivation) is the basis of their professional goals and aspirations. This motivation encourages teachers to constantly seek opportunities for self-improvement, the acquisition of new knowledge and experience, as well as professional

and personal development. Their desire for teaching and interest in science have a positive impact not only on professional success, but also on the formation of students ' attitude to the STEM field. As a result, such teachers can motivate students and motivate them to choose STEM professions in the future. One of the main career aspirations of STEM chemistry teachers is continuing education and the development of professional skills. They are well aware of the constantly updated nature of their field and the importance of being aware of the latest advances in content education and pedagogical methods (Penuel et al., 2017).

For teachers, it is important not only to improve scientific knowledge, but also to update teaching methods, use modern technologies and master ways to effectively organize students ' learning. For this reason, many STEM teachers attend professional development courses, become members of professional associations and seek to share experiences with colleagues. This process contributes to their professional growth, improving the quality of training and deepening their contribution to the education system as a whole. Teachers aspire to engage in ongoing professional development activities, such as workshops, seminars, and graduate courses, that enable them to refine their teaching practices and enhance student learning outcomes. For many STEM chemistry teachers, developing students ' scientific thinking and engaging them in the STEM field is an important part of their professional mission. They strive not only to convey the content of the subject during the lesson, but also to form students ' research skills, stimulate creative thinking and involve them in solving specific scientific problems. Through this approach to education, teachers aim to motivate students to build careers in STEM fields in the future. STEM chemistry teachers' one of the natural stages of development on their professional path is the pursuit of leadership and mentoring roles within educational institutions. Teachers seek to carry out leadership tasks that allow them to be more deeply involved in the educational process and influence strategic decisions within the school. They are interested, for example, in positions such as being the head of a subject Association, developing or updating curricula (Strobel & van Barneveld, 2009). Such leadership roles allow teachers not only to realize their experience, but also to support colleagues and become an example for the entire school community. In addition, these positions allow them to achieve high-level goals, such as participation in educational policy, improving the quality of teaching, and indirectly contributing to student success. Thus, leadership and mentoring are one of the most important areas of career development for STEM teachers. Additionally, teachers aspire to serve as mentors for novice educators, sharing their expertise and experiences to support the next generation of teachers.

In an increasingly digital and technologically driven world, STEM chemistry teachers aspire to integrate innovative technologies into their instructional practices. They recognize the potential of digital tools and resources to enhance student engagement, facilitate inquiry-based learning, and provide personalized learning experiences. Teachers seek to develop their technological proficiency and explore innovative teaching strategies that leverage the power of technology to enrich the learning environment. Many STEM chemistry teachers aspire to contribute to the broader scientific community through research and scholarship. STEM chemistry teachers are also well aware of the importance of conducting research related to the field of education to improve teaching efficiency. They supplement their pedagogical experience with evidence-based solutions by studying topics such as the effectiveness of learning strategies, assessment methods, and learning outcomes of students (Barman et al., 2010). Such research activities deepen the professional reflection of teachers, allow them to critically look at their experience and constantly improve it. In addition, working in this direction will allow them to contribute scientifically to the education system. Teachers aspire to publish their findings in peer-reviewed journals, present at conferences, and engage in collaborative research projects that contribute to the advancement of science education.

Teachers' career aspirations are strongly influenced by both intrinsic and extrinsic motivations. Intrinsic motivation is an internal desire that arises from the need for a person to feel satisfaction and self — realization directly from his activities. This concept is expressed through factors such as, for example, a sincere love of teaching or a sincere desire to positively influence the lives of students (Ryan & Deci, 2000). For STEM chemistry teachers, such intrinsic motivation is an important basis for their professional stability and long-term success. Teachers who work with inner enthusiasm are dedicated to their work, approach the learning process creatively and strive for continuous development. And extrinsic motivations, on the contrary, are associated with external factors that are not directly related to the activities of the teacher, but affect his professional activity. These include the size of wages, guarantees of a permanent place of work, career growth opportunities and professional status. Such external incentives can affect the choice of a profession for STEM chemistry teachers, stay in the industry, or switch to other areas of activity. Therefore, the combination of internal and external motivation is considered an important factor in the professional development and career decisions of a teacher. According to studies by Skaalvik and Skaalvik (2011), intrinsic motivation is often closely related to a teacher's genuine interest in their subject and belief in its importance to society. These factors play a key role in the formation of long-term

career aspirations of teachers. For STEM chemistry teachers, this subject is seen as not only academic content, but also as one of the tools to educate a scientifically literate generation and contribute to national development. This belief strengthens their commitment to the profession and increases their desire for professional development. In the field of STEM education, especially in disciplines such as chemistry, intrinsic motivational factors – love for the subject and the spiritual pleasure that future generations receive from education – contribute to the formation of clear and stable career aspirations of teachers (Goe, 2007). Such intrinsic motivations serve as the basis for the teacher to remain faithful to his work and to serve in the educational field for a long time and purposefully, despite the difficulties that he faces on his professional path. For STEM chemistry teachers, these motivations are directly related to their desire to positively influence the future of students, as well as their interest in continuous development and professional growth. STEM teachers may also aspire to take on leadership roles within their schools, such as becoming department heads or curriculum coordinators, in order to have a broader impact on the teaching and learning process. These aspirations are often driven by a desire for professional growth and recognition within their field.

Professional development (PD) plays a significant role in shaping teachers' career aspirations. High-quality professional development programs aimed at improving teachers ' pedagogical skills, subject knowledge, and teaching strategies increase their motivation for career growth and contribute to a deeper commitment to their professional responsibilities (Darling-Hammond et al., 2009). Such programs allow STEM chemistry teachers to master modern teaching methods, improve the quality of their classes, and lead in the field of Education. As a result, teachers begin to perceive their professional path not just as a service, but as a means of influencing society. Research shows that teachers who participate in professional development programs aimed at long-term and specific goals see their professional growth trajectory more clearly and are better prepared to move towards leadership or specialized areas of learning (Borko, 2004). Such programs clarify the professional goals of teachers and create conditions for them to deepen pedagogical experience, implement innovative initiatives and strive for leadership roles in the field of Education. For STEM chemistry teachers, these development paths provide an opportunity for professional self-realization, strengthening motivation, and long-term service in the industry. For teachers of STEM subjects, especially chemistry, the availability of opportunities for professional development is essential so that they do not lag behind the latest advances in science and modern teaching methods (Teemant & Cahnmann – Taylor, 2013). Such development programs allow not only to strengthen the

subject competence of teachers, but also to introduce innovative approaches to the teaching process. This, in turn, improves the ability of teachers to increase the cognitive interest of students and contributes to improving the quality of Education. For example, educators who participate in workshops on the integration of technology into the teaching process or who become members of professional associations of teachers who study in collaboration often show a special desire to mentor their colleagues or to take on roles that influence educational policy (Penuel et al., 2007). Such practices have a positive effect on the professional self-esteem of teachers, pushing them to leadership and the introduction of innovative initiatives. For STEM chemistry teachers, this is an opportunity to make a comprehensive contribution to the education system, not just teaching.

The work environment has a significant impact on the career aspirations of teachers. Research shows that factors such as support from the school administration, cooperation between colleagues and the cultural climate in the work collective directly contribute to the formation of the level of job satisfaction and long-term professional goals of teachers (Ingersoll & Strong, 2011). For STEM chemistry teachers, such a favorable environment is the basis for their full realization of their professional potential, perseverance in the path of continuous development, and constant activity in the field of Education. Pleasant working conditions will support and develop the professional aspirations of teachers. In such environments, teachers are provided with the freedom to apply innovative approaches in the classroom, the ability to access the necessary resources, and the conditions to collaborate with colleagues (Kunter et al., 2013). For STEM chemistry teachers, these factors not only increase their creativity, but also strengthen their motivation for professional development and have a positive impact on the quality of Education. Conversely, unfavorable working conditions – such as lack of adequate support, excessive workload, and lack of recognition for professional work-weaken teachers ' career aspirations and increase the risk of professional stress and leaving the profession (Guarino et al., 2006). For STEM chemistry teachers, these issues can reduce their interest in the subject and motivation to teach, and hinder professional development. In the case of STEM Chemistry teachers, the availability of resources—such as laboratory equipment, access to research materials, and support for continuing education—directly impacts their ability to pursue aspirations related to advancing their teaching practices and career trajectories. Research by Kunter et al. (2013) shows that teachers who work in a supported environment have higher professional aspirations because they feel more capable of taking on new responsibilities and responsibilities within the school. Such an environment contributes to the fact that teachers feel more effective, take the initiative and

actively strive for career development. In particular, for chemistry teachers in the field of STEM, this will allow them to perform such important tasks as not only mastering the subject, but also increasing the scientific interest of students, introducing innovative methods and forming science — based thinking. Such a favorable working environment reveals the creative potential of teachers and opens the way for their professional development. In addition, these circumstances encourage teachers to look at school activities in the long term, strive for leadership roles, and contribute systematically to education. Therefore, the creation of favorable working conditions for teachers on the part of the school administration, educational organizations and society as a whole is considered a decisive factor for their success in their professional path.

The career aspirations of teachers develop and change over time. Teachers, especially at the initial stage of their career, that is, in the first five years of their professional activity, often pay attention to the effective acquisition of their subject, the formation of classroom management skills and the establishment of pedagogical professional identity (Richter et al., 2011). At this stage, the main task for teachers is to organize the daily learning process, establish effective communication with students, understand the assessment system and adapt to the internal culture of the school. Therefore, it is possible that their long-term career goals have not yet been clearly formed, because they are going through a process of adaptation to the requirements of the professional environment. As experience and confidence increase over time, so do the professional aspirations of teachers. At this stage, they begin to set new goals, such as a deeper specialization in their subject, improving the quality of teaching, and a comprehensive impact on the success of students. In addition, teachers are interested in sharing experience with colleagues, improving training programs, participating in professional development seminars, and strive to play leadership roles within the educational institution. Research by Ingersoll and Strong (2011) highlights that most experienced teachers are interested in developing curricula, mentoring young professionals, or taking an active role in school administration. The career development of stem chemistry teachers also follows these trends. At the first stage, they pay attention to the issues of effective organization of laboratory work, understandable presentation of scientific concepts and increasing students ' interest in the subject, at the later stage they strive to increase their potential through the management of scientific projects, coordination of Olympic training and improvement of teaching methods. Such a transformational process demonstrates the responsibility and commitment of teachers to their profession and is an important factor in maintaining quality personnel in the education system. Experienced teachers, especially those who

work in the STEM field, seek to contribute to educational reforms, conduct research, or mentor young colleagues (Skaalvik & Skaalvik, 2011). This sets the goal for teachers not only to develop their own professional, but also to have a positive impact on the education system as a whole. They aim to improve the quality of education by introducing new teaching methods, updating curricula and developing professional communities within the school. In addition, experienced teachers intend to play an active role in improving scientific research in the field of STEM, introducing new methods and pedagogical innovations through research work. Such aspirations help to form changes and innovations in the field of Education, based on their pedagogical experience and scientific knowledge. However, the alignment between teachers' career aspirations and the available opportunities can be a determining factor in whether they remain motivated and committed to their careers. In the case of limited opportunities for career growth in educational systems, the professional aspirations of teachers are inhibited, which in turn can lead to job dissatisfaction and high turnover of personnel (Guarino et al., 2006). In such cases, teachers are more likely to lose interest in work, not seeing the paths of their professional development. This situation is especially important for young professionals and teachers who are eager for new beginnings. If teachers are not given the opportunity to advance their careers, participate in improving educational programs, or share their experience, the likelihood that they will quit increases. Also, such situations can negatively affect the quality of the working environment in educational institutions and lead to a decrease in the quality of education in general. Therefore, understanding how career aspirations align with the structural conditions of educational institutions is crucial in developing strategies that retain and motivate skilled teachers.

Teachers’ career aspirations are also shaped by broader societal and institutional factors. Public perceptions of the teaching profession, societal respect for STEM fields, and the broader educational policy landscape can all influence the way teachers perceive their professional futures. For instance, research by Friedrichsen et al. (2013) suggests that teachers in the STEM field, especially chemistry teachers, perceive their work as socially significant in terms of developing scientific literacy and preparing students for careers in the fields of Science and technology. For these teachers, teaching their subjects is not only an educational process, but also an opportunity to contribute to the development of society, the formation of a new generation of scientific thinking and the development of innovative technologies. Such socially significant tasks will increase the commitment of teachers to their profession and become a motivating factor for them for continuous development and professional growth. In addition, chemistry teachers, in carrying out

these social missions, can contribute to the renewal of the education system and the creation of important research in the scientific field. However, external factors, such as standardized exams and policy changes, can affect the independence of teachers and cause stress and resentment if they come into conflict with their career aspirations (Lauermann & Karabenick, 2013). Such pressures limit teachers ' ability to creatively organize their teaching methods and the learning process. The requirements of standardized tests and public policy often limit the freedom of teachers to implement the curriculum, and this, in turn, reduces their ability to improve the quality of education and influence the comprehensive development of students. If teachers are engaged in tasks that do not correspond to their professional values and career goals, they may experience a decrease in motivation and dissatisfaction with the work. These circumstances are likely to have a negative impact on the professional development of teachers and the effectiveness of the education system. Educational reforms, especially changes in STEM education, have a bilateral impact on the professional aspirations of teachers. On the one hand, reforms can offer new professional development opportunities and the possibility of promotion to leadership roles. When new methodologies and technologies are introduced in STEM education, teachers have the opportunity to accept these changes and effectively implement them in the learning process, which in turn paves the way for their professional growth. On the other hand, if teachers are not prepared for new demands or do not have enough resources and training programs to support them, this situation can increase their stress levels and cause dissatisfaction and stress (Teemant & Cahnmann-Taylor, 2013). If teachers have difficulty adapting to new educational standards, their motivation for work and career aspirations may be under pressure, and the quality of learning may decrease. Therefore, for the successful implementation of educational reforms, it is important to support and provide teachers with the necessary resources. The tension between these two forces can shape teachers' career goals, as they must navigate the challenges and opportunities presented by these reforms.

Mentorship and peer support networks are vital components of career development for teachers. Having received help and support from experienced colleagues or mentors, teachers usually clearly define their career goals and are more willing to look for career growth opportunities (Ingersoll & Strong, 2011). Such support allows teachers to more clearly plan their professional development paths. The mentoring system and collaboration between colleagues help teachers share their experiences and learn new techniques, which in turn guide them towards achieving their career goals. In addition, the advice and support of experienced teachers plays an important role for new teachers in

adapting to their work, developing their professional skills. Such a support network can increase the motivation of teachers to work and affect their success in the field of Education. For STEM chemistry teachers, the mentoring system helps them understand complex issues in the subject area, improve teaching methods, and explore career advancement opportunities in leadership roles or curriculum development (Borko, 2004). The experience and professional advice of mentors allow teachers to deepen their subject knowledge and improve approaches to effective teaching of chemistry to students. In addition, mentoring support encourages STEM teachers to develop leadership qualities and encourage them to play an important role in the education system. When teachers consider moving to higher-level positions, such as developing new curricula or forming educational policies, the experiences of mentors and colleagues play a major role in their professional development. Studies by Penuel et al. (2007) indicate that collaborative professional learning communities and exchange of experience in professional communities is particularly effective in developing the career aspirations of teachers. In such communities, teachers are encouraged to share their ideas, solve common problems together and participate in the continuous learning process. In addition to providing emotional and professional support to teachers, these networks allow them to increase their career aspirations by facing new challenges and developing new skills. Professional development associations contribute to the self-confidence of teachers and the acquisition of new knowledge and experience, which, in turn, paves the way for their professional development. Such cooperation will allow teachers to improve their professional skills, get acquainted with new methods and approaches, and rise to new roles in the field of Education. Identifying teachers' career aspirations is a complex and multifaceted process that involves understanding the motivations, influences, and external factors that shape their professional goals. Career aspirations are influenced by both intrinsic factors, such as personal passion for teaching, and extrinsic factors, such as workplace support, professional development, and societal attitudes. Teachers' aspirations evolve over time, often in response to the evolving demands of their careers and the educational environments in which they work. By recognizing the factors that contribute to teachers' career aspirations, educational leaders and policymakers can create conditions that support teacher motivation and career development, ensuring that teachers remain committed, engaged, and capable of delivering high-quality education.

1.4. STEM teachers, particularly in chemistry and other scientific disciplines, play a pivotal role in preparing the next generation of scientists, researchers, and innovators. However, despite the significance of STEM education, many teachers, especially those in

chemistry, may face challenges in realizing their career aspirations. Identifying and addressing these needs is essential for fostering a motivated and empowered teaching workforce capable of inspiring the next generation of scientists and engineers. As the global demand for STEM professionals continues to rise, it is crucial to understand the challenges STEM teachers face in developing and achieving their career aspirations. Enhancing these aspirations not only improves teacher satisfaction but also has significant implications for student outcomes and the broader educational system.

One of the primary needs for improving career aspirations among STEM chemistry teachers is access to high-quality professional development opportunities. Continuous professional development-plays a crucial role for teachers to continuously improve their knowledge and pedagogical experience in subject content (Penuel et al., 2017). Since the STEM field, especially chemistry, is one of the fastest growing branches of science, teachers need to be aware of new scientific advances and teaching methods. This process not only ensures high-quality education for students, but also increases the interest of teachers in their profession, professional confidence and desire for career growth. Continuing education in the modern education system is an important prerequisite for improving the quality of education, introducing innovations and active participation of teachers in the professional community. Providing teachers with opportunities for ongoing professional growth, such as workshops, seminars, and graduate courses, can help them develop the skills and expertise needed to excel in their careers.

Another critical need is the establishment of mentorship and support networks for STEM chemistry teachers. The complex nature of pedagogical activity makes it particularly difficult for novice teachers (Strobel & van Barneveld, 2009). The learning process is not limited to academic knowledge, but includes multifaceted tasks such as classroom management, taking into account student diversity, effective application of assessment methods, and communication with parents and colleagues. Teachers need professional support and guidance to effectively accomplish these complex tasks. Especially for teachers with little experience, this support contributes to their professional adaptation, an increase in the level of confidence and the determination of career goals. Therefore, the presence in the education system of structural mechanisms aimed at supporting novice teachers (mentoring, professional training, platforms for the exchange of experience, etc.) directly affects their long-term professional development. Pairing teachers with experienced mentors who can provide guidance, support, and encouragement can help alleviate feelings of isolation and promote professional growth. Additionally, fostering

collaborative networks among teachers allows for the sharing of resources, best practices, and innovative teaching strategies.

STEM chemistry teachers often possess a wealth of expertise and experience that should be recognized and valued within their educational institutions and the broader community. Recognizing and appreciating the contribution of teachers to the educational process in the field of science is one of the most important ways to increase their professional motivation and career aspirations. In this context, giving teachers the opportunity to demonstrate their achievements – that is, to present them for awards, to be published in scientific and methodological publications, to make reports at conferences and seminars-strengthens their professional value and increases confidence in their work (Barman et al., 2010). Such practice not only raises the authority of teachers in the pedagogical community, but also encourages them to take leadership, innovative initiatives and share their experience with others. In addition, public recognition of the achievements of teachers will create a positive image of the educational institution and strengthen the desire of young professionals to build a long-term career in this area. Recognizing teachers as experts in their field not only boosts morale but also fosters a sense of pride and ownership in their work.

Incorporating innovative technologies and resources into STEM chemistry classrooms can enhance the teaching and learning experience for both teachers and students. However, many teachers may lack access to the necessary tools, training, and support needed to effectively integrate technology into their instructional practices. Providing teachers with access to state-of-the-art laboratory equipment, digital resources, and professional development opportunities focused on technology integration can help bridge this gap and empower teachers to embrace innovative teaching methods. Creating clear career pathways and advancement opportunities for STEM chemistry teachers is essential for fostering long-term career satisfaction and retention. Many teachers feel that they have limited opportunities in relation to their professional future, especially in terms of promotion and professional development (Penuel et al., 2017). Such a situation is often associated with the lack of clarity of the trajectory of career growth, limited opportunities for promotion to leadership in the education system, or insufficient programs for professional training and advanced training. These factors can negatively affect teachers ' motivation, job satisfaction, and desire to serve in the industry for a long time. As a result, teachers feel stuck professionally and lose the desire to introduce an innovative approach to the educational process. Therefore, it is especially important to form specific support

mechanisms in the education system aimed at the career development of teachers. Establishing opportunities for advancement, such as leadership roles, specialized training programs, and opportunities for research and scholarship, can provide teachers with the motivation and incentive to pursue lifelong careers in education. Cultivating a culture of collaboration and support within educational institutions is crucial for improving career aspirations among STEM chemistry teachers. Creating a favorable working environment in which the teacher feels respected, valued and entitled to make professional decisions – increases his sense of belonging and professional commitment to the team (Strobel & van Barneveld, 2009). In such a supported environment, teachers tend to innovate in pedagogical practice, grow professionally, and openly collaborate with colleagues. In addition, an environment based on trust and respect strengthens the intrinsic motivation of teachers and increases their motivation to improve the quality of teaching and plan their careers in the long term. In such an environment, teachers are recognized as not only active participants in the educational process, but also leaders who contribute to its improvement. Encouraging collaboration among teachers, administrators, and other stakeholders promotes the exchange of ideas, fosters professional growth, and ultimately enhances the quality of STEM education.

One of the most significant needs for improving career aspirations among STEM teachers is access to high-quality, continuous professional development (PD). STEM educators face the challenge of staying up to date with rapidly evolving scientific knowledge, technological advancements, and innovative teaching practices. Research shows that opportunities for professional development tailored to the needs of STEM teachers are crucial for deepening their subject competence, improving teaching experience, and enhancing their professional career aspirations (Darling-Hammond et al., 2009; Garet et al., 2001). Such focused professional development programs allow teachers not only to update their pedagogical methods, but also to get acquainted with scientific achievements in the field of STEM, effectively use modern educational technologies and adapt the content of training to the needs of students. As a result, teachers begin to feel like professionals who are developing professionally and strive for new roles and leadership opportunities in the industry. (Darling-Hammond et al., 2009; Garet et al., 2001). STEM teachers, particularly those in specialized subjects like chemistry, benefit from PD that not only covers subject-specific content but also provides strategies for integrating technology, inquiry-based learning, and interdisciplinary approaches into their classrooms (Penuel et al., 2007). Long-term professional development programs play a key role in increasing teachers ' motivation and ensuring their professional development because they

provide teachers with the tools and confidence, they need to take on leadership roles or extended teaching tasks (Borko, 2004). Through such programs, teachers have the opportunity not only to improve their pedagogical skills, but also to rise to the level of professional leaders who make strategic decisions in the educational process and guide their colleagues. This, in turn, contributes to the determination of their career goals, the deepening of teaching experience and the improvement of the quality of Education. When teachers actively participate in long-term professional development (PD) programs, they tend to pursue higher professional aspirations, such as curriculum development, leadership in the teaching process, or engaging in academic research (Garet et al., 2001). The experience of such professional development increases the readiness of teachers to deeply understand the subject content, effectively apply modern pedagogical methods, and contribute to strategic decisions in the education system. In addition, it has a positive effect on their professional self-esteem and strengthens their motivation to pursue a sustainable and meaningful career in the field of Education. The provision of cooperative, mentoring and collaborative learning opportunities within the professional development (PD) initiatives for STEM subject teachers contributes to the formation of a sense of professional community among them, which in turn increases the career motivation of teachers (Penuel et al., 2007). Such initiatives create conditions for teachers to exchange experience, learn from each other and jointly solve complex problems in teaching. As a result, teachers feel that they are professionally supported, valued and recognized, which strengthens their desire for professional growth and leadership. In addition, working in such an environment has a positive effect on the emotional well-being of teachers, increasing their interest in sustainable and long-term activities.

A supportive and collaborative work environment is crucial for improving the career aspirations of STEM teachers. Many teachers express a desire for greater autonomy in their teaching and more opportunities for leadership within their schools (Ingersoll & Strong, 2011). However, such aspirations are often hindered by rigid school structures, lack of support from administration, and insufficient resources. For STEM teachers, particularly those teaching chemistry, access to well-equipped labs, research materials, and opportunities to engage in scientific inquiry are vital for both personal fulfillment and professional growth (Kunter et al., 2013).

Support from school leadership is critical in fostering an environment that nurtures career aspirations. When school leaders recognize and support the potential of STEM teachers to take on leadership roles, teachers are more likely to pursue career advancement

opportunities. Research has shown that schools that foster teacher leadership and provide mentorship programs for new or aspiring STEM educators have higher teacher retention rates and more satisfied, motivated teachers (Ingersoll & Strong, 2011; Guarino et al., 2006). Additionally, providing a collaborative culture where STEM teachers can share best practices and solve problems together can contribute significantly to their career development (Teemant & Cahnmann-Taylor, 2013).

One of the key barriers to improving career aspirations among STEM teachers is the high workload and the stress associated with teaching in demanding fields. Many STEM teachers, particularly in high schools, face large class sizes, extensive grading, and the pressure to meet standardized testing benchmarks, all of which contribute to burnout and attrition. Research by Guarino et al. (2006) highlights that teachers who experience burnout are less likely to pursue leadership roles or further their professional development, which stifles their career aspirations.

To address this issue, educational systems need to recognize the importance of reducing teacher workload and providing adequate mental health and wellness support. A balanced workload, adequate planning time, and strategies to manage stress are essential for maintaining teachers' motivation and long-term career aspirations (Richter et al., 2011). Furthermore, research suggests that when STEM teachers feel supported in managing their workload and are provided with sufficient resources to deliver high-quality instruction, they are more likely to stay in the profession and pursue advanced career goals (Guarino et al., 2006).

Mentorship plays a crucial role in enhancing the career aspirations of STEM teachers. Beginning teachers often lack the experience and confidence to navigate their careers and may feel isolated in their professional development. A strong mentorship program that pairs novice teachers with experienced colleagues can provide invaluable support, guidance, and encouragement. According to studies by Ingersoll and Strong (2011), mentorship improves teacher retention, increases job satisfaction, and boosts career aspirations by offering both emotional and professional support. Mentorship programs specifically designed for STEM teachers can have even greater benefits. These programs provide opportunities for teachers to discuss challenges unique to teaching STEM subjects, such as integrating technology into the classroom, fostering scientific inquiry, and promoting STEM careers among students. Peer networks also allow STEM teachers to collaborate on curriculum development, share teaching strategies, and engage in

professional discussions that promote career advancement (Teemant & Cahnmann-Taylor, 2013).

Financial incentives are another important factor in shaping the career aspirations of STEM teachers. While intrinsic motivation such as a passion for teaching is crucial, extrinsic factors like salary and career advancement opportunities also play a significant role in teachers' decisions to remain in the profession or pursue leadership positions (Skaalvik & Skaalvik, 2011). Offering competitive salaries and bonuses for STEM teachers, particularly in underfunded schools, can serve as an incentive for teachers to stay in the profession and invest in their professional growth. Incentive structures such as performance-based pay, opportunities for additional qualifications, or sabbaticals for research or advanced study can also motivate STEM teachers to pursue career aspirations beyond the classroom (Friedrichsen et al., 2013). Research by Richter et al. (2011) suggests that financial incentives, when combined with professional development and supportive work environments, can lead to greater career satisfaction and improved teacher retention rates in STEM fields.

While extrinsic rewards are important, intrinsic motivation remains a critical driver of career aspirations among STEM teachers. Teachers who are intrinsically motivated by a love for their subject, a desire to make a difference in students' lives, or a passion for science and discovery tend to pursue long-term career goals that align with their personal values (Ryan & Deci, 2000). For STEM teachers, fostering this intrinsic motivation is essential in helping them overcome challenges and maintain long-term career aspirations. To cultivate intrinsic motivation, educational systems should focus on creating conditions that allow teachers to experience a sense of autonomy, mastery, and purpose in their work (Deci & Ryan, 2008). Providing teachers with opportunities for creativity in lesson planning, the freedom to pursue innovative teaching methods, and recognition for their contributions to student learning can help sustain their passion for teaching and encourage them to pursue leadership roles within their schools (Ryan & Deci, 2000).

Societal perceptions of the teaching profession, particularly in STEM fields, also play a significant role in shaping career aspirations. Research indicates that teachers in high-status professions, such as law and medicine, often have greater societal recognition, which can influence their aspirations and career satisfaction (Buchanan et al., 2013). Conversely, teaching is often perceived as a less prestigious profession, which can discourage talented individuals from pursuing long-term careers in education. To improve the career aspirations of STEM teachers, it is essential to change the public perception of

teaching as a profession. Increasing societal respect for teachers, particularly those in STEM disciplines, can help elevate the status of the profession and make it more attractive to potential teachers. Public campaigns, media representation, and educational policies that highlight the importance of STEM education and the contributions of teachers can help foster a culture that values educators and motivates them to pursue career advancement (Buchanan et al., 2013).
The Commonwealth of Independent States (CIS), a regional organization comprising former Soviet republics, faces unique challenges and opportunities in the realm of education, particularly in STEM (Science, Technology, Engineering, and Mathematics) fields. Within this context, the career aspirations of STEM Chemistry teachers in the CIS are shaped by the region's educational history, evolving political and economic conditions, and the global emphasis on STEM education as a driver of innovation. Identifying the career aspirations of Chemistry teachers in this region is important for understanding how educators envision their professional futures, as well as for formulating policies and support systems that can enhance STEM education across the CIS.

The educational landscape in the CIS is diverse, with each member state having distinct educational policies and practices. However, common historical and cultural roots in the Soviet education system have shaped the approaches to teaching and learning across the region. During the Soviet era, science education, including chemistry, was highly emphasized, with a focus on technical expertise and rigorous academic training . However, the transition to market economies in the 1990s led to shifts in educational priorities, with an increasing focus on reforms aimed at modernizing the curriculum, improving teacher training, and enhancing international competitiveness in science and technology fields.

In recent years, many CIS countries have recognized the need to improve STEM education to foster innovation and prepare students for the global economy. This has led to various educational reforms aimed at enhancing the quality of STEM teaching and attracting qualified professionals into the teaching workforce . However, despite these reforms, there remain significant challenges, such as outdated educational infrastructure, insufficient funding, and varying levels of support for STEM teachers. These challenges also impact the career aspirations of STEM Chemistry teachers in the region. In the CIS, career aspirations of STEM Chemistry teachers are influenced by a variety of personal,

institutional, and societal factors. Understanding these aspirations requires considering the unique political, cultural, and economic context of the region.

Like their counterparts in other parts of the world, STEM Chemistry teachers in the CIS are often motivated by a strong passion for the subject and a desire to impart scientific knowledge to the next generation. However, the perceived prestige and societal status of the teaching profession in the CIS may influence how teachers view their career prospects. In many CIS countries, teaching is not always seen as a high-status profession, especially in comparison to careers in business or technology. As a result, Chemistry teachers may aspire to move into leadership roles, such as becoming department heads, school principals, or curriculum designers, in order to gain recognition and influence within their institutions. The career aspirations of STEM Chemistry teachers in the CIS are often shaped by the availability of professional development opportunities. Historically, professional development in the region has been limited, particularly in rural or remote areas, where teachers may have fewer opportunities for workshops, conferences, or further education . This lack of support can limit teachers' aspirations to move into more advanced roles, such as researchers or educational policymakers. However, in urban centers and more developed countries within the CIS, such as Russia and Kazakhstan, there are growing opportunities for teachers to participate in international exchange programs, research projects, and STEM conferences. These opportunities can inspire teachers to aspire to more advanced and influential roles, both within education and in the broader scientific community . In countries like Russia, Armenia, and Kazakhstan, educational reforms have created new opportunities for STEM Chemistry teachers to shape curricula, adopt innovative teaching methods, and engage in interdisciplinary teaching . These reforms often emphasize the integration of technology and modern pedagogical strategies, which can influence teachers’ aspirations. Teachers may aspire to incorporate new tools and approaches into their classrooms, such as blended learning environments or STEM research projects. At the same time, the pressure to meet new curricular standards or to prepare students for international assessments may lead to career burnout or a desire to leave the profession, especially if teachers feel unsupported or overworked. In many CIS countries, there is a gendered dimension to the teaching profession. Like in other parts of the world, STEM fields, including chemistry, have been historically dominated by men, while women have often been encouraged to pursue teaching roles. While women make up the majority of teachers in the CIS, their career aspirations are sometimes constrained by societal expectations about their roles in education and family life. Female Chemistry

teachers, especially in more traditional societies, may face additional challenges when it comes to advancing into leadership roles or pursuing advanced research opportunities. However, recent initiatives aimed at gender equality in education, particularly in countries like Azerbaijan and Kazakhstan, are beginning to challenge these stereotypes, leading to more diverse aspirations among female STEM teachers. Retaining skilled STEM Chemistry teachers in the CIS is an ongoing challenge, particularly in less urbanized areas. Low salaries, lack of professional recognition, and limited career advancement opportunities often result in high turnover rates among STEM teachers, which can diminish the overall quality of STEM education. As a result, many teachers in the region aspire to leave the classroom for better-paying jobs in industry or research, where their qualifications can be more readily recognized and rewarded . In countries like Russia and Ukraine, where the demand for qualified STEM professionals in the private sector is high, Chemistry teachers may view teaching as a temporary or less desirable career path, unless there are sufficient incentives to remain in the profession. Identifying the career aspirations of STEM Chemistry teachers in the CIS requires a nuanced understanding of the region's educational landscape, societal expectations, and the challenges faced by teachers. While many teachers in the region are motivated by a passion for their subject, their career aspirations are often influenced by factors such as professional development opportunities, educational reforms, and the overall status of the teaching profession. In order to better support these teachers, educational leaders in the CIS must address the systemic issues that limit career growth, enhance teacher training and development, and create policies that increase the prestige and recognition of STEM education. By doing so, they can foster an environment that encourages Chemistry teachers to aspire to greater professional achievements, ultimately improving the quality of STEM education in the region. Since 2014, the UK and Kazakhstan have been collaborating through the "Newton - al-Farabi" Partner Program, which spans five years and has a total budget of £20 million. The goal of this program is to enhance scientific and innovation capacities, facilitate the exchange of expertise, and establish joint research centers between the two nations. As a result, Kazakhstan is progressing in parallel with developed countries in terms of educational advancement. STEM education serves as a vital link between academic learning and professional careers. This approach equips students with the knowledge and skills necessary for thriving in a technologically advanced world, where expertise across various fields of natural sciences, engineering, technology, and mathematics is essential for future professionals. In recent years, Kazakhstan has made significant strides in advancing STEM education. According to the Ministry of Education and Science of the Republic of Kazakhstan (MEARK, 2022),

the elective course "Robotics" was introduced in 2500 schools starting from the 2016–2017 academic year to promote STEM education among middle and high school students. Additionally, robotics laboratories have been established in 1100 schools, and a total of 1626 schools (23.1%) now offer robotics elective courses, engaging more than 32,000 students. To further encourage interest in robotics, various annual competitions, such as the Republican Olympiad in Robotics and the International Robotics Festival "RoboLand," have been held since 2016. Successful participants in these events can even qualify for the World Robotics Olympiad (WRO).

However, government initiatives to expand STEM education in Kazakhstan have primarily focused on robotics up until now (Japashov et al., 2024). This year, the State Program for the Development of Education and Science has introduced a new approach, emphasizing interdisciplinary connections across STEM subjects. The new educational policy aims to deepen students' understanding of emerging technologies, scientific innovations, and mathematical modeling in subjects such as Physics, Mathematics, Biology, Chemistry, and Technology (Japashov et al., 2024).

2. Methodology

2.1. Procedure

To explore the career aspirations of STEM Chemistry teachers, a structured online survey methodology was adopted. The primary aim of the procedure was to gather both quantitative and qualitative data that would provide a well-rounded understanding of teachers’ professional goals, motivations, perceived barriers, and required institutional support. The survey was developed using **Google Forms**, which enabled broad and efficient online distribution.

To ensure inclusivity and accessibility, the survey was made available in **three languages**: Kazakh, Russian, and English. This multilingual format allowed participants to respond in their preferred language, thereby increasing clarity and comfort during completion. The survey link was shared via email, messaging platforms, and through professional networks and STEM teacher groups.

The online format also ensured standardized data collection and facilitated later statistical analysis. The survey instrument was composed of 14 questions categorized

into six thematic sections. A detailed overview of the survey structure is presented in **Table 1**.

Table 1. Structure of the Online Survey Instrument

Section	Number of Questions	Question Type
Demographic Information	4	Multiple choice
Career Aspirations & Motivation	4	Likert scale (1–5)
Career Path Preferences	1	Single-answer multiple choice
Perceived Career Challenges	1	Checklist (multiple answers allowed)
Support Needs for Development	1	Checklist (multiple answers allowed)
Open-ended Questions	3	Open text (qualitative responses)

2.2. Sampling

This study involved 62 STEM Chemistry teachers who participated in the online survey. All participants were practicing teachers representing different educational levels—secondary, upper secondary, and university—within the context of STEM education. Importantly, all respondents specialized in teaching chemistry as part of the STEM framework. A convenience sampling strategy was employed, where participants were selected based on accessibility and voluntary willingness to participate. The survey link was distributed via professional STEM teaching networks, email, and institutional contacts. Teachers completed the questionnaire online using Google Forms.

It is important to note that the number of STEM Chemistry teachers in Kazakhstan is relatively limited compared to teachers of other subject areas. Therefore, reaching 62 respondents in this specific domain provides valuable insight into a niche but critical segment of the educational workforce. Although the sample was not randomly selected, the diversity in teaching levels and professional experience allowed for a meaningful exploration of career aspirations, perceived challenges, and development needs within this specialized teaching population.

2.4. Data collection

The survey was conducted entirely online through the Google Forms platform. A unique survey link was disseminated via email, messaging apps, and STEM-focused professional networks. The form began with an informed consent statement that clarified the voluntary and anonymous nature of participation. Teachers were encouraged to complete the survey at their convenience within the assigned data collection period. The online format ensured uniformity in delivery, minimized logistical barriers, and enabled real-time storage of responses. All data were automatically recorded in a secure spreadsheet format, allowing for efficient cleaning, coding, and statistical analysis in subsequent phases of the study.

2.4. Data analysis

The data analysis process was conducted in accordance with the mixed-method design of the study, combining both **quantitative** and **qualitative** techniques to address the research questions. The quantitative data were exported from Google Forms into Microsoft Excel and subsequently analyzed using statistical software tool-Jamovi to ensure clarity, accuracy, and consistency in interpretation.

Quantitative analysis

Descriptive statistics were used to summarize participants' demographic characteristics and their responses to Likert-scale items. Measures such as **means, standard deviations, and frequency distributions** were calculated to examine general trends in satisfaction levels, professional aspirations, and perceptions of support.

To assess the internal consistency of Likert-scale items related to career motivations and development goals, **Cronbach's Alpha** was calculated. **Reliability analysis** showed that the "Professional Development" scale (comprising two items) had a higher internal consistency with an alpha value of **0.768**.

Bivariate relationships between key variables were explored using **Pearson correlation analysis**. The strongest positive correlation was found between the aspiration to pursue further education and the desire to be involved in curriculum or research activities ($r = 0.65$), suggesting a close link between continuous learning and professional engagement in STEM education development.

Qualitative analysis

The three open-ended questions were analyzed using **thematic coding**. Responses were first reviewed to identify recurring phrases and ideas, which were then grouped into broader categories reflecting teachers' long-term goals, sources of motivation, and desired changes in the profession. This qualitative data provided valuable context and enriched the interpretation of the quantitative findings.

3. RESULT

3.1. Survey finding

The survey was structured into six thematic sections, and findings are presented below based on item types and response trends.

1.Demographic Characteristics

Participants represented various educational backgrounds and levels of experience.

- **Gender**

  Among the 62 STEM Chemistry teachers who participated in the survey, a significant majority identified as **female (80.6%)**, while **male respondents** accounted for **19.4%**. This gender imbalance reflects a broader trend observed in the teaching profession in Kazakhstan and many other countries, where female educators are more prevalent, particularly in the field of secondary education. The gender distribution provides an important contextual background when interpreting motivations, aspirations, and career challenges reported later in the study.

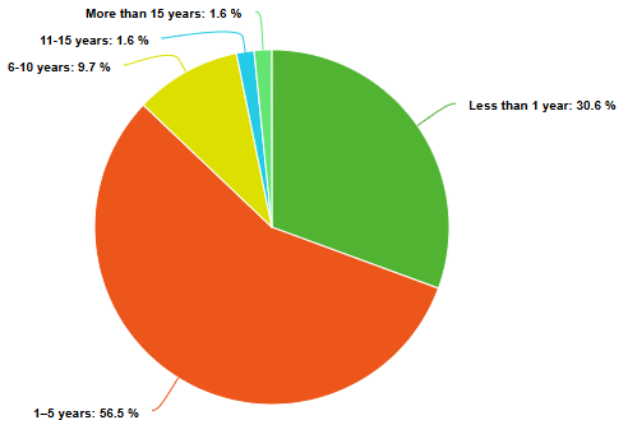
Table 2. Gender Distribution of Respondents

Gender	Frequency	Percentage (%)
Female	50	80.6%
Male	12	19.4%
Total	**62**	**100%**

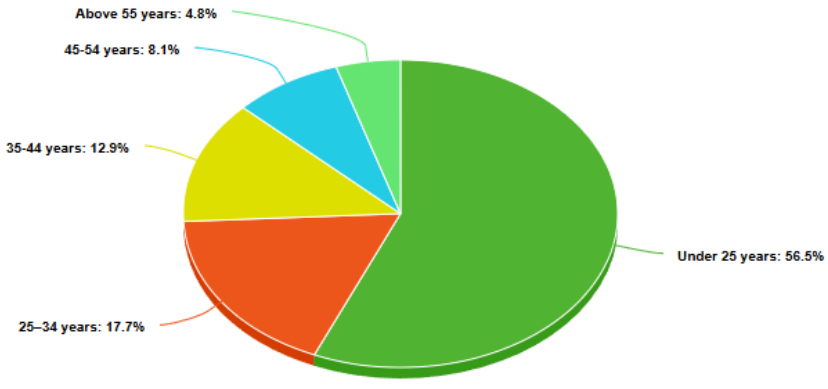
- **Age**

56.5% of the respondents are in the 25-34 years age range, which indicates a dominant group of relatively younger STEM Chemistry teachers. 17.7% are under 25 years old, suggesting that a portion of the sample includes early-career educators.The age groups 35-44 years and 45-54 years contribute to 12.9% and 8.1% of the respondents, respectively, reflecting a moderate presence of mid-career professionals. 4.8% of the respondents are aged 55 or above, which points to a small portion of teachers nearing retirement or with extensive experience in the field.This age distribution suggests that the majority of STEM Chemistry teachers are in the early to mid-career stages, which could indicate a relatively young, dynamic workforce within the profession.

- Teaching experience



56.5% of respondents have been teaching STEM Chemistry for 1-5 years, making it the largest group. This suggests that a significant portion of teachers in this sample are relatively new to the profession, likely still in the early stages of their career. 30.6% of



respondents have less than 1 year of teaching experience, reflecting a high influx of teachers just starting their careers in STEM Chemistry. 9.7% have between 6-10 years of

teaching experience, which indicates a smaller group of mid-career professionals. 1.6% have between 11-15 years of experience, and an even smaller percentage, 1.6%, have more than 15 years of experience. These percentages suggest that the sample contains very few teachers with long-term experience, which could be reflective of the relatively young demographic in this field. This distribution indicates a high concentration of new or early-career teachers, reinforcing the idea that professional development, mentorship, and support for younger educators could be critical for their growth and retention in the STEM Chemistry teaching field.

- **Educational background**

59.7% of respondents hold a **Bachelor's Degree**. This is the largest group, suggesting that a significant portion of the sample has completed undergraduate studies, likely providing foundational knowledge in chemistry and education. **32.3%** have a **Master's Degree**, indicating a considerable percentage of teachers have pursued advanced studies, which may reflect a higher level of specialization or commitment to the teaching profession. Only **8.1%** of respondents have a **PhD**. This suggests a relatively small number of STEM Chemistry teachers in the sample have pursued doctoral-level education, which could imply that most of the teachers in this study focus more on teaching rather than research-based academic careers.

Figure 3. Educational background of STEM Chemistry Teachers

Career aspirations and motivations (Likert-Scale items)

Four Likert-scale questions (rated from 1 to 5) assessed participants' satisfaction with their current career and their future professional goals.

Table 3. Descriptive Statistics of Likert-Scale Survey Items

Survey Question	Mean	Median	Mode	Standard Deviation
Satisfaction with current career	4.02	4.00	4	0.88
Aspiration for leadership roles	3.93	5.00	5	1.41
Desire to pursue further education	4.46	5.00	5	1.01
Interest in curriculum/research involvement	4.57	5.00	5	0.76

This result shown in Table 3 indicates a **generally high level of satisfaction** among STEM Chemistry teachers regarding their current professional position. The small standard deviation suggests that most responses were close to the average, reflecting a relatively **consistent sentiment of satisfaction** across the sample.

Although the median and mode indicate a strong inclination toward leadership roles, the **high standard deviation** shows that there was significant **variation in responses**. This suggests that while some teachers are highly motivated to take on leadership responsibilities, others may feel less inclined, possibly due to perceived barriers or lack of institutional pathways.

The **high mean and central tendency values** (median and mode at 5) reflect a strong and widespread desire among respondents to engage in **ongoing academic and professional development**. This suggests that further training, postgraduate education, or certification programs are perceived as valuable and desirable for career advancement in STEM fields.

This item received the **highest average score**, showing that STEM Chemistry teachers are highly interested in contributing to curriculum development and engaging in research activities**.** The low standard deviation further indicates that this aspiration is shared across the majority of participants, making it one of the most consistent and pronounced findings in the survey. The findings suggest that STEM Chemistry teachers not only feel satisfied with their current roles but are also **highly motivated to grow professionally**, particularly through further education and involvement in curriculum or research work. Leadership aspirations vary more widely, potentially due to contextual or structural differences in opportunity.

Perceived Career Challenges

Participants were asked to select their preferred direction for future career development. The most commonly selected options were: Further specialization in chemistry/STEM. Promotion to leadership positions. Horizontal career change (e.g., transitioning into

research or education management). A smaller number expressed uncertainty or interest in entrepreneurship.

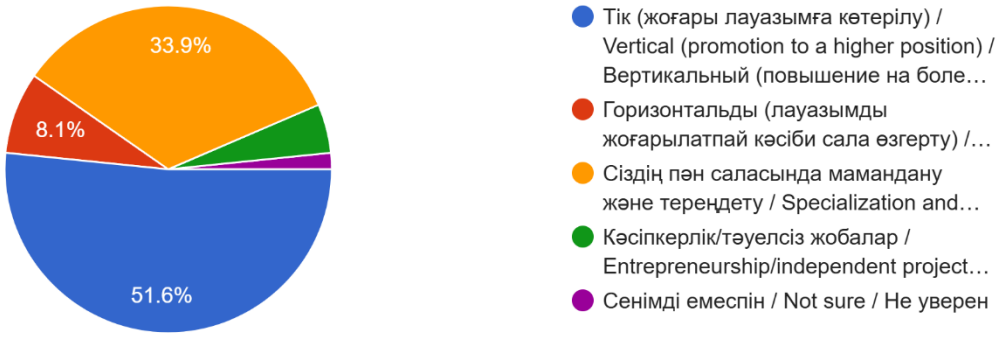


Figure 4. Career aspirations of STEM Chemistry Teachers

Support Needs

Participants were asked what types of support they believed would enhance their career development. Most commonly selected needs included:

- Access to professional development and training
- Reduced administrative workload
- Better resources for laboratory teaching
- Mentorship and clearer career progression pathways

Open-ended Responses

Three open-ended questions provided qualitative insights into teachers' personal aspirations, motivations, and expectations. Preliminary thematic coding revealed recurring themes such as:

- A desire for **academic growth** and recognition
- Motivation to **inspire students and contribute to STEM literacy**
- Need for **institutional support** to reduce burnout and increase career satisfaction

Table 4. Cronbach's Alpha Reliability of Likert-scale Items

Scale	Items Included	Cronbach's Alpha
General Career Aspiration Scale	Satisfaction, Leadership Aspiration, Further Education, Research Interest	0.658
Professional Development Focus (subscale)	Further Education, Research Involvement	0.768

- The overall reliability coefficient ($\alpha = 0.658$) for the four Likert-scale items suggests an **acceptable level of internal consistency** for exploratory research in the field of education. This indicates that the items collectively measure a relatively unified construct related to teachers' career aspirations.
- The **Professional Development subscale**, which includes items on further education and curriculum/research engagement, yielded a higher alpha value ($\alpha = 0.768$), reflecting **good internal consistency**. This implies that these two items are strongly related and can be interpreted as part of a consistent dimension of teachers' professional growth motivation.

Correlation Analysis

Pearson correlation analysis was conducted to examine the relationships between the four core Likert-scale items related to STEM Chemistry teachers' career aspirations:satisfaction with current career, aspiration for leadership roles, desire to pursue further education, interest in curriculum/research involvement

Variables Compared	Correlation (r)	Interpretation
Further Education ↔ Research Involvement	**0.65**	Strong positive correlation: teachers who want more education also value research.
Satisfaction ↔ Leadership Aspiration	**0.42**	Moderate correlation: more satisfied teachers tend to seek leadership roles.
Satisfaction ↔ Further Education	**0.31**	Weak to moderate: satisfaction relates slightly to desire for academic growth.

Variables Compared	Correlation (r)	Interpretation
Leadership Aspiration ↔ Research Involvement	**0.28**	Weak: only some leadership-aspiring teachers are drawn to research.

The strongest observed correlation was between **the desire to pursue further education** and **interest in curriculum or research involvement** (r = 0.65). This indicates that teachers who value advanced academic development are also more likely to engage in broader professional contributions such as curriculum innovation or educational research.

The moderate correlation between **career satisfaction** and **leadership aspiration** (r = 0.42) suggests that teachers who feel secure and fulfilled in their current role are more confident or willing to take on leadership responsibilities.

Weaker correlations (r < 0.3) indicate that not all professional interests align uniformly, highlighting the **diverse profiles of career aspirations** within the STEM Chemistry teaching community.

Table 5. Pearson correlation coefficients between core Likert-scale items related to career satisfaction and aspirations among STEM Chemistry teachers.

	Satisfaction	Leadership Aspiration	Further Education	Curriculum/Research Interest
Satisfaction	1.00	0.42	0.31	0.35
Leadership Aspiration	0.42	1.00	0.28	0.40
Further Education	0.31	0.28	1.00	0.65
Curriculum/Research Interest	0.35	0.40	0.65	1.00

Overall, the correlations suggest that **professional growth areas** such as further education and curriculum involvement are **mutually reinforcing**, and often aligned with **higher satisfaction and leadership ambition**. These findings emphasize the importance of providing opportunities for **advanced study, research participation, and structured career pathways** in supporting the aspirations of STEM Chemistry teachers.

Frequency analysis

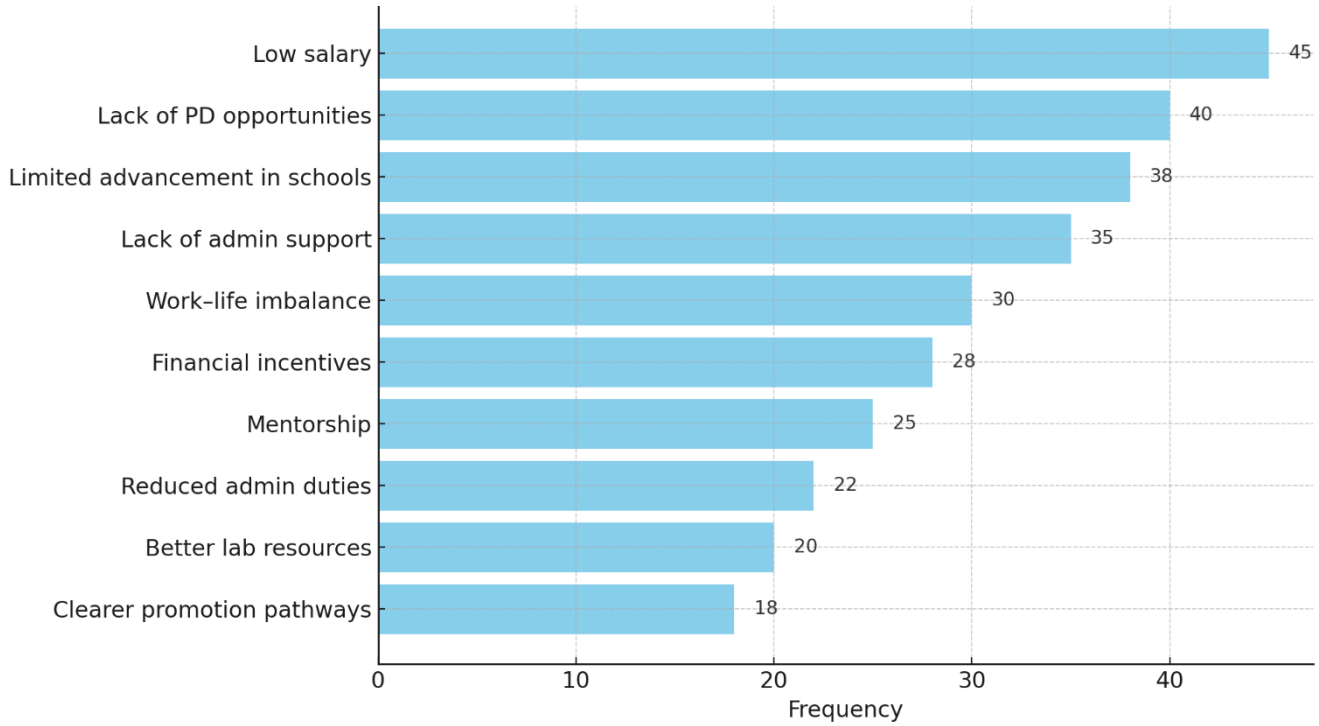


Figure 5. Most Reported Career Barriers and Support Needs

The frequency analysis revealed that **low salary** is the most commonly cited barrier to career growth among STEM Chemistry teachers, followed closely by the **lack of professional development opportunities** and **limited advancement options within school systems**. These findings point to structural and systemic issues that hinder the professional progression of teachers in this field.

Furthermore, teachers expressed a strong need for **financial incentives**, **mentorship**, and **administrative support** to enhance their career satisfaction and motivation. The frequency of these responses underscores the importance of establishing sustainable support mechanisms that address both personal and institutional challenges.

An independent samples t-test was conducted to compare the mean scores of **leadership aspiration** between two groups of teachers based on their **years of chemistry teaching experience as shown in Table below**:

- **Group 1:** Teachers with 10 years of experience or less
- **Group 2:** Teachers with more than 10 years of experience

The test revealed that the mean aspiration score was slightly higher in the >10 years group (M = 4.25) compared to the ≤10 years group (M = 3.80).

However, this difference was **not statistically significant**, *t(60) = –1.154, p = 0.258*.

Table 6. Independent Samples t-test: Leadership Aspiration by Teaching Experience

Group	N	Mean	t-statistic	p-value
≤10 years of experience	44	3.80	–1.154	0.258
>10 years of experience	18	4.25		

While experienced teachers (over 10 years) showed a slightly higher inclination toward leadership roles, the statistical analysis suggests that **teaching experience alone does not significantly influence leadership aspirations** among STEM Chemistry teachers.

This implies that **career goals are likely shaped by other factors**, such as institutional culture, professional development opportunities, administrative support, or intrinsic motivation. The absence of a significant difference emphasizes the complexity of teacher career progression and the need to look beyond years of service when designing support strategies for aspiring teacher leaders.

Table 7. One-Way ANOVA: Research Interest by Age Group

Age Group	Mean Research Interest (1–5)
Under 25	4.40
25–34	4.73
35–44	4.62
45–54	5.00
55+	5.00

F-statistic = 1.223 ; **p-value** = 0.311

A one-way ANOVA was conducted to determine whether there were statistically significant differences in **interest in curriculum development or educational research** among teachers of different **age groups**.

Although the highest average interest was observed in the **older age groups (45–54 and 55+)**, the difference in mean scores across all age groups was **not statistically significant**, *F(4,57) = 1.223, p = 0.311*.

This result indicates that **age does not significantly influence teachers' interest in participating in curriculum development or research projects**. While older teachers

tend to score slightly higher on average, the variation in responses was not large enough to be considered statistically meaningful.

A one-way ANOVA was conducted to explore whether STEM Chemistry teachers' **interest in curriculum development or research** differed significantly based on their **years of teaching experience in chemistry**. While the average research interest increased slightly with more experience (notably all groups with more than 10 years scored at or near 5.00), this difference was **not statistically significant**, *F = 1.463*, *p = 0.216*.

Table 8. One-Way ANOVA: Research Interest by Teaching Experience

Experience Group	Mean Research Interest (1–5)
1–5 years	4.39
5–10 years	4.90
10–15 years	5.00
15–20 years	4.43
20–25 years	5.00
More than 25 years	5.00

The results suggest that **years of teaching experience do not significantly influence teachers' desire to engage in curriculum development or educational research projects**. This implies that such interest is **consistently high across all experience levels**, reflecting a shared motivation among both early-career and veteran STEM Chemistry teachers. These analyses aimed to determine whether significant mean differences existed across subgroups based on teaching experience and age.

An independent samples t-test was conducted to compare teachers' aspiration for leadership roles between those with 10 years of teaching experience or less and those with more than 10 years. Although the mean score for experienced teachers was slightly higher (M = 4.25) compared to early-career teachers (M = 3.80), the result was not statistically significant (t (60) = –1.154, p = 0.258). This finding suggests that teaching experience alone does not significantly influence aspiration toward leadership positions, and other factors such as institutional support or personal motivation may play a more influential role.

A one-way ANOVA was used to test for differences in teachers' interest in curriculum development or research projects across age groups. While older teachers (45–54 and

55+) reported higher average scores (M = 5.00) compared to younger groups, the differences were not statistically significant, $F(4, 57) = 1.223$, $p = 0.311$.

This result implies that interest in participating in educational research and curriculum innovation is consistently high across all age groups, indicating a broadly shared professional commitment among STEM Chemistry teachers regardless of age.

Another one-way ANOVA was performed to examine differences in research interest across six levels of teaching experience. Although all groups with more than 10 years of experience had mean scores at or near the maximum (M = 5.00), the variation in responses was not statistically significant, $F(5, 56) = 1.463$, $p = 0.216$.

This suggests that regardless of the number of years teaching chemistry, teachers are generally highly motivated to engage in curriculum development and educational research, and experience level does not constitute a barrier or enhancer of this interest.

The analysis indicates that neither age nor teaching experience significantly differentiates teachers' career aspirations or professional interests. These findings underscore the idea that career motivation and engagement in development initiatives are more likely driven by individual passion, institutional culture, and access to opportunities, rather than demographic characteristics alone.

4. Discussion

This study aimed to explore the career aspirations of STEM Chemistry teachers in Kazakhstan, identifying the factors that influence their professional goals, motivation, and the challenges they encounter. The results revealed several important insights into how STEM Chemistry teachers perceive their career paths.

Quantitative findings showed that teachers generally exhibited high aspirations for **leadership roles**, **further education**, and **engagement in research or curriculum development**. These aspirations were consistent across gender, age, and experience levels, indicating a **broad-based professional ambition** within this group. This aligns with previous research suggesting that STEM educators are typically motivated by both intrinsic passion for their subject and a desire to make meaningful contributions to education (Friedrichsen et al., 2013).

5. Conclusion

This research has provided a comprehensive view of the career aspirations of STEM Chemistry teachers in Kazakhstan. The key findings indicate that:

- Teachers generally aspire to leadership roles, advanced education, and participation in curriculum development or research.
- Career aspirations are **not significantly influenced by age or teaching experience**, suggesting a shared motivation across different groups.
- Barriers such as low salary, limited advancement, and lack of support remain critical challenges.

The study contributes to the existing literature by focusing on a **specialized and underrepresented group**—STEM Chemistry teachers—whose role is pivotal in advancing science education. These findings can inform **educational policymakers, school leaders, and teacher training institutions** in designing more effective support systems, career development pathways, and incentive programs. Ultimately, enabling STEM Chemistry teachers to pursue their professional goals will not only improve their job satisfaction and retention but also enhance the quality of STEM education for future generations.

However, inferential analyses (t-tests and ANOVA) found no statistically significant differences in career aspiration based on **teaching experience or age**. While more experienced or older teachers showed slightly higher mean scores in leadership and research interest, these differences were not strong enough to be considered significant. This may suggest that **career aspirations are influenced more by institutional or contextual factors**, such as access to opportunities, recognition, and support structures, rather than by demographic characteristics alone. Thematic content analysis of open-ended responses further emphasized the need for **continuous professional development**, **mentorship**, and **institutional support**. Teachers repeatedly cited barriers such as **low salary**, **limited career progression within schools**, and **lack of administrative support** as obstacles to their career growth. Simultaneously, many teachers expressed a desire to contribute to educational reform, highlighting a disconnect between their ambitions and the current structural constraints. Overall, the discussion supports the idea that **STEM Chemistry teachers in Kazakhstan are highly motivated**, but face systemic limitations that may inhibit the full realization of their career goals.

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