

Article

Pedagogical-Didactical Self-Efficacy of Future Educators: A Case Study of Pre-Service STEM Teachers

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Abstract

The contemporary educational system places complex demands on educators, emphasizing the importance of pedagogical-didactical competencies and teacher self-efficacy alongside subject-matter expertise. The purpose of this study was to examine how future STEM educators assess their own perceived pedagogical-didactical capabilities for direct teaching and classroom management through the construct of teacher self-efficacy, examining variations by gender, student cohort, and academic major. The research was conducted in autumn 2025 using a near-census sample of graduate teaching track students at the Faculty of Science in Split, utilizing the Norwegian Teacher Self-Efficacy Scale. The descriptive and non-parametric results indicate that future teachers express higher baseline scores in the domains of instruction and coping with changes, whereas the lowest self-assessment was recorded regarding the adaptation of teaching to individual student needs. While gender and student cohort demonstrated no statistically significant impact on overall self-efficacy, a significant difference was determined in the domain of maintaining discipline with respect to the study major, with Informatics and Technology students exhibiting the greatest sense of confidence. In conclusion, the findings highlight that while students are well-prepared for content delivery, there remains a critical need to enhance initial teacher education programs by introducing practical tools for managing challenging student behaviors and working within heterogeneous classrooms.

Keywords: teacher self-efficacy; STEM education; initial teacher education; pedagogical competencies; classroom management; Norwegian Teacher Self-Efficacy Scale (NTSES)

1. Introduction

The contemporary educational system faces rapid and intensive changes that place complex, multidimensional demands on teachers. In today's educational climate, educators are no longer expected to merely transmit factual knowledge; they must also successfully manage the overall classroom climate, effectively implement innovative digital tools, and adapt to heterogeneous student groups. In such a dynamic environment, a teacher's professional success does not depend exclusively on foundational disciplinary expertise (e.g., in mathematics, computer science, physics, or biology), but largely on developed pedagogical-didactical competencies and their subjective belief in their ability to apply those competencies in practice. The central concept and theoretical anchor of this research is teacher self-efficacy, a construct rooted in Albert Bandura's social-cognitive learning theory (Bandura 1977). According to this framework, self-efficacy does not refer to the objective level of skills or knowledge an individual possesses, but rather to their personal, subjective assessment of their own capacities to successfully organize and execute the



Academic Editor: Yolanda Abel

Received: 12 June 2026

Revised: 12 July 2026

Accepted: 14 July 2026

Published: 15 July 2026

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specific activities required to achieve desired outcomes (Bandura 1977). In the field of initial teacher education, it is essential to conceptually distinguish broad professional readiness from perceived self-efficacy. While general readiness often encompasses broad institutional or declarative knowledge, this study structurally operationalizes readiness specifically as a didactical capability. This capability is indirectly inferred from and measured through the construct of perceived teacher self-efficacy, reflecting the future teacher's subjective capacity to execute core professional standards, design adaptive learning experiences, and effectively govern the instructional process within the classroom ecosystem (Abraham and Sickel 2025). Empirical research consistently demonstrates that teachers with a high sense of professional self-efficacy motivate students much more easily, exhibit greater persistence when working with diverse learners, and are generally more open to the application of modern, active teaching methods and participating in curricular reforms (Brickman and Olsson 2021). For final-year students in teacher education programs, this sense of efficacy is critical and formative, as the transition from the role of a student to the role of a practicing teacher represents one of the most challenging periods in professional development. A unique challenge is found in the STEM field (science, technology, engineering, and mathematics), where future teachers face a structural dichotomy in their initial education (Brickman and Olsson 2021). STEM teacher preparation programs are often structured around domain-specific science modules, which can limit curricular opportunities for practical training in the complex socio-emotional dynamics of classroom management (Miralles-Cardona et al. 2025). Pre-service STEM teachers must maintain high professional precision while simultaneously mastering the ability to make complex, abstract concepts accessible and interesting for students with highly diverse levels of background knowledge and abilities (Brickman and Olsson 2021; Sannino et al. 2024). Recent research confirms that teachers with a high level of self-efficacy use innovative teaching methods more frequently, manage professional stress and burnout more successfully, and exhibit greater motivation and general job satisfaction (Wettstein et al. 2021; Zhang et al. 2023). Beyond this, such educators are more inclined to foster a positive and supportive classroom climate, overcome disciplinary challenges more easily, and openly accept changes in modern education (Brickman and Olsson 2021; Izquierdo et al. 2025). Despite extensive international literature on general teacher efficacy, an empirical gap remains concerning how self-efficacy profiles differentiate among specific STEM subdisciplines within Southern European institutional contexts, such as Croatia. By examining these specific variations rather than treating STEM as a homogenous cohort, higher education institutions can identify the precise domains where future educators' express confidence as well as areas requiring further field-based training prior to career entry. To address this gap, the primary objective of this quantitative cross-sectional survey was to examine how future STEM teachers at the University of Split assess their own self-efficacy across six core professional domains immediately prior to full-time career entry. Furthermore, the study investigated whether these perceptions vary based on gender, graduate student cohort, and specific academic major, thereby providing targeted institutional feedback necessary for refining the practical and methodological preparation of pre-service teachers within contemporary school systems.

2. Literature Review

The following literature review is organized around four core thematic areas central to contemporary STEM teacher preparation: foundational instruction and professional identity, inclusive practices, relational dynamics, and classroom behavior management.

2.1. Professional Identity and Foundational Instruction in STEM Education

Instruction represents the fundamental aspect of teaching activity through which student academic achievements are directly shaped and directed. The quality and effectiveness of this process primarily depend on the teacher's ability to deliver clear, structured content and to stimulate the cognitive engagement of students, making the assessment of one's own self-efficacy a key predictor of professional success (Luketić and Rončević Zubković 2022). A high level of self-efficacy in this area strongly correlates with the firm belief of teachers that they can successfully clarify complex material and solve intricate tasks, even when working with students who traditionally achieve poorer results or demonstrate resistance to learning (Luketić and Rončević Zubković 2022). In STEM tracks, foundational instruction is deeply connected with the development of professional identity. Pre-service science and technology teachers often derive their early professional confidence from their solid mastery of exact subject matter (Barros et al. 2012). However, a comprehensive instructional capacity requires a balance between domain expertise and a developed readiness for systematic reflection on one's own practice (Elaldı and Yerliyurt 2016; Vukelić 2020). Such teachers systematically evaluate student progress, critically analyze their own actions, and flexibly adapt their instructional methods based on feedback received from students and peers, which significantly increases their overall professional satisfaction (Zee and Koomen 2016). This professional identity and instructional flexibility are heavily tested in an era of intensive curricular reforms and technological revolutions, where the ability of teachers to successfully adapt to transitions becomes a crucial determinant of educational quality. Pre-service teachers frequently display an initially high level of declarative readiness for implementing modern, collaborative, or project-based teaching methods (Luketić and Rončević Zubković 2022). However, long-term sustainable changes and professional resilience depend on continuous development based on practical work and deep personal reflection, rather than on the passive absorption of information (Bognar 2017). Teachers who possess a high level of specific self-efficacy deal much more constructively with the inevitable uncertainty brought by reform changes, viewing programmatic shifts as opportunities for growth rather than operational threats (Inocian 2013). Conversely, deep-seated beliefs about the nature of instruction rooted in a candidate's own schooling can provoke internal resistance toward student-centered instruction, particularly during early career entry (Barros et al. 2012).

2.2. Differentiated Instruction and Inclusive Practices Within Heterogeneous Classrooms

The contemporary educational system strives to ensure equal opportunities for learning and development for all students, independent of their specific abilities, difficulties, or social circumstances, requiring an exceptionally high level of didactical flexibility from future teachers. In this context, pedagogical-didactical self-assessment becomes a key determinant of success because belief in one's own efficacy directly determines an individual's motivation to execute differentiated tasks, as well as their persistence in facing inclusive challenges. Previous research indicates that approximately 60% of teachers assess themselves as competent for successfully adapting work to individual needs, which includes planning tasks of varying difficulty, creating adapted materials, and providing additional individual support during the lesson. Nevertheless, an empirical gap exists between accepting inclusion at a conceptual level and feeling capable of its classroom execution. Pre-service teachers frequently report a lack of confidence when implementing technical modifications for diverse learners in the absence of institutional support (Kranjčec Mlinarić et al. 2016; Tirić 2022). This structural anxiety highlights a broader challenge in teacher preparation: as emphasized by Miralles-Cardona et al. (2025), general teacher education tracks frequently underprepare future educators for the logistical demands of inclusive teaching,

yielding lower self-efficacy compared to specialized or dual-certification models that explicitly embed practice-based opportunities to learn inclusive strategies. The assessment of self-efficacy in the area of instructional adaptation is one of the most critical factors for long-term professional success and stress prevention (Luketić and Rončević Zubković 2022). Differentiated instruction extends beyond technical execution, as it relates closely to the teacher's professional motivation to ensure supportive learning conditions for all students. This implies a developed ability of the teacher to timely simplify content for students with disabilities, provide clear instructions, and utilize diverse visual aids or structural frameworks, which represent a legal obligation that ensures equal access to education (Ministarstvo znanosti i obrazovanja 2021). A teacher's self-assessment in this specific area is often strongly conditioned by external factors; challenges in teacher self-efficacy may emerge when adequate support from professional associates in the school is absent, while the type and severity of the student's disability directly affect the subjective experience of one's own professional efficacy. Furthermore, teachers who express a strong belief that their specific approach can positively influence the progress of every student utilize strategies that promote independence and active participation significantly more often (Lalić-Vučetić and Ševkušić 2023). Ultimately, the pedagogical-didactical readiness of teachers proves decisive for the true success of inclusion; their openness and professional attitudes crucially determine whether students with disabilities will be genuinely accepted and integrated into the classroom community or whether they will remain merely formally integrated (Kranjčec Mlinarić et al. 2016; Tirić 2022).

2.3. Relational Dynamics: Student Engagement, Motivation, and Stakeholder Collaboration

Motivation represents one of the most vital factors in the contemporary educational system, given that it directly influences the level of student engagement, the quality of acquired knowledge, and the final academic outcome. Highly motivated students achieve higher academic outcomes and display greater persistence when solving complex cognitive tasks, alongside a lasting interest in the process of acquiring knowledge (Luketić and Rončević Zubković 2022). In a psychological sense, motivation is a dynamic process that initiates, directs, and maintains behavior aimed at achieving specific goals (Luketić and Rončević Zubković 2022). Modern pedagogical approaches strongly emphasize that motivation is not exclusively a fixed internal trait of the student, but also a direct result of continuous interaction with the teaching staff, peers, and the broader classroom environment (Guilloteaux 2007). In the scientific literature, motivation is primarily differentiated into internal (intrinsic) and external (extrinsic) types. While internal motivation flows from an authentic interest in a certain subject, external motivation is based on secondary incentives such as grades, rewards, or social recognition. In this context, the phenomenon of "duty toward parents" warrants attention, serving in certain socio-cultural environments as an influential extrinsic factor that drives students to invest effort primarily to meet family expectations. Although grades are traditionally the most common motivational tool, studies point out their short-term effectiveness and the tendency to orient students toward performance outcomes rather than toward deep knowledge retention. In contrast, students driven primarily by intrinsic interest develop much more durable educational habits and achieve more stable long-term academic results (Stan 2012). The quality of the instruction itself plays a decisive role here, which includes effective classroom management, high-level cognitive activation, and the systematic nurturing of curiosity (Trškan 2006). The effectiveness and choice of motivational techniques in the classroom are heavily correlated with the attitudes, enthusiasm, and beliefs of the teachers themselves. Teacher self-efficacy—namely, their firm belief in their own ability to motivate and engage all learners, is crucial for creating a positive and stimulating classroom climate that subsequently correlates

with students' academic success (Blackburn 2007; Luketić and Rončević Zubković 2022; Zee and Koomen 2016). Among the most significant strategies is the setting of clear, attainable learning goals, specific praise, and constructive feedback, which anchors the student's self-confidence (Williams and Williams 2011). The diversity of the instructional process, achieved through active learning methods, problem-based teaching, and the purposeful use of digital tools, effectively prevents a decline in interest and increases cognitive involvement (Burić and Kim 2020). In initial teacher education, student engagement is deeply intertwined with relational networks. Pre-service teacher engagement is not merely an individual trait but a socially constructed resource; embedding peer-supported, collaborative spaces across a degree program significantly enhances student persistence, allowing candidates to collectively process instructional anxieties and build professional identity (Duchesne et al. 2025). Delegating responsibility, allowing autonomy, and granting the right to choose topics further stimulates a sense of personal responsibility over the learning process (Burić and Kim 2020). Additionally, introducing elements of gamification through modern digital platforms and quizzes contributes to reducing anxiety related to classical grading and transforms learning into a stimulating experience (Trškan 2006). A substantial challenge is represented by students with chronically lower academic achievements or those showing pronounced resistance to school. Research indicates that teachers with high self-efficacy are highly willing to invest additional effort to adapt teaching to the specific interests of such students, demonstrating greater persistence in challenging environments (Alibakhshi et al. 2020; Luketić and Rončević Zubković 2022). In these cases, the application of multimedia content and teamwork can greatly reinforce a sense of belonging to the class and powerfully motivate students who are otherwise disengaged from school activities (Burić and Kim 2020; Williams and Williams 2011). Crucially, these instructional relational dynamics extend beyond the classroom walls. Interpersonal relationships within the educational system, primarily those that teachers establish with parents and colleagues, form the very backbone of the success and sustainability of the instructional process and correlate directly with the subjective sense of professional self-efficacy. The perception of parental criticism or resistance can lower a teacher's motivation and increase professional anxiety (Luketić and Rončević Zubković 2022). High-quality cooperation presupposes a symbiosis of the teacher's professional expertise and personal communication skills, such as active listening and conflict resolution (Westergård 2013). Although family-school partnerships are declaratively recognized as a fundamental component, in everyday practice they are often reduced to formalized communication channels. However, scientific findings indicate that the active involvement of parents in school life directly results in higher academic achievements, better school attendance records, and a reduction in risky behaviors (Yang and Liu 2023). Traditional channels of communication are supplemented today by collaborative projects that parents value highly due to the opportunity for open dialogue (Cankar et al. 2009). Inclusive education presents a significant challenge here, as cooperation with parents of students with disabilities requires mutual respect and coordination with multidisciplinary expert teams (Ministarstvo znanosti i obrazovanja 2021). Parallel to external cooperation, horizontal cooperation among colleagues within the school collective is a crucial factor for professional development and the prevention of burnout. A high level of trust and collegiality reduces the feeling of professional isolation and encourages the exchange of pedagogical experiences, with teachers traditionally displaying a higher level of trust toward fellow colleagues than toward parents due to a shared working context (Bilgic and Gumuseli 2012). For novice teachers, collaborating with parents represents a challenging aspect of professional practice for which they may feel insufficiently prepared, suggesting a need for integrating communication skills training and structured mentoring in initial teacher education (Mahmood 2013).

2.4. Classroom Governance and Behavioral Self-Regulation

In the contemporary pedagogical context, discipline is no longer conceptualized primarily as an instrument of external behavioral control or coercion; rather, it is viewed as a supportive prerequisite for the successful functioning of the school system and the holistic development of the student's personality. Discipline encompasses a complex set of norms, rules, and behavioral patterns that ensure the necessary structure and safety of the educational process, thereby allowing unhindered knowledge acquisition and undisturbed teacher work (Sewnarain 2024). The modern pedagogical paradigm emphasizes a clear shift away from traditional, punitive methods toward the systematic encouragement of personal responsibility, mutual respect, and behavioral self-regulation. In this sense, the concept of self-discipline is crucial, describing an individual's internal capacity to consciously manage their own impulses and emotions without the need for constant external coercion or the threat of punishment (Şimsir and Dilmaç 2020). The development of self-discipline directly correlates with an encouraging school environment and a fair normative framework (Bear 2010). The process of establishing discipline in the classroom is gradual and deeply intertwined with the applied teaching methods and the general quality of the teacher-student relationship. Key elements include the proactive setting of clear boundaries, the collaborative creation of behavioral rules, and the consistent application of restorative practices (Annisa 2018). From the perspective of pedagogical-didactical self-assessment, it is important to emphasize that an authoritative leadership style—balancing high expectations with emotional warmth and support—positively influences student behavior (Belle 2016). The primary goals of such an approach to classroom management are the immediate assurance of a safe learning environment and the long-term encouragement of internal cognitive and emotional self-control (Bear 2010). An ordered and structured school environment significantly reduces stress levels among both teachers and students and optimizes academic achievements, whereas a chronic lack of discipline correlates with increased aggression, anxiety, and a significant decline in motivation (Ching et al. 2015). Classrooms characterized by a lack of clear structure frequently encounter regular disruptions and higher levels of peer conflict, which negatively affect teacher job satisfaction (Ching et al. 2015). Pre-service STEM teachers often confront a specific challenge here: while their training prepares them for the technical demands of a physics lab or an informatics workshop, it may provide fewer behavioral guidance techniques to manage disruptive or aggressive actions. This lack of practical behavior management tools is identified as a primary contributor to early teacher burnout and professional stress (Wettstein et al. 2021). Recent causal modeling demonstrates that a pre-service teacher's sense of preparation regarding the classroom environment acts as a baseline requirement for their subsequent readiness to engage in the profession; candidates must feel confident in structuring safe, supportive learning environments before they can fully enact advanced instructional tasks (Abraham and Sickel 2025). Modern strategies for improving discipline encompass proactive action through the introduction of fair rules, positive behavioral guidance techniques, and the active involvement of parents (Annisa 2018; Sadruddin 2012). It is vital to provide continuous emotional support and guide students toward constructive actions through dialogue, emphasizing public affirmation and praise for desirable behaviors rather than merely focusing on negative aspects (Gaustad 2006; Tarmen 2016). From a didactical standpoint, interesting and cognitively stimulating instruction acts as the best prevention against disciplinary problems; engaged students rarely manifest resistance or disruptive behavior. Methods of participatory classroom rulemaking at the beginning of the school year hold distinct value, developing a strong sense of ownership and personal responsibility for the classroom climate within students (Sadruddin 2012). In this modern model, corrective actions are always focused on logical consequences and taking responsibility for one's

choices. Finally, it is vital to recognize the causal link between low motivation and the application of rigid disciplinary measures. Overly strict, authoritarian rules or a complete lack of empathy from the teacher can provoke a strong sense of injustice and resentment in students, which results in a significant decline in interest in work and the appearance of reactive defiance. In order to minimize these risks, it is necessary to systematically carry out instruction adapted to individual needs, ensure open communication channels, and build a positive school climate that provides every single student with a sense of safety and belonging to the community (Tarman 2016).

2.5. The Present Study and Hypotheses

The primary objective of this study is to examine how future STEM educators assess their pedagogical-didactical self-efficacy across core professional domains prior to full-time career entry. To ensure a robust conceptual framework, the study's hypotheses are explicitly anchored in Bandura's (1977) social-cognitive theory and established empirical literature regarding teacher socialization. According to social-cognitive theory, self-efficacy beliefs are dynamically shaped through mastery experiences, vicarious modeling, and social persuasion within a specific environment. Within higher education settings, male and female pre-service teachers participate in identical institutional socialization, attending the same pedagogical lectures, methodological exercises, and structural curricula. Consequently, because their primary sources of efficacy are uniformly structured by the training institution, theoretical frameworks support an aligned baseline of pedagogical-didactical self-beliefs regardless of gender (Mustadi et al. 2023). Based on these theoretical foundations, the first hypothesis is formulated:

H1. *It is assumed that male and female students evaluate their self-efficacy capacities equally across the domains of instruction, student motivation, classroom discipline, cooperation, and adaptability.*

Furthermore, educational literature emphasizes that early teacher self-efficacy is often derived from declarative readiness and pre-service teachers' own historical memories as school pupils, which can lead to highly idealized professional expectations (Luketić and Rončević Zubković 2022). A substantive recalibration or shift in these self-beliefs typically occurs only after continuous, independent classroom placement, during a phase widely recognized as "reality shock" (Burić and Kim 2020). Because both first- and second-year graduate student cohorts within this academic track remain enclosed within the same university training environment and have not yet faced independent full-time practice, their underlying self-efficacy profiles are theoretically expected to remain stable and aligned. Therefore, the second hypothesis states:

H2. *It is assumed that first- and second-year graduate student cohorts assess their level of teacher self-efficacy equally across all instructional and classroom management domains.*

Finally, while general didactical confidence may appear uniform across academic tracks, discipline-specific microclimates selectively shape practical self-efficacy expectations (Wang et al. 2022). Although pre-service teachers across all STEM fields receive similar theoretical foundations in instruction and motivation, specialized tracks like Informatics and Technology operate within laboratory and technical workshop settings where the enforcement of strict behavioral protocols and safety norms is required from the very beginning (Annisa 2018). This early, hands-on exposure to structural management inherently fosters higher discipline-specific governance expectations compared to fields without mandatory workshop structures, such as Biology and Chemistry. Conversely, general teacher preparation tracks frequently lack practice-based opportunities for inclusive logis-

tics, yielding lower universal confidence in managing heterogeneous classrooms across subdisciplines (Miralles-Cardona et al. 2025). Thus, the third hypothesis is advanced:

H3. *It is assumed that students from different teacher education majors evaluate their self-efficacy for core instruction and student motivation equally but differ significantly in their perceived confidence regarding maintaining discipline and adjusting instruction to individual student needs.*

3. Materials and Methods

3.1. Research Design and Framework

The framework for this study was established to analyze how future STEM educators evaluate their pedagogical-didactical self-efficacy for classroom teaching and process management. By examining perceptions across different teacher education majors, this study aims to identify the specific competencies in which students feel most secure, as well as critical areas requiring further training prior to full-time career entry. This approach provides institutional feedback necessary for refining the practical and methodological preparation of pre-service teachers within contemporary school systems. The study is designed as a quantitative cross-sectional survey based on self-reported data. Within this framework, student readiness is structurally operationalized through the construct of perceived teacher self-efficacy, capturing the students' subjective beliefs in their professional capabilities to execute specific instructional and management tasks. Furthermore, the study investigates whether these self-efficacy perceptions vary significantly based on gender, student cohort, and specific academic major. To guide the inferential analysis, three central hypotheses (H1, H2 and H3) were formulated and conceptually anchored in social-cognitive theory at the conclusion of the literature review.

3.2. Participants and Context

The sample for this cross-sectional survey consisted of $N = 65$ graduate students enrolled in teacher education tracks at the Faculty of Science, University of Split. In Croatia, initial STEM teacher preparation programs are offered at only two university centers (Zagreb and Split). Consequently, student enrollment within specific tracks is naturally limited, often yielding cohorts of only one to three students per generation. Therefore, while the total sample size is small, it includes nearly the entire student population in the pedagogical track at this institution, providing a reliable insight into the preparation of future STEM teachers in this region. However, due to the localized nature of the sample, the generalizability of the findings is limited. The specific characteristics of the curricula and teaching practice requirements at the University of Split mean that these results cannot be automatically applied to the national level. Furthermore, because this study uses a single-point cross-sectional design rather than a longitudinal approach, the sample consists of two separate and independent groups of students surveyed at the same time. For this reason, comparing first- and second-year students does not show actual professional development or individual change over time, but rather highlights differences between two distinct student cohorts. The demographic and academic characteristics of the participants were as follows:

- (a) The largest group consisted of future Informatics teachers ($N = 21$; 32.3%). The dual majors of Informatics and Technology, and Mathematics and Physics, were represented by an equal number of participants ($N = 16$; 24.6% per major). The smallest group comprised Biology and Chemistry dual-major students ($N = 12$; 18.5%). It is important to emphasize that these small and unequal group sizes across majors reduce the statistical power of subgroup comparisons, requiring caution when interpreting discipline-specific differences.

- (b) In line with general trends in teacher education, the sample was predominantly female, with $N = 49$ female students (75.4%) and $N = 16$ male students (24.6%).
- (c) Participants were at different stages of their graduate program: $N = 38$ students (58.5%) were in their first year, and $N = 27$ students (41.5%) were in their second (final) year.

3.3. Data Collection and Ethical Considerations

The data collection process was carried out during the autumn of 2025. To ensure methodological compliance and participant protection, the procedure commenced after obtaining formal ethical approval from the Ethics Committee of the Faculty of Science, University of Split. The survey instrument was administered digitally using Google Forms, with access links delivered via institutional electronic mail. Prior to completing the questionnaire, the purpose of the study was clarified to all participants. Participation was voluntary and anonymous, focusing on the students' subjective perception of readiness for their future teaching roles. The gathered data were processed solely for the objectives of this study, maintaining confidentiality and data integrity. As the data collection relied on self-reported measures, the findings should be considered alongside potential self-report and social desirability biases, where participants may overestimate their classroom capabilities. Furthermore, given the quantitative cross-sectional design, the results reflect a comparison between distinct student cohorts at a single point in time rather than longitudinal tracking of individual professional development.

3.4. Instrument

To measure the participants' subjective perceptions of competence, the Norwegian Teacher Self-Efficacy Scale (NTSES), developed by Skaalvik and Skaalvik (2007), was applied. This instrument was selected because, unlike more generalized self-efficacy tools, it provides a differentiated, multidimensional insight into specific aspects of the contemporary instructional process (such as inclusion and coping with changes), which directly aligns with the objectives of this study. Furthermore, it is theoretically and empirically grounded in Albert Bandura's social-cognitive framework. Within this framework, the pedagogical-didactical readiness of pre-service teachers is operationalized through the construct of perceived teacher self-efficacy. While general readiness for profession entry can be viewed through the lens of declarative knowledge or institutional standards, this study defines readiness as a didactical capability that is indirectly inferred from the pre-service teachers' subjective beliefs in their own capacities to successfully organize and execute specific instructional activities. The scale consists of 23 items evaluating teacher self-efficacy across six core dimensions of educational work. Participants expressed their agreement with the statements on a Likert-type scale ranging from 1 (not certain at all) to 4 (completely certain). This study utilized the Croatian version of the instrument, which has been previously culturally adapted and psychometrically validated within the Croatian educational context (Burić et al. 2020), demonstrating high validity and reliability. The overall scale demonstrated high reliability in this study, yielding a total Cronbach's alpha coefficient of 0.954. The six subscales, along with their respective internal consistency coefficients, are detailed below:

Instruction (Cronbach's $\alpha = 0.825$): Examines confidence in explaining instructional content and answering student questions.

Differentiated Instruction (Cronbach's $\alpha = 0.766$): Relates to the perceived ability to organize work for students with diverse levels of ability and individual needs.

Motivating Students (Cronbach's $\alpha = 0.873$): Assesses the capacity to activate cognitive engagement in all students, including those who are disengaged or uninterested.

Maintaining Discipline (Cronbach's $\alpha = 0.886$): Focuses on classroom management and addressing disruptive or challenging student behaviors.

Cooperation (Cronbach's $\alpha = 0.852$): Examines readiness for teamwork with colleagues and constructive communication with parents.

Coping with Changes (Cronbach's $\alpha = 0.843$): Measures perceived teaching efficiency and flexibility under conditions of curricular reforms and organizational transitions.

3.5. Data Analysis

Statistical processing was executed using non-parametric procedures due to the characteristics of the data distribution. Initial screening via the Kolmogorov-Smirnov and Shapiro-Wilk tests revealed significant deviations from a normal distribution ($p < 0.05$) across all Likert-scale items and subscales. Consequently, medians (*Me*) and interquartile ranges (*IQR*) were utilized as the primary indicators of central tendency, alongside arithmetic means (*M*) and standard deviations (*SD*) for descriptive completion. The inferential analysis was structured as follows: Mann-Whitney U tests were conducted to examine differences in pedagogical-didactical self-assessment based on binary grouping variables: gender (male vs. female) and year of study (first year vs. second year). Corresponding effect sizes (*r*) were calculated to evaluate the practical significance of these outcomes. Kruskal-Wallis H tests were used to determine the impact of the four distinct study majors on the subscale dimensions, with the practical strength of major-based differences evaluated using the epsilon-squared (ϵ^2) effect size criterion. Dunn-Bonferroni post-hoc pairwise comparisons were subsequently applied to specify the location and direction of significant differences discovered through the global Kruskal-Wallis test, utilizing a Bonferroni *p*-value correction to control for Type I error inflation. All statistical analyses were performed with the significance threshold set at $\alpha = 0.05$.

4. Results

With the goal of determining the pedagogical-didactical self-assessment of future teachers in the STEM field, an initial screening of the distribution parameters was conducted. Utilizing the Kolmogorov-Smirnov and Shapiro-Wilk tests, a statistically significant deviation from a normal distribution ($p < 0.05$) was found across all measured items and Likert-type subscales. Given the observed data asymmetry and the violated assumption of normality, subsequent processing relied exclusively on non-parametric statistical analyses. Consequently, alongside arithmetic means (*M*), medians (*Me*) and interquartile ranges (*IQR*) were interpreted as more robust indicators of central tendency.

Table 1 presents the descriptive indicators for the six examined dimensions of teacher self-efficacy.

Table 1. Descriptive indicators of pedagogical-didactical self-assessment of future teachers.

Subscales	<i>M</i>	<i>SD</i>	<i>Me</i>	<i>IQR</i>
Instruction	3.28	0.611	4	1
Differentiated Instruction	2.83	0.655	3	2
Motivating Students	2.85	0.726	3	1
Maintaining Discipline	2.84	0.765	3	1
Cooperation	3.17	0.695	3	1
Coping with Changes	3.21	0.721	4	1

As shown in Table 1, the pre-service teachers reported the highest levels of self-efficacy in the domains of Instruction and Coping with Changes. Conversely, the lowest self-efficacy scores were recorded for Differentiated Instruction. The subscales with lower mean values

generally displayed wider interquartile ranges, indicating higher variance in participants' perceptions regarding the more challenging aspects of classroom management.

To examine potential differences in pedagogical-didactical self-assessment based on gender, a Mann-Whitney U test was conducted, with the descriptive statistics and test results presented in Table 2.

Table 2. Descriptive statistics by gender and Mann-Whitney U test results.

	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	Mann-Whitney U Test	<i>z</i> -Value	<i>p</i>	Effect Size (<i>r</i>)
	Male (N = 16)		Female (N = 49)					
S1	3.23	0.915	3.30	0.484	331.500	−0.936	0.349	0.116
S2	2.78	0.811	2.84	0.605	381.000	−0.169	0.866	0.021
S3	2.77	0.863	2.87	0.683	362.000	−0.463	0.643	0.057
S4	3.09	0.978	2.76	0.673	271.000	−1.852	0.064	0.230
S5	3.16	0.908	3.17	0.622	351.500	−0.623	0.533	0.077
S6	3.17	0.911	3.22	0.658	366.000	−0.403	0.687	0.050

Note: S1—Instruction, S2—Differentiated Instruction, S3—Motivating Students, S4—Maintaining Discipline, S5—Cooperation, and S6—Coping with Changes.

The inferential analysis presented in Table 2 indicates that gender did not have a statistically significant effect on any of the six examined dimensions ($p > 0.05$). Consequently, hypothesis H1 is supported, with the calculated effect sizes showing negligible practical significance across most domains ($r < 0.12$). A notable trend was observed in the Maintaining Discipline (S4) dimension, where male participants scored slightly higher than their female peers, though this difference did not reach the threshold for formal statistical significance ($p = 0.064$, $r = 0.230$). To evaluate potential differences in teacher self-efficacy based on the student cohort, a Mann-Whitney U test was conducted to compare first- and second-year graduate students, with the results presented in Table 3.

Table 3. Descriptive statistics by year of study and Mann-Whitney U test results.

	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	Mann-Whitney U Test	z-Value	<i>p</i>	Effect Size (<i>r</i>)
	First Year of Study (N = 38)		Second Year of Study (N = 27)					
S1	3.24	0.730	3.35	0.388	503.500	−0.128	0.898	0.016
S2	2.84	0.791	2.81	0.408	480.500	−0.437	0.662	0.054
S3	2.79	0.811	2.93	0.592	484.500	−0.385	0.700	0.048
S4	2.86	0.877	2.81	0.587	450.500	−0.838	0.402	0.104
S5	3.09	0.791	3.27	0.528	471.500	−0.558	0.577	0.069
S6	3.11	0.806	3.35	0.566	437.000	−1.030	0.303	0.128

Note: S1—Instruction, S2—Differentiated Instruction, S3—Motivating Students, S4—Maintaining Discipline, S5—Cooperation, and S6—Coping with Changes.

The data presented in Table 3 indicate the absence of statistically significant differences between the two student cohorts across all examined aspects of teacher self-efficacy ($p > 0.05$). For example, the scores within the foundational dimension of Instruction (S1) remained closely aligned between the first-year and final-year students. The calculated effect size coefficients fell within the range of negligible effects ($r < 0.128$), reflecting consistency in self-efficacy perceptions throughout the graduate program. Based on these indicators, hypothesis H2 is supported. To evaluate the potential impact of the specific academic major on the participants' pedagogical-didactical self-assessment, a Kruskal-Wallis H test was conducted across the four distinct fields of study, with the descriptive indicators and test results detailed in Table 4.

Table 4. Descriptive indicators by study major and Kruskal-Wallis H test results.

	Biology and Chemistry (N = 12)	Informatics (N = 21)	Informatics and Technology (N = 16)	Mathematics and Physics (N = 16)		
	<i>M</i>	<i>M</i>	<i>M</i>	<i>M</i>	Kruskal-Wallis H	<i>p</i>
S1	3.31	3.06	3.48	3.36	3.98	0.264
S2	2.92	2.68	2.89	2.89	1.473	0.689
S3	2.58	2.82	2.97	2.95	2.406	0.493
S4	2.44	2.63	3.2	3.06	10.083	0.018
S5	3.13	3.02	3.44	3.11	3.416	0.332
S6	3.28	2.9	3.44	3.31	5.166	0.16

Note: S1—Instruction, S2—Differentiated Instruction, S3—Motivating Students, S4—Maintaining Discipline, S5—Cooperation, and S6—Coping with Changes.

From the results presented in Table 4, it is evident that the choice of study major does not generate statistically significant differences in most of the examined dimensions (such as instruction, cooperation, or coping with changes), where the student profiles appear uniform. However, within the dimension of Maintaining Discipline (S4), a significant statistical difference was determined with respect to the study major ($\chi^2 = 10.083$; $p = 0.018$), though this result should be interpreted with caution due to the small and unequal sizes of the subgroup cohorts. The calculated effect size for this test is $\eta^2 = 0.116$, which, according to Cohen's criteria, represents a medium-to-large practical effect and indicates that the study major explains as much as 11.6% of the total variance in the perceived competence of classroom behavior management. Due to this selective but robust difference, hypothesis H3 is partially accepted. To precisely determine the location and direction of the resulting differences between specific majors, it was necessary to conduct a post-hoc analysis. Since the global Kruskal-Wallis H test does not specify within which pairs of groups the differentiation occurs, a Dunn-Bonferroni post-hoc test with a rigorous p -value correction for multiple comparisons was applied.

Since the global Kruskal-Wallis H test determined statistically significant differences in the perceived competence of managing classroom discipline with respect to the study major, a Dunn-Bonferroni post-hoc analysis was conducted to establish the direction and location of these differences. The results of the pairwise comparisons (Table 5) identified two pairs with statistically significant differences under a strict Bonferroni correction at the $p < 0.05$ level. The first pair is Biology/Chemistry–Informatics/Technology ($p = 0.014$), where pre-service teachers in the dual major of Informatics and Technology ($M = 3.20$) report a higher level of self-efficacy in managing discipline compared to their colleagues from the Biology and Chemistry major ($M = 2.44$). The second pair is Informatics–Informatics/Technology ($p = 0.021$), identifying a statistically significant difference between students of the single major of Informatics ($M = 2.63$) and the dual major of Informatics and Technology ($M = 3.20$). However, given the cross-sectional nature of the study and the small, unequal sample sizes within individual majors, these subgroups differences should be interpreted with caution. The difference between the Mathematics/Physics major ($M = 3.06$) and the Biology/Chemistry major ($M = 2.44$) after the application of the rigorous correction did not cross the threshold of formal statistical significance ($p = 0.079$) and remains exclusively at the level of a trend. All other mutual pairwise comparisons of study majors proved to be statistically non-significant ($p > 0.05$).

Table 5. Dunn-Bonferroni post-hoc pairwise comparisons of study majors for the Maintaining Discipline (S4) dimension.

Compared Pairs of Study Majors ¹	Mean Rank Difference	Standard Error	Standardized Test Statistic (Z)	Original (p)	Adjusted p (Bonferroni)
A	−3.952	6.552	−0.603	0.546	1
B	−17.219	6.942	−2.48	0.013	0.079
C	−21.156	6.942	−3.047	0.002	0.014
D	−13.266	5.887	−2.253	0.024	0.144
E	−17.204	5.887	−2.922	0.003	0.021
F	−3.938	6.319	−0.623	0.533	1

Note: ¹ (A)—Biology/Chemistry–Informatics, (B)—Biology/Chemistry–Math./Physics, (C)—Biology/Chemistry–Informatics/Technology, (D)—Informatics–Mathematics/Physics, (E)—Informatics–Informatics/Technology, (F)—Mathematics/Physics–Informatics/Technology.

5. Discussion

By applying the Norwegian Teacher Self-Efficacy Scale (NTSES), a specific profile of teacher self-beliefs among future STEM teachers at the Faculty of Science in Split was identified. The results indicate a clear baseline difference between the candidates' perceived readiness for direct content delivery and their lower confidence regarding the inclusive demands of contemporary classrooms. The highest scores reported by the participants were in the domains of Instruction ($M = 3.28$; $Me = 4$) and Coping with Changes ($M = 3.21$; $Me = 4$). These outcomes align with findings by [Luketić and Rončević Zubković \(2022\)](#) and [Prat-Corominas et al. \(2023\)](#) regarding the pedagogical confidence patterns often observed in pre-service teacher cohorts. Because STEM tracks are structurally grounded in explicit discipline knowledge and logical content mastery, this academic background may offer candidates a professional foundation for structuring learning activities. Furthermore, high self-assessment scores in coping with curricular reforms suggest a flexible pedagogical attitude toward educational innovations among younger generations, which corresponds with the observations of [Aslan and Agiroglu Bakir \(2017\)](#). However, from the perspective of social-cognitive learning theory ([Bandura 1977](#)), these early efficacy patterns should be framed as generalized instructional expectations rather than stable professional convictions, as didactical capabilities are primarily reinforced through direct classroom practice. Given that the surveyed students have not yet engaged in continuous, independent teaching placement, their initial self-assessments could vary during full-time teaching, a phase characterized in pedagogical literature as “reality shock” ([Burić and Kim 2020](#)). This initial baseline pattern is further supported when analyzing the lowest-rated domains within this study. The lowest level of perceived capability was recorded for Differentiated Instruction to individual student needs ($M = 2.83$; $Me = 3$) and in items measuring confidence to handle classroom disruptions ($Me = 2$). These outcomes correspond with international and regional research pointing to the structural difficulties general teacher education tracks face when preparing candidates for the practical realities of inclusive classrooms ([Miralles-Cardona et al. 2025](#); [Tirić 2022](#); [Vujičić et al. 2023](#)). Although the legislative framework ([Ministarstvo znanosti i obrazovanja 2021](#)) establishes differentiated instruction as a standard professional requirement, pre-service STEM teachers exhibit uncertainty regarding its technical and didactical implementation within heterogeneous school settings. Furthermore, as causal modeling by [Abraham and Sickel \(2025\)](#) demonstrates, a pre-service teacher's sense of preparation regarding the learning environment functions as a structural prerequisite before candidates can fully enact advanced instructional or curricular tasks. In the absence of targeted didactical tools for classroom management, candidates often report being un-

derprepared for the social dynamics of modern classrooms, which serves as a recognized contributor to early teaching difficulties and burnout (Wettstein et al. 2021). Because effective instructional quality relies on a structured learning environment (Burić and Kim 2020; Guilloteaux 2007), enhancing didactical confidence in classroom governance remains an important task for initial teacher education design. The comparative analysis revealed an absence of statistically significant differences in self-efficacy levels between first- and final-year graduate student cohorts ($p > 0.05$ across all subscales). In the foundational dimension of Instruction (S1), for instance, the evaluations of students at the beginning of their graduate track ($M = 3.24$) were nearly identical to those at the end of the program ($M = 3.35$; $p = 0.898$). While it is important to note that a cross-sectional design measures cohort differences at a single point in time rather than individual professional development, these uniform scores suggest that the graduate years may offer a limited direct effect on the candidates' perceived readiness for independent work. To achieve a substantive shift in pedagogical identity and educational values, teacher preparation models benefit from integrating continuous reflective practice and collaborative spaces rather than relying primarily on traditional classroom lectures (Bognar 2017; Duchesne et al. 2025; Vukelić 2020). The only domain demonstrating a statistically significant difference among subdisciplines was the impact of the study major on the perception of Maintaining Discipline (S4), where the global test established clear variation ($\chi^2 = 10.083$; $p = 0.018$) with a medium-to-large practical effect size ($\epsilon^2 = 0.116$). The Dunn-Bonferroni post-hoc analysis isolated differences between students majoring in Informatics and Technology ($M = 3.20$) and their peers from the Biology and Chemistry ($M = 2.44$; $p = 0.014$) and single-major Informatics tracks ($M = 2.63$; $p = 0.021$). These variations can be interpreted through situated learning frameworks and the specific curriculum microclimate of the disciplines (Wang et al. 2022). Instruction in technical workshops and laboratories inherently requires early and structured enforcement of behavioral protocols and safety norms due to direct material and resource risks. Consequently, these candidates undergo more intensive early exposure to classroom process management, supporting Annisa's (2018) observation that proactive limit-setting is central to pedagogical governance. Conversely, the lower scores among Biology and Chemistry students suggest that natural science laboratory structures do not automatically transfer into generalized didactical confidence within broader school environments. Finally, although the differences regarding gender did not reach formal statistical significance ($p = 0.064$), a medium practical effect size ($r = 0.230$) was observed in the domain of maintaining discipline, with male participants scoring slightly higher ($M = 3.09$) than female students ($M = 2.76$). In the context of a heavily feminized STEM teaching population at the institution (75.4% female respondents), this pattern may reflect didactical variations in the staging of authority and classroom leadership roles, as noted by Mustadi et al. (2023). Collectively, the empirical indicators suggest that while higher education contexts successfully facilitate subject-matter preparation, there remains an ongoing need to reinforce the inclusive, instructional, and relational readiness of future STEM educators. Integrating simulation exercises, communication skills training for family-school collaboration (Mahmood 2013; Westergård 2013), and practice-based opportunities within heterogeneous classrooms could help bridge the gap between theoretical knowledge and the actual didactical realities of contemporary education (Miralles-Cardona et al. 2025).

Contributions and Limitations

Although teacher self-efficacy is a well-established construct, this study provides localized insight by analyzing specific differences among STEM tracks within the context of initial teacher education in Croatia. However, several methodological limitations must be acknowledged when interpreting the results. First, the total sample size ($N = 65$) is

small and derived from a single higher education institution, which limits the automatic generalizability of the findings to the national level. Second, the small number of participants in certain subgroups (e.g., Biology and Chemistry, $N = 12$) reduces statistical power, which requires caution when interpreting major-based variations. Third, the study relies entirely on self-reported survey measures, which are susceptible to social desirability and self-report biases where candidates might overestimate their professional capabilities. Lastly, because of the cross-sectional, single-point research design, it is impossible to establish causal relationships among variables, and individual development or individual change over time was not directly tracked. Future research should utilize longitudinal designs encompassing multiple national centers to provide a comprehensive country-level understanding of how instructional competencies evolve throughout initial teacher training. Furthermore, because this study uses a single-point cross-sectional design rather than a longitudinal approach, the sample consists of two separate and independent groups of students surveyed at the same time. For this reason, comparing first- and second-year students does not show actual professional development or individual change over time, but rather highlights differences between two distinct student cohorts.

6. Conclusions

The conducted research provided detailed insight into the perceived pedagogical-didactical self-efficacy of future teachers in the STEM field, with a special emphasis on their perceived confidence to face contemporary educational challenges. Utilizing the Norwegian Teacher Self-Efficacy Scale (NTSES), the areas in which students report the greatest professional confidence were identified, alongside critical points that suggest a need for additional reinforcement during initial teacher education. Future teachers exhibit the highest level of self-efficacy in the domains of direct instruction and coping with changes, reflecting positive self-beliefs regarding the explanation of instructional content and adaptability to curricular reforms. Conversely, the lowest level of confidence was recorded in adapting instruction to individual student needs and resolving challenging situations such as aggressive behavior. These data suggest that, despite their theoretical knowledge, students perceive a lack of practical tools for working in heterogeneous classrooms. The study confirmed that, within the examined cohort, the study major significantly influences the perception of the ability to maintain discipline, with Informatics and Technology, as well as Mathematics and Physics students, expressing greater confidence in classroom management compared to their peers from Biology and Chemistry tracks. Factors such as gender and year of study did not show a statistically significant impact on the overall level of self-efficacy, indicating a uniform perception of professional competencies within the observed sample. While these findings cannot be broadly generalized due to the contextual nature and size of the sample, the scientific contribution of this work is reflected in a better understanding of the factors that influence the professional self-efficacy of pre-service teachers. Increasing the sense of competence and readiness to face educational challenges serves as an important pathway for enhancing instructional quality and building an effective educational system.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was approved by the Ethics Committee of the Faculty of Science, University of Split, KLASA: 602-04/25-01/0042; URBROJ: 2181-204-01-25-0013 on 15 October 2025.

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

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The author declares no conflicts of interest.

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