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Teacher Development

An international journal of teachers' professional development

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rtde20

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To cite this article: Özkan Yılmaz (04 Apr 2025): Foundations of reflective teaching process: analysis of knowledge and tendencies of prospective science teachers, Teacher Development, DOI: 10.1080/13664530.2025.2483279

To link to this article: https://doi.org/10.1080/13664530.2025.2483279

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Foundations of reflective teaching process: analysis of knowledge and tendencies of prospective science teachers

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ABSTRACT

Reflective teaching encompasses higher-order cognitive processes throughout the teaching process, enabling educators to adapt their pedagogical approaches to address student needs. This study examined the perceptions and utilization of reflective teaching techniques among prospective science teacher candidates. Qualitative research methodologies, including individual interviews, were employed with fourth-year science students. The interview data were recorded, transcribed, and analyzed using NVivo software to identify thematic patterns and visualize perspectives. While teacher candidates generally demonstrate proficiency in reflective teaching techniques, this study elucidates areas for improvement in instructional planning, assessment practices, student development, and learning management. This study underscores the significance of reflective teaching in developing effective instructional practices and suggests potential avenues for enhancing teacher preparation programs to equip future educators with these essential competencies.

ARTICLE HISTORY
Received 29 October 2023
Accepted 2 October 2024

KEYWORDS
Reflective teaching; science education; teacher preparation; higher education

Introduction

Learning is a lifelong process that undergoes changes over time. In the twenty-first century, new ways of learning are emerging. Individuals can choose from various learning paths. However, in this new century, it has become essential to possess certain skills for the learning process to be efficient. One of these skills is the ability to think critically (Thoman and Jolls 2003). At the higher education level, universities and institutes make adjustments in their instructional programs to enhance and utilize these skills (Choy and San Oo 2012). At the primary education level, it has been emphasized that research-based teaching strategies should be the foundation of the national curriculum. Additionally, the National Education Curriculum Program highlights the importance of 'analytical thinking,' placing it first among life skills for our era (MoNE 2018). The acquisition of this skill, which is given special importance at various levels of education, is a significant issue. In these educational settings, educators must customize their instruction to accommodate the diverse needs and abilities of students. At the same time, they should emphasize cultivating critical thinking skills by integrating reflective methods into their teaching approach

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(Raber Hedberg 2009; Tsangaridou and Siedentop 1995; Yeboah, Ohene Gyang, and Yeboah 2024).

In order for the process to progress toward students achieving the targeted skills, new and effective approaches in teaching must be employed. Reflective thinking and teaching are important concepts in this regard. Reflective teaching is a two-stage (problem identification and problem-solving) teaching method (Bayles 1960). Different interpretations can be derived from the concept of reflection presented here. However, in a general sense, it can be considered as the identification of problems and their frames or the reshaping of the existing frame (Loughran 2006). In reflective teaching, it is important to put forth a reflection related to the lesson after instruction (Larson and Keiper 2007). Therefore, identifying which problem has arisen in practice is the starting point for the reflection process (Loughran 2006).

It is not possible to adapt a singular definition and a model developed based on that definition to different situations (detection and solutions of problems) (Silcock 1994). Reflection is defined as a ubiquitous cognitive process. It serves as a tool not only for processing knowledge into skills but also for translating one experience (academic knowledge) into another (practical application) (Silcock 1994). Schön (2017) has defined reflection as a process whereby a practitioner thinks about and evaluates their practice, the various situations encountered, and the underlying norms.

Reflective teaching combines the acts of teaching and learning with a reflective process that involves the teacher looking critically at their own classroom practices. The aim is to continuously improve teaching strategies and learning outcomes (Ramage and Shipp 2020).

The teacher uses reflection as a tool to evaluate the effectiveness of both teaching performance and student learning outcomes, and makes informed adjustments to practice. This reflective process allows for ongoing professional development and can lead to a more learner-centered approach to education. It is an iterative loop of planning, acting, observing, and reflecting with the goal of continuous improvement (Schön 2017).

There are three types of reflection practices: reflection-in-action, reflection-on-action, and reflection-for-action. These encompass reflection during action, reflection after action, and reflection for future action, respectively (Larson and Keiper 2007).

In reflection-in-action, the teacher monitors students' activities and progress within the classroom in real-time. In situations of need, the teacher provides immediate interventions to organize and modify students' learning. The process involves continuous planning and is implemented throughout classroom activities (Larson and Keiper 2007). In reflection-on-action, the reflection takes place after the completion of any activity or work. It involves evaluating what went well, what did not go well during the process, and considerations for changes in teaching that need to be planned for future repetitions (Larson and Keiper 2007). Both forms of reflection play a complementary role in enhancing professional performance. Reflection-on-action contributes to deeper learning that can improve future practice, while reflection-in-action allows practitioners to manage and adapt their actions in real-time to maintain immediate effectiveness (Cattaneo and Motta 2021). Together, these reflections form a cyclical and iterative process that is essential for continuous professional growth, improving the quality of both actions and outcomes in vocational settings. The idea is that by engaging in ongoing reflection, a professional can develop a more nuanced and competent approach to their work (Cattaneo and Motta 2021).

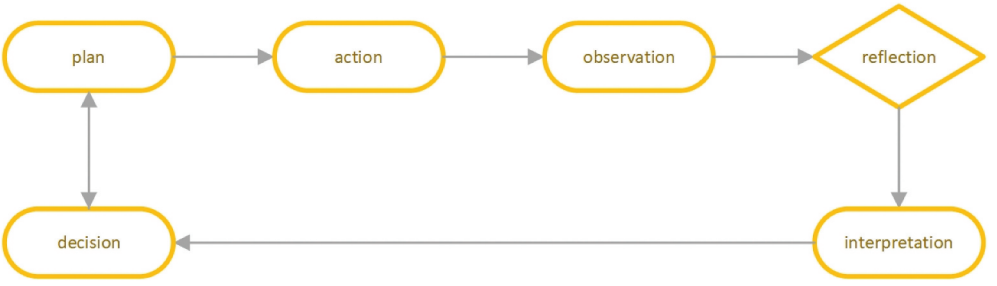

Figure 1. Reflection for action (adapted from Killion and Tondem 1991).

The third type of reflection encompasses the other two types of reflection. Additionally, it involves reflection on what needs to be done to support students in the teacher's future instruction. Essentially, assessments of what the teacher did in the instructional process, what the students learned, and how effective the outcomes were play a crucial role in determining the teacher's behaviours in future instructional plans (Killion and Tondem 1991; Larson and Keiper 2007).

The process of reflection within an action is depicted in Figure 1. Reflection involves interpreting the reflections that emerge as a result of observations made during the implementation of a pre-prepared plan within an action. Based on these reflections, a decision is reached within the current situation, and if necessary, adjustments and changes are made to the planning.

In each reflective process, an inference is made. This inference helps identify the unknown aspects of the action that has been or is being taken. Thus, it enables the clarification of unknown effects (Dewey 1998). In this regard, reflections obtained through reflective observations in teaching are used to enhance the effectiveness of future teaching strategies. These reflections contribute to the improvement of teaching methods for more effective utilization in the future (Larson and Keiper 2007).

Review of literature and summaries of studies

Reflective teaching practices are observed to be used for various purposes in different lessons within the field of education and instruction. In Stout (1989), middle school teachers' perspectives on reflective thinking and reflective teaching were examined. In the study, reflective teaching was analyzed in four main categories: (1) retrospective and prospective thinking, (2) critical questioning, (3) problem-solving skills, and (4) acceptance and use of feedback. The research revealed that teachers engage in reflective thinking and teaching at low or moderate levels. Another study investigates the development of reflective thinking processes among prospective teachers and examines criteria for evaluating reflective thinking. As teacher candidates accumulate experience, it has been indicated by the research that their interest in student-related topics intensifies, and the depth of reflective thinking evolves in response to these experiences (Lee 2005). In their study, Stevenson and Willott (2008) revealed that both students and academics have mixed views regarding the necessity and purpose of reflective practices. Some find

reflective practices to be highly beneficial, while others perceive them as a waste of time. In contrast to academics, students are less convinced about the impact of reflective practices on their learning and course work. While reflective practices can aid students in their learning by helping them learn from mistakes and recognize their achievements, students do not view these benefits as positively as academics do. Kayapinar and Ata Alkhaldi (2023) examined the findings of a survey with five response options, which was voluntarily filled out by 257 university faculty members from more than 20 countries. The aim was to identify reflective thinking and behaviors among experienced faculty. The research unveiled a significant result: despite expressing interest in self-discovery, gaining deeper understanding of their teaching subjects, assessing their own performance, and valuing feedback, individual proficiency in reflective thinking appeared to be inadequate. Aqadoh and Trimasse's (2024) study found no significant differences in reflective thinking abilities of English teachers in Morocco based on gender or teaching experience. In Aslangiray and Usta Gezer's (2023) research, the effects of implementing the enhanced REACT strategy as an instructional method on students' reflective thinking abilities were investigated. The findings revealed a notable disparity in reflective thinking scale scores between the pre- and post-application assessments for the experimental group. Moreover, there was a marked rise in total scores on the reflective thinking scale for students in the experimental group. Conversely, no improvement was observed in reflective thinking scale scores from pre-test to post-test evaluations among students in the control group. Lithoxoidou and Georgiadou's (2023) study found that using recommendations for transdisciplinary education, incorporating new technologies as tools, and creating narratives and cartographies led to the activation of reflective thinking in teacher candidates. This, in turn, triggered creativity and supported collaborative group work and idea contributions. Another article concludes that integrating art and reflective thinking in teacher education through a transdisciplinary approach can transform teachers' perceptions and practices. Additionally, it emphasizes that this approach helps motivate educators toward a more equitable, sensitive, and democratic understanding of education. The use of creative methods in education has been observed to enhance students' abilities to cope with their internal struggles and develop awareness of the issues around them (Soto-González, Rodríguez-López, and Renovell-Rico 2023). Alshamrani's (2023) research focused on examining the viewpoints of high school computer science educators in Riyadh, Saudi Arabia, regarding critical reflective practices. The results indicated that there was no significant gender-based differences in the level of critical reflective practices. Additionally, teachers' educational levels did not have a noteworthy impact on their assessment of critical reflective practices. However, an increase in teaching experience revealed notable variations in the evaluation of critical reflective practices, particularly among those with over 10 years of experience.

Upon analyzing the research as a whole, it is clear that reflective teaching methods in education encompass diverse viewpoints and yield varied outcomes. Many educators are found to be involved in reflection, but generally at limited or moderate levels, indicating room for improvement in professional growth initiatives. Additionally, experience appears crucial; results indicate that seasoned teachers engage in deeper reflection on their teaching practices, especially when dealing with student-related concerns. These research

findings emphasize the ongoing necessity for continual improvement and advancement of reflective teaching approaches within educational environments.

The importance and objectives of the research

All conducted studies provide information on reflective teaching for relevant fields. This information is crucial for identifying problems and making improvements in instruction. A conducive learning environment is necessary for the development of students' critical thinking and problem-solving skills, recognized as twenty-first-century skills (Fadel 2008), highlighting the significance of the subject. Furthermore, toward the year 2030, it is anticipated that there will be no place for a linear curriculum in education. Instead, a dynamic and flexible curriculum program will take center stage, emphasizing the increasing importance of individual learning (OECD 2019). In this context, teachers will play an active role in the implementation of the curriculum (OECD 2019).

Both for students to acquire twenty-first-century skills and for the effective implementation of the changing curriculum, it is essential for teachers to possess the necessary knowledge and skills. In this regard, the examination of the knowledge and skill levels of teachers and teacher candidates becomes crucial. In the context of reflective thinking and teaching, various studies have been conducted in the literature. When these studies are reviewed, it is observed that there is relatively less research in the field of science education. However, considering the science education curriculum, it is expected to be at the forefront of research as a domain where various knowledge and skills, such as scientific process skills, analytical thinking, decision-making, creative thinking, and innovative thinking, are imparted.

Conducted in this study is an examination of the knowledge and views of prospective science teachers, who are positioned as the teachers of the future, regarding reflective thinking and teaching (RTT). This study evaluates the RTT process in four main dimensions: planning, assessment, student development, and student learning. In this context, the study sought answers to the following questions.

- What do prospective science teachers do in the 'planning' dimension of RTT?
- What do prospective science teachers do in the 'assessment' dimension of RTT?
- What do prospective science teachers do in the 'student development' dimension of RTT?
- What do prospective science teachers do in the 'student learning' dimension of RTT?

Materials and methods

Before the research was conducted, the necessary ethical approval was obtained with the decision dated 22 February 2023 and numbered E-88012460-050.1 April 243886 from the Erzincan Binali Yıldırım University Human Research Social and Humanities Ethics Committee

In this study, a qualitative research approach was adopted, focusing on social phenomena and revealing the emotions and perceptions of the participants (Lodico, Spaulding, and Voegtle 2006). In this approach, the interview technique, commonly encountered in qualitative research, was used to obtain in-depth information from

participants about their experiences (deMarrais and Lapan 2003). To determine the knowledge and tendencies of teacher candidates toward reflective teaching, a survey form was used as the data collection tool, and thematic analysis was employed to analyze these data. More detailed information about the methodology is provided below.

Participants

Participants are students enrolled in the Department of Mathematics and Science Education, Division of Science Education, Faculty of Education, located in the eastern part of Turkey. These students, at the 4th-grade level, have completed the necessary teaching courses and are engaged in internship activities in secondary education institutions as part of the teaching practice course. In the Turkish education system, to become a science teacher, one needs to graduate from the Department of Mathematics and Science Education, specializing in Science Education, within the Faculty of Education. During the four-year education process, teacher candidates receive pedagogical training. Throughout the education process, they take various courses such as classroom management, learning psychology, developmental psychology, guidance, instructional planning, and science teaching.

This study aims to investigate how future science teacher candidates perceive and utilize reflective teaching techniques in their instructional practices. Therefore, purposive sampling was chosen as all teacher candidates who have completed all pedagogical formation courses would be more suitable for the research. As part of their teacher training, fourth-grade students commence their internships in schools to gain practical teaching experience. Purposeful sampling was preferred for the sampling type due to this aspect.

In this study, interviews were conducted with prospective science teachers to analyze their knowledge and tendencies regarding reflective teaching. The ideal number of participants for thematic analysis in one-on-one interviews is not fixed but is based on reaching data saturation. This means when additional interviews do not yield new or different information, and themes appear to be saturated, it is accepted that a sufficient number of participants has been reached. This can often be achieved with 12 to 20 participants, although the exact number may vary depending on the context of the research. The crucial aspect is to collect data that is deep and comprehensive enough to answer the research questions. In some cases, a smaller sample may suffice, while more complex subjects might require a larger number of participants (Creswell and Poth 2016; Ridder 2014).Therefore, it is crucial to gather enough information to effectively address the research question while also taking available resources into consideration (Krueger 2014; Morgan 1996).

In the participant selection process, two primary criteria were considered. First, we adhered to the optimum number of participants as recommended in the literature. Second, we aimed to ensure equal gender representation among individuals selected for the study. These criteria were determined to ensure that the total number of participants was suitable for the depth of data required and to create a balanced perspective in terms of gender diversity.

Interviews were conducted with 12 students (6 males, 6 females) randomly selected from students participating in internship activities at the 4th-grade level.

According to ethical rules, the participants have attended the interviews on a voluntary basis.

Data collection

During the interviews, a structured questionnaire was utilized to pose inquiries in a predetermined sequence and offer detailed clarifications as necessary. Subsequently, all interviews were documented and transcribed into written files before being imported into NVivo software for thematic examination. The interview guide encompassed queries regarding: the process of lesson planning and its factors, assessment of teaching methods, monitoring student progress, and evaluation of the impact of teaching activities on student learning. Supplementary explanations and questions were integrated as needed during the interviews.

Data analysis

In individual face-to-face interviews, student responses were recorded with an audio recording device and later transferred to the NVivo computer program in the form of written text files. Thematic analysis was performed for this data transferred to the NVivo program.

Thematic analysis is often used in qualitative research methods to gain a deep understanding of specific questions or topics. This technique involves a detailed examination of the textual content to identify emerging patterns, themes, and relationships. During the process of thematic analysis, researchers typically use a coding system to organize the data, which helps in pinpointing significant findings and interconnections among the identified categories (Braun and Clarke 2006, 2022; Squires 2023). For data analysis, the following procedures were conducted in sequence:

Familiarization with data

The research data was reviewed several times to thoroughly understand it. Notes were made and important ideas were marked.

Initial coding

The dataset was carefully analyzed by assigning 'codes' to important segments, which were then grouped to identify key themes or ideas that stood out within the dataset.

Theme exploration and refinement

Codes were systematically analyzed and grouped based on thematic similarities and content relationships, facilitating the identification of emergent patterns within the data. Consultation with a subject matter expert in the academic domain was sought to evaluate the relevance and integrity of the determined themes and codes, leading to pivotal refinements.

Table 1. Corresponding percentages of agreement and disagreement sample.

Code	File	File Folder	File Size	Agreement (%)	Disagreement (%)	A and Not B (%)	B and Not A (%)
Evaluation	DS550107	Files	3196 chars	97,78	2,22	0	2,22
Evaluation	DS550109	Files	12064 chars	99,25	0,75	0,75	0
Evaluation	DS550112	Files	4005 chars	98,95	1,05	0	1,05

Theme review

The identified themes underwent a rigorous validation process to ensure coherence with the full dataset. This process entailed the independent coding of the dataset by two distinct coders according to pre-defined themes and codes. The 'inter-coder reliability' was ascertained through the evaluation of percentages reflecting agreement and disagreement during the coding phase, offering a measure of consistency between the coders' analyses of the same dataset. These percentages, therefore, served as indicators of the research's reliability and validity. Calculations of these percentages for each thematic and coding instance were conducted utilizing NVivo software for analytical precision. To maintain brevity within the methodological exposition of this study, a representative sample of the coding, along with corresponding percentages of agreement and disagreement, is delineated in Table 1.

The compiled data yield the following aggregate percentages for concurrence and divergence across all examined themes and coding categories: Concordance is outstandingly high at 99.76%, whereas discordance is minimal at 0.24%. Instances where category A is selected without category B account for 0.14% of the data, and conversely, selections of category B exclusive of category A constitute 0.11% of the data.

Writing the final report

The themes, along with a word frequency cloud, exemplar quotes, and analysis results, have been documented. These findings are elaborated on in detail in the Results section.

Reflective thinking and teaching

Reflective teaching combines the acts of teaching and learning with a reflective process that involves the teacher looking critically at their own classroom practices. The aim is to continuously improve teaching strategies and learning outcomes. Schön (2017) proposes a circular framework that frequently includes the subsequent stages:

Teaching

Educators deliver lessons using various strategies and methods designed to facilitate student learning.

Learning

Students engage with the lessons, and their understanding and skills develop through this engagement. Teachers observe student interactions and learning progress.

Reflective teaching

After teaching and observing student learning, the teacher reflects on what occurred in the classroom. This reflection focuses on what worked well and what didn't, why certain outcomes were achieved, and how students responded to different teaching methods.

Revising practice

Based on these reflections, the teacher adjusts and improves their teaching practices to better address student needs, promote engagement, and support deeper learning.

The study examined the reflective teaching process in the following areas.

Planning

Lesson preparation is not a rigid template that needs to be strictly adhered to; rather, it functions as a roadmap for teachers' activities. When implementing a plan, unexpected circumstances may arise, requiring the teacher to adapt with flexibility. Therefore, lesson preparation should be flexible in order to address students' needs and accommodate the dynamics of the classroom. Proficient lesson planning is essential for educators to assist their students and achieve learning goals successfully. This procedure also fosters teachers' professional growth and constitutes an essential element in establishing an effective learning atmosphere (Ruiz 2009).

Assessment

During this stage, the teacher takes on the role of an evaluator, scrutinizing the effectiveness of their lesson planning in the context of teaching and learning activities. This reflective assessment provides insight into the efficacy of instructional strategies and can be integrated as an ongoing process, as well as being a conclusive step at the lesson's or topic's end. The objective is to understand and enhance the teaching approach, ensuring that the planning translates successfully into student learning throughout the educational experience (Kitchen et al. 2019).

Student development

As a result of the teaching activities, changes and development occur in students. In this stage, the extent to which the teacher has achieved the outcomes they aimed to develop in students is examined (Morel 2021; Patton et al. 2016).

Student learning control

The effectiveness of teaching methods is closely associated with student learning outcomes, which are crucial for educators to evaluate and refine their instructional approaches. By observing the progress and comprehension levels of their students, teachers can assess the success of their educational strategies and make adjustments to enhance the learning experience (Burroughs et al. 2019; Fernández and Felipe Martínez 2022).

Results

In this study, which examines the knowledge and opinions of prospective science teachers about reflective thinking and teaching, the findings obtained are presented under four different themes as follows. Also, exemplar quotes were presented for each theme.

The original data is in Turkish. The analysis process was conducted using this data with the relevant computer program. After thematic analysis, the themes and the nodes that constitute the themes are presented in English.

Planning

Planning plays a crucial role in every teaching endeavor. Upon analyzing Figure 2, it is apparent that all teacher candidates are engaged in the planning process except for one. There are three primary factors that emerge from this planning phase: the method of approach, the timing of planning, and specific elements taken into account. One candidate described their planning approach as follows: 'I carefully design a comprehensive lesson plan, including considerations on how to initiate, progress through, and conclude the lesson to optimize learning outcomes.' Another candidate emphasized the importance of timing by explaining: 'I anticipate upcoming subject matters and tailor my plans according to children's learning processes and comprehension levels.' Additionally, there are 10 different aspects that teacher candidates consider during their preparation; among these include 'characteristics of the subject matter' and 'student grade level' as pivotal factors. Regarding consideration for subject matter during preparation, 'In my preparatory phase I focus on relevant components related to this topic; emphasizing concepts while formulating challenging questions aimed at promoting critical thinking among students.' With regards student grade levels, they noted 'The content pertinent to that particular level holds significant weight in my preparations.'

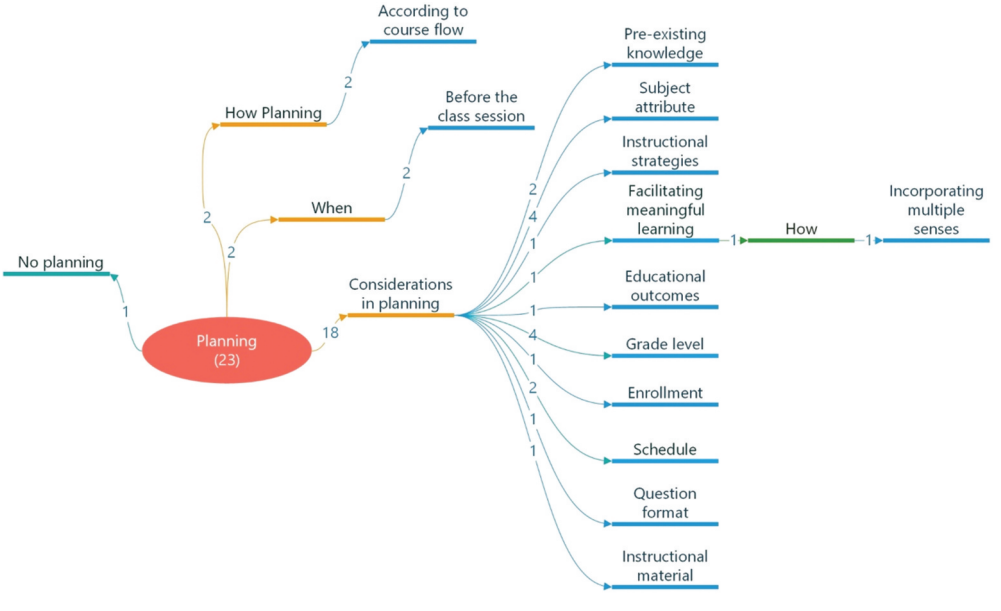

Figure 2. Knowledge and trends of prospective teachers in RTT (Reflective thinking and teaching) regarding planning.

Assessment

The implementation and subsequent evaluation of the plan are pivotal elements of RTT. Within this framework, the assessments conducted by teacher candidates regarding their executed teaching methods are illustrated in Figure 3. It is observed that all candidates, with the exception of one, carry out assessment. During the assessment phase, two primary factors are noted: the timing of events and the methodology. It is evident that teacher candidates place the highest importance on the methodology of their assessment, with a particular emphasis on posing questions. One candidate articulates this approach as follows: 'Certainly, in providing feedback, I can also guide through questions, employing a question-and-answer format. Thus, the assessment process unfolds, determining whether they have learned or not, after which I measure and furnish feedback.'

Student development

Through instructional activities, students undergo change and growth, which is further leveraged in the reflective process. In this vein, Figure 4 depicts the methods employed by prospective teachers to monitor student development. It is noted that two teacher candidates do not track student development, and one is unsure of how to implement tracking. Despite this, the majority of candidates consider student progress to be of importance. They utilize various assessment tools such as oral and written exams, academic achievement tests, and homework to measure student development. Among these tools, homework is identified as the most frequently emphasized means of assessment. A teacher candidate expressed their approach as follows:

> I assign homework to gauge their understanding. Performance tasks related to the subject matter we've discussed are regularly given. I assign homework in a manageable way for the children, and if I receive their completed assignments as feedback, it signifies that there is progress in their understanding of the material I've taught.

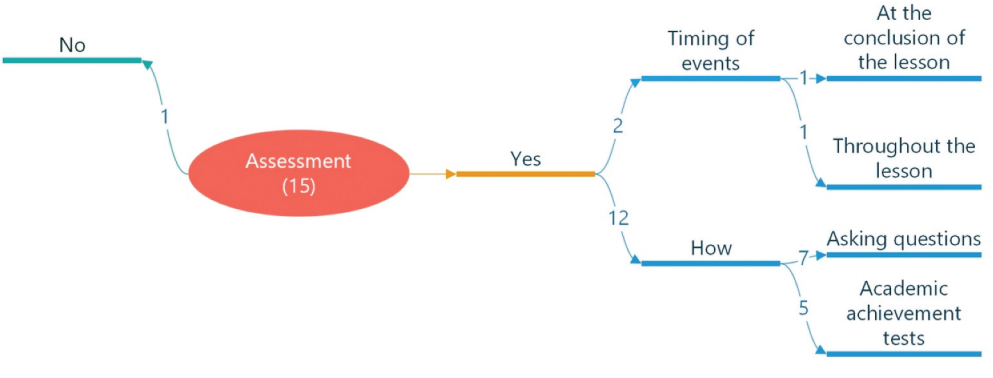

Figure 3. Knowledge and trends of prospective teachers in RTT regarding assessment.

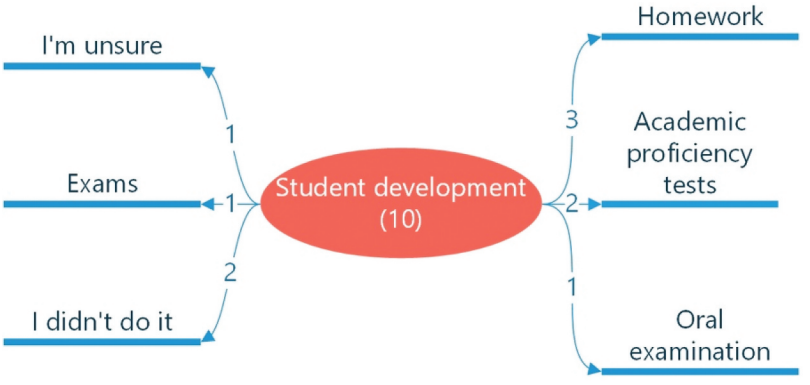

Figure 4. Prospective teachers' knowledge and trends in RTT regarding student development.

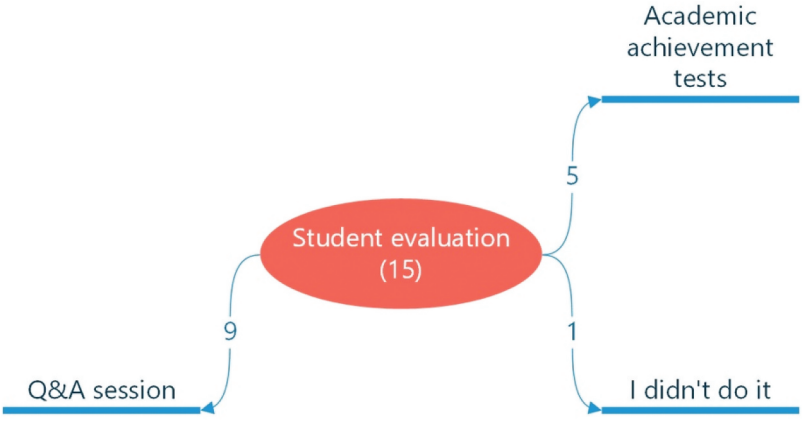

Figure 5. Prospective teachers' knowledge and trends in RTT regarding student learning control.

Student learning control

The efficacy of the instruction in educational activities is intrinsically linked to the students' learning levels. Students' learning outcomes serve as a critical reflective resource for teachers in self-evaluating their instructional techniques. In examining Figure 5, it is apparent that teacher candidates predominantly employ direct question-answer techniques and academic achievement tests to assess student comprehension within lessons. Notably, only one teacher candidate is observed to not monitor student learning. The most favored method among the candidates for controlling student learning appears to be the use of question-answer sessions. One candidate elucidates their approach as such: 'I utilize questioning to verify whether they have grasped the key points I emphasized while teaching the topic. My queries are geared towards confirming that understanding, you know . . . .'

Discussion and conclusion

This section aims to reflect upon the findings of the investigation into the understanding and attitudes of prospective science teachers toward reflective thinking

and teaching. As the educators of the future, their integration of RTT into educational practices was found to be critical. The study, which probed into planning, assessment, student development, and student learning, culminated in nuanced insights across these dimensions. We will now explore the implications of these findings, discuss their significance, and consider their impact on the field of education, all as a response to the research question posed at the outset of this study.

What do prospective science teachers do in the 'planning' dimension of RTT?

When prospective teachers prepare a lesson plan, they typically focus on factors such as 'how planning,' 'when,' and 'considerations in planning.' Under these factors, various considerations are outlined. Essentially, each factor holds equal importance and is utilized by prospective teachers during the planning process. However, it is observed that primarily two factors come to the forefront: 'subject attribute' and 'grade level.' These two factors play pivotal roles in shaping the planning process and guiding instructional strategies based on RTT. Schön (2017) suggested that teachers should maintain flexibility in their planning to accommodate the individual understandings and needs of their students. Viewing the lesson plan as an adaptable framework rather than a strict guide is important, with a focus on addressing topics that align with students' understanding and skills rather than strictly following the provided materials. At this point, it is observed that prospective teachers take into account many factors when planning. Yeboah, Ohene Gyang, and Yeboah (2024) emphasized the importance of comprehensive preparation for teachers, taking into consideration the classroom environment, as well as the needs, interests, and goals of their students. Additionally, they stressed considering the curriculum and class schedule to help both educators and learners identify areas that may require additional focus in teaching and learning. The Ministry of National Education directive emphasizes the importance of creating annual and daily plans in primary and secondary education institutions (MoNE 2014). When preparing a lesson plan, teachers should consider lesson content, class level, topic patterns, achievements and target behaviors, tools, and resources, necessary safety measures if required, student individual characteristics and differences, as well as evaluation of teaching-learning experiences and measurement activities. The findings from Figure 2 show that prospective teachers' planning activities within the scope of RTT are comprehensive and diverse according to MoNE criteria. However, less emphasis is placed on annual planning within the context of RTT in their overall planning activities by prospective teachers. When examining the planning abilities of teacher candidates from an RTT perspective, it was found that these abilities were generally strong. However, there is a tendency for current planning practices to be limited to daily and weekly plans. As a result, it is suggested that teacher candidates should receive training on long-term planning strategies as part of comprehensive programs, learning how to create monthly, quarterly, and annual plans. Long-term planning not only ensures the coherence and depth of educational processes but also allows for continuous monitoring and support of students' academic progress. Therefore, special attention should be given in the training of future teachers to enhance this crucial aspect of reflective teaching practice.

What do prospective science teachers do in the 'assessment' dimension of RTT?

Examining the knowledge and trends of prospective teachers in the second important topic for RTT, which is 'assessment,' it has been found that prospective teachers engage in assessment activities both throughout the course and after the completion of the process. When the findings related to how these assessments are conducted are examined, it seems that they prefer academic achievement tests at the end of the process and question-answer assessment methods during the process. It can be said that prospective teachers have knowledge and trends that can be considered suitable for RTT. However, their preferred methods and techniques appear to be somewhat limited in scope.

Assessment helps determine how much knowledge and skills students have gained. It is necessary to assess how well students understand and can apply the course material (Göçer 2019; YÖKAK 2023). Within this context, it can be said that the academic achievement tests and question-answer methods employed by prospective teachers are suitable for RTT. However, assessment is not only necessary for measuring success but also for monitoring student development, improving the teaching process, evaluating learning objectives, providing feedback, and contributing to decision-making processes (Rogers 2021; OECD 1999). Additionally, portfolio assessments empower students to take greater ownership of their learning, encouraging them to actively engage in the educational journey. This approach facilitates deep learning through personalized choices and presentations, allowing students the autonomy to shape their own academic path. Additionally, it cultivates critical thinking and reflective skills by prompting students to thoughtfully evaluate their learning processes, resulting in enhanced metacognition abilities. Ultimately, these reflective portfolio assessments have the potential to elevate student achievement and self-efficacy (Fernsten and Fernsten 2005). Therefore, integrating portfolios and associated reflective activities into educational practices is crucial for enhancing the learning experience. In line with their approach to planning, prospective teachers mainly depend on daily lesson plans for using assessment tools. Schön (2017) underlines the significance of assessing decisions and actions throughout the process to facilitate effective reflective teaching. Long-term planning and continuous assessment play a crucial role in determining the effectiveness of this teaching method and are essential for enhancing teaching practices consistently. However, it seems that teachers lack sufficient knowledge and skills in these areas. Thus, there is a clear necessity for teacher education programs to enhance the focus on long-term planning and assessment, providing teachers with the insights needed to reflect on and improve their methods over time.

What do prospective science teachers do in the 'student development' dimension of RTT?

Regarding the important component of RTT, 'student development,' it is observed that prospective teachers mostly assess student development at the end of the learning and teaching process through assignments, written/oral exams, and academic knowledge tests. Additionally, there are prospective teachers who either lack knowledge on how to assess this developmental process or, despite having knowledge, do not engage in it. This indicates a significant deficiency in this area. Tracking student development, starting from an initial point and understanding the student's learning pace and individual preferences

over time, is necessary for adjusting educational strategies according to needs, increasing student motivation, improving the teaching process, and enhancing the student's individual self-confidence (Akdeniz 2016; Cornell-University 2024; İlçin et al. 2018; Rogers 2021). However, it has been revealed that the efforts made by prospective teachers to track and assess student development are not sufficient for RTT.

What do prospective science teachers do in the 'student learning' dimension of RTT?

Effectiveness of instructional activities is directly related to the students' level of learning. It is important for teachers to observe and analyze student learning to assess their own teaching methods and strategies (Dunlosky et al. 2013). Within this context, another important aspect for RTT is 'student learning control.' It has been found that prospective teachers resort only to academic achievement tests and question-answer methods and techniques for learning control. Additionally, there are prospective teachers who do not engage in student learning control at all. Teachers use student learning as a reflective tool to evaluate and improve their own instructional activities. Monitoring student performance and receiving feedback provide teachers with the opportunity to determine which teaching methods are more effective. This helps teachers enhance their ability to adjust teaching strategies to increase student learning levels (Assessment, Cambridge 2019; Yale-University 2023). Prospective teachers use methods and techniques that can be considered suitable for RTT. However, it has been revealed that they have a limited level of knowledge and skills in this regard.

Upon a general examination of the knowledge and skills of prospective teachers in the four domains required for RTT – Planning, Assessment, Student Development, and Student Learning Control – it has been observed that the methods and techniques used are generally appropriate but there are many aspects that can be improved. Additionally, it has been revealed that there is a lack of knowledge in some areas. In his study with prospective teachers, Gürkan (2019) revealed that they lacked sufficient knowledge about the concepts of education program, instruction, planning instruction, and evaluating instruction. In fact, they coded the concept of evaluating instruction more independently compared to other concepts. Another study conducted directly with teachers in the field of RTT revealed that the levels of using reflective teaching practices by science teachers were low (Bawaneh, Moumene, and Aldalalah 2020).

Recommendations

Reflective thinking and teaching are important learning strategies and pedagogical approaches that help students understand their thought processes and learning experiences in depth. The knowledge and trends of science teacher candidates in this regard are open to improvement. Therefore, the following recommendations are outlined.

For professional development, educational content should be organized to assist in the development of reflective thinking skills within the undergraduate education curriculum of teacher candidates. In this context, it is aimed for teacher candidates to focus more on educational programs, teaching strategies, planning, and evaluation concepts. More time

should be allocated to educational programs to provide teacher candidates with more comprehensive knowledge in these areas.

Teacher candidates should not only focus on academic achievement tests and question-answer methods but should also pay attention to a wider variety of assessment methods. The use of methods such as portfolio assessment, performance tasks, and project-based assessment should be encouraged.

Teacher candidates should not only base student development assessments on standard criteria but should also develop personalized strategies that take into account individual student characteristics and differences more effectively.

Teacher candidates should not limit student learning control only to academic achievement tests; instead, they should focus on reflexive methods that involve monitoring and analyzing student performance to make teaching strategies more effective.

The higher education system needs to constantly develop and enhance itself (Soto-González, Rodríguez-López, and Renovell-Rico 2023). Licensure education should be considered as the fundamental first step in professional training. In this context, teacher candidates should participate in continuous professional development opportunities and acquire updated information on new teaching methods, assessment techniques, and student monitoring strategies.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

Özkan Yılmaz is currently employed as a professor at Erzincan Binali Yildirim University. Dr. Yılmaz's expertise and research interests cover a diverse range of educational topics, including mobile and digital learning, science education, augmented reality applications, educational technologies, blended learning approaches, e-assessment methodologies, and self-regulated learning strategies.

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