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Secondary school chemistry teachers' attitudes toward developing entrepreneurial competencies in chemistry education

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Abstract: Entrepreneurial competencies are increasingly recognized as important for everyone's personal growth and future professional engagement. This study aims to provide a descriptive overview of secondary school chemistry teachers' attitudes toward entrepreneurial competencies in chemistry education. In this exploratory quantitative research, data were collected from 132 chemistry teachers from Serbia via a structured online questionnaire comprising 21 items. Findings indicate that, although teachers demonstrate a substantial positive attitude toward the relevance and importance of entrepreneurial competencies, this understanding is not consistently reflected in classroom practice. Moreover, teachers reported limited acquisition of expertise regarding entrepreneurial competencies through initial teacher education and continuing professional development. These results highlight opportunities to enhance teacher preparation by explicitly integrating the development of entrepreneurial competencies into existing chemistry and pedagogical courses. The relatively small sample, combined with potential biases inherent in self-reported questionnaires, may limit the generalizability of the findings. Systematic and practical professional development initiatives could support teachers in linking instructional strategies with the cultivation of creativity, initiative, problem-solving, and other key entrepreneurial traits among students.

Keywords: chemistry education; chemistry entrepreneurship; entrepreneurial competencies; chemistry teachers; chemistry teacher education

1 Competency-based education

Competency-based education (CBE) represents one of the dominant concepts of contemporary educational policy and pedagogical practice.¹ The interest in this concept and its spread can be explained by the emphasis on the productivity of education, which has become a central theme over the last three decades. Various authors^{2,3} agree that this approach is based on: 1) ideas of the industrial revolution and the need to organize industrial training; 2) neoliberal economics and theories of human capital; and 3) behavioral psychology. The following definition of CBE was created on the basis of the data collected from the literature with key persons: *CBE is defined as an outcome-based approach to education that incorporates modes of instructional delivery and assessment efforts designed to evaluate mastery of learning by students through their demonstration of the knowledge, attitudes, values, skills, and behaviors required for the degree sought.*⁴

Referring to Lisbon Strategy 2000,⁵ competency development can be influenced by fostering critical thinking, creativity, initiative, risk assessment, decision-making and constructive management of available intellectual

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resources. Competency development should be cyclical and integrated into the delivery of the curriculum. Promoting the development of competencies is highlighted as the expected goal of the educational process and it is emphasized that competencies are developed in all aspects of the educational program and that they are assessed at certain educational levels, for example, at the end of the school year, after the first cycle of primary education and at the end of secondary school.⁶

In recent decades, competencies in education have not only been the subject of interest for researchers, but have also become part of official education policy at the international and national levels. One approach to competency-based education is the OECD project DeSeCo (Definition and Selection of Competencies: Theoretical and Conceptual Foundations).⁷ This project lasted seven years, from 1997 to 2005, and involved 12 countries: Austria, Belgium (Flanders), Denmark, Finland, France, the Netherlands, Germany, Norway, New Zealand, the United States, Sweden and Switzerland. The DeSeCo report highlighted three broad areas of competencies: 1) *Using Tools Interactively*: This competency involves interacting with language, texts, information, and technology to understand and communicate; 2) *Interacting in Heterogeneous Groups*: This competency focuses on collaborative skills, including cooperation, conflict resolution, and the ability to work effectively with diverse groups of people; and 3) *Act autonomously*: This competency involves the capacity of individuals to act autonomously to participate effectively in the development of society and to function well in different spheres of life, such as the workplace, family life, and social life.⁷ These broad areas encompass a range of specific skills like problem-solving, creativity, communication, critical thinking, and the ability to learn. The project emphasized that these competencies are not subject-specific but general skills and dispositions needed for personal fulfillment, social inclusion, and effective participation in society.

For some time, the OECD has been working on a new model built on the DeSeCo framework. The OECD Learning Framework 2030 builds closely on the previous work of the DeSeCo report and responds to challenges that require a further set of competencies and capabilities that relate to environmental, economic and social challenges. This line of thinking about what weaves with what has clearly evolved in the OECD 2030 model, there are three “transversal” competencies: 1) *Taking responsibility*: There is an overarching aim to encourage students to take agency for their learning and for their actions in the world. They can only do this if they are more proactive in accepting responsibility; 2) *Creating new value*: On the surface, this could be seen as being entrepreneurial. However, the briefing notes suggest a wider scope. This is about collaborative knowledge work recombining what different people know to arrive at new insights and solutions; and 3) *Recognizing tensions and dilemmas*: This cross-cutting competency draws attention to the volatile and uncertain conditions that characterize life in the 21st century. It sends a signal that students should be learning about risk and uncertainty, and how to make decisions and take action under such conditions.⁸

In March 2019, the European Commission published a recommendation on key competencies for lifelong learning. The recommendation identifies eight key competencies essential for citizens’ personal fulfillment, a healthy and sustainable lifestyle, employability, active citizenship, and social inclusion. All key competencies are considered equally important, and aspects essential to one domain support competency development in another. The framework identifies the following eight key competencies: 1) literacy competency; 2) multilingual competency; 3) mathematical competency and competency in science, technology and engineering; 4) digital competency; 5) personal, social and learning to learn competency; 6) citizenship competency; 7) entrepreneurial competency; and 8) cultural awareness and expression competency.⁹

2 Entrepreneurship competency frameworks in Europe and Serbia

The development of entrepreneurship and entrepreneurship education is a priority in many EU member states and is included in numerous documents issued by the European Union: Lisbon Strategy 2000,⁵ European Charter for Small Enterprises from 2000,¹⁰ Green Paper on Entrepreneurship in Europe from 2000¹¹, Recommendation of the European Parliament and of the Council on Key Competencies for Lifelong Learning 2006,¹² Oslo Agenda for Entrepreneurship Education in Europe,¹³ as well as the Entrepreneurship 2020 Action Plan,¹⁴ which was adopted in 2013 as part of a comprehensive EU strategy for sustainable development and aims to unleash entrepreneurship

potential and remove existing barriers to the development and strengthening of entrepreneurial culture in Europe.¹⁵⁻¹⁷ Integral to these initiatives is the Entrepreneurship Competence Framework (EntreComp), which serves to standardize the conceptualization of entrepreneurship capacity across the union.^{18,19} Developed by the Joint Research Centre (JRC) of the European Commission, this is the most prominent framework. This framework provides a comprehensive model of entrepreneurial competency for all citizens, which is divided into three competency areas: 1) *Ideas and opportunities*; 2) *Resources*; and 3) *Into action*; and 15 specific competencies (opportunity perception, creativity, vision, evaluation of ideas, ethics and sustainable development, self-awareness and personal efficiency, motivation and perseverance, resource mobilization, financial and economic literacy, engaging others, taking initiative, planning and managing, resolving unclear and risky situations, working with others, learning through experience).¹⁸ The EntreComp framework also serves as a foundational reference for the development of curricula within the formal education and training sectors. This framework aims to establish a bridge between education and the world of work with respect to entrepreneurial competency. Almost a decade after the introduction of EntreComp, Eurydice's flagship report, *Entrepreneurship Education at School in Europe*, provides a comprehensive overview of how European countries have integrated EntreComp into their national curricula. Eurydice's report highlights a shift from optional entrepreneurship modules to core competency integration in primary and secondary education. The report states that, while progress is evident, practical entrepreneurial experiences are still often confined to extracurricular activities rather than core subjects.²⁰ It is worth mentioning that from December 2021 until December 2023, an initiative of the European Union, *Achieving Synergies and Champions in the Implementation of the European Entrepreneurship Competence Framework*, was ongoing. The final report of this initiative presents a set of resources and findings that demonstrate how EntreComp is being used across different sectors (youth work, higher education, and employment). This report also includes case studies of "EntreComp Champions" who have successfully implemented the framework.²¹

The relevant study¹⁵ pointed out that the introduction and organization of entrepreneurship education in Serbia is regulated by several documents adopted in recent years. The Law on the Foundations of the Education System in the Republic of Serbia²² regulates issues related to the implementation of entrepreneurship education. The Strategy for the Development of Vocational Education in the Republic of Serbia²³ opens new avenues for the development of entrepreneurship education and entrepreneurial competencies among students at secondary vocational schools. The National Youth Strategy²⁴ support and promotes entrepreneurship as an area necessary for the development and employment of young people. The Strategy for Education Development in Serbia 2020²⁵ emphasizes the role of education in promoting economic growth and social progress, the development of comprehension skills and critical thinking, and the promotion of initiative, creativity, and entrepreneurship, along with teamwork and positive social values, which sufficiently illustrates the importance of entrepreneurship education. The Memorandum of Understanding on the Development and Implementation of Lifelong Entrepreneurial Learning Strategies²⁶ emphasizes the processes and steps required to design and operationalize comprehensive lifelong entrepreneurial learning strategies. Given that the concept of lifelong entrepreneurial learning is still relatively new, education and training providers can benefit substantially from access to innovative practices and clearly defined guidance. As entrepreneurial learning increasingly becomes a key pillar for strengthening competitiveness, employability, and active citizenship, strategic support should prioritize currently underdeveloped areas, including: 1) the development of entrepreneurial competencies; 2) the clear articulation of entrepreneurial learning outcomes; 3) effective models of teacher engagement and professional development; and 4) coherent frameworks for lifelong entrepreneurial learning that integrate formal, non-formal, and informal education.²⁷ Moreover, two important educational documents in the Republic of Serbia, *General Competency Standards after Primary Education*²⁸ and the *Interdisciplinary Competency Standards after Secondary Education*²⁹ were developed in accordance with the European Framework of Reference for Key Competencies for Lifelong Learning, which recognizes competencies for entrepreneurship education.

3 Chemistry teacher preparation for developing entrepreneurial competencies

The relationship between chemistry and entrepreneurship can be considered from multiple perspectives. Chemistry, as a science with broad applications in industry, technology, health, and environmental sustainability, offers a particularly rich context for developing entrepreneurial thinking. Innovations in fields such as materials, pharmaceuticals, renewable energy, and green technologies are often grounded in chemical knowledge, making chemistry a natural entry point for: 1) fostering the ability to recognize opportunities; 2) translating scientific insights into practice; and 3) creating added value.³⁰ Accordingly, chemistry education serves not only as a means of cultivating scientific literacy but also as a valuable platform for developing entrepreneurial competencies.

Entrepreneurial competencies are widely recognized as transversal competencies that extend beyond establishing a business, encompassing taking initiative, creativity, problem-solving, resilience, teamwork, and the ability to act under uncertainty.³¹ In the Serbian educational context, entrepreneurship gradually entered the educational agenda in the early 2000s, first as an explicit outcome in vocational education and later as a cross-curricular competency within general and primary education.³² This development placed new expectations on schools and teachers, who became one of the key actors in fostering entrepreneurial spirit among young people.

For this task, teachers themselves need to be adequately prepared. Both initial teacher education and continuous professional development (CPD) should provide opportunities not only to learn about the entrepreneurship conceptually, but also to develop entrepreneurial competencies and reflect on how they can be embedded in everyday teaching. Scholars argue that entrepreneurship education for student teachers should focus on helping them identify entrepreneurial goals, explore their own potential, and develop personal dispositions such as independence, perseverance, self-confidence, and collaboration.³³ To translate these goals into classroom practice, teachers require familiarity with a range of active and experiential teaching strategies, including project-based and problem-based learning, simulations, role-play, group work, case studies, and participation in entrepreneurial initiatives.^{34,35} These methods align particularly well with science education, where experimentation and inquiry are already central, and where linking abstract content with real-life applications can naturally reinforce entrepreneurial ways of thinking.^{36,37}

Nevertheless, despite these advances, the integration of entrepreneurship into teacher education in Serbia remains uneven and underdeveloped.³⁸ This trend is also evident in chemistry teacher preparation. The education of future chemistry teachers in Serbia is organized at five universities, within the faculties of chemistry and the faculties of natural sciences and mathematics. At some institutions, teacher education follows an integrated model from the outset, while at others, students initially engage in general and disciplinary chemistry courses before gradually transitioning toward pedagogical and professional specialization. This ensures that, depending on the structure, students either develop subject-matter knowledge and teaching competencies in parallel, or first consolidate their disciplinary foundation before focusing on professional preparation. At all five faculties, applied chemistry and/or similar disciplines are addressed through several individual courses available across study programs, but without systematic emphasis on entrepreneurial skills. Alongside the disciplinary curriculum, the programs include a substantial number of pedagogical, psychological, and didactic-methodological courses, aimed at preparing students for classroom practice and equipping them with broader educational perspectives. However, an examination of available course syllabi and teaching materials reveals that there is still no clearly defined framework, plan, or allocated time specifically dedicated to the systematic development of entrepreneurial competencies. A clearly defined framework for the development of entrepreneurial competencies should be introduced because it ensures systematic, coherent, and purposeful integration of these competencies into chemistry teaching. Without such a framework, the presence of entrepreneurial elements remains incidental, inconsistent, and highly dependent on individual teachers' initiative rather than on structured educational goals.

At the same time, continuous professional development programs and training courses for teachers are available, addressing the development of entrepreneurial competencies in students. These programs, while currently less numerous compared to offerings on general pedagogy or subject-specific topics, are accessible through professional development initiatives targeting secondary vocational schools as well as general aspects of

teaching practice. Organized by institutions such as the Institute for the Advancement of Education and Up-bringing, universities, and professional associations, these programs provide teachers with practical knowledge and methodological tools that can be applied in everyday classroom practice to develop entrepreneurial competencies, thus offering avenues for teachers to complement their initial training in this area. Information on current programs is available in the Catalog of Professional Development.³⁹

Teachers play an important role in shaping students' career aspirations and developing key competencies. Five main categories of competencies relevant to teachers who tend to develop entrepreneurship can be identified: 1) intrapersonal (e.g., self-efficacy); 2) entrepreneurial (e.g., autonomy and initiative); 3) organizational (e.g., adaptability); 4) communication (e.g., digital literacy); and 5) social (e.g., teamwork).⁴⁰ Teachers' capacity to integrate chemical entrepreneurship into classroom practices can encourage students to perceive science education as a pathway toward self-reliance and economic empowerment. Nevertheless, based on contemporary evidence, many teachers lack either the necessary entrepreneurial competencies or the confidence to consistently implement such initiatives within their curriculum.⁴¹

The assumption that contemporary chemistry teacher education programs provide insufficient opportunities for developing expertise related to entrepreneurial competency serves as the conceptual starting point for the present research. Accordingly, this study aims to provide a descriptive overview of secondary school chemistry teachers' attitudes toward entrepreneurial competencies in chemistry education. The following research questions have arisen from this aim and the literature review:

- (1) What are the chemistry teachers' attitudes toward (a) initial teacher education and (b) continuous professional development in terms of preparing teachers to develop students' entrepreneurial competencies?
- (2) What are the chemistry teachers' attitudes toward (a) relevance and (b) importance of entrepreneurial competencies in chemistry education?
- (3) What are the chemistry teachers' self-reported frequencies of (a) employing teaching approaches and (b) implementing activities aimed at developing students' entrepreneurial competencies?

4 Methods

This study was conducted between October 2023 and July 2024 and employed an exploratory quantitative design. Secondary school chemistry teachers in the Republic of Serbia were surveyed to examine their attitudes toward the development of entrepreneurial competencies through chemistry education. Data were collected using an online questionnaire developed on the basis of a literature review and existing frameworks. The questionnaire was validated through expert review and reliability testing (Cronbach's alpha).

4.1 Participants

A convenience sampling procedure was employed due to its effectiveness and ability to access a large, geographically diverse population of teachers, ensuring that the study captured perspectives across different school contexts and experience levels.⁴² Demographic and professional characteristics of the teachers were collected through a separate section of the questionnaire. This section included questions related to gender, type of school, school location, and length of teaching experience. The research included 132 secondary school chemistry teachers, both female (120) and male (12), employed across grammar schools (56) and vocational schools (76). Teachers represented both rural (76) and urban (56) school contexts. The sample covered a broad range of professional experience: teachers with less than five years of service (22), as well as those with 6–10 years (19), 11–15 years (18), 16–20 years (18), 21–25 years (29), and more than 25 years of experience (26). This distribution ensured the inclusion of perspectives from early-career, mid-career, and highly experienced teachers.

4.2 Data collection tool

Data for this study were collected using an online questionnaire specifically designed for chemistry teachers. The questionnaire consisted of 21 closed-ended items with predefined response options, presented on a three-point Likert scale.^{43,44} The items were developed based on an extensive literature review and relevant research^{31,45} and were subsequently modified and adapted to meet the needs of the present study. The final content of the questionnaire was validated through consultation with four independent experts in education and entrepreneurship, ensuring that the items accurately captured the constructs under investigation and were suitable for the Serbian educational context. This process resulted in minor conceptual, syntactic, and grammatical modifications, thereby ensuring the initial validity of the questionnaire. The reliability of the questionnaire was assessed using Cronbach's Alpha coefficient, which yielded a value of $\alpha = 0.83$, indicating high internal consistency (>0.70). In addition, the questionnaire included two negatively worded items, which were reverse-coded prior to analysis to ensure consistent interpretation of responses and accurate calculation of descriptive and reliability statistics.

The questionnaire was developed to examine secondary school chemistry teachers' attitudes toward both their initial teacher education and CPD in terms of preparing teachers to develop students' entrepreneurial competencies, their attitudes toward the relevance and importance of entrepreneurial competencies, as well as their self-reported frequencies of employing teaching approaches and implementing activities aimed at developing entrepreneurial competencies among students. The selected teaching approaches and activities were included because they have been recognized in prior research and practice as effective in developing entrepreneurial competencies among students.^{31,37,45-47} Approaches such as group and individual work, project-based learning, problem-based learning, and experimental learning are particularly valued for their capacity to stimulate creativity, problem-solving, initiative, collaboration, and responsibility, which are widely regarded as essential qualities for entrepreneurial thinking and action.

4.3 Data collection and analysis

The questionnaire was administered via the Google Forms platform, allowing efficient data collection from a geographically diverse sample of teachers. It was delivered in the teachers' native language (Serbian), but for the purposes of reporting and publication, the questionnaire was subsequently translated into English. The collected data were analyzed quantitatively, focusing primarily on descriptive statistics. All items were coded and summed to calculate response frequencies and percentages. Graphical representations were used to illustrate teachers' responses and to highlight frequencies in the self-reported use of teaching approaches and activities, as well as attitudes toward entrepreneurial competencies and their development among students. Given the exploratory nature of this study, the emphasis was placed on summarizing trends and distributions rather than performing inferential statistical tests.

5 Results and discussion

5.1 Chemistry teachers' attitudes toward their initial teacher education and continuous professional development in terms of preparing teachers to develop students' entrepreneurial competencies

This subsection presents chemistry teachers' attitudes toward both their initial teacher education and continuous professional development (CPD) in terms of preparing teachers for developing entrepreneurial competencies among students. Overall, the findings indicate that teachers have had limited opportunities to develop their expertise in developing entrepreneurial competencies. The data presented in Figure 1 indicates a clear trend: a

majority of teachers reported disagreement with all three statements. Specifically, over half of the respondents (approximately 55–57 %) stated that their initial teacher education did not adequately address entrepreneurial competencies. Similarly, a substantial proportion disagreed that a sufficient number of CPD trainings on this topic are currently provided. These findings suggest a gap between the intended integration of entrepreneurship into teacher education and the actual experiences of teachers. The prevalence of disagreement underscores the need for more systematic inclusion of the development of entrepreneurial competencies in both initial teacher education and continuing professional development programs. The relatively lower levels of agreement regarding participation in CPD trainings may reflect limited awareness of the importance of entrepreneurial competencies, suggesting a need to raise awareness and provide targeted opportunities for skill development.

A closer examination of participation patterns indicates a clear misalignment between teachers' prior preparation, their perceived availability of professional development opportunities, and their actual engagement in CPD related to entrepreneurial competencies. Among teachers who perceive that sufficient CPD trainings exist, only about half (16 of 29) actually participate. This indicates that awareness of available CPD trainings does not necessarily translate into active participation, pointing to the influence of additional factors beyond perceived availability. Teachers who stated that their initial teacher education did not adequately address entrepreneurial competencies, participate in CPD trainings at a minimal rate, with only 4 of 52 attending. This suggests that limited early exposure may reduce both awareness of and motivation for further professional learning in this area. Conversely, among those who did receive some initial exposure, nearly half (22 of 47) are actively engaged in CPD trainings, indicating that prior preparation alone does not ensure continued professional engagement. These proportions highlight that prior exposure and awareness of opportunities could influence participation, but do not guarantee it. Interestingly, 19 out of the 29 teachers who had participated in CPD trainings reported that there are not sufficient opportunities available. This indicates an imbalance between actual engagement and perceived availability and may further suggest that teachers consider the existing trainings insufficiently adequate. Taken together, these results point to structural limitations in both initial teacher education and CPD trainings and highlight the need for more coherent, accessible, and practice-oriented professional development pathways focused on entrepreneurial competencies.

The findings of the present study align with a broader body of international research indicating that limited initial teacher education and insufficiently structured professional development represent persistent barriers to the development of entrepreneurial competencies in chemistry education. Across different educational systems and time periods, studies consistently report insufficient preparedness among teachers. Similar to the results of this study, the online survey in Albania performed in 2022 involved 233 teachers, showed that fewer than half survey respondents had participated in entrepreneurship-related training and that only about one-third perceived their entrepreneurial competencies as sufficient.³¹ The findings from research conducted in Spain from September 2017 to March 2020 further emphasize the role of initial teacher education in shaping entrepreneurial competencies. In this longitudinal study with 17 pre-service primary teachers, all participants acknowledged that

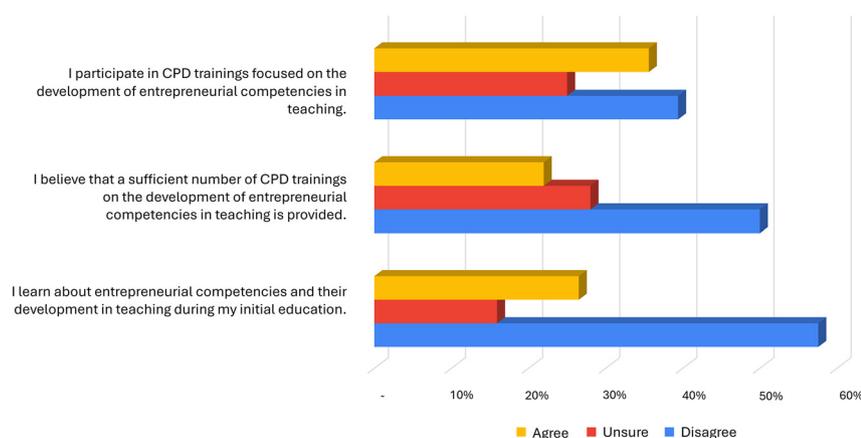


Figure 1: Chemistry teachers' attitudes toward their initial teacher education and continuous professional development in terms of preparing teachers to develop students' entrepreneurial competencies (% of responses).

practice-oriented learning experiences had a positive impact on their entrepreneurial mindset, helping them better understand entrepreneurship and apply it within teaching contexts.⁴⁰ Challenges comparable to those identified by teachers in Serbia were also reported among 108 chemistry students in the United Kingdom.⁴⁸ In the study, conducted in 2017, participants expressed concerns about insufficient opportunities within the curriculum to develop creativity and business-related skills.⁴⁸ Evidence from secondary education in Rwanda, based on a sample of 75 teachers, likewise highlighted considerable practical and systemic barriers to integrating entrepreneurial concepts into science teaching.⁴¹ In the study conducted in 2025, identified barriers included a lack of formal training, limited time, inadequate laboratory resources, and the absence of clear assessment frameworks.⁴¹ Large-scale research from China, conducted as a rolling survey from September 2018 to January 2019, and involving 12,596 teachers, emphasized that professional training, innovative teaching methods, entrepreneurial culture, and institutional policy support are key predictors of teachers' entrepreneurial competencies, factors perceived as lacking among Serbian chemistry teachers.⁴⁹ Taken together, this body of evidence suggests that preparing teachers for developing entrepreneurial competencies requires a systemic approach rather than isolated training initiatives. Specifically, the findings highlight the importance of embedding entrepreneurship more explicitly within initial teacher education, strengthening practice-oriented CPD opportunities, and ensuring institutional and policy-level support that enables sustained pedagogical change.

5.2 Chemistry teachers' attitudes toward relevance and importance of entrepreneurial competencies in chemistry education

This subsection presents chemistry teachers' attitudes toward relevance and importance of entrepreneurial competencies in chemistry education. The analysis of the obtained data reveals a clear gap between theory and practice. Although a considerable majority expresses positive attitudes and generally recognizes the importance and relevance of entrepreneurial competencies for students' overall development, their theoretical understanding is not consistently translated into practical implementation.

The analysis of the data shown in Figure 2 demonstrates a generally positive attitude regarding entrepreneurial competencies among teachers involved in the research, despite the previously noted relatively lower participation in CPD trainings. A substantial majority (87.88 %) agrees that it is necessary to develop entrepreneurial competencies in students, indicating a strong recognition of their educational value. Similarly, 83.33 % consider entrepreneurial competencies important for every individual, which highlights the perceived general relevance of these skills beyond formal education. Regarding professional context, 63.64 % of teachers recognize the importance of entrepreneurial competencies specifically for the chemistry profession, suggesting that while there is strong awareness, the perceived direct applicability to their professional field is slightly lower than their general educational relevance. When examining understanding of educational frameworks, 64.39 % of teachers agree that they understand the importance of integrating entrepreneurial competencies within the set of key educational competencies, and 31.06 % report familiarity with this integration, indicating that conceptual awareness exists, though practical familiarity may be less widespread. Furthermore, only 38.64 % indicate that they explicitly identify entrepreneurial competencies through planning teaching, suggesting a gap between recognizing importance and actively integrating these concepts into lesson planning. All these findings suggest that, although teachers value the entrepreneurial competencies conceptually, there are barriers, such as limited familiarity with educational frameworks or practical implementation strategies, that prevent them from fully embedding these competencies into their practice. This gap between theory and practice underscores the need for targeted professional development that not only raises awareness but also equips teachers with concrete methods for integrating entrepreneurship into chemistry education. This pattern, high perceived importance but with lower levels of implementation in planning, may reflect the cumulative demands faced by respondents. The evolving expectations in teaching practice, with new competencies being gradually added, could contribute to reduced application in pedagogical planning despite strong awareness and recognition of their value. These results are in accordance with data presented in the Swedish study⁵⁰ conducted in 2018. Findings from that research⁵⁰ reveal that teachers, although entrepreneurship education is not an entirely new phenomenon in

Swedish education, face challenges in interpreting and translating educational policies into practice. This can lead to variability in the implementation of entrepreneurship education across different contexts. Similarly, researchers from Finland,⁵¹ in their study conducted from 2019 to 2020, also emphasize that while preservice teachers recognize the value of entrepreneurial competencies, their confidence in teaching these skills is limited, potentially affecting their willingness to integrate them into classroom practice. Furthermore, previously mentioned research from Albania³¹ highlights that only 29.6 % of teachers consider their entrepreneurial competencies as sufficient to effectively support and facilitate students' learning. A majority of participants from that research in Albania reported partial competency (54.9 %), while 15.5 % indicated a lack of entrepreneurial competencies altogether, underscoring the widespread need for targeted professional development in this area.³¹ Taken together, these findings indicate that chemistry teachers largely acknowledge relevance and importance of entrepreneurial competencies, yet struggle to translate this awareness into systematic pedagogical planning and classroom practice. The observed discrepancy suggests that the challenge lies not in teachers' attitudes, but in the lack of concrete guidance on how entrepreneurial competencies can be meaningfully embedded within subject-specific instruction. Addressing this gap requires professional development initiatives that move beyond conceptual discussions and explicitly demonstrate how entrepreneurial competencies can be operationalized in chemistry lesson planning, assessment, and everyday teaching activities. Strengthening teachers' practical familiarity with educational frameworks and providing subject-adapted examples may therefore represent a key step toward aligning positive attitudes with consistent instructional practice.

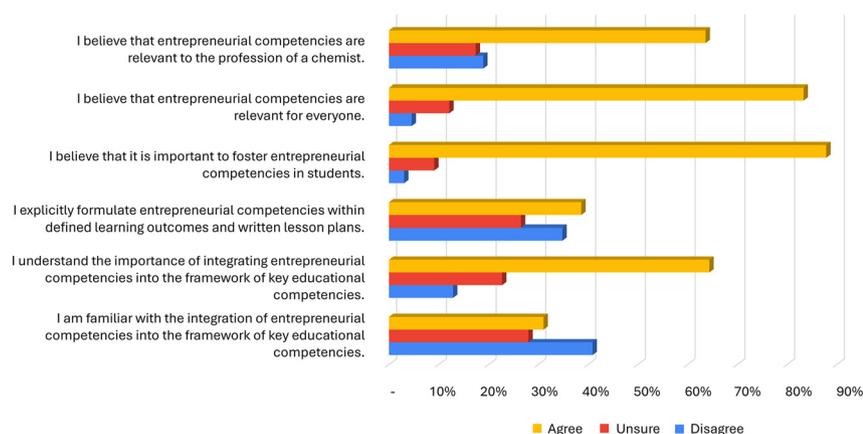


Figure 2: Chemistry teachers' attitudes toward relevance and importance of entrepreneurial competencies in chemistry education (% of responses).

5.3 Chemistry teachers' self-reported frequencies of employing teaching approaches and implementing activities aimed at developing students' entrepreneurial competencies

This subsection presents chemistry teachers' self-reported frequencies of employing teaching approaches and implementing activities aimed at developing entrepreneurial competencies among students. The data presented in Figure 3 illustrates the self-reported frequencies of teaching approaches employed by chemistry teachers to develop entrepreneurial competencies in students. A significant majority of teachers employ a mix of collaborative and individualized approaches. Individual work is the most frequently employed approach, with 50 % of teachers using it frequently and 42.42 % occasionally, followed closely by pair work (frequently 42.42 %, occasionally 50.76 %) and group work (frequently 39.39 %, occasionally 47.73 %), highlighting a strong emphasis on both personalized and cooperative learning formats. These results are consistent with previously mentioned research⁴⁵ involving 688 teachers from 25 Croatian primary schools, which found that teaching methods promoting students' autonomy and teamwork were the most frequently applied and highly valued.

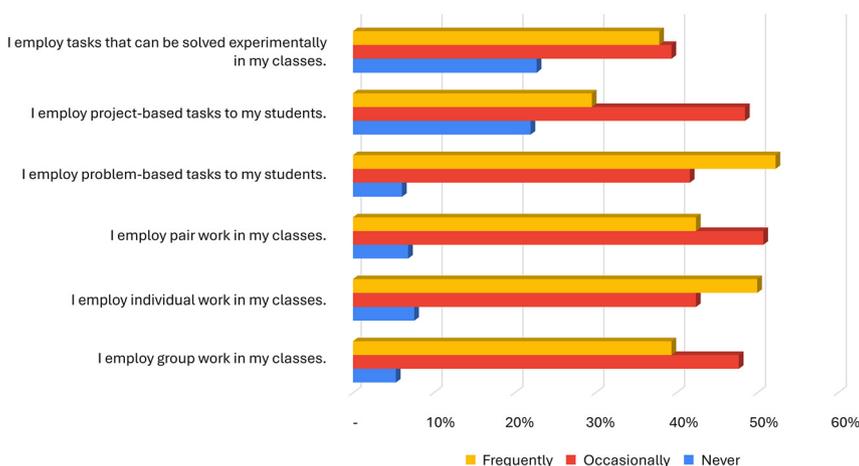


Figure 3: Chemistry teachers' self-reported frequencies of employing teaching approaches aimed at developing students' entrepreneurial competencies (% of responses).

Data from Figure 3 further indicate that problem-oriented tasks are widely used, with 52.27 % of teachers assigning them frequently and 41.67 % using them occasionally. In contrast, project-based tasks are less often implemented on a frequent basis (29.55 %), while nearly half of the teachers (48.48 %) report occasional use, which may reflect the greater planning time and organizational demands typically associated with project-based learning. Notably, tasks that can be solved experimentally, which are particularly effective for hands-on learning and developing entrepreneurial thinking, are the least frequently implemented, with 37.88 % of teachers assigning them frequently and 39.39 % occasionally. This lower prevalence likely reflects practical constraints in schools, such as limited laboratory facilities, materials, or class size, rather than a lack of recognition of their pedagogical value.⁵² This aligns with the aforementioned study,⁴¹ which reveals that Rwandan chemistry teachers struggled to implement real-world, collaborative, problem-based and project-based tasks consistently. In that study,⁴¹ only 32 % of teachers reported encouraging students to collaborate on chemical projects, and agreement on connecting chemistry concepts to real-world applications was moderate (21 %), with high neutrality (32 %). Moreover, the same teachers highlighted the value of hands-on, experiential projects, such as producing homemade beverages, cosmetics, or soap, to link chemistry with potential business ventures, fostering creativity, critical thinking, and entrepreneurial skills.⁴¹ Consistent with these findings,⁴¹ research with teachers from Indian secondary schools⁵³ showed that guiding teachers to adapt and modify existing laboratory experiments through hands-on, inquiry-based workshops can enhance their ability to implement experiential, problem-, and project-based learning, thereby supporting pedagogical development.

Overall, these findings suggest that teachers are integrating a wide range of effective instructional strategies, with individual and cooperative approaches being the most prominent. The combination of group, pair, and individual work with problem-solving and project-based tasks provides multiple avenues for nurturing skills such as initiative, creativity, decision-making, and practical problem-solving, all of which are central to entrepreneurial competencies. While the experimental approach is somewhat less utilized, its incorporation remains crucial for developing experiential learning opportunities. Researchers who investigated how to stimulate an entrepreneurial mindset in chemistry students⁵⁴ note that entrepreneurship education in science often overlooks core chemistry content, limiting student engagement and familiarity with the subject. They recommend integrating specific chemistry case studies and participatory, hands-on activities, including opportunities for students to run real business projects on campus, to develop both subject knowledge and an entrepreneurial mindset. These patterns highlight the potential of chemistry instruction to naturally support the integration of entrepreneurial competencies into everyday classroom practice.

The results presented in Figure 4 suggest that teachers incorporate a broad range of entrepreneurial-oriented activities into their chemistry instruction, albeit with varying intensities. According to teachers' reports, the most frequently implemented activities are those in which students apply their previously acquired knowledge, with nearly 70 % indicating frequent use and an additional quarter reporting occasional use. This suggests that such activities are present in nearly all classrooms. Similarly, more than half of teachers frequently implement

activities that foster creativity and idea development, while an additional 44 % do so occasionally, pointing to a strong overall orientation toward encouraging creativity. Other competencies, such as student initiative, risk-taking, or recognizing the value-creation potential of ideas, are somewhat less often implemented at the frequent level (around 31 %), but the combination of frequent and occasional responses reveals that these practices are present in the majority of classrooms. Likewise, the implementation of activities that mobilize students' strengths or promote financial and economic awareness appears less dominant when looking only at frequent use; however, when occasional implementation is considered, nearly two-thirds of teachers engage students in these activities at least to some degree.

Taken together, the data indicate that teachers incorporate a variety of activities relevant to the development of entrepreneurial competencies. Similarly, regional data from Croatia⁴⁵ shows that over half of teachers occasionally engage in school activities promoting student entrepreneurship, reflecting a moderate but meaningful integration of such practices. The emphasis is more pronounced on practices that align with traditional pedagogical orientations, such as applying prior knowledge and fostering creativity, while those more directly associated with entrepreneurial mindsets (risk-taking, value creation, financial literacy) appear less prominent. This pattern aligns with study,⁴¹ where teachers demonstrated moderate strengths in communication and collaboration but reported limited confidence in financial planning, market research, and problem-solving related to chemical-based business ventures. Nonetheless, the relatively small proportion of teachers reporting “never” using these methods suggests that entrepreneurial-oriented teaching practices are already meaningfully present in chemistry instruction, even if not consistently at the highest frequency. This imbalance may reflect both the disciplinary focus of chemistry curricula and the limited prioritization of such competencies within teacher preparation programs.

Overall, the findings indicate that chemistry teachers already employ a range of teaching approaches and activities that have strong potential for developing entrepreneurial competencies, particularly those aligned with applying prior knowledge, creativity, collaboration, and problem-solving. However, activities that more explicitly target entrepreneurial dimensions, such as risk-taking, financial awareness, and value creation, are implemented less intensively. This pattern suggests that entrepreneurial learning is often embedded implicitly within existing instructional practices rather than being intentionally planned and articulated as a learning objective. To strengthen the educational impact of these approaches, targeted support is needed to help teachers recognize the entrepreneurial potential of their current practices and to systematically align them with clearly defined entrepreneurial learning outcomes. Such alignment may enable chemistry instruction to more fully contribute to the intentional development of entrepreneurial competencies without requiring substantial changes to existing curricula.

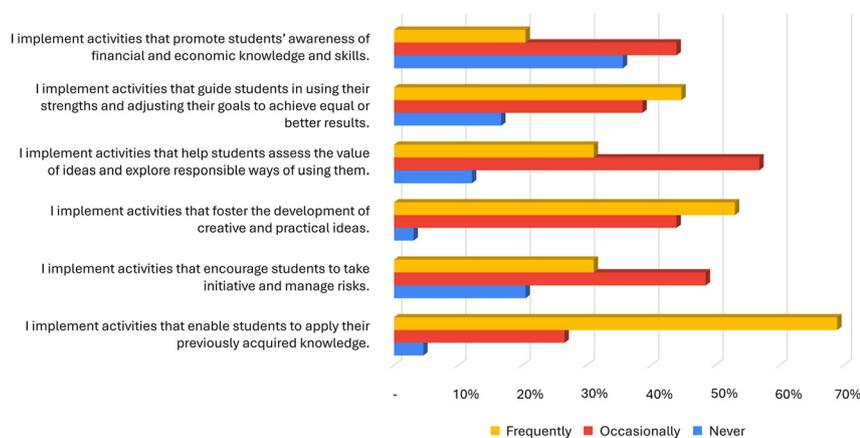


Figure 4: Chemistry teachers' self-reported frequencies of implementing activities aimed at developing students' entrepreneurial competencies (% of responses).

6 Conclusions, implications and limitations

The findings of this study indicate a consistent gap between chemistry teachers' attitudes toward the importance and relevance of entrepreneurial competencies and their systematic integration into classroom practice. While teachers largely express a positive attitude toward the value of entrepreneurial competencies for students' development, this attitude is not consistently translated into explicit lesson planning. At the same time, many teaching approaches that could develop entrepreneurial competencies, such as individual, pair, group, and problem-oriented work, are already commonly used. However, these approaches are likely applied implicitly, without a clear connection to entrepreneurial learning goals, which limits their educational potential.

The relatively small sample size, comprising teachers exclusively from secondary schools, may constrain the generalizability of the findings to the wider Serbian educational context. The use of self-reported questionnaires could also have introduced certain biases, as participants' responses might have been influenced by social desirability or by limited familiarity with entrepreneurial terminology.

Despite these limitations, the study provides valuable insights into chemistry teachers' attitudes toward developing students' entrepreneurial competencies and their attitudes regarding how initial teacher education supports this development, offering several practical implications. Rather than designing entirely new study programs, existing chemistry-specific and pedagogical-methodological courses could be enhanced to explicitly illustrate how current lessons can be adapted to develop students' entrepreneurial competencies. Similarly, continuing professional development programs should be systematically offered, ensuring they are practical, concrete, and directly applicable, so that teachers are consistently supported in integrating entrepreneurship-oriented activities into classroom practice. In the context of chemistry entrepreneurship, this involves integrating practical chemistry knowledge with business management, innovation, and market analysis, aligning with the constructivist principle of learning by doing, where students actively explore concepts, experiment, and derive meaning from their experiences. Overall, the study suggests that strengthening the link between teachers' positive attitude and instructional practice requires targeted, practice-oriented support. By explicitly connecting existing teaching approaches to entrepreneurship competency frameworks, teacher education programs can more effectively support chemistry teachers in intentionally developing students' entrepreneurial competencies in a structured and meaningful way.

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