Learning, Culture and Social Interaction 60 (2026) 101049

Contents lists available at ScienceDirect

Learning, Culture and Social Interaction

journal homepage: www.elsevier.com/locate/lcsi

Pedagogical infrastructure to support students' self-regulation in flipped learning: A learning diary with individualized learning goals

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ARTICLE INFO

Keywords:
Flipped learning
Diversification
Individualized learning
Learning goal
Learning diary
Pedagogical infrastructure
Self-regulated learning
Teacher education

ABSTRACT

Large variations in the knowledge, skills, and interests of entry-level students are increasingly challenging higher education learning designs to support the individualization of learning experiences. To provide pedagogical infrastructure with space for individualization and capable of activating students to take accountability for their own learning, a flipped-learning environment to support students' self-regulative learning was designed. This study focuses on learning goals and students' use of a semi-structured learning diary—an important part of the pedagogical infrastructure. Based on their entry-level content knowledge, students were divided into novice and advanced learners to understand differences in their diary keeping and learning performance. Qualitative analysis of the learning diary entries showed that the diary, scheduled to facilitate starting and completing flipped-learning tasks, systematized students' setting of learning goals and reflections on goal attainment. Novice and advanced students alike were active in setting individualized and well-founded learning goals. Comparisons between novice and advanced student groups suggest that when approximated by setting individualized learning goals and reflections on goal attainment, self-regulative performance is independent of disciplinary expertise. That is, the differences between the two groups were smaller than those between individual students. However, situational and contextual factors such as task-type or character of the subject could also have an effect on actualized performance. The results suggest that learning designs need to consider individualizing support for content and self-regulation.

1. Introduction

Considering individual students' interests and aptitudes is a global educational challenge (National Academy of Engineering, 2017). Higher education, faced with increasing student diversity, is no exception (Goedhart et al., 2019). Therefore, teacher education can expect diverse populations of student teachers who should not only learn but also learn how to facilitate—and individualize—the learning of their own pupils.

Approaches such as flipped learning and flipped classrooms (later referred to as flipping) have been promoted as solutions to the increasing need for diversified and individualized teaching practices (Goedhart et al., 2019). For us, flipping provides a model that supports our long-term aim: to provide learning designs that encourage students to actively plan their coursework and fully utilize

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https://doi.org/10.1016/j.lcsi.2026.101049
Received 11 October 2025; Received in revised form 16 June 2026; Accepted 2 August 2026
Available online 11 August 2026

course resources to reach their individualized developmental goals, rather than merely succumbing to given learning objectives and aligning their efforts to meet the minimum course requirements. Towards that long-term aim, we designed a flipped skill-learning course implementation with pedagogical support to facilitate students in taking accountability for their own learning. In the following, we introduce the main design elements (flipping, self-regulation of learning, and a structured learning diary), and the tool to describe our pedagogical design: Lakkala's (2010) framework of pedagogical infrastructure.

1.1. *Flipped learning*

As an active learning approach (Abeysekera & Dawson, 2015), flipping changes teachers' and students' roles and the focus of teaching. The teacher provides materials that students are expected to acquaint themselves with before class (Goedhart et al., 2019). Lessons are transformed from lecturing to supporting student learning and higher-level learning activities, such as applying, evaluating, or synthesizing their learning (Abeysekera & Dawson, 2015; Goedhart et al., 2019; Talbert, 2017). Effectively, students' engagement with preparatory materials is a precondition for the success of flipping.

Balancing pre-class materials with in-class activities requires careful planning and subject-matter expertise from teachers (Sointu et al., 2019), especially as many students resist pre- and in-class active elements (McNally et al., 2017). For students, active engagement with these elements requires self-regulation skills (Abeysekera & Dawson, 2015), which several studies have found to be underdeveloped (e.g., Lai & Hwang, 2016; Shih et al., 2019). Nevertheless, learning designs need to support all students in terms of motivation, content learning, and self-regulation. Specific for flipping, support in the preparatory phase is critical.

For teacher education, we argue that flipping provides an additional benefit. Teachers' tendency to reproduce ways of teaching they have experienced as learners (Britzman, 2003) emphasizes the importance of learning experiences gained during teacher education. By relieving contact lessons for teacher–student interaction, flipping offers student teachers a chance to experience and observe a variety of scaffolding techniques that could otherwise remain mere theories. That is, flipping increases student teachers' adaptive expertise (Darling-Hammond et al., 2024), which allows them to meet the needs of the diverse pupil population that they, in turn, will meet in their own classrooms.

In Finnish teacher education, flipping enhanced with practices that support self-regulation provides added benefits. A central directive document, the National Core Curriculum for Basic Education (Finnish National Agency of Education [FNAE], 2014), defines (among other things) principles for guidance, support and differentiation of instruction. Differentiation (for instance, allocating individual learning objectives, homework, tasks, and materials) is not limited to special needs pupils but aims to promote each individual pupil's learning and wellbeing (FNAE, 2014). Responding to various levels of pupils' needs through scaffolding is demanding for teachers, especially if their own pedagogical studies have not involved such approaches and the scaffolding of self-regulation. Therefore, teacher education should provide students with experiences of active learning approaches that are supportive of diversification, individualization—and self-regulation.

1.2. *Self-regulated learning*

Self-regulated learning (SRL) could be considered an "umbrella under which a considerable number of variables that influence learning (e.g., self-efficacy, volition, cognitive strategies) are studied within a comprehensive and holistic approach" (Panadero, 2017, p. 1). SRL is connected to life-long learning and academic achievement (Lai & Hwang, 2016; Pintrich, 2004; Puustinen & Pulkkinen, 2001; Xu et al., 2023), academic stress, exhaustion (Heikkilä et al., 2012), and non-completion of studies (Heublein, 2014). Thus, higher education faces pressures to foster students' SRL skills.

SRL is one of the most important research areas within educational psychology (Panadero, 2017), and there are multiple related accounts and reviews. As reviewed by Panadero (2017), Pintrich (2004), and Puustinen and Pulkkinen (2001), several SRL frameworks share some commonalities. Such commonalities include understanding learners as individuals actively constructing meanings, goals, and strategies for their own learning. Learners have the potential to monitor, control, and regulate their learning, which involves comparisons between one's learning process and individually set goals or criteria. Leaners can have multiple, varied goals and utilize diverse strategies to reach their goals. Importantly, learners' efforts are guided and constrained by learners' goals and learning environments (Panadero, 2017; Pintrich, 2004). Thus, whether students cultivate SRL skills is not independent of learning designs.

Different methodological approaches towards SRL outline the construct differently. Panadero et al. (2016) discusses the first wave of SRL measurements involving self-reporting instruments such as questionnaires, surveys, and interviews. These measures are mainly retrospective and represent a rather static conceptualization of SRL. The second wave treats SRL as a dynamic series of behavioral, cognitive, metacognitive, motivational, and emotional events, which can be measured through thinking aloud protocols, traces, and observations. This wave is represented, for instance by Pintrich (2000) and Zimmerman (2002). It is interested in learners' situated regulatory process and follows learners' actual activities during learning tasks and SRL (Panadero et al., 2016).

According to the second-wave researchers, self-regulation is not a trait or an innate skill (Zimmerman, 2002). The development of self-regulation skills requires practice, feedback, and observation over time (Panadero, 2017). However, SRL performance is distinct from SRL skills as high-level SRL skills are not necessarily employed universally (Zimmerman, 2013). Due to motivational and situational factors, high-level SRL skills do not guarantee high-level SRL performance (Pintrich, 2000). As SRL is context- and outcome-specific, existing SRL skills can be challenged by engaging with a new type of task (Zimmerman, 2013) or discipline. For instance, Zheng et al. (2024) developed an engineering-oriented SRL-model that combines Zimmerman's SRL-model with an engineering design circle (a problem-solving approach with specific adaptive and iterative SRL practices). Similarly, Greene et al. (2019) discuss a need for design-discipline specific approach towards SRL. It appears that cultivating one's self-regulative skills necessitates repeated opportunities that are supported by learning designs in discipline- or task-relevant contexts. Therefore, discipline-specific expertise does not guarantee expert-level self-regulatory performance, and being a discipline novice does not necessarily imply underdeveloped self-regulative skills (Härkki et al., 2023).

1.3. Self-regulated learning for teacher education

SRL is important for all higher education students, but student teachers are (implicitly or explicitly) expected to approach SRL simultaneously as learners and as future teachers. They need to understand SRL theory and model(s), and to gain SRL expertise as learners to successfully observe and support their own pupils' SRL (Kramarski, 2018; Panadero, 2017). This dual approach calls for heightened self-awareness, metacognition, and motivation (Karlen et al., 2023; Kramarski, 2018). Pintrich (2000) notes that learning of academic material can also occur through more tacit, implicit, or unintentional ways, without explicit or conscious self-regulation. However, due to their dual need, student teachers heightened self-awareness, metacognition and motivation translate into employing SRL consciously. This entails capability to consciously reflect on and document one's strategy choices, performance, goal attainment, and related attributions. Moreover, the capability to professionally observe and support their own pupils in a timely manner requires student teachers to become familiar with and to appreciate the discipline- and context-specific, and dynamic character of SRL (Panadero, 2017; Zimmerman, 2002), that is, to recognize moment-to-moment shifts in individual's regulatory activities. For all this to occur, learning environments need to be purposefully designed to support students' SRL skills.

A recent study (Latva-aho et al., 2024) found that student teachers had an underdeveloped understanding of observing and supporting pupils' SRL skills. Karlen et al. (2023) compiled previous research findings that indicated notable differences in teachers' SRL skills. It appears that teacher education neither sufficiently supports this dual approach to SRL (Karlen et al., 2023), nor acknowledges the complexity that student diversity (interests, goals, and capabilities, among other things) brings to supporting their SRL.

For this study, we chose Pintrich's (2000, 2004) SRL framework (Fig. 1), which separates the learning process into four phases (forethought, monitoring, control, reflection) and four areas of regulation (cognition, motivation/affect, behavior, context). Pintrich (2000, p. 472) suggests that researchers can use his framework to "spy underexplored territories in need of further investigation and examination." We argue that understanding the separations in this framework is valuable for student teachers' future work. The framework details a variety of SRL-related activities that serve the planning, execution, and reflection of teaching. Supportive of teacher-student interaction, the framework itemizes kinds of activities and strategies for teachers to actively pay attention, scaffold, and provide formative feedback.

A central idea shared by many SRL frameworks is that students actively set goals and then, use the goals as a reference point to evaluate and decide whether continuation or change is necessary for those goals to be reached (Pintrich, 2000). Goal-setting interventions are a common SRL support approach in higher education, but the results on students' academic achievements or performance appear mixed (Martins van Jaarsveld et al., 2025). Goal-focused SRL research has encompassed various levels and types of goals, such as life goals, academic goals at the level of a course, exam, or degree, and task-specific goals (Martins van Jaarsveld et al., 2025). While having various levels and types of goals is important for an individual, this research follows Pintrich (2000) in centering on task- and study-session-level goals due to their specificity, and therefore, effectiveness. For the participating student teachers, this level is beneficial as it responds to the emphasis on diversification in the Finnish core curriculum.

Considering the multifaceted character of SRL, focusing on a single regulatory activity (such as goal setting) is unlikely to explain students' performance (Pintrich, 2004). Nor does it serve the dual approach towards SRL. Heightened self-awareness, metacognition and motivation are needed, as discussed above. Whereas continuous articulation and documentation of SRL are impractical, this need could be seen as means of conscious self-regulation and condensed as reflection (phase 4 in Pintrich, 2000, 2004). For teacher education, reflection is not only a component of SRL. Rather, it represents a pedagogical practice central to the profession (e.g., Korthagen and Nuijten, 2011). Therefore, learning to reflect on one's experience is, in itself, a learning objective (Boud, 1999). Pintrich's (2000, 2004) phase 4 (the combination of reaction and reflection) involves judgements and evaluations of self, task and context, and related attributions. According to Boud (1999), reflection involves learners engaging with their experience, exploring and constructing their own meanings, focusing on their lack of understanding and probing discrepancies.

Capturing reflective explorations and constructed meanings is methodologically challenging. As SRL is an internal process, it eschews a reliable and valid way to measure (Panadero et al., 2016) and document. Panadero et al. (2016) promote learning diary as a method that simultaneously promotes SRL and measures the progress of students' SRL. For the purposes of this study, a learning diary provides focus on conscious and explicated goal setting and self-reflection.

1.4. A learning diary to support self-regulated learning

An effective learning design element that supports SRL is the learning diary (Schmitz & Wiese, 2006). A learning diary facilitates students' articulation of their evolving understanding of the learning content, and ideally, results in well-informed actions (Kivimäki et al., 2023). The diary provides deliberate practice in SRL (Fabriz et al., 2014) and acts as an intervention as the reflection stimulated by the diary also has an effect on students' future learning actions (Panadero et al., 2016). However, the learning diary—or any other metacognitive tool alone—is not sufficient to promote students' SRL skills; it needs to be combined with other interventions (Pesonen et al., 2020). In this study, the other intervention involved the designed flipped-learning environment.

Learning diaries can be open, semi-structured, or structured (Fabriz et al., 2014), depending on the instructions and type of guiding questions and prompts. According to Schmitz and Wiese (2006), a structured learning diary that targets all components of self-regulation (such as goal setting, learning strategies, and results) could provide effective support for students' SRL. Structure

	Cognition	Motivation/Affect	Behavior	Context
Phase 1 Forethought, planning, and activation	Target goal setting Prior content knowledge activation Metacognitive knowledge activation	Goal orientation adoption Efficacy judgements Perceptions of task difficulty Task value activation Interest activation	Time and effort planning Planning for self-observations of behaviour	Perceptions of task Perceptions of context
Phase 2 Monitoring	Metacognitive awareness and monitoring of cognition	Awareness and monitoring of motivation and affect	Awareness and monitoring of effort, time use, need for help Self-observation of behavior	Monitoring changing task and context conditions
Phase 3 Control	Selection and adaptation of cognitive strategies for learning, thinking	Selection and adaptation of strategies for managing, motivation, and affect	Increase/decrase effort Persist, give up Help-seeking behavior	Change or renegotiate task Change or leave context
Phase 4 Reaction and reflection	Cognitive judgements Attributions	Affective reactions Attributions	Choice behavior	Evaluation of task Evaluation of context

Fig. 1. SRL phases and areas.
Adapted from Pintrich (2000).

encourages students to consciously engage with and articulate their SRL activities, as it prompts students to consider specific issues, serves task-specific cues, reminds students of certain learning strategies, and stimulates metacognition (Schmitz & Wiese, 2006). Moreover, diary structure guides the grain-size of students' reflective activities, as well as capturing and recording relevant cognitive events, chosen strategies and reasoning not easily captured by surveys and questionnaires (Pintrich, 2004).

However, a learning diary implies that considerable effort is required from the students (Panadero et al., 2016; Pesonen et al., 2020), which is why they need to be assured by the learning design that the extra effort will be worth their while. In theory, the learning diary fits well with active learning approaches such as flipping, as they both support students' active role in their learning. In practice, timing diary activities to converge with activities necessary for successful flipping minimizes their appearance as extra work. In this study, the designed semi-structured diary (detailed in the Methods section) is used for two purposes. First, to systematize students' engagement in preparative activities, which are foundational elements crucial for in-class learning, but resisted by many students (McNally et al., 2017). Second, to instruct post-task self-reflection, which represents conscious completion of the SRL cycle (i.e., Phase 4, Pintrich, 2000, 2004) and a central professional practice (Korthagen & Nuijten, 2011).

1.5. Pedagogical infrastructure

In general, research on the effects of flipping remains contradictory (Shi et al., 2020). This could partly be due to a multitude of flipping implementation strategies (Birgili et al., 2021), which many publications do not fully disclose. To provide transparency to our research, we utilize Lakkala's (2010) pedagogical infrastructure framework, which is intended as a general tool to analyze and evaluate learning designs (Lakkala, 2010). The framework renders visible indirect background conditions that mediate intended social and cultural practices (Lakkala, 2010). Therefore, it is suitable for describing principles of our flipped-learning environment and SRL support. Previously, the framework has been adapted for various learning environments by, for instance, Seitamaa-Hakkarainen et al. (2017), Riikonen et al. (2020), and Juurola et al. (2022).

The framework divides the learning environment into four components: social, technical, cognitive, and epistemological (Lakkala, 2010; Lakkala et al., 2008). These components partly overlap yet studying them separately emphasizes that all these components need to be purposefully designed and supported (Lakkala, 2010). The components of the original version of the framework (Lakkala, 2010) can be briefly described as follows:

- Social: Organization of students' social interaction and students' (individual, pair, group) responsibilities to produce learning outcomes.
- Cognitive: Provided cognitive models, scaffolding, meta-level guidelines, and inquiry strategies.
- Epistemological: Nature of the provided knowledge resources, practices of knowledge advancement promoted by the teacher, and nature of the epistemic processes that the learning tasks promote.
- Technical: Provided tools and technology, their suitability, functionality, and related instructions.

Notably, the organization of in-class sessions and student–teacher interaction are central pedagogical components of flipping. Therefore, we enhance Lakkala's (2010) social component by employing Bielaczyc's (2001, 2006) concept of social infrastructure (on which Lakkala's framework was partly based). Bielaczyc identified six levels of social infrastructure: 1) *culture* involving classroom culture and norms; 2) *activities* orienting students to interact, organize their work and teaming, as well as end-of-session culminating events in which students share their learning with the rest of the class; 3) *teacher's role*; 4) *tools* involving the chosen affordances of the tools; 5) the level of *curriculum integration*; and 6) *curriculum content*. For this study, Bielaczyc's levels 1–3 are relevant.

2. Study aims and research questions

Our long-term aim is to encourage students to plan their coursework actively and to fully utilize course resources to reach their individualized developmental goals. This requires supportive pedagogical designs that activate students to take accountability for their own learning and pedagogical approaches (such as flipping) that provide space for individualization. However, flipping challenges students' SRL skills, the development of which is elemental for student teachers' own learning, but also for their future success in supporting their own students' SRL. To describe the study context—a flipped skill-learning course in subject teacher education—and the role of the learning in the learning design, we utilize Lakkala's (2010) pedagogical infrastructure framework.

From these premises, this study explores the possibilities of facilitating students' conscious SRL via a semi-structured learning diary. Specifically, the focus is on the connection between setting and reflecting on the attainment of learning goals, that is, students' conscious performance related to Pintrich's (2000, 2004) forethought and reflection phases. We assume that comparing these two aspects could provide further guidance for designing pedagogical infrastructures that support the learning needs of individual student teachers.

Therefore, two research questions (RQs) were set:

RQ1: To what extent did students set individualized, well-founded learning goals?
RQ2: In what ways did students utilize the learning diary to reflect the attainment of their learning goals?

The following section introduces the methodological elements of the study. The description of the educational context of the flipping course and the learning diary is enhanced by utilizing Lakkala's (2010) pedagogical infrastructure framework to map the design elements of the flipping implementation onto Pintrich's (2000, 2004) SRL framework. Then, we describe the study participants, data collection, and analysis methods.

3. Methods

3.1. Study setting

The context involved an intermediate-level flipped course in the teacher education department of a Finnish university. This second-year course teaches traditionally central yarn-craft techniques in the subject of craft. The course was comprised of two lectures, four learning tasks (exercises), and a larger piece of coursework. This study focuses on four exercises (two individual, two pair work) and related flipped in-class sessions (3 groups, 16 students per group).

Globally, craft belongs to a group of artistic and practical school subjects which continue to develop, renegotiate, and reinterpret their contents. Such subjects include, for instance, Arts, Architecture, Design, Technology, Food and Home Economics, Music, Physical Education and Health. In many countries, they have been integrated into other subjects, ceased to exist, or have never appeared on curricula as standalone school subjects in the first place (e.g., Gray et al., 2021; Kokko et al., 2020; McLain, 2021; Perignat and Katz-Buonincontro, 2019). In Finland, the subject of craft is mandatory for all grades 1–7 basic education pupils. A substantial part of the learning activities consists of experiments, materializations, and designs. According to the national core curriculum (FNAE, 2014), craft activities are based on craft expression, design, and technology. Working with various visual, material, and technical solutions and production methods promotes the development of creativity, spatial awareness, and design skills, sense of touch, and motor skills (FNAE, 2014).

From the perspective of the studied course content, the development of dexterity shares similarities with subjects Arts, Design, Music, Technology and Physical Education as the development of elemental knowledge and skills is not confined to formal education. Typically, informal craft learning during leisure activities and hobbies (Kouhia, 2015) shared with peers, friends, and family members offers rich possibilities to explore, try, and learn. This "on-demand" learning is initiated to answer learner's individual needs and interests (Liu & Falk, 2014). Endless possibilities to become experts early on exists due to the availability of tutorials and other inspirational materials on the internet and can be enhanced by social media trends. This easy access to informal learning materials and desire to seek knowledge due to personal interests is likely to change their relationship with learning—at least when the learning is related to their interests.

In artistic and practical subjects such as craft, it is not uncommon that when a certain technique is introduced at school, dexterous teens could have more than five years of practice while their peers have none. Moreover, as the learning tasks often result in artifacts materialized through physical activities (Pöllänen, 2009), that is, demonstrations of skills enacted in the makerspace, learners' dexterity (or lack thereof) soon becomes overt and visible. This reinforces the need for individualized learning tasks and teachers' increased capability to scaffold pupils' motivation when their (at times vastly) different skill levels become obvious to everyone in the classroom.

3.2. Semi-structured learning diary for flipping

The success of flipping—and students' learning—depends crucially on the preparatory activities students perform independently before in-class sessions. Thus, the semi-structured learning diary was designed to direct students' activities through open-ended questions in two phases: in goal setting during the preparatory phase (phase 1 in Pintrich, 2000, 2004) and in the post-task reflection (phase 4 in Pintrich, 2000, 2004).

One in-class session was dedicated to each of the four course learning tasks. Before in-class sessions, students were instructed to acquaint themselves with the learning task's minimum requirements and technique videos and activate their prior knowledge of the technique in question. To facilitate students' goal setting, a variety of "standard learning goals" for each learning task was available in Moodle. These standard goals exemplified appropriate task-level goals and the students' freedom to individually seek motivating ways to fulfill the requirements. These "standard goals" involved core techniques, but also more challenging or little-known ones to inspire more advanced (or aspiring) students. Instead of settling with the provided standard goals, students were encouraged to define individualized and motivating learning goals. However, identifying and formulation of individualized and interesting goals required students to activate their prior knowledge of the technique in question. To ensure that the students' goals were specific and challenging enough (Locke, 1968; McCardle et al., 2017), each in-class session began with a brief round of teacher–student goal review dialogues. By gently challenging students' reasoning, the teacher ensured that the goal was motivating and attainable within the course time limits and students' capacity, that is, the goal was well-founded and individualized.

For the post-task reflection, the students were guided to state whether they had reached their goals, and to reflect on their successes, challenges and learning as well as suitability of their initial learning strategies, alternative strategies tried and suggestions for suitable strategies for deepening their skills. This reflection was left to students' independent work, to be done after the in-class session. However, the diary module featured a dashboard view for the teacher, who followed students' activities and, when necessary, reminded them to complete their post-task entries.

3.3. Designed pedagogical infrastructure to support SRL in flipping

Our design was guided by Lakkala's (2010) pedagogical infrastructure framework enhanced by Bielaczyc's (2001, 2006) social infrastructure levels, resulting in Epistemological, Cognitive, Social/Classroom culture, Social/Organizing student interaction, Social/Teacher's role and Technical components. As flipping shifts much of the regulatory burden to students and outside classroom, the design prioritized on-line support activities for Pintrich's (2000, 2004) phases 1 and 4, course-level principles targeting the Motivation/Affect area, and balancing between preparatory independent on-line activities and teacher-facilitated in-class activities.

The following outlines our adaptation of the pedagogical infrastructure. To avoid not seeing the forest for the trees, the outline is limited to main design features and mappings. Due to the interconnected character of SRL areas and phases, several other mappings are possible. However, that shown represents the intent of our pedagogical design. Each component is described as a set of principles, resources, and activity types, which, in turn, are mapped to Pintrich's (2000, 2004) SRL phases and areas they were intended to support. The intended support could relate to one or several areas and phases, references to which are detailed below in parentheses (initials of the area followed by the phase number(s), e.g., M/A:1–4). A visual summary of the mapping is also available in Fig. 2.

The epistemological component refers to the characteristics of the instructional materials, other knowledge resources, and knowledge processing, as well as students' and the teacher's roles in knowledge construction. The epistemological elements inform all the phases.

1. Knowledge and skills are constructed through experiments, curiosity and deliberate practice, via both individual work and peer interaction (M/A:1–4, B:1–4)
2. The teacher promotes acknowledging failures and mistakes as valued learning opportunities (M/A:1–4)
3. Every student is valued as capable of understanding and performing at their own speed and skill level, as everyone's experience is valuable for all participants' construction of professional knowledge (M/A:1–4)
4. The acquisition of (propositional and) procedural knowledge and related fine-motor and spatio-cognitive skills is framed as a central professional capability (M/A:1–4)

The cognitive component involves Moodle-based exercises and instructional materials, instructions and scaffolding during in-class sessions.

	Cognition	Motivation/Affect	Behavior	Context
Phase 1 Forethought, planning and activation	C.1, C.2, C.4, C.4.1 S1.3 S3.1, S3.3 T.1, T.2, T.3, T.4	E.1, E.2, E.3, E.4 C.1., C.2, C.4, C.4.1 S1.1, S1.2, S1.3, S1.4 S2.1 S3.1, S3.2, S3.3 T.2, T.3, T.4	E.1 C.1, C.2, C.4, C.4.1 S2.1 S3.1 T3	C.3, C.1, C.4.1 S1.4
Phase 2 Monitoring	C.5 S1.3 S3.1, S3.3 T4	E.1, E.2, E.3, E.4 C.6 S1.3, S1.4 S2.3 S3.1, S3.2, S3.3 T4	E.1 C.6 S2.1, S2.3 S3.1	C.3 S1.4
Phase 3 Control	C.5 S1.3 S3.1, S3.3 T4	E.1, E.2, E.3, E.4 C6 S1.3, S1.4 S.2.3 S3.1, S3.2, S3.3 T4	E.1 C.6. S2.1, S2.3 S3.1	C.3 S1.4
Phase 4 Reaction and reflection	C.2, C.5 S1.3, S1.4 S2.2.1, S2.2.2, S2.2.2 S3.1, S3.3 T.3	E.1, E.2, E.3, E.4 C.2, C.6 S1.2, S1.3, S1.4 S2.2.2. S2.2.3, S2.2.4 S3.1, S3.2, S3.3 T.3	E.1 C.2, C.6 S2.2.2, S2.2.3 S3.1 T.3	S1.4

Fig. 2. Designed SRL support features outlined through components of pedagogical infrastructure (Lakkala, 2010) and mapped to Pintrich's (2000, 2004) SRL areas and phases. E = epistemological component, C = cognitive component, S = social component, T = technical component. Numbers refer to the list item numbers in the description of our pedagogical infrastructure. For instance, E.1 = List item number 1 of the Epistemological component (i.e., Knowledge and skills are constructed through experiments, curiosity and deliberate practice, via both individual work and peer interaction).

1. Moodle-based task instructions: instructional materials, minimum requirements per each exercise, examples of learning goals for various skill levels and interests (Cog:1, M/A:1, B:1)
2. Moodle-based learning diary structure (Cog:1, 4, M/A:1, 4, B:1, 4)
3. Instructions to search for (online or printed) materials that meet one's learning needs and preferences (videos, diagrams, pattern models), if those available in Moodle appear suboptimal (Con:1–3)
4. In-class teacher–student discussions on students' learning goals and prior knowledge/skills, at the individual and group level (Cog:1, M/A:1)
   - o At times, these discussions result in students revising their goals either upwards or downwards, depending on the case (Cog:1, M/A:1, B:1, Con:1)
5. The teacher demonstrates (at group-level) and scaffolds (at individual level) details of techniques (Cog:2–4)
6. The teacher demonstrates monitoring and controlling activities (M/A: 2–4, B:2–4)

The social component 1/Classroom culture

1. The first exercise involves a creative pair task encouraging openness in trying out novelties and curiosity shared with one's pair and all the participants, as well as taking responsibility for one's own learning (M/A:1)
2. The teacher promotes acknowledging successes and sensitively neutralizing of failures (M/A:1, 4)
3. When appropriate, failures are treated as valued opportunities for constructing and sharing pedagogical content knowledge (that is, explicated and collectively reflected on as examples of the need for scaffolding) (Cog:1–4, M/A:1–4)
4. The teacher continuously reminds students that their varying skill levels (demonstrated in the individualization of learning goals, experiences, and issues confronted) provide rich opportunities for collective knowledge construction on how to support their future pupils' learning (M/A:1–4, Con:1–4)

The social component 2/Organizing student interaction

1. Combination (and order) of pair-work exercises (to encourage peer support) and individual exercises (to maximize one's efforts to learn the techniques) (M/A:1, B:1–3)
2. In-class sessions end with culminating events in which, one by one, students
   - o share their learning (Cog:4)
   - o share related ups and downs (Cog:4, M/A:4, B:4)
   - o learn from their peers' experiences what technical and skill-learning-related issues in SRL they should be monitoring when teaching their own pupils (cf. Auerbach et al., 2018) (Cog:4, M/A:4, B:4)
   - o neutralize challenges and failures (M/A:4)
3. U-shaped classroom organization maximizes interaction and peer support (M/A:2–3, B:2–3)

The social component 3/Teacher's role

1. Being firm (about students' accountability for their own learning) but sensitive (Cog:1–4, M/A:1–4, B:1–4)
2. Creating as open and relaxed an atmosphere as possible, as many struggle with the exercises (M/A: 1–4)
3. Continuously encouraging students to learn something new, and challenge themselves by, for instance, choosing individualized and aspiring goals (Cog:1–4, M/A:1–4)

The technical component involves course virtual learning environment and physical resources.

1. Moodle-based instructional materials (Cog:1)
2. Moodle-based instructions for the exercises and links to support videos (Cog:1, M/A:1)
3. A structured learning diary in Moodle (Cog:1, 4, M/A:1, 4, B:1, 4)
4. Physical resources include classrooms equipped for yarn technologies (library, yarns, needles, scissors, knitting machines, etc.) (Cog:1–3, M/A:1–3)

3.4. Participants and data collection

Of the 43 student teachers who participated in the course, 41 gave their informed consent to participate in this study. The study followed the ethical principles issued by the Finnish National Board on Research Integrity TENK (2023). The course started with a pre-survey on students' skills and interests. In total, 26 students were identified as novices and 14 as advanced. Furthermore, learning diaries written in Finnish language were submitted by 38 students (25 novices and 13 advanced), which resulted in 304 diary entries (38 students, 4 exercises, 2 entries per exercise). The surveys and diaries were acquired as research data.

The survey involved (total 38) questions on students' yarn-craft involvement: familiarity with techniques; extracurricular engagement and skills in course-relevant techniques; students' views of themselves as craft makers and as yarn-crafters; and completed yarn-products. Detailed questions probed students' skills related to the basic-level course content and to contents they were supposed to master by the end of the intermediate course. For instance, separate questions probed hand and machine knitting skills in casting, garter and purl stitch, decreasing, hand knitting of sock heels and pattern knitting with machine. The self-evaluation scale rated skill-levels from 1 to 5 (1 = none; 2 = some; 3 = good; 4 = excellent; 5 = can act as peer tutor). Depending on the activity, levels 1–3 were deemed as novices and levels 4–5 as advanced. The pre-survey was completed by 40 students. Together with a colleague, the teacher reviewed students' self-evaluations and after a discussion, the teachers agreed that one self-evaluated novice was at the advanced level.

It is likely that the practical character of the subject craft made it relatively easy to distinguish novices and advanced students—at the level of an individual course. At the subject-level, it is much more complicated. When compared with other subjects, making a course-level division is likely more problematic (for example) in biology, but not too difficult in mathematics.

3.5. Qualitative content analysis

The diary data were analyzed by adopting Hsieh and Shannon's (2005) qualitative conventional (i.e., data-driven) content analysis by two native Finnish language speakers. Pintrich (2000) understands self-regulatory processes as conscious activities which aligns with the interests of teacher education and the focus of this study. With an assumption that only documented reflection can be counted as conscious reflection, the analysis was limited to manifest content. A diary entry was chosen as the unit of analysis. The analysis process involved the first author acquainting herself with the data through repeated readings and deriving initial codes. (It should be noted that in Finnish language, using lexical criteria such as "use of word I" is difficult as the pronoun is usually embedded within verb inflection. Therefore, more detailed content-based criteria are necessary.) Next, the initial codes were revised into one category (with three codes) per research question. The second author coded 20% of the data, which resulted in 69% agreement. The discrepancies were related to "standard goals" (no textual additions or interpretations were allowed, that is, analysis was limited to manifest content) and the definition of well-grounded (explicit grounding in previous *personal* experience rather than a general aim). After a discussion, the second round of coding produced 81% agreement, which was deemed sufficient (cf. Miles & Huberman, 1984). The final coding scheme with code descriptions and example quotes translated from Finnish is shown in Table 1.

Table 1
Final coding scheme.

RQ1 Category: Goal setting
Code: Standard goals
Description: Goal copied as such from "standard learning goals" in Moodle
Example: Learn to knit rib.
Code: Individualized goals
Description: Goal reflects defined interests, needs, future plans, etc. which could be individual's own, but expressed at a general level OR Goal is based on standard goals but amended to reflect defined interests, needs, future plans, etc. which could be individual's own, but still expressed at a general level
Example: Learn a new special technique, which I can use later as a teacher.
Code: Individualized, well-grounded goals
Description: Goal reflects stated individual interests, needs, future plans, etc. AND the reasoning for selecting this particular goal is grounded in personal experience rather than in general considerations. *Reasoning* should include words such as *because*, *since*, *as* (In Finnish: *siksi*, *koska*) or other phrasing that answers to the question *Why is this important for me?*
Example: Learn to read textual instructions. I usually watch videos, as that is so much easier. But then I forget the names of the stitches, even though I can knit them very well.
RQ2 Category: Reflection on goal attainment
Code: Goal attainment explicated
Description: A clear statement: Fully or partly reached goals
Example: I managed to finalize the sock, which made me gloriously happy. After many hours, concentration, and desperation, it was done. The sock, from start to finish, was a success, especially the tip decreases and the cuff. I reached my goals.
I reached one of my two learning goals. I didn't even try to reach the second, as it did not feel meaningful after all.
Code: Goal attainment not explicitly commented on
Definition: Goals are not mentioned. Instead, the comments are related to the exercise, completed product, one's feelings, learning, or such.
Example: I did not break the machine and the exercise was completed.
[In this case, the set goals were "learn to use the machine smoothly" and "learn more about pair work"].

4. Results

The results were compiled according to familiar versus novel techniques (exercises 1–2 versus 3–4), individual versus pair exercises (exercises 2 and 4 versus 1 and 3), and a creative, unconventional exercise for traditional techniques versus a traditional exercise for familiar techniques (exercise 1 versus 2). The underlying rationale for these combinations was to understand whether familiarity with the task type or disciplinary content had an effect on the results. Below, these results are provided in the order of the RQs, and the example quotations have been translated from Finnish.

4.1. RQ1: To what extent did students set individualized, well-founded learning goals?

For both novel and familiar techniques, well-founded individualized goals were the most common when considering all students (Fig. 3). In general, individualized well-founded goals were the most common, individualized the next, and standard goals the least common. One exception appeared: advanced students chose standard goals more often than individualized goals in case of novel techniques. Overall, this could imply that the set of standard goals available in Moodle served their purpose as a starting point to reach the minimum level when understanding the possibilities of the technique was underdeveloped for tailoring the goals.

The standard goals aimed to cater to various skill levels while also featuring skills such as fluent and even working and careful finishing, that is, skills that demonstrate expertise, are motivating and challenging, including for advanced students, and are valuable for future teachers. In addition to some students adopting standard goals, many individualized goals were inspired by the standard goals. For instance, the word *independently* in the standard goal ("I learn to ... independently") was refined to more detailed version such as "with written instructions" (Theo, novice) or "without instructions" (Lauren, advanced).

The level of content expertise (familiarity versus novelty) was visible. For familiar techniques, most novices and advanced students set well-founded individualized learning goals, and individualized goals had more detailed and knowledgeable formulations than those for novel techniques. Content expertise enabled comparisons between existing knowledge and the standard goals, as well as identification of personalized learning needs.

For comparisons between individual and pair exercises, or traditional (individual exercises) versus unconventional creative (pair) exercises, data aggregation employing a novice–advanced division was not possible, as some pairs comprised one novice and one advanced student. Therefore, the following treats novices and advanced students as a single group.

When comparing the goal setting of all students in pair versus individual exercises, small differences were identified. The percentages for standard, individualized, and well-founded individualized goals were 21/27/51 (pair exercises) and 14/31/55 (individual exercises), respectively. That is, students favored standard goals more often for pair exercises, but individualized and well-founded individualized goals for individual exercises. This could signal that students deemed negotiating over goals too time-consuming or otherwise unnecessary.

Furthermore, when comparing goal setting in traditional versus creative unconventional exercises (for familiar techniques), the percentages for standard, individualized, and well-founded individualized goals were 5/28/67 (traditional exercises) and 8/23/69 (creative unconventional exercises), respectively. That is, both extremes (standard and well-founded individualized goals) were slightly more frequent for creative unconventional exercises.

4.2. RQ2: In what ways did students utilize the learning diary to reflect the attainment of their learning goals?

Unlike most of the SRL-oriented research, the RQ2 targeted *the ways of reflecting* rather than mere goal attainment. In total, no meaningful difference appeared between familiar and novel techniques; a good two-thirds of the students explicitly stated whether they had reached at least one of their learning goals (Fig. 4). The rest of the students typically approached their goal attainment indirectly by commenting on completing a product and on its quality rather than on actual goal attainment. For instance, one student's individualized goals were "To practice a neat and correct way to change colors, and to learn to knit the heel from memory", but the respective reflection read as follows: "I completed the sock without any real problems. I could recall techniques and phases rather quickly. The sock appears flawless, but the stitches are a bit loose"(Whitney, novice). At surface-level, the diary entry appears to report a satisfactory result, both from the process performance and the product viewpoint. Yet, performance and learning related to set goals (neatness and correctness of color changes and reaching automated-level performance in heel-knitting) remain unclear.

To understand whether well-founded individualized goals were pursued more consistently than other goal types, reflection of goal attainment was contrasted with goal types. However, only small differences were identified: explicitly stated goal attainment for standard goals was 71%, for individualized goals, it was 67%, and for well-founded individualized goals, it was 71%. Furthermore, no difference was identified between pair and individual exercises (72% vs. 71%). Some differences were found between traditional (individual) exercises (61%) and creative unconventional (pair) exercises (77%), in which the techniques were familiar.

Generally, creative exercises invited longer reflections than traditional exercises. For novel techniques, pair exercise reflections were longer than individual exercise reflections; however, the individual novel technique exercise could have suffered from "fatigue", as it was the last of the four exercises. Notably, verbosity was not a guarantee of high-quality reflection. Quite often, long diary entries missed the point, describing the qualities and features of the produced artifacts rather than learning or goal attainment—that is, experiences or behavior relevant for SRL. Eventually, group-level differences between advanced and novice students' reflections were smaller than differences between individuals. In both groups, reflections on learning and goal attainment ranged from surface-level descriptions of performed activities to deep introspection with ambitious future plans.

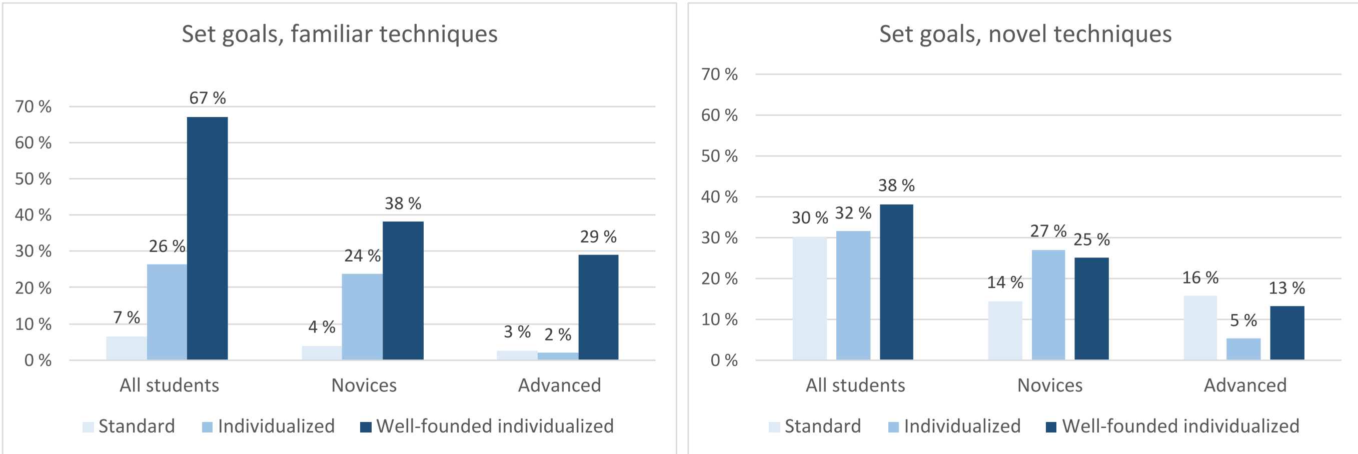

Fig. 3. Learning goals set by novices and advanced students for familiar techniques (exercises 1–2) and novel techniques (exercises 3–4). The 'All students' bars show the results for all students as percentages. These percentages are further disaggregated into two groups: novice and advanced students.

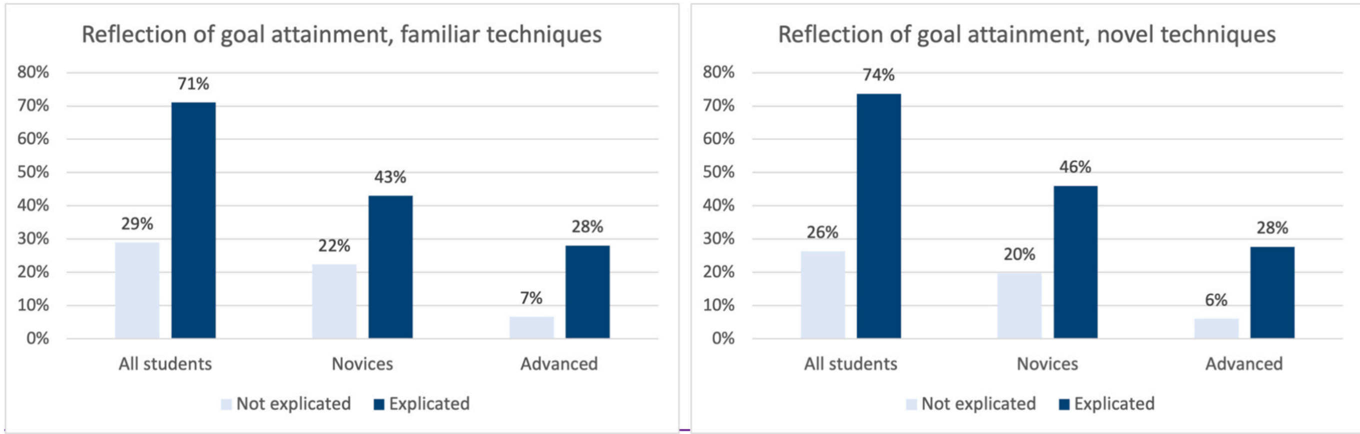

Fig. 4. Students' utilization of a learning diary to reflect the attainment of their learning goals for familiar techniques (exercises 1–2) and for novel techniques (exercises 3–4). The 'All students' bars show the results for all students as percentages. These percentages are further disaggregated into two groups: novice and advanced students.

5. Discussion

Participating in blended flipped learning equips student teachers with personal experience of several beneficial practices: Flipping is an active learning approach (Abeysekera & Dawson, 2015) with potential for diversification and individualization (Goedhart et al., 2019), but demanding self-regulation (Abeysekera & Dawson, 2015). Therefore, flipping is aligned with our aims to encourage students to plan their coursework actively and to reach their individualized developmental goals. Moreover, flipping increases student teachers' adaptive expertise (Darling-Hammond et al., 2024), which, in turn, enhances their capabilities to meet the diversification needs of their own pupils.

Goal setting interventions have frequently been used to enhance performance (Martins van Jaarsveld et al., 2025). However, in this study, goals were chosen as the focal point due to the acknowledged need to diversify and provide space for individualization. The dual approach to SRL in teacher education (Kramarski, 2018; Panadero, 2017) suggests that student teachers need capabilities for conscious SRL, including reflection. However, support for this dual approach in teacher education is insufficient (Karlen et al., 2023). Similarly, research into learning designs supportive of SRL in flipped learning environments is scant (Yoon et al., 2021).

In this study, we set two RQs that targeted 1) learning goals, which SRL frameworks assume are drivers for self-regulatory activities and learning (Panadero, 2017; Puustinen & Pulkkinen, 2001), and 2) conscious reflection explicated as learning diary entries. Together, these two perspectives could be assumed to indicate how goals chosen at the beginning of a task serve throughout the task as sustained performance guides, further guiding students' reflections on their goal attainment, that is, supported good SRL.

In line with our pedagogical emphasis on providing space for individualization, the first RQ asked to what extent students set individualized, well-founded learning goals. In these data, the popularity of individualized and well-founded individualized goals over standard goals suggests that students were motivated to capitalize on the possibility to tailor their learning objectives according to their individual needs.

For novel techniques, standard goals were popular, either as such or as inspirational sources for more tailored formulations. This is in line with the context specificity of SRL (Pintrich, 2000; Zimmerman, 2013). Goal-setting support appeared crucial. However, advanced students chose standard goals almost as often as individualized or well-founded individualized goals—a pattern not replicated by novices. This contradicts the idea that content expertise anticipates better task-analysis skills, which, according to Zimmerman (2013) should result in more specific, proximal, and challenging goals. This suggests that it is not mere content expertise that determines the level of *actualized* regulatory performance. This could also imply that a couple of well-thought-out standard goals that crystalized the core content to be learned appeared to serve most students' aspirations.

In contrast, the need for individualization (and discussions with peers and the teacher) was more sizable for so-called familiar techniques, as there was a significant variation in individual students' familiarity with the techniques and in (especially advanced) students' interests. As the techniques in question offer practically endless learning possibilities, pairing a student's existing skills with a motivating and challenging enough new feature is not straightforward. Students' eagerness to delve into the wealth of possibilities could also be related to the character of the subject craft, as discussed earlier. These exercises could have transitioned students to hobby-like performance and raised their "on-demand" learning (Liu & Falk, 2014) aspirations, resulting in increased motivation and SRL performance.

The character of the subject could also explain that the difference in goal setting between traditional and creative unconventional exercises was small. Unfamiliar task type could have resulted in students resorting to standard goals, yet it did not. This unfamiliar task likely resembled hobbyists' projects, that is, even if the task was unconventional in the context of Finnish subject craft, it could have felt familiar from the context of hobby-craft. This hobby-like character could have translated to motivation and increased SRL performance.

It is possible that for students' motivation—and for the performance related to the goal setting—the discussions and teacher attention, focusing on the students' wider aspirations and interests, were as important as the actual identification of learning goals. These supportive discussions were also meaningful for group-wide learning. Listening to these discussions benefited students' peers: they captured sources of inspiration for their own goals and examples enhancing their subject-specific knowledge. Specifically for teacher education, in-class discussions with peers and the teacher could be valuable: students' varying skill levels and interests form a fruitful base for their co-construction of pedagogical knowledge. Student teachers have the opportunity to acknowledge their and their peers' enthusiasm, doubts, affects, and control issues as valuable material for developing practical pedagogical solutions for the future. Moreover, these discussions facilitated probing students' interests and their underlying reasoning, which further enhanced the teacher's capabilities to find motivating and challenging tasks—that is, her capabilities to diversify. Altogether, flipping with familiar content could be more demanding for the teacher: Students expect wider and deeper content expertise, flexibility, and adaptive in-situ responsiveness from the teacher, which is typical for active learning designs (Auerbach et al., 2018).

The second RQ asked about the ways in which students utilized the learning diary to reflect the attainment of their learning goals. According to the results, most students stated explicitly whether they had reached at least one of their goals. Differences between student groups or task types were small. According to the results, explicit statements about goal attainment were no more often related to individualized well-grounded goals than other goal-types. That is, individualized well-grounded goals did not yield more conscious SRL and reflection. Moreover, the depth and precision of diary entries differed more between individuals than between novice and advanced groups. Interestingly, the creative pair exercise with uncommon requirements (such as creating organic, irregular, and three-dimensional shapes) inspired students to produce remarkably long reflections. This could signal that the novel task type (as such, or through its hobby-craft character) inspired students to reflect on their unconventional learning experience and the products that differed notably from traditional yarn-craft learning artifacts.

Some diary entries avoided commenting on the exact goals, instead discussing quality issues and constructed products, which suggests that the diary structure could have been more directing. Alternatively, this could imply that students had adjusted and changed their goals during the task as a function of monitoring, control and reflection—a possibility suggested by Pintrich (2000). Moreover, this behavior could also be related to the character of subject craft and students' familiarity with informal, hobby-related craft learning experiences such as described by Liu and Falk (2014) and Kouhia (2015). When a learning task is interpreted as a project based on one's practical needs and individual wishes, the idea of rigorously proceeding towards the initial ideas (i.e., goals) of aspired learning could be buried under novel ideas sparked during the project or by enthusiasm related to the emerging product.

In these data, advanced content-specific skills did not guarantee better conscious SRL performance (approximated by setting individualized, well-founded learning goals, and reflecting on the attainment of set learning goals). Quality reflections on the attainment of learning goals were found in both groups, as well as descriptions of learning artifacts that replaced reflection on learning and goal attainment. However, previous research (Chye et al., 2021) noted that the quality of student teachers' reflections does not necessarily demonstrate their reflective skills. Moreover, reflection is a keenly studied and multifaceted topic in teacher education (Korthagen & Nuijten, 2011), which suggests that easy answers on how to teach reflection are unlikely to surface.

In this study, the learning diary provided an ecologically valid way (Schmitz & Wiese, 2006) to measure and support (Panadero et al., 2016) students' SRL in terms of setting goals, documenting and reflecting on challenges, successes, and goal attainment. Like Schmitz and Wiese (2006), we concur with the difficulty of disentangling the effects of the diary and the flipping design. However, the diary structure facilitated taking the first steps towards systematizing students' planning and reflection: diary entries were scheduled as elemental parts of flipping, and the diary supported getting started with the exercises. All students were active in setting well-founded individualized learning goals and describing them in the diary, yet the reflections left room for improvement. Again, competence does not guarantee performance. In this study, support for reflection was insufficient.

Schmitz and Wiese (2006) suggest learning diaries targeting all components of self-regulation. This is in line with the use of Lakkala's (2010) pedagogical infrastructure framework for a balanced and coherent design. Diary structure gives clear guidance to engage with and articulate prompted SRL activities, and it could remind students of certain learning strategies (Schmitz & Wiese, 2006) and guide the grain-size of reflective activities. It provides deliberate practice in SRL (Fabriz et al., 2014). Technological enhancements, such as metacognitive prompts and learning analytics dashboards (Yoon et al., 2021), provide scalable online support designs.

Considering the dual approach to SRL (Kramarski, 2018; Panadero, 2017) necessary for teacher education, conscious engagement with self-regulation and reflective activities are needed. For student teachers, reflection is not merely a SRL component. Rather, it represents an elemental pedagogical practice (Korthagen & Nuijten, 2011), and is, in itself, a learning objective (Boud, 1999). Thus, our decision to use open-ended instead of more structured questions was conscious. Boud (1999) warns against imposing reflection on learners as answers to a series of prompts that could be understood to imply that reflection is a simple process resulting in deep understanding. Increased structuredness, especially changing open-ended questions to drop-down menu choices, likely increases precision of the diary entries. Receiving ostensibly explicit answers to mandatory questions might hide the actualized process, such as abandoned or changed goals, or whether the goal ever guided their work in the first place. For student teachers, conscious capturing of their actualized SRL process represents the skill level that enables them to scaffold their future pupils' learning and SRL (Panadero, 2017). On the other hand, diary design needs to balance the considerable effort required (Panadero et al., 2016) with student-perceived gains.

Whereas a diary provides more privacy and space for exploring ideas, in-class sessions allow questions and experiences to be shared. In Chye et al. (2021) study, deep reflection was typically reserved for situations which legitimized or privileged it; that is, the depth of the reflection was linked to the wider learning context. In this study, the blended flipped learning setting afforded socio-cognitive elements such as in-class (facilitated and spontaneous) peer discussions, which potentially further increased student motivation. Thus, rather than increasing online scaffolds for reflection, we advocate actively employing the socio-cognitive support possibilities of blended flipping and in-class sessions to increase students' consciousness of their set learning goals throughout the task and conscious reflection on their learning. Guiding students to continuously reflect on their performance translates to the practices advocated by Panadero (2017), that is, deliberate practice in small and less effortful pieces that ensure peer and teacher feedback and observation over time. This necessitates allocating in-class session time for peer discussions and shared reflections on the role of set goals, chosen strategies, changes in motivation, and half-time self-evaluations. Along comes the additional benefit of equipping student teachers with personal experiences of productive in-class interaction, scaffolding, and diversification, which increases the likelihood that they reproduce related teaching approaches (cf. Britzman, 2003).

To summarize, the study results look promising given the aim of encouraging students to plan their coursework actively. From the teacher education perspective, the results on reflection suggest further support is needed. However, it appears that group-level differences between novices' and advanced learners' SRL performance were smaller than differences between individuals. This corroborates our previous results (Härkki et al., 2023) and suggests the need to individualize pedagogical support not only content-wise but also SRL-wise if the intervention aims to facilitate students' SRL. Furthermore, especially in higher education, support for motivation has proven beneficial (Panadero, 2017). Additional consideration could be given to Dignath and Veenman's (2021) suggestion that a learning design aiming to facilitate students' SRL needs to involve direct teaching of SRL strategies, which the studied design did not involve.

Future research could probe whether pedagogical infrastructures borrowing socio-cognitive characteristics from hobbyists' projects and "on-demand" learning (Liu & Falk, 2014) are experienced as more engaging and motivating by students. Similarly worth researching is whether the easy availability of informal learning materials in social media and hobbyists' desire to seek knowledge due to personal interests changes their relationship with learning—and whether formal learning could capitalize on this development.

5.1. Limitations

Rather than a large-scale learning context, this study involved a single course in subject teacher education, which limits the extent to which conclusions and generalizations can be derived. Therefore, the findings are limited to the local-level theory and are subject to further validation. Due to the sensitivity of SRL performance to context (Panadero, 2017; Pintrich, 2000), the main design elements of the study context were described through Lakkala's (2010) pedagogical infrastructure framework to enable informed comparisons and conclusions by other researchers. For instance, large-scale flipping designs have different challenges from small designs (Auerbach et al., 2018), and online and blended flipping entail different constraints and affordances. These affordances have effects on, for instance, scaffolds for motivation and reflection. Moreover, the character of the Finnish subject craft (involving experimental, material, and creative elements) could have had an effect on the results. Further, as craft (and other artistic and practical school subjects) could have strong linkages to some students' leisure activities, or in general, have strong associations with informal and "on-demand" learning (Liu & Falk, 2014), students' expectations for learning (and reflection) could be different from those in school subjects more oriented to theoretical and text-based contents.

One of the authors was also the course teacher, which addresses a common concern that active learning implementation differs from the intended design (Auerbach et al., 2018). Nevertheless, this involvement could have had an effect on the results and on the mapping between the designed (i.e., documented) components of the pedagogical infrastructure and SRL support features. However, the meticulous description of the learning environment aimed to provide documentation that was sufficient for other researchers and learning designers to evaluate the design (cf. Goedhart et al., 2019). To minimize this possible bias, the mapping was scrutinized by another author familiar with the course.

For all students but two, this was their first flipped-learning experience. Neither were the students accustomed to keeping learning diaries. Unfamiliarity could have had effects on their performance. The diary task was mandatory but not graded. Possibly, the entries included unauthentic reconstructions, yet strengths and weaknesses were also treated, which appears sincere. The diary method and reflection continue to be typical learning tasks in teacher education, where students' SRL skills have been found to be underdeveloped (Latva-aho et al., 2024). Based on this study's results, meaningful local decisions regarding future compositions of pedagogical infrastructure and learning diary structures could be made; thus, the study has consequential validity (Messick, 1993).

6. Conclusions

Flipping has been advocated as a framing for individualizing and diversifying learning designs, that is, for answering the increasing needs facing higher education. However, accounting for variability in students' prior knowledge and skills in learning content is not enough. Varying self-regulatory skills are as important a factor, and the potential for SRL skills does not always actualize as performance universally (cf. Zimmerman, 2013). Yet, the pedagogical designs described in educational research rarely account for both content and SRL. The situation- and context-specific elements of SRL, outlined by Pintrich's (2000, 2004) framework are likely to cause temporal variability. The visibility of this variability is a function of the measuring instrument (cf. Panadero et al., 2016). For teachers, this variability becomes meaningful through their daily interactions with their pupils.

Evidence on flipped approaches elevating student performance remains mixed, possibly due to the large variety of enacted (and often insufficiently documented) implementations, their strategies, and objectives. Signatory elements of blended learning flipping include in-class activities in which the teacher serves the students, facilitating their learning efforts and self-regulation (Abeysekera & Dawson, 2015; Goedhart et al., 2019). For the success of intended in-class learning, students' engagement with preparatory self-study activities is crucial (Goedhart et al., 2019). In case low level SRL skills result in inadequate preparations, in-class activities and therefore, the flipped approach fails to deliver.

For student teachers, learning to regulate their own learning is insufficient. After graduation, they need to support their own pupils with various content and SRL skills. For student teachers, capability to engage in conscious SRL and reflection is a learning objective in itself, as is appreciating the contextual and temporal (Panadero et al., 2016; Pintrich, 2004) character of SRL. As discussed previously, many SRL frameworks assume that learning goals are drivers for self-regulation and learning, that is, central to student accountability. Despite this, neither students setting their learning goals nor pedagogical support for goal setting is an overly researched feature of flipped learning designs in teacher education. Moreover, research-based consensus on beneficial support of SRL in flipping remains underdeveloped (Yoon et al., 2021). Considering the dual approach to SRL in teacher education, future research could target pedagogical practices and curricula aiming at *developing* SRL skills, while also considering the need for individualization and diversification.

To reach set objectives, learning environments should be purposefully designed, and implemented accordingly. Creating a coherent design balancing various elements of a learning environment is challenging. Likewise, capturing the underlying conditions and intentions of learning designs for academic publications is complicated, as are the specifics of in-class activities and the classroom climate. To analyze and purposefully design and balance these aspects, Lakkala's (2010) pedagogical infrastructure provides a practical yet theoretically grounded tool. Combined with Pintrich's (2000, 2004) SRL framework, Lakkala's (2010) pedagogical infrastructure provides a methodologically sound way to analyze the designed SRL support. Further, the combination assisted in disclosing how the support was distributed over Pintrich's SRL areas and phases—understanding of which is important for teacher education aiming to implement the dual approach towards SRL.

In this study, the RQs focused on setting task level individualized learning goals and reflecting on goal attainment, that is, activities that manifest the sufficiency of student teachers' central SRL skills. The studied learning design used a semi-structured learning diary to measure students' SRL and act as an SRL intervention (Panadero et al., 2016). Specifically, the diary systematized students' engagement in preparatory activities and, to an extent, in post-task reflection. As flipping emphasizes active and social in-class activities (Abeysekera & Dawson, 2015), further support for reflection could combine individual and peer reflection tasks and focus more on in-class sharing of more or less successful learning strategies. These kinds of activities necessitate safe, supportive and carefully facilitated environments (Marshall et al., 2022). Additional structured online facilitation (e.g., Guan et al., 2024; Yoon et al., 2021) could also be beneficial.

Due to the multifaceted character of SRL, it is probably the interplay between components of purposefully designed and implemented pedagogical infrastructure (rather than any single pedagogical element), which proves beneficial for a certain student population in a certain context. The detailed designing of the supports is likely to benefit from systematic use of Lakkala's (2010) pedagogical infrastructure framework to render visible the contributions of all the components of the pedagogical infrastructure—to result in coherent and balanced results. Therefore, we propose that more empirical research is needed to investigate various student teacher populations in research settings targeting manifestations of elemental SRL skills. Moreover, research focusing on learning environment designs with the help of transparency-providing tools, such as the pedagogical infrastructure framework, is central for the advancement of theory and practice.

CRediT authorship contribution statement

Tellervo Härkki: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Teija Koskela:** Writing – review & editing, Writing – original draft, Conceptualization. **Marja-Leena Rönkkö:** Writing – review & editing, Writing – original draft, Validation, Resources, Conceptualization.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

Acknowledgements

We would like to thank all the participating students for sharing their experiences and reflections. This research had not been possible without you. Furthermore, we thank the anonymous reviewers for their insightful comments and critiques. Finally, we gratefully acknowledge Ike Laine for their valuable contribution to the development of the visualizations presented in this article.

Data availability

The authors do not have permission to share data.

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