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Impact of Team Teaching on Student Teachers' Professional Identity: A Bayesian Approach

Loan De Backer [1,*], Wouter Schelfhout [1], Mathea Simons [1], Ellen Vandervieren [1] and Jose Rivera Espejo [2]

[1] Faculty of Social Sciences, Antwerp School of Education, University of Antwerp, 2000 Antwerp, Belgium
[2] Faculty of Social Sciences, Edubron, University of Antwerp, 2000 Antwerp, Belgium; josemanuel.riveraespejo@uantwerpen.be
* Correspondence: loan.debacker@uantwerpen.be

Abstract: Workplace learning in teacher education is essential for creating and recreating the professional identity of student teachers. Innovative interventions, such as team teaching between student teachers and mentors at the workplace, are assumed to facilitate learning to teach. This experimental study provides valuable insight into the impact of team teaching on student teachers' professional identity by implementing distinct student teaching formats: team teaching ($A_{1\ intervention}$), team teaching with support ($A_{2\ intervention}$), and traditional teaching ($C_{control\ intervention}$). In this study, professional identity is understood as a multidimensional concept that consists of six components: student teachers' learning and regulation activities, reflective thinking, teacher efficacy, beliefs about learning and teaching, motivation, and collaborative activities. A total of 464 student teachers from a Flemish College of Education were randomly assigned to one of the three student teaching formats. The overall findings of Bayesian structural equation modeling reveal significant impacts of team teaching with support compared to both team teaching and traditional teaching as well as a significant impact of team teaching over traditional teaching on three crucial components of student teachers' professional identity, i.e., their learning and regulation activities, reflective thinking, and motivation.

Keywords: team teaching; student teachers; mentors; workplace learning; professional identity; experimental study; Bayesian statistics

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1. Introduction

Learning to teach through creating and recreating a professional identity is a complex process for student teachers [1], particularly given the diversity of modern classroom environments [2] and the corresponding educational demands of the 21st century [3,4]. In teacher education, workplace learning—also referred to as internship—is considered essential for bridging the gap between theoretical and practical knowledge [5,6] in the process of becoming a teacher [7]. During this period, student teachers work alongside experienced teachers who act as mentors, providing support and guidance in forming student teachers' professional identity [2]. How student teachers interact and learn with their mentors can determine the quality of their workplace learning and influence their professional identity to a large extent [8].

The nature of workplace learning in teacher education programs shows considerable variation both within and between programs, largely depending on the level of support provided to student teachers [9]. While observation and individual teaching at the workplace are components of the traditional student teaching format [10–12], there is a growing trend in emphasizing the development of student teachers' collaboration skills [13] and the provision of student teachers' support [12] to prepare them for a successful future teaching career. The collaborative student-teaching format of team teaching, which includes co-teaching, allows student teachers to simultaneously develop and enhance collaborative classroom practices [2]. In team teaching, both student teachers and mentors are actively

involved in planning, implementing, and evaluating lessons during workplace learning for all learners [14] while co-teaching focuses on learners with special educational needs [15,16]. Although other formations, such as two student teachers and a mentor (2:1) are also possible [17,18], the focus of this study is on student teachers and their mentors in a one-to-one (1:1) formation.

Several universities and colleges, including those in Flanders (Belgium, i.e., the study site), have recently included team teaching in the curriculum of their teacher education program [19]. The underlying assumption is that team teaching can facilitate mutual learning, with all practitioners benefiting from the experience [9]. As stated by Zach [20]: "student teachers bring a fresh new spirit of optimism and innovation to teaching, while veteran teachers bring their experience and familiarity with the learners" (p. 1403). Consequently, mentors are focused on supporting the growth of student teachers' professional identity while also enhancing their own practice through team teaching [11]. Moreover, team teaching mitigates the sharp or hierarchical distinction between student teachers and mentors when compared to traditional teaching [17]. Additionally, student teachers may find team teaching more feasible if extensive support (i.e., tailored support, feedback, and suggestions) is provided specific to team teaching itself [12], referred to as team teaching with support.

To date, several studies have shown the positive impact of team teaching as an innovative student teaching format [3,4,11,21,22]. However, in order to make more convincing claims about the effectiveness of team teaching with and without support compared to traditional teaching, further research using experimental designs is needed [12]. Furthermore, while there is a growing body of research on professional identity, little is known about how student teachers' professional identity evolves throughout teacher education [7]. This is an important gap because understanding the evolution of professional identity with distinct student teaching formats is crucial in learning to teach. The current study aims to address this gap by adopting an experimental design in which 464 student teachers were randomly assigned to one of three student teaching formats: team teaching ($A_{1\ intervention}$), team teaching with support ($A_{2\ intervention}$), and traditional teaching ($C_{ontrol\ intervention}$). The present study seeks to generate insight into the impact of team teaching with and without extended support on student teachers' professional identity during workplace learning. The findings of the current study will provide further insight into effective teacher education practices and inform policy and practice in this field.

2. Student Teachers' Professional Identity

Creating strong professional identities in future teachers is a crucial component of teacher education [23]. A solid teacher identity not only supports them during their teacher education but also sustains them in their future profession [24]. In this context, exploring questions such as "Who am I?" and "What/who am I as an educator?" is central to student teachers [25]. According to Canrinus et al. [26], professional identity is not a fixed construct but rather a dynamic one created and recreated by experiences and various influences and evolving over time. In this process, teacher educators and mentors play a crucial supporting role [8]. This dynamic nature of professional identity is particularly evident in the transition from novice to experienced (student) teacher. Therefore, professional identity serves as a valuable framework for exploring the development of student teachers in the process of learning to teach [27].

Although professional identity is widely recognized as an important multidimensional concept in teacher education [28], the existing literature provides different definitions and central components [29]. Rodrigues and Mogarro [7] proposed a working definition, defining professional identity as "the perceptions, meanings, images, and self-knowledge individuals have of themselves" (p. 11). In the literature on professional identity and learning to teach, common components of professional identity are student teachers' learning and regulation activities [28,30,31], reflective thinking [31,32], (teacher) efficacy [26,29,33–37], beliefs (about learning and teaching) [29,31,38], motivation [25,26,33,39], and (6) collabora-

tive activities [13,28,38]. Within the context of (team) teaching, these elements are identified as indicators of student teachers' professional identity in the present study, as shown in Figure 1.

Figure 1. Multidimensional concept of student teachers' professional identity.

Firstly, in students' learning process regarding teaching, they undertake, inter alia, various **learning and regulation activities** that involve both cognitive processing activities (i.e., thinking activities that lead to learning) and regulation of learning [28,30,31]. These activities include (1) *proactive and broad use of the mentor*, the extent to which student teachers use their mentor for practical suggestions and interpreting teaching situations; (2) *independent search for conceptual information*, the extent to which student teachers recognize a problem and independently and proactively search for conceptual information; (3) *actively relating theory and practice*, the activities student teachers undertake to use conceptual information from others to interpret their own practice; (4) *developing views/ideas through discussion*, student teachers' intentional use of experienced colleagues in developing their ideas and vision for teaching; and (5) *pupil-oriented evaluation criteria*, the criteria student teachers use to evaluate their teaching [30]. The associations between *independent search for conceptual information*, *developing views/ideas through discussion*, and *actively relating theory and practice* indicate the presence of a more independent pattern of learning to teach. In contrast, the associations between *proactive and broad use of the mentor* and *pupil-oriented evaluation criteria* suggest a more dependent pattern of learning to teach. From the viewpoint of higher-quality learning outcomes, a more independent pattern of learning to teach is the preferred way to engage in learning [30].

Secondly, a reflective approach is essential to student teachers' development of their professional identity [31,32]. To operationalize the level of **reflective thinking**, four types are identified, hierarchically outlined from non-reflective thinking to highly reflective thinking, namely (1) *habitual action*, performing automatically with little conscious thought; (2) *understanding*, comprehension without relating to other situations; (3) *reflection*, the process of internal examination and exploration; and (4) *critical reflection*, critical reviewing of presuppositions from prior learning. *Habitual action* and *understanding* represent two types of non-reflective action whereas *reflection* and *critical reflection* represent two types of reflective action, with the latter operating at a higher-order level [32].

Thirdly, **teacher efficacy** is an important component of professional identity [26,29,33–37]. It involves (1) *adaptive teaching*, adjusting teaching strategies based on pupils' characteristics [37]; (2) *intensive and activating lessons*, facilitating intensive and active learning [36]; and (3) *instructional strategies*, using and providing effective assessments, questions, and

explanations [35]. Student teachers with a strong sense of teacher efficacy are more open to new ideas and strategies that benefit pupils [35].

Fourthly, professional identity is shaped through **beliefs about learning and teaching** [29,31,38]. These beliefs often distinguish between *subject matter-oriented beliefs* and *pupil-oriented beliefs* [38]. The former concerns the transmission and learning of content and knowledge while the latter focuses on the development of skills and competencies among pupils to facilitate their active construction of knowledge. Student teachers who adopt more *pupil-oriented beliefs* tend to engage more actively in learning activities themselves [38].

Fifthly, **motivation** is often mentioned as a key component of professional identity [25,26,33,39] and can be conceptualized within the framework of self-determination theory (SDT) which distinguishes the quantity of motivation from the quality of motivation [40]. This theory enables the identification of distinct motivational profiles, ordered from least to most optimal forms of motivation: (1) *external regulation*, which is driven by pressure from external sources; (2) *introjected regulation*, which is driven by self-imposed pressure; (3) *identified regulation*, which is driven by personal relevance; and (4) *intrinsic motivation*, which is driven by the activity itself [39].

Lastly, involvement in **collaborative activities** with other teachers is viewed as an essential career-long learning activity regarding professional identity [13,28,38]. Collaboration is defined by Vangrieken et al. [13] as "joint interaction in the group in all activities that are needed to perform a shared task" (p. 23). Within the context of workplace learning, these activities include various aspects such as talking about teaching problems, exchanging innovative teaching ideas, sharing new teaching ideas and learning experiences, and experimenting with new teaching methods alongside other teachers [38].

3. Formats of Student Teaching

3.1. Traditional Teaching

For over two centuries, traditional teaching (also referred to as individual teaching or solo teaching) has been a widely used approach for workplace learning. This model typically involves a mentor transferring instructional responsibilities to a student teacher, often with an extended period of solo time [11]. In doing so, student teachers commonly start with observing the classroom context followed by gradually taking over the class and individual student teaching [10–12]. Despite student teachers' limited experience and preparation, student teachers are expected to assume responsibilities similar to those of mentors. Moreover, inconsistent quality of mentor supervision can result in inadequate support and feedback for student teachers [12]. This may lead to several challenges, such as difficulties in applying teaching theory into practice, feelings of isolation, insufficient knowledge about pupils, and a focus on survival over learning [41]. Nevertheless, purposeful support from the mentor, including modeling, co-planning, frequent feedback, repeated practice, and reflection, can help overcome these challenges as student teachers gradually assume more teaching responsibility [9]. Even more, team teaching is one upcoming intervention that offers additional potential for addressing these obstacles [11,14].

3.2. Team Teaching

In recent years, 1:1 team teaching, characterized by collaborative planning, implementation, and evaluation of lessons, involving a student teacher and a mentor, has become a more widely implemented format for student teaching [12]. The format differs from traditional teaching in that student teachers who have limited experience with the classroom environment are not solely responsible; rather, they share responsibility with mentors who have a comprehensive understanding of the school context. This approach facilitates student teachers' learning by allowing student teachers to be learners more than teachers [3]. Through active participation in the collaborative process of planning, teaching, evaluating, and reflecting on lessons with their mentors, student teachers receive the essential support needed to develop confidence and practice, enhancing both the teaching and reflective skills required for effective teaching [9,12].

In practice, team teaching is a collaborative practice that entails a development trajectory [4,22] indicating a growth path that helps student teachers adapt to the team teaching process while developing as teachers. In a study conducted by Chang [42], four models of team teaching, categorized according to the nomenclature of Baeten and Simons [14], were applied and their level of collaboration was evaluated: (1) the observation model (i.e., one teach, one observe; notably this is not the same as observation in the traditional format since here, lessons are deliberately planned together in the observation model), (2) the assistant teaching model (i.e., one teach, one assist), (3) the equal status model (i.e., both teach) of parallel, sequential, and station teaching, and (4) the teaming model (i.e., both teach in full collaboration). Chang's findings suggest a strategy for applying these models in teacher education for both novice and advanced student teachers, as illustrated in Figure 2.

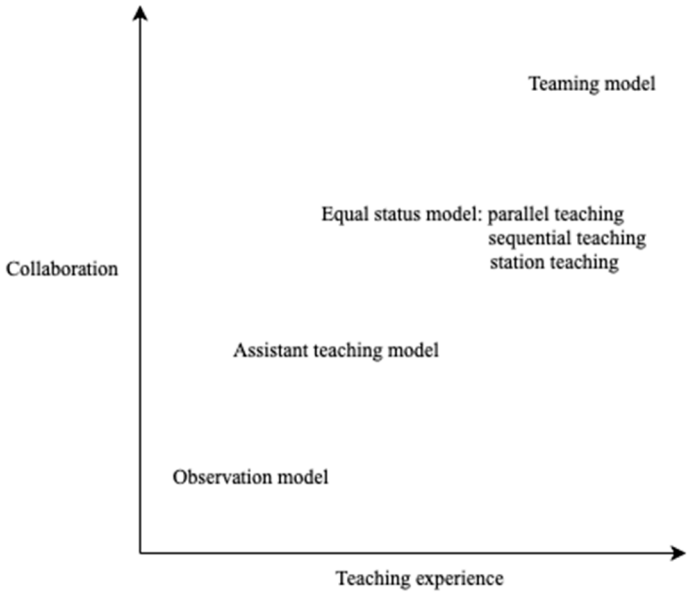

Figure 2. Growth path of team teaching during workplace learning.

Firstly, in early workplace learning, the use of the observation model and the assistant teaching model can aid novice student teachers in becoming familiar with classroom routines. Later on, the equal status model of station teaching and sequential teaching can be applied to increase student teachers' responsibilities. Finally, advanced student teachers can expand their team teaching practices with more challenging models, such as the equal status model of parallel teaching and the teaming model, given that both teachers share equal responsibilities (for a more detailed overview of all models see Baeten and Simons [14]). It should be emphasized that there is no single best model as each model serves a unique purpose in supporting instructional delivery, curriculum learning goals, and classroom environments [43]. However, during the implementation of these models, team teachers should assume diverse roles, especially when one team teacher takes the lead, aiming to optimize the learning outcomes of all participants [44]. Furthermore, opportunities to experiment with different models and to switch between them are important to optimize team teaching [45,46].

3.3. Team Teaching with Extended Support

In the context of 1:1 team teaching, a beneficial partnership with the mentor is all the more essential to improve teaching, increase motivation, and provide more expertise [47], all of which contribute to student teachers' professional identity. Recent research based on a quantitative study explored student teachers' perceptions of team teaching in a 2:1 formation. This study identified three distinct performance profiles: non-functional

team teaching, functional team teaching, and highly functional team teaching [18]. These profiles exhibit similarities to patterns found in a qualitative study with in-service teachers conducted by Härkki et al. [4].

The non-functional team teaching profile is characterized by a lack of collaboration, co-creation, and coaching, along with a heightened perception of complexity. In contrast, functional team teaching signifies effective collaboration, co-creation, and coaching while maintaining a moderate level of complexity. Furthermore, the highly functional team teaching profile demonstrates high levels of collaboration, co-creation, and coaching with minimal perceived complexity [18].

These findings suggest that student teachers in the non-functional and functional team teaching profiles may require custom support and evaluative feedback when practicing team teaching to succeed. Specifically, the study highlights the importance of providing tailored support and feedback to address the challenges, for example, a lack of compatibility or an increased workload, that may arise during team teaching. In alignment with the findings of this study and research conducted by Härkki et al. [4] and Stapleton et al. [12], the student-team teaching format has been expanded to include extended support from teacher educators and peers with a specific focus on team teaching.

4. Research Question

Considering the need for experimental designs [12] and building further on previous research regarding professional identity and team teaching, the current study aims to investigate the impact of team teaching. The focus is on team teaching with and without support and on student teachers' professional identity in a 1:1 formation with a mentor. In doing so, three distinct student teaching formats were implemented in a Flemish College of Education: team teaching ($A_{1\ intervention}$), team teaching with support ($A_{2\ intervention}$), and traditional teaching ($C_{ontrol\ intervention}$). The central research question guiding this study is the following: *to what extent does team teaching or team teaching with support impact student teachers' professional identity related to their learning and regulation activities (RQa), reflective thinking (RQb), teacher efficacy (RQc), beliefs about learning and teaching (RQd), motivation (RQe), and collaborative activities (RQf)?*

5. Methodology

5.1. Context and Participants

The present study was conducted at a Flemish College of Education as part of a three-year teacher education program aimed at preparing students to obtain a bachelor's degree in either preschool or primary education. The program offers four education paths including the standard study path (i.e., day classes) for preschool or primary education, as well as the flexible study path (i.e., evening classes) for preschool or primary education. A randomized complete block design was adopted [48]; within each education path, a total of 464 student teachers were randomly assigned to one of three student teaching formats: team teaching ($A_{1\ intervention}$, $n = 128$), team teaching with support ($A_{2\ intervention}$, $n = 129$), or traditional teaching ($C_{ontrol\ intervention}$, $n = 207$). The control intervention also included student teachers who were not assigned a permanent mentor in the classroom due to the current teacher shortage in Flanders at the time of the intervention. The study was conducted during the second semester of the academic year, from February to April. All student teachers were involved in (team) teaching at a designated workplace and were assigned to a fixed class and mentor. Although workplace learning was mandatory, student teachers had the right to withdraw from the study at any stage by not completing the questionnaires.

A selection of team teaching models based on the growth path [42] was made in dialogue with the College of Education to implement this new format of student teaching. Student teachers of the team teaching and the team teaching with support interventions were asked to implement various team teaching models. They were instructed to follow a sequential approach, starting with four iterations of the assistant teaching model (ATM)

followed by an equal number of iterations of the equal status model of sequential teaching (ESMsequential). Subsequently, two additional iterations of both the assistant teaching model and the equal status model of sequential teaching were implemented. The sequence ended with two repetitions of the equal status model of station teaching (ESMstation), as shown in Figure 3. In the application of the assistant teaching model, each team teacher performed three lessons as the main teacher (with the other partner assisting) and three lessons as the assistant (while the other partner was teaching). Subsequently, in the application of sequential teaching, each team teacher taught different learning content in turn. Finally, in the implementation of station teaching, the class was divided into subgroups and each team teacher taught different learning content to a subgroup, followed by subgroup rotation. Notably, the teaming model was intentionally omitted due to its complexity and the constraints of the limited time available in the second semester.

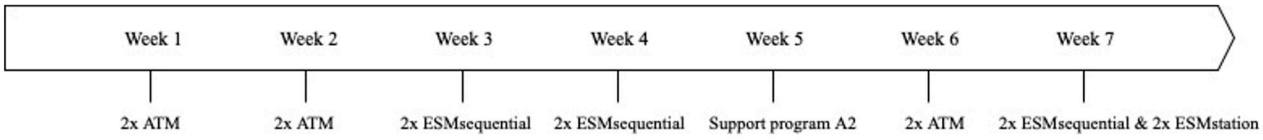

Figure 3. Sequence of the team teaching models and support session.

The extended team teaching support program, strategically scheduled after the first eight team teaching lessons but before the last six (as shown in Figure 3), consisted of a two-hour session led by a teacher educator serving as a facilitator. This timing was chosen to align with the rationale that student teachers had gained preliminary team teaching experiences in the initial phase, allowing them sufficient time to assimilate and apply their learnings to upcoming team teaching lessons. The decision to have the intervention last only two hours was based on the need to balance comprehensive support with time constraints without overloading the participants. Each support group consisted of three to four student teachers who were assigned to the student teaching format of team teaching with support. The small group size was deliberately chosen to ensure a comfortable and supportive environment for all participants [49]. During the support session, the student teachers were assigned various tasks that required critical reflection on both the difficulties and successes encountered during team teaching. Specifically, they were prompted to report on challenges faced and identify potential solutions and actions for improvement. Through a collaborative process, the facilitator and student teachers of the support group provided feedback, offered suggestions, and helped generate potential solutions for each student teachers' unique set of challenges.

5.2. Instrument

The instrument used in this study was a composite questionnaire that primarily incorporated various validated scales found in the existing literature. The reliability of all scales was verified by testing the internal consistency, with interpretation relying on the use of Cronbach's alpha values: $\alpha < 0.60$ = bad, $0.60 \leq \alpha < 0.80$ = reasonable, and $\alpha \geq 0.80$ = good [50]. Firstly, to measure **learning and regulation activities** regarding the scales *proactive and broad use of the mentor* (UM), *independent search for conceptual information* (IS), *actively relating theory and practice* (AR), *developing views/ideas through discussion* (DD), and *pupil-oriented evaluation criteria* (EC), the 20-item validated ILTP-R by Endedijk et al. [30] was used. Secondly, **reflective thinking** concerning *habitual action* (HA), *understanding* (U), *reflection* (R), and *critical reflection* (CR) was included by using the 16-item validated reflection questionnaire by Kember et al. [32]. Thirdly, **teacher efficacy** related to *adaptive teaching* (AT) and *intensive and activating lessons* (IL) was measured using items composed of an observation instrument [37]. In addition, the four-item validated scale *efficacy for instructional strategies* (IS) developed by Tschannen-Moran and Hoy [35] was adopted. Fourthly, to measure **beliefs about learning and teaching** related to the scales of *subject matter-oriented beliefs* (SM) and *pupil-oriented beliefs* (P), the 12-item validated instrument

developed by de Vries et al. [38] was employed. Fifthly, **motivation** concerning the scales *external regulation* (ER), *introjected regulation* (IN), *identified regulation* (ID), and *intrinsic motivation* (IM) was measured by using the 16-item validated academic self-regulation scale by Vansteenkiste et al. [39]. Lastly, **collaborative activities** (CA) were measured by including the 14-item validated scale by de Vries et al. [38]. In addition to these instruments, control variables such as education path and time were included to obtain unbiased estimations of the intervention effects. Time was also included to account for the possible dynamic nature of the scales since professional identity is not a fixed concept [26]. All items, with the exception of the ILPT-R, were assessed using a five-point Likert scale ranging from *I totally disagree* (1) to *I totally agree* (5) while the items of the ILPT-R were measured on a seven-point Likert scale, ranging from *I totally disagree* (1) to *I totally agree* (7), to increase sensitivity in capturing changes during workplace learning [30]. The composite questionnaire was administered twice: at time point 1 (T_1) before workplace learning and at time point 2 (T_2) after workplace learning, with a response rate of 71% (n = 330) and 41% (n = 190), respectively.

5.3. Model

To generate insight into the impact of team teaching, with and without support, on student teachers' professional identity, a Bayesian approach to structural equation modeling (SEM) was adopted using the software programs R (version 4.2.2) and Stan (version 2.26.1). SEM is a widely recognized and broad class of statistical methods used to construct models that specify how different observed and latent variables are thought to be causally related to one another [51]. This approach consists of two distinct parts: a measurement part and a structural part [52]. In the measurement part, latent variables are indirectly constructed from a set of survey items through a mathematical model. This process assumes that the latent variables cause the covariance among the items [53]. The structural part involves specifying regression-like relationships between the latent variables and other observable variables. This allows for testing hypotheses regarding their causal relationships [52]. For a detailed overview of the estimation procedure, see Appendix A.

Overall, the Bayesian approach was chosen based on three key properties relevant to the present study. Firstly, it has the ability to work properly for relatively small sample sizes [54–56]. Secondly, it allows for the incorporation of prior information, ensuring that certain parameters are confined within specified boundaries (e.g., the estimation of positive factor variances). This helps to mitigate issues of non-convergence or improper parameter estimation commonly observed in classical methods [57,58]. Lastly, the Bayesian approach allows for the utilization of the full posterior distribution to interpret the parameter estimates.

5.4. Measurement Invariance

Measurement invariance (MI), as defined by Vandenberg and Lance [59], pertains to the statistical characteristic of measurement that ensures consistent measurement of the same construct across multiple groups and time points. Its purpose is to determine whether measurement operations yield equivalent measures of the same attribute when observing and studying phenomena under different interventions. When MI is violated, the basis for drawing scientific conclusions weakens as differences observed between and within individuals cannot be unambiguously interpreted [60].

To ensure the unambiguous interpretation of the results, the present study assumed MI for all the scales described in the Instrument Section. Specifically, this study assumed strict invariance in all SEM measurement models across the two time points (see Appendixes B–G). Strict invariance entails that the model configuration, loadings, intercepts, and item residual variances are assumed identical between the two measurement points. Imposing these restrictions on the measurement model is considered a sufficient requirement for achieving MI [61,62] (for a comprehensive explanation of measurement invariance and its implications see Wu et al. [63]).

5.5. Missing Data

In statistical analysis, there are multiple approaches for handling missing data, which can be broadly classified into two methods: deletion (i.e., excluding missing observations) and imputation of missing values (i.e., filling in missing observations) [64]. Depending on the pattern and amount of missing data, the choice of missing data handling methods can significantly impact parameter estimates and the sample size of the study [52]. This consideration also applies to SEM analysis. To mitigate potential biases caused by excluding or imputing missing observations and to ensure accurate parameter estimates, the present study adopted the full information maximum likelihood method (FIML) [65]. In essence, FIML calculates a case wise likelihood function using all available observed records in the data and maximizes the likelihood across the entire dataset. Research on the statistical properties of FIML suggests that, under ignorable missing data patterns (i.e., missing completely at random and missing at random [65]), FIML estimates are unbiased and more efficient than deletion or imputation [66] (for a detailed discussion of the method see Little and Rubin [65] and for computational specifics see Arbuckle et al. [67]).

5.6. Noncompliance

To ensure that potential noncompliance (i.e., the failure or refusal to comply with the assigned intervention) does not compromise the validity of the inferences, this study adopted the intention-to-treat (ITT) assumption [68]. ITT analysis compares the outcomes of the intervention group with those of participants assigned to the control group, regardless of the actual intervention they received. It follows the principle of 'analyze as you randomize' [68]. Among the benefits of ITT are that the method maintains group comparability and allows for the inference of causality by preserving the integrity of random assignment. Moreover, the causal interpretation of ITT analysis does not require assumptions beyond those needed for randomized experiments whereas newer techniques often require considerably stronger and often untestable assumptions [69].

5.7. Interpretation

To assess the strength of the comparisons between interventions and the effect of time on the various latent variables, effect sizes (*ES*) as defined by Cohen [70] and expanded by Sawilowsky [71] were adopted. The Bayesian effect sizes were calculated following the approach outlined by Kruschke and Liddell [72]:

$$ES = \frac{\beta_{I1}^{LV} - \beta_{I2}^{LV}}{\sigma^{LV}}$$

The parameter estimate for intervention A_1, A_2, or C is denoted as β_{I1}^{LV} while β_{I2}^{LV} is the parameter estimate for an intervention different from β_{I1}^{LV} for each latent variable. Additionally, σ^{LV} denotes the variance in each latent variable (i.e., components) of professional identity. The effect sizes serve as a valuable complement to the statistical hypothesis testing process by providing an assessment of the magnitude of the statistical claim [73]. In the interpretation of effect sizes, the conventional criteria of Cohen [70] and Sawilowsky [71] were considered as rules of thumb: <0.01 = no effect, 0.01–0.20 = very small effect, 0.21–0.50 = small effect, 0.51–0.80 = medium effect, 0.81–1.20 = large effect, 1.21–2.00 = very large effect, and >2 = huge effect.

In addition, the 95% highest posterior density interval (HPDI) was adopted to assess statistical significance. However, solely rejecting the null hypothesis based on the 95% HPDI is inadequate for fully examining the impact of different student teaching formats on student teachers' professional identity. Therefore, a comprehensive investigation of the posterior distribution of parameters is necessary, which was executed by adopting a region of practical equivalence (ROPE) as proposed by Kruschke [74]. The ROPE represents a narrow range of parameter values that are considered practically equivalent to the null value. In the present study, a ROPE ranging from $ES = -0.1$ to $ES = 0.1$ was considered

equivalent to the null hypothesis. Relatedly, this study presented the posterior probability density of pairwise comparisons for interventions on all scales that did not reach statistical significance, provided they met a minimum threshold of 70%.

5.8. Fitted Models

For each instrument that constitutes the professional identity of student teachers, six distinct models were estimated. Each model represented a specific manner to investigate the research hypotheses. The models differed in terms of (1) the inclusion or exclusion of variables such as education path, time, intervention and the interaction of time and intervention in the structural models as well as (2) the assumptions regarding variances and covariances of the latent variables, assuming either equal or different variances and covariances across the two-time points within each instrument. A detailed overview of the fitted models can be found in Table 1.

Table 1. Fitted models.

		Parameters				
Model	**Latent Variables' Covariances at T1 and T2**	**Intercept**	**Education Path**	**Time**	**Intervention**	**Interaction Time, Intervention**
1A	Equal	x				
1B	Different	x				
2A	Equal	x	x	x	x	
2B	Different	x	x	x	x	
3A	Equal	x	x	x	x	x
3B	Different	x	x	x	x	x

Note. x = presence of the parameter.

5.9. Model Selection

The present study adopted the information–theoretic approach [75,76] for model selection. In this regard, the widely applicable information criterion (WAIC) [77] was employed as the criterion for choosing among competing models. The use of WAIC is justified based on two fundamental characteristics of the criterion. Firstly, WAIC incorporates all the information encompassed in the posterior distribution of the parameters, effectively integrating the uncertainty inherent in the parameter estimates. Secondly, the criterion provides the most accurate approximations for the cross-validated deviance [78], which serves as the closest estimate to the Kullback–Leibler divergence [79]. This measures the degree to which a model accurately represents the actual data distribution. Consequently, by comparing WAIC values across different models, the present study evaluates the degree to which each model deviates from achieving 'perfect predictive accuracy' for the given data [78]. Additionally, this evaluation provides an indication of the level of uncertainty associated with the findings. Specifically, models with lower WAIC values exhibit less deviation from 'perfect predictive accuracy' for the data compared to alternative models, as shown in Appendix H through Appendix I.

6. Results

The results of the six components of professional identity and their underlying scales are presented, comparing the distinct student teaching formats—team teaching ($A_{1\ intervention}$), team teaching with support ($A_{2\ intervention}$), and traditional teaching ($C_{ontrol\ intervention}$)—through pairwise comparisons for the selected models. Subsequently, the results of the posterior distributions of the parameters for the retained components are presented.

6.1. Professional Identity Related to Learning and Regulation Activities (RQa)

6.1.1. Proactive and Broad Use of the Mentor

The Cronbach's alpha coefficient for *proactive and broad use of the mentor* showed good internal consistency ($\alpha = 0.81$). The results of Table 2 indicate that no statistically

significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.216; 0.506]), A_2 versus C (95% HPDI = [−0.042; 0.664]), and A_2 versus A_1 (95% HPDI = [−0.211; 0.559]). Relatedly, the effect size posterior mean for the contrasts indicated a small effect for interventions A_2 versus C (*ES* = 0.313) and very small effects for A_1 versus C and A_2 versus A_1 (*ES* = 0.143 and 0.17, respectively). However, time was statistically significant (95% HPDI = [0.037; 0.5]) with a small effect (*ES* = 0.272). In summary, the evolution of student teachers' *proactive and broad use of the mentor* was significantly explained by time, with a small effect, regardless of the intervention.

Table 2. Learning and regulation activities—proactive and broad use of the mentor.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	0.143	[−0.216; 0.506]
Intervention A_2—intervention C	0.313	[−0.042; 0.664]
Intervention A_2—intervention A_1	0.17	[−0.211; 0.559]
Time	0.272	[0.037; 0.5]

Note. Control variable: education paths.

6.1.2. Independent Search for Conceptual Information

The Cronbach's alpha coefficient for *independent search for conceptual information* showed reasonable internal consistency (α = 0.78). Table 3 shows that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.493; 0.255]), A_2 versus C (95% HPDI = [−0.286; 0.434]), and A_2 versus A_1 (95% HPDI = [−0.236; 0.532]). Moreover, the effect size posterior mean indicated very small effects for all comparisons (*ES* = −0.111, 0.055, and 0.166, respectively). However, time was statistically significant (95% HPDI = [0.202; 0.726]) with a small effect (*ES* = 0.464). In summary, the evolution of student teachers' *independent search for conceptual information* was significantly explained by time, with a small effect, regardless of the intervention.

Table 3. Learning and regulation activities—independent search for conceptual information.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.111	[−0.493; 0.255]
Intervention A_2—intervention C	0.055	[−0.286; 0.434]
Intervention A_2—intervention A_1	0.166	[−0.236; 0.532]
Time	0.464	[0.202; 0.726]

Note. Control variable: education paths.

6.1.3. Actively Relating Theory and Practice

The Cronbach's alpha coefficient for *actively relating theory and practice* showed reasonable internal consistency (α = 0.67). The results of Table 4 indicate that a statistically significant difference was observed between student teachers of interventions A_2 versus C (95% HPDI = [0.212; 0.972]) with a medium effect (ES = 0.574). In contrast, no statistically significant difference was found between student teachers of interventions A_1 versus C (95% HPDI = [−0.048; 0.718]) and A_2 versus A_1 (95% HPDI = [−0.167; 0.639]). Furthermore, the effect size posterior mean indicated small effects for A_1 versus C (*ES* = 0.327) and A_2 versus A_1 (*ES* = 0.247). Additionally, time had a statistically significant impact (95% HPDI = [0.026; 0.546]), with a small effect (*ES* = 0.302). To summarize, both time and team teaching with support, when compared to traditional teaching, significantly explained the evolution of student teachers' *actively relating theory and practice* with a small and medium effect, respectively.

Table 4. Learning and regulation activities—actively relating theory and practice.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	0.327	[−0.048; 0.718]
Intervention A_2—intervention C	0.574	[0.212; 0.972]
Intervention A_2—intervention A_1	0.247	[−0.167; 0.639]
Time	0.302	[0.026; 0.546]

Note. Control variable: education paths.

6.1.4. Developing Views/Ideas through Discussion

The Cronbach's alpha coefficient for *developing views/ideas through discussion* showed good internal consistency (α = 0.81). Table 5 presents the results which demonstrate that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.272; 0.103]), A_2 versus C (95% HPDI = [−0.304; 0.103]), or A_2 versus A_1 (95% HPDI = [−0.213; 0.183]). Moreover, the effect size posterior mean indicated very small effects for all comparisons (*ES* = −0.08, −0.102, and −0.021, respectively). However, time had a statistically significant impact on the development of views/ideas through discussion among student teachers (95% HPDI = [0.32; 0.562]), with a small effect (*ES* = 0.448). In brief, the *development of student teachers' views/ideas through discussion* was significantly, though with a small effect, explained by time but not by intervention.

Table 5. Learning and regulation activities—developing views/ideas through discussion.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.08	[−0.272; 0.103]
Intervention A_2—intervention C	−0.102	[−0.304; 0.103]
Intervention A_2—intervention A_1	−0.021	[−0.213; 0.183]
Time	0.448	[0.32; 0.562]

Note. Control variable: education paths.

6.1.5. Pupil-Oriented Evaluation Criteria

The Cronbach's alpha coefficient for *pupil-oriented evaluation criteria* showed reasonable internal consistency (α = 0.65). The results presented in Table 6 reveal that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.383; 0.185]), A_2 versus C (95% HPDI = [−0.406; 0.162]), or A_2 versus A_1 (95% HPDI = [−0.339; 0.287]). Furthermore, the effect size posterior mean indicated a very small effect for all comparisons (*ES* = −0.097, −0.116, and −0.02, respectively). In contrast, time was statistically significant (95% HPDI = [0.118; 0.49]) with a small effect (*ES* = 0.303). In short, time significantly explained the evolution of student teachers' use of *pupil-oriented evaluation criteria*, indicating a small effect, regardless of the intervention.

Table 6. Learning and regulation activities—pupil-oriented evaluation criteria.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—Intervention C	−0.097	[−0.383; 0.185]
Intervention A_2—Intervention C	−0.116	[−0.406; 0.162]
Intervention A_2—Intervention A_1	−0.02	[−0.339; 0.287]
Time	0.303	[0.118; 0.49]

Note. Control variable: education paths.

6.2. Professional Identity Related to Reflective Thinking (RQb)

6.2.1. Habitual Action

The Cronbach's alpha coefficient for *habitual action* showed reasonable internal consistency (α = 0.65). Table 7 shows that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.504; 0.437]), A_2 versus C (95% HPDI = [−0.447; 0.456]), or A_2 versus A_1 (95% HPDI = [−0.455; 0.534]).

Furthermore, the effect size posterior mean indicated very small effects for all comparisons (*ES* = −0.054, −0.001, and 0.052, respectively). Additionally, time was not statistically significant for the comparisons A_1 versus C (95% HPDI = [−0.533; 0.338]), A_2 versus C (95% HPDI = [−0.416; 0.446]), or A_2 versus A_1 (95% HPDI = [−0.321; 0.592]), with small effects (*ES* = −0.115, 0.02, and 0.135, respectively). This finding suggests that neither intervention nor time per comparison had a significant impact on student teachers' *habitual action* or automatic performance.

Table 7. Reflective thinking—habitual action.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.054	[−0.504; 0.437]
Intervention A_2—intervention C	−0.001	[−0.447; 0.456]
Intervention A_2—intervention A_1	0.052	[−0.455; 0.534]
Time intervention A_1—time intervention C	−0.115	[−0.533; 0.338]
Time intervention A_2—time intervention C	0.02	[−0.416; 0.446]
Time intervention A_2—time intervention A_1	0.135	[−0.321; 0.592]

Note. Control variable: education paths.

6.2.2. Understanding

The Cronbach's alpha coefficient for *understanding* showed reasonable internal consistency (α = 0.67). The results of Table 8 show that a statistically significant difference was observed between student teachers of interventions A_2 versus A_1 (95% HPDI = [0.158; 1.027]). Moreover, no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.665; 0.128]) or A_2 versus C (95% HPDI = [−0.083; 0.736]). In terms of the effect size posterior mean, the differences between A_1 versus C (*ES* = −0.264) and A_2 versus C (*ES* = 0.347) had small effects and A_2 versus A_1 had a medium effect (*ES* = 0.612). Additionally, time was statistically significant for interventions A_2 versus C (95% HPDI = [−0.83; −0.067]) and A_2 versus A_1 (95% HPDI = [−0.911; −0.092]) but not for A_1 versus C (95% HPDI = [−0.331; 0.422]), with a small effect for A_2 versus C (*ES* = −0.442), a medium effect for A_2 versus A_1 (*ES* = −0.505), and a very small effect for A_1 versus C (*ES* = 0.063). In brief, when comparing team teaching with support to both team teaching and traditional teaching, there was a significant impact of the comparison of time per intervention with a small to medium effect on student teachers' *understanding* without relation to other situations.

Table 8. Reflective thinking—understanding.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.264	[−0.665; 0.128]
Intervention A_2—intervention C	0.347	[−0.083; 0.736]
Intervention A_2—intervention A_1	0.612	[0.158; 1.027]
Time intervention A_1—time intervention C	0.063	[−0.331; 0.422]
Time intervention A_2—time intervention C	−0.442	[−0.83; −0.067]
Time intervention A_2—time intervention A_1	−0.505	[−0.911; −0.092]

Note. Control variable: education paths.

6.2.3. Reflection

The Cronbach's alpha coefficient for *reflection* showed reasonable internal consistency (α = 0.74). Table 9 shows that a statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [0.286; 1.488]) and A_2 versus C (95% HPDI = [0.524; 1.775]) but not for interventions A_2 versus A_1 (95% HPDI = [−0.357; 0.872]), with large effects for A_1 versus C (*ES* = 0.889) and A_2 versus C (*ES* = 1.131) and a small effect for A_2 versus A_1 (*ES* = 0.242). Additionally, time was statistically significant for comparisons A_1 versus C (95% HPDI = [−1.506; −0.316]) and A_2 versus C (95% HPDI = [−1.653; −0.488]) but not for A_2 versus A_1 (95% HPDI = [−0.769; 0.396]),

with large effects for A_1 versus C ($ES = -0.906$) and A_2 versus C ($ES = -1.068$) and a very small effect for A_2 versus A_1 ($ES = -0.162$). In summary, significant impacts of interventions and time on the evolution of student teachers' *reflection* were observed when comparing team teaching with and without support to traditional teaching. These effects were found to have a large effect size.

Table 9. Reflective thinking—reflection.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	0.889	[0.286; 1.488]
Intervention A_2—intervention C	1.131	[0.524; 1.775]
Intervention A_2—intervention A_1	0.242	[−0.357; 0.872]
Time intervention A_1—time intervention C	−0.906	[−1.506; −0.316]
Time intervention A_2—time intervention C	−1.068	[−1.653; −0.488]
Time intervention A_2—time intervention A_1	−0.162	[−0.769; 0.396]

Note. Control variable: education paths.

6.2.4. Critical Reflection

The Cronbach's alpha coefficient for *critical reflection* showed reasonable internal consistency ($\alpha = 0.63$). The results of Table 10 indicate that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.275; 0.253]) with no effect ($ES = -0.007$). In contrast, a statistically significant difference was observed between student teachers of interventions A_2 versus C (95% HPDI = [0.057; 0.591]) and A_2 versus A_1 (95% HPDI = [0.039; 0.625]), with small effects for both comparisons ($ES = 0.319$ and 0.326, respectively). Relatedly, time was statistically significant for interventions A_2 versus C (95% HPDI = [−0.721; −0.177]) and A_2 versus A_1 (95% HPDI = [−0.618; −0.04]) but not for A_1 versus C (95% HPDI = [−0.414; 0.138]), with small effects for A_2 versus C ($ES = -0.467$) and A_2 versus A_1 ($ES = -0.321$) and a very small effect for A_1 versus C ($ES = -0.146$). In summary, when comparing team teaching with support to both traditional teaching and team teaching individually, a significant impact with a small effect was observed for *critical reflection*. Similarly, time had a significant impact when comparing team teaching with support to traditional teaching and team teaching, with a small size on student teachers' *critical reflection*.

Table 10. Reflective thinking—critical reflection.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.007	[−0.275; 0.253]
Intervention A_2—intervention C	0.319	[0.057; 0.591]
Intervention A_2—intervention A_1	0.326	[0.039; 0.625]
Time intervention A_1—time intervention C	−0.146	[−0.414; 0.138]
Time intervention A_2—time intervention C	−0.467	[−0.721; −0.177]
Time intervention A_2—time intervention A_1	−0.321	[−0.618; −0.04]

Note. Control variable: education paths.

6.3. Professional Identity Related to Teacher Efficacy (RQc)

6.3.1. Adaptive Teaching

The Cronbach's alpha coefficient for *adaptive teaching* showed reasonable internal consistency ($\alpha = 0.76$). Table 11 shows that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−1.466; 10.484]), A_2 versus C (95% HPDI = [−1.082; 10.11]), or A_2 versus A_1 (95% HPDI = [−5.889; 4.313]). Moreover, the effect size posterior mean indicated huge effects for interventions A_1 versus C and A_2 versus C ($ES = 3.889$ and 3.519, respectively) and a small effect for A_2 versus A_1 ($ES = -0.37$). Additionally, time was statistically significant for A_1 versus C (95% HPDI = [−14.243; −0.048]) but not for A_2 versus C (95% HPDI = [−10.672; 0.968]) and A_2 versus A_1 (95% HPDI = [−2.806; 7.494]), with huge effects ($ES = -5.942$, $ES = -3.803$

and *ES* = 2.138, respectively). This finding suggests that time had a significant impact on student teachers' *adaptive teaching* when comparing team teaching to traditional teaching, while the interventions had no significant impact.

Table 11. Teacher efficacy—adaptive teaching.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	3.889	[−1.466; 10.484]
Intervention A_2—intervention C	3.519	[−1.082; 10.11]
Intervention A_2—intervention A_1	−0.37	[−5.889; 4.313]
Time intervention A_1—time intervention C	−5.942	[−14.243; −0.048]
Time intervention A_2—time intervention C	−3.803	[−10.672; 0.968]
Time intervention A_2—time intervention A_1	2.138	[−2.806; 7.494]

Note. Control variable: education paths.

6.3.2. Intensive and Activating Lessons

The Cronbach's alpha coefficient for *intensive and activating lessons* showed reasonable internal consistency (α = 0.77). The results presented in Table 12 show that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.642; 0.882]), A_2 versus C (95% HPDI = [−0.063; 1.438]), or A_2 versus A_1 (95% HPDI = [−0.254; 1.409]). Furthermore, the effect size posterior mean indicated a very small effect for A_1 versus C (*ES* = 0.138) and medium effects for A_2 versus C (*ES* = 0.683) and A_2 versus A_1 (*ES* = 0.545). Moreover, time was statistically significant for interventions A_2 versus C (95% HPDI = [−1.49; −0.079]) but not for A_1 versus C (95% HPDI = [−1.174; 0.29]) or A_2 versus A_1 (95% HPDI = [−1.124; 0.451]), with a medium effect for A_2 versus C (ES = −0.756) and small effects for A_1 versus C (*ES* = −0.415) and A_2 versus A_1 (*ES* = −0.341). This finding suggests that only time had a significant impact with a medium effect on student teachers' *intensive and activating lessons* when comparing team teaching with support to traditional teaching.

Table 12. Teacher efficacy—intensive and activating lessons.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	0.138	[−0.642; 0.882]
Intervention A_2—intervention C	0.683	[−0.063; 1.438]
Intervention A_2—intervention A_1	0.545	[−0.254; 1.409]
Time intervention A_1—time intervention C	−0.415	[−1.174; 0.29]
Time intervention A_2—time intervention C	−0.756	[−1.49; −0.079]
Time intervention A_2—time intervention A_1	−0.341	[−1.124; 0.451]

Note. Control variable: education paths.

6.3.3. Instructional Strategies

The Cronbach's alpha coefficient for *instructional strategies* showed reasonable internal consistency (α = 0.73). The findings of Table 13 indicate that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.166; 0.291]), A_2 versus C (95% HPDI = [−0.023; 0.429]), or A_2 versus A_1 (95% HPDI = [−0.107; 0.37]). Furthermore, the effect size posterior mean indicated very small effects for all comparisons (*ES* = 0.065, 0.186, and 0.121, respectively). In contrast, time was statistically significant for interventions A_1 versus C (95% HPDI = [−0.431; −0.032]) and A_2 versus C (95% HPDI = [−0.393; −0.01]) but not for A_2 versus A_1 (95% HPDI = [−0.166; 0.237]), with small effects for A_1 versus C (*ES* = −0.233) and A_2 versus C (*ES* = −0.2) and a low effect for A_2 versus A_1 (*ES* = 0.033). This finding suggests that only time had a significant impact, with small effects, on student teachers' *instructional strategies* when comparing team teaching with and without support to traditional teaching.

Table 13. Teacher efficacy—instructional strategies.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	0.065	[−0.166; 0.291]
Intervention A_2—intervention C	0.186	[−0.023; 0.429]
Intervention A_2—intervention A_1	0.121	[−0.107; 0.37]
Time intervention A_1—time intervention C	−0.233	[−0.431; −0.032]
Time intervention A_2—time intervention C	−0.2	[−0.393; −0.01]
Time intervention A_2—time intervention A_1	0.033	[−0.166; 0.237]

Note. Control variable: education paths.

6.4. Professional Identity Related to Beliefs about Learning and Teaching (RQd)

6.4.1. Subject Matter-Oriented Beliefs

The Cronbach's alpha coefficient for *subject matter-oriented beliefs* showed reasonable internal consistency ($\alpha = 0.79$). The results of Table 14 indicate that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.797; 0.021]), A_2 versus C (95% HPDI = [−0.492; 0.333]), or A_2 versus A_1 (95% HPDI = [−0.127; 0.782]). Relatedly, the effect size posterior mean indicated small effects for the comparisons A_1 versus C (*ES* = −0.39) and A_2 versus A_1 (*ES* = 0.324) while it indicated a very small effect for the comparison between A_2 versus C (*ES* = −0.066). However, time was statistically significant for all interventions (95% HPDI = [0.328; 0.704]) with a medium effect (*ES* = 0.515). In summary, time showed a significant impact with a medium effect on student teachers' *subject matter-oriented beliefs*, regardless of the intervention.

Table 14. Beliefs about learning and teaching—subject matter-oriented beliefs.

Effect Size	Posterior Mean	95% HPDI
Cohen's d contrasts		
Intervention A_1—intervention C	−0.39	[−0.797; 0.021]
Intervention A_2—intervention C	−0.066	[−0.492; 0.333]
Intervention A_2—intervention A_1	0.324	[−0.127; 0.782]
Time	0.515	[0.328; 0.704]

Note. Control variable: education paths.

6.4.2. Pupil-Oriented Beliefs

The Cronbach's alpha coefficient for *pupil-oriented beliefs* showed reasonable internal consistency ($\alpha = 0.72$). Table 15 shows that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.352; 0.134]), A_2 versus C (95% HPDI = [−0.214; 0.27]), or A_2 versus A_1 (95% HPDI = [−0.111; 0.413]). Furthermore, the effect size posterior mean indicated very small effects for all comparisons (*ES* = −0.119, 0.022, and 0.142, respectively). Additionally, time was not statistically significant for any of the interventions (95% HPDI = [−0.083; 0.15]) and had a very small effect (*ES* = 0.035). This finding suggests that neither time nor intervention had a significant impact on student teachers' *pupil-oriented beliefs*.

Table 15. Beliefs about learning and teaching—pupil-oriented beliefs.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.119	[−0.352; 0.134]
Intervention A_2—intervention C	0.022	[−0.214; 0.27]
Intervention A_2—intervention A_1	0.142	[−0.111; 0.413]
Time	0.035	[−0.083; 0.15]

Note. Control variable: education paths.

6.5. Professional Identity Related to Motivation (RQe)

6.5.1. External Regulation

The Cronbach's alpha coefficient for *external regulation* showed good internal consistency (α = 0.89). The results presented in Table 16 reveal that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.021; 0.35]), A_2 versus C (95% HPDI = [−0.156; 0.207]), or A_2 versus A_1 (95% HPDI = [−0.35; 0.066]). Furthermore, the effect size posterior mean indicated small effects for all comparisons (*ES* = 0.17, 0.027, and −0.143, respectively). Additionally, time was not statistically significant on student teachers' *external regulation* across all interventions (95% HPDI = [0; 0.139]), with a very small effect (*ES* = 0.074). Overall, neither time nor interventions had a significant impact on student teachers' *external regulation*, which represents the least desirable form of motivation.

Table 16. Motivation—external regulation.

Effect Size	Posterior Mean	95% HPDI
Cohen's d contrasts		
Intervention A_1—intervention C	0.17	[−0.021; 0.35]
Intervention A_2—intervention C	0.027	[−0.156; 0.207]
Intervention A_2—intervention A_1	−0.143	[−0.35; 0.066]
Time	0.074	[0; 0.139]

Note. Control variable: education paths.

6.5.2. Introjected Regulation

The Cronbach's alpha coefficient for *introjected regulation* showed reasonable internal consistency (α = 0.73). Table 17 shows that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.182; 0.753]), A_2 versus C (95% HPDI = [−0.501; 0.414]), or A_2 versus A_1 (95% HPDI = [−0.823; 0.217]). Furthermore, the effect size posterior mean indicated small effects for A_1 versus C (*ES* = 0.273) and A_2 versus A_1 (*ES* = −0.291) and a very small effect for A_2 versus C (*ES* = −0.018). Additionally, time was not statistically significant for any of the interventions (95% HPDI = [−0.119; 0.29]), showing a very small effect (*ES* = 0.09). This finding suggests that neither time nor intervention had a significant impact on student teachers' *introjected regulation*, which represents the second least desirable form of motivation.

Table 17. Motivation—introjected regulation.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	0.273	[−0.182; 0.753]
Intervention A_2—intervention C	−0.018	[−0.501; 0.414]
Intervention A_2—intervention A_1	−0.291	[−0.823; 0.217]
Time	0.09	[−0.119; 0.29]

Note. Control variable: education paths.

6.5.3. Identified Regulation

The Cronbach's alpha coefficient for *identified regulation* showed reasonable internal consistency (α = 0.68). The results of Table 18 show that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.306; 0.167]), A_2 versus C (95% HPDI = [−0.146; 0.341]), or A_2 versus A_1 (95% HPDI = [−0.104; 0.438]). Furthermore, the effect size posterior mean indicated very small to small effects for all comparisons (*ES* = −0.082, 0.08, and 0.163, respectively). In contrast, time was statistically significant on student teachers' identified regulation across all interventions (95% HPDI = [0.096; 0.333]), with a small effect (*ES* = 0.212). Overall, time had a small significant impact on student teachers' *identified regulation*, indicating motivation driven by personal relevance, regardless of the intervention.

Table 18. Motivation—identified regulation.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.082	[−0.306; 0.167]
Intervention A_2—intervention C	0.08	[−0.146; 0.341]
Intervention A_2—intervention A_1	0.163	[−0.104; 0.438]
Time	0.212	[0.096; 0.333]

Note. Control variable: education paths.

6.5.4. Intrinsic Motivation

The Cronbach's alpha coefficient for *intrinsic motivation* showed reasonable internal consistency (α = 0.78). The results of Table 19 indicate that a statistically significant difference was observed between student teachers of interventions A_2 versus A_1 (95% HPDI = [0.083; 1.156]) with a medium effect (*ES* = 0.627). In contrast, no statistically significant difference was found between student teachers of interventions A_1 versus C (95% HPDI = [−0.82; 0.159]) or A_2 versus C (95% HPDI = [−0.203; 0.766]). Furthermore, the effect size posterior mean for the comparisons indicated small effects (*ES* = −0.325 and 0.302, respectively). Additionally, time was statistically significant for all interventions (95% HPDI = [0.04; 0.45]), with a small effect (*ES* = 0.253). In summary, both time and team teaching with support, compared to team teaching, had a significant impact on student teachers' *intrinsic motivation*, the most optimal form of motivation, with a small and moderate effect, respectively.

Table 19. Motivation—intrinsic motivation.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	−0.325	[−0.82; 0.159]
Intervention A_2—intervention C	0.302	[−0.203; 0.766]
Intervention A_2—intervention A_1	0.627	[0.083; 1.156]
Time	0.253	[0.04; 0.45]

Note. Control variable: education paths.

6.6. Professional Identity Related to Collaborative Activities (RQf)

Collaborative Activities

The Cronbach's alpha coefficient for *collaborative activities* showed good internal consistency (α = 0.89). The results of Table 20 show that no statistically significant difference was observed between student teachers of interventions A_1 versus C (95% HPDI = [−0.103; 0.42]), A_2 versus C (95% HPDI = [−0.244; 0.278]), or A_2 versus A_1 (95% HPDI = [−0.448; 0.129]). Furthermore, the effect size posterior mean indicated no to very small effects for all comparisons (*ES* = 0.168, 0.005, and −0.163, respectively). In contrast, time was statistically significant on student teachers' *collaborative activities* (95% HPDI = [0.64; 0.857]), with a medium effect (*ES* = 0.75). In brief, time had a significant impact with a medium effect on student teachers' *collaborative activities*, regardless of the intervention.

Table 20. Collaborative activities.

Effect Size	Posterior Mean	95% HPDI
Intervention A_1—intervention C	0.168	[−0.103; 0.42]
Intervention A_2—intervention C	0.005	[−0.244; 0.278]
Intervention A_2—intervention A_1	−0.163	[−0.448; 0.129]
Time	0.75	[0.64; 0.857]

Note. Control variable: education paths.

6.7. Posterior Probability Distributions

Table 21 presents the results of the pairwise comparison posterior probability distribution for the retained components and their scales. The results show that for the scales

actively relating theory and practice of **learning and regulation activities**, *adaptive teaching* of **teacher efficacy**, and *external regulation*, *introjected regulation* of **motivation**, the posterior probability distribution of A_1 versus C exceeding a ROPE of 0.1 was 88.0%, 96.9%, 77.2%, and 76.5%, respectively. Furthermore, for the scales *proactive and broad use of the mentor* of **learning and regulation activities**, *understanding* of **reflective thinking**, *adaptive teaching*, *intensive and activating lessons*, *instructional strategies* of **teacher efficacy**, and intrinsic motivation of **motivation**, the posterior probability distribution of A_2 versus C above a ROPE of 0.1 was 88.1%, 88.6%, 94.5%, 94.0%, 77.3%, and 79.1%, respectively. Next, for the scales *actively relating theory and practice* of **learning and regulation activities**, *intensive and activating lessons* of **teacher efficacy**, and *subject matter-oriented beliefs* of **beliefs about learning and teaching**, the posterior probability distribution of A_2 versus A_1 above a ROPE of 0.1 was 76.1%, 85.4%, and 82.8%, respectively. In summary, team teaching with and without support compared to traditional teaching had a non-negligible positive influence on multiple scales of multiple components. Relatedly, team teaching with support had a larger influence compared to team teaching alone.

Table 21. Posterior probability distribution.

	P (Comparison < −0.1)	P (Comparison > 0.1)
Learning and regulation activities		
Proactive and broad use of the mentor		$A_2 > C = 88.1\%$
Actively relating theory and practice		$A_1 > C = 88.0\%$
		$A_2 > A_1 = 76.1\%$
Reflective thinking		
Understanding	$A_1 < C = 77.8\%$	$A_2 > C = 88.6\%$
Teacher efficacy		
Adaptive teaching	$A_2(time) < C(time) = 96.3\%$	$A_1 > C = 96.9\%$
		$A_2 > C = 94.5\%$
		$A_2(time) > A_1(time) = 85.1\%$
Intensive and activating lessons	$A_1(time) < C(time) = 80.5\%$	$A_2 > C = 94.0\%$
	$A_2(time) < A_1(time) = 73.2\%$	$A_2 > A_1 = 85.4\%$
Instructional strategies		$A_2 > C = 77.3\%$
Beliefs about learning and teaching		
Subject matter-oriented beliefs	$A_1 < C = 91.5\%$	$A_2 > A_1 = 82.8\%$
Motivation		
External regulation		$A_1 > C = 77.2\%$
Introjected regulation	$A_2 < A_1 = 76.8\%$	$A_1 > C = 76.5\%$
Intrinsic motivation	$A_1 < C = 81.7\%$	$A_2 > C = 79.1\%$

In contrast, the results show that for the scales *understanding* of **reflective thinking**, *subject matter-oriented beliefs* of **beliefs about learning and teaching**, and *intrinsic motivation* of **motivation**, the posterior probability distribution of A_1 versus C below a ROPE of -0.1 was 77.8%, 91.5%, and 81.7%, respectively. Furthermore, for the scale *introjected regulation* of **motivation,** the posterior probability distribution of A_2 versus A_1 below a ROPE of -0.1 was 76.8%. In brief, team teaching compared to traditional teaching had a non-negligible negative influence on multiple scales. Relatedly, team teaching with support had a smaller influence compared to team teaching alone.

Finally, the results revealed that for the scale *adaptive teaching* of **teacher efficacy**, the posterior probability distribution of the time between A_2 versus A_1 exceeding a ROPE threshold of 0.1 was 85.1%. In contrast, for the scale *intensive and activating lessons* of **teacher efficacy**, the posterior probability distribution of time between A_1 versus C, as well as A_2 versus A_1 falling below a ROPE threshold of -0.1, were 80.5% and 73.2%, respectively. In summary, the evolution over time was more prominent in team teaching with support compared to team teaching alone for *adaptive teaching*. However, for *intensive and activating lessons*, team teaching with support exhibited a less prominent evolution over time compared to team teaching, with team teaching evolving at a slower pace than traditional teaching ($A_2 << A_1 << C$).

7. Discussion

7.1. Findings

The present study examined the impact of three distinct student teaching formats: team teaching ($A_{1\ intervention}$), team teaching with support ($A_{2\ intervention}$), and traditional teaching ($C_{ontrol\ intervention}$) on the professional identity of student teachers. In this respect, professional identity is conceptualized as a multidimensional concept that includes student teachers' learning and regulation activities (RQa) [28,30,31], reflective thinking (RQb) [31,32], teacher-efficacy (RQc) [26,29,33–37], beliefs about learning and teaching (RQd) [29,31,38], motivation (RQe) [25,26,33,39], and collaborative activities (RQf) [13,28,38]. The reliability analyses indicate that all scales demonstrated reasonable to good levels of internal consistency. Moreover, overall findings of Bayesian structural equation modeling reveal significant impacts of team teaching with support compared to both team teaching and traditional teaching as well as a significant impact of team teaching over traditional teaching on three crucial components of student teachers' professional identity, i.e., those related to their **learning and regulation activities**, **reflective thinking**, and **motivation**. Likewise, the detailed examination of the posterior distribution indicates some evidence supporting the influence of team teaching and/or team teaching with support versus traditional teaching on various crucial components of professional identity. Table 22 provides a clear overview of these results. In addition, time was found to have a significant impact on different scales of various components, thus confirming the expectation of the dynamic nature of these scales [26,31]. However, in view of the scope of the present study, these findings are not further discussed.

Table 22. Overview results.

Component of Professional Identity	Scale	Significance and Effect Size	Posterior
Learning and regulation activities	*Proactive and broad use of the mentor*		$A_2 > C$
	Independent search for conceptual information		
	Actively relating theory and practice	$A_2 > C$ (medium)	$A_1 > C$
			$A_2 > A_1$
	Developing views/ideas through discussion		
	Pupil-oriented evaluation criteria		
Reflective thinking	*Habitual action*		
	Understanding	$A_2 > A_1$ (medium)	$A_2 > C$
			$A_1 < C$
	Reflection	$A_1 > C$ (large)	
		$A_2 > C$ (large)	
	Critical reflection	$A_2 > C$ (small)	
		$A_2 > A_1$ (small)	
Teacher efficacy	*Adaptive teaching*		$A_1 > C$
			$A_2 > C$
	Intensive and activating lessons		$A_2 > C$
			$A_2 > A_1$
	Instructional strategies		$A_2 > C$
Beliefs about learning and teaching	*Subject matter-oriented beliefs*		$A_2 > A_1$
			$A_1 < C$
	Pupil-oriented beliefs		
Motivation	*External regulation*		$A_1 > C$
	Introjected regulation		$A_1 > C$
			$A_2 < A_1$
	Identified regulation		
	Intrinsic motivation	$A_2 > A_1$ (medium)	$A_2 > C$
			$A_1 < C$
Collaborative activities	*Collaborative activities*		

Note. X > Y = X is higher than Y and X < Y = X is lower than Y.

Firstly, findings related to **learning and regulation activities** (RQa) indicate that *proactive and broad use of mentor* and *pupil-oriented criteria*, which are associated with a more dependent pattern of learning, as well as *independent search for conceptual information* and *developing views/ideas through discussion*, which are associated with a more independent pattern of learning, were not significantly impacted by the intervention to which student teachers were assigned. However, some evidence supporting the positive influence of team teaching with support over traditional teaching for *proactive and broad use of the mentor* was found. This finding makes sense since both student teachers and mentors are actively involved in planning, implementing, and evaluating lessons [14], with the mentor serving as a provider of information that relates to student teachers' existing needs and problems [31]. Furthermore, compared to traditional teaching, team teaching with support had a significant medium impact on student teachers' *actively relating theory and practice*, associated with an independent pattern of learning. In line with this, a detailed examination also indicated some evidence supporting the positive influence of team teaching with support compared to team teaching and of team teaching compared to traditional teaching. These findings are particularly noteworthy as they suggest the potential development of a more independent learning pattern among student teachers [30] when engaged in team teaching with support or even in team teaching alone.

Next, findings related to **reflective thinking** (RQb) show no significant impacts of the interventions on *habitual action* but significant impacts on the higher levels of *understanding*, *reflection,* and *critical reflection*. However, some evidence supporting the positive influence of team teaching with support as compared to traditional teaching and the negative influence of team teaching compared to traditional teaching for *understanding*, was found. This suggests that team teaching with support can help student teachers understand classroom practice without already relating it to other situations [30]. Furthermore, team teaching had a significant large impact on the evolution of student teachers' *reflection* when comparing it to traditional teaching. Moreover, team teaching with support showed a significant medium impact on student teachers' *understanding* compared to team teaching alone, a significant large impact on *reflection* when comparing it to traditional teaching, and a small significant impact on *critical reflection* in comparison to both team teaching and traditional teaching. These findings are important given the limited observations of perspective transformation in the literature, particularly at the level of critical reflection [32]. The findings suggest that team teaching, especially when supplemented with support, can facilitate deeper, more thoughtful, and more profound reflection among student teachers [9,12].

Additionally, findings related to **teacher efficacy** (RQc) indicate that the interventions did not have a significant impact on *adaptive teaching*, *intensive and activating lessons*, or *instructional strategies*. However, some evidence supporting the positive influence of both team teaching with and without support compared to traditional teaching was found for *adaptive teaching*. The same is true for team teaching with support in comparison with team teaching and traditional teaching in terms of *intensive and activating lessons* and team teaching with support compared to traditional teaching in terms of *instructional strategies*. Despite the lack of a significant impact observed from the distinct student teaching formats, these findings suggest that there is some evidence of their positive influence on the development and application of student teachers' *adaptive teaching strategies*, *intensive and activating lessons*, and *instructional strategies*. In other words, team teaching, with or without support, has the potential to guide student teachers in adapting teaching strategies to promote intensive and interactive lessons characterized by effective questioning techniques and explanations.

Similarly, findings related to **beliefs about learning and teaching** (RQd) show that student teachers' *subject matter-oriented* and *pupil-oriented beliefs* were not significantly impacted by the interventions to which student teachers were assigned. However, some evidence supporting the positive influence of team teaching with support compared to team teaching and the negative influence of team teaching in comparison with traditional teaching was found for *subject matter-oriented beliefs*. Although the distinct student teaching

formats did not have a significant impact, these findings suggest that there is some evidence for their potential influence on student teachers' *subject matter-oriented beliefs*. However, it is important to emphasize that *pupil-oriented beliefs* represent the ideal self regarding student teachers' development. It might be that student teachers' prior beliefs were primarily oriented towards *subject matter*, highlighting the need for reconstructing their existing frame of reference by balancing these prior beliefs about teaching and learning [31]. In addition, it is worth considering that the duration of the team teaching interventions, both with and without support, may have been insufficient for significant changes to occur.

Furthermore, findings related to **motivation** (RQe) reveal no significant impacts of the interventions on the scales measuring lower forms of motivation. However, there was some evidence supporting the influence of team teaching, as compared to traditional teaching, on *external* and *introjected regulation*. This indicates that team teaching may exert some pressure on student teachers to engage in activities stemming from external or self-imposed sources. In contrast, team teaching with support had a negative influence on *introjected regulation* in comparison with team teaching alone. Moreover, in comparison to team teaching alone, team teaching with support had a significant medium impact on student teachers' *intrinsic motivation*, which represents the highest form of motivation. The same is true for team teaching with support but not for team teaching when compared to traditional teaching as a positive influence was observed. These findings suggest that student teachers were intrinsically motivated to engage in team teaching with support purely out of enjoyment and interest, without external reinforcement or perceived contingency [40]. It underscores the vital role of team teaching with support in fostering intrinsic motivation among student teachers.

Finally, findings related to **collaborative activities** (RQf) do not indicate significant impacts nor any influence of the interventions. This suggests that student teachers did not experience an increase in collaborative activities when practicing a specific student teaching format. However, it was expected that both team teaching with and without support would promote student teachers' involvement in collaborative activities because both student teachers and mentors are actively involved in planning, implementing, and evaluating lessons [14]. A possible explanation for these findings could be the individual differences among student teachers, such as personal preferences or prior experiences with collaboration, which could have influenced their level of involvement in collaborative activities [80,81].

7.2. Limitations and Future Research

The present study contributes valuable insight into the field of collaborative workplace learning, specifically within the context of team teaching. However, it is important to acknowledge the limitations of this study and explore potential avenues for future research.

Firstly, the use of a composite questionnaire was the only feasible approach to gathering data from a substantial number of student teachers in order to investigate their professional identity over time. However, this approach limited the depth of information obtained regarding the nature and impact of their experiences. Like any survey method that relies on self-report measurement, the answers to the survey items might be influenced by social desirability or reflect an optimistic view of student teachers' professional identity. Therefore, future research in this field is encouraged to employ mixed methods, incorporating qualitative techniques such as interviews and observations. This approach will facilitate a more comprehensive and detailed understanding of the evolution of student teachers' professional identity and the specific impact of distinct student teaching formats.

Secondly, conducting an experimental study with three interventions in the same College of Education might not constitute a representative sample of the student–teacher population. Furthermore, applying intervention in one College of Education might lead to contamination between the interventions. Contamination occurs when participants from different interventions interact, share information, or inadvertently influence each other's experiences, thus compromising the internal validity of the study. Therefore, future

research should consider replicating the study in other institutes or with a diverse range of participants, exploring the possibility of conducting further analyses or combining the current results with new data in a meta-analysis. In the first case, researchers could utilize the posterior probability parameters obtained from the present study as prior probabilities for the analysis.

Thirdly, while ITT analysis manages to handle noncompliance by maintaining group comparability, it compromises the ability to isolate and measure the specific effect of the received intervention. Sheiner and Rubin [82] emphasized that ITT addresses a different question: what are the expected outcomes for a typical participant who, within the context of the experiment, is instructed to follow the assigned intervention? Thus, the ITT estimate reflects both the intervention efficacy and the effectiveness of the instruction to comply within the specific experimental context. This combination implies that ITT is likely to provide an estimate of the effect that confounds intervention efficacy with intervention compliance, potentially leading to an underestimation or overestimation of the effects. Future research is encouraged to design experiments considering the possibility of noncompliance and to use alternative analytic approaches to disentangle the efficacy of the intervention from the effectiveness of the instruction.

Finally, while measurement invariance was assumed for nearly all the scales in student teachers' professional identity, none of the studies reported a formal test of measurement invariance. Furthermore, for the scales assessing teacher efficacy related to *adaptive teaching* and *intensive and activating lessons*, validation has not yet been conducted. Therefore, future research is encouraged to validate these scales and perform formal tests of measurement invariance for all instruments.

8. Conclusions

The present study highlights the positive impacts of team teaching with and without support on student teachers' professional identity. Specifically, providing extended support to student teachers during team teaching practices holds significant potential [12]. The findings show the benefits of these student teaching formats in promoting independent learning, reflective thinking, and intrinsic motivation among student teachers. These insights have implications for the design and implementation of teacher education programs, emphasizing the importance of incorporating collaborative and supportive pedagogical practices to enhance student teachers' professional development.

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Informed Consent Statement: Written informed consent was obtained from all participants involved in the study.

Data Availability Statement: The data from this study are available upon request.

Acknowledgments: We thank the participating teacher educators, student teachers, and mentors for their contributions.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Estimation

The data were analyzed using R software version 4.2.2 [83] and Stan version 2.26.1 [84]. The Hamiltonian Monte Carlo (HMC) procedure, specifically the No-U-Turn Sampler (NUTS) [85], was employed in Stan. Four Markov chains were executed with different starting values provided for each chain. Resulting from using the HMC procedure, no burn-in or thinning was necessary. Instead, a warm-up phase was conducted whereby each chain was run for 4000 iterations in which the first 2000 iterations served as a warm-up and the remaining 2000 were considered as 'effective' samples from the parameter's posterior distribution.

The assessment of chain performance in terms of stationarity, convergence, and mixing involved visual inspection of the trace, trace rank, and autocorrelation plots (ACF) for each parameter, as suggested by McElreath [78], as well as for the Gelman and Rubin [86] statistics, namely the potential scale reduction factor (Rhat) and effective sample size (neff). The trace plots indicated that all parameters' chains appeared to visually converge to a constant mean and variance in the post-warm-up section of the chain for each parameter. Furthermore, the trace rank plots revealed that each chain explored the parameter space in a seemingly random manner. Lastly, the ACF plots showed low autocorrelation.

Regarding the Gelman and Rubin [86] statistics, a maximum value of 1.05 was set as the threshold for the Rhat to confirm convergence while no cut-off was established for the parameter's neff statistic; rather, their effective sample size adequacy was assessed by considering if the parameter's posterior distribution had sufficient sample points. The statistics diagnostics indicated that convergence was attained in the post-warm-up iterations for each chain and that each parameter had an adequate number of sample points from its posterior distribution. In summary, the plots and supporting statistics indicated that the parameters achieved stationarity, convergence, and good mixing.

Appendix B

The measurement (see Figure A2) and structural model (see Figure A2) of learning and regulation activities employed an assumption of non-homogeneous–latent–variable-variances.

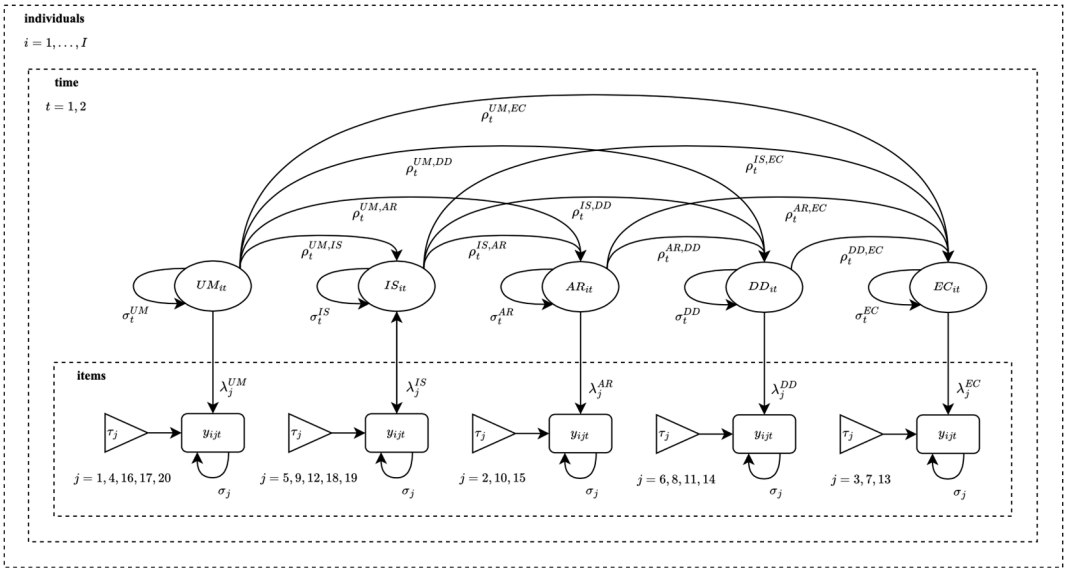

Figure A1. Measurement model of learning and regulation activities.

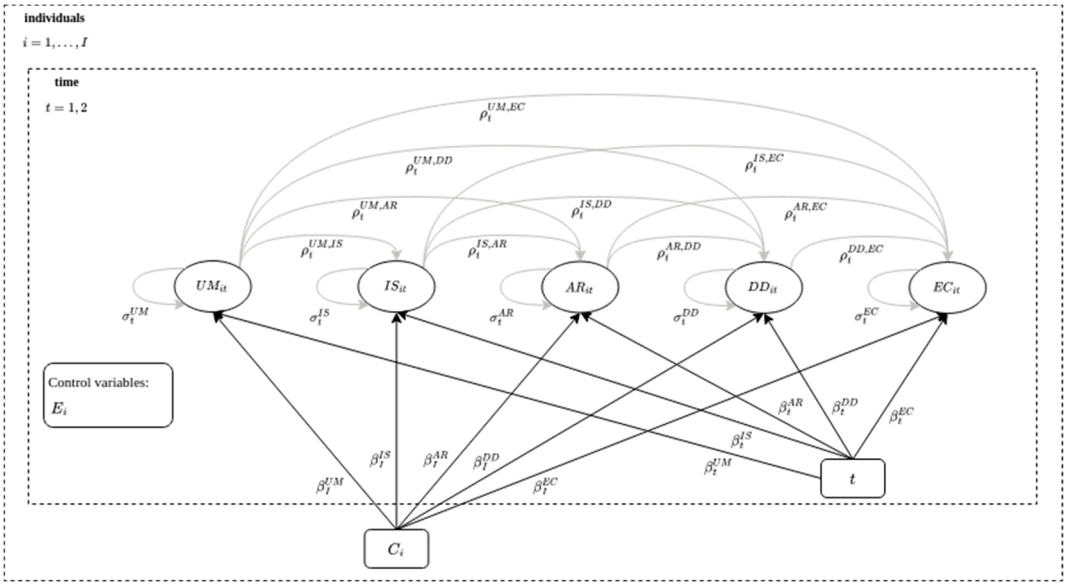

Figure A2. Structural model of learning and regulation activities.

Appendix C

The measurement (see Figure A3) and structural model (see Figure A4) of reflective thinking employed an assumption of non-homogeneous–latent–variable-variances.

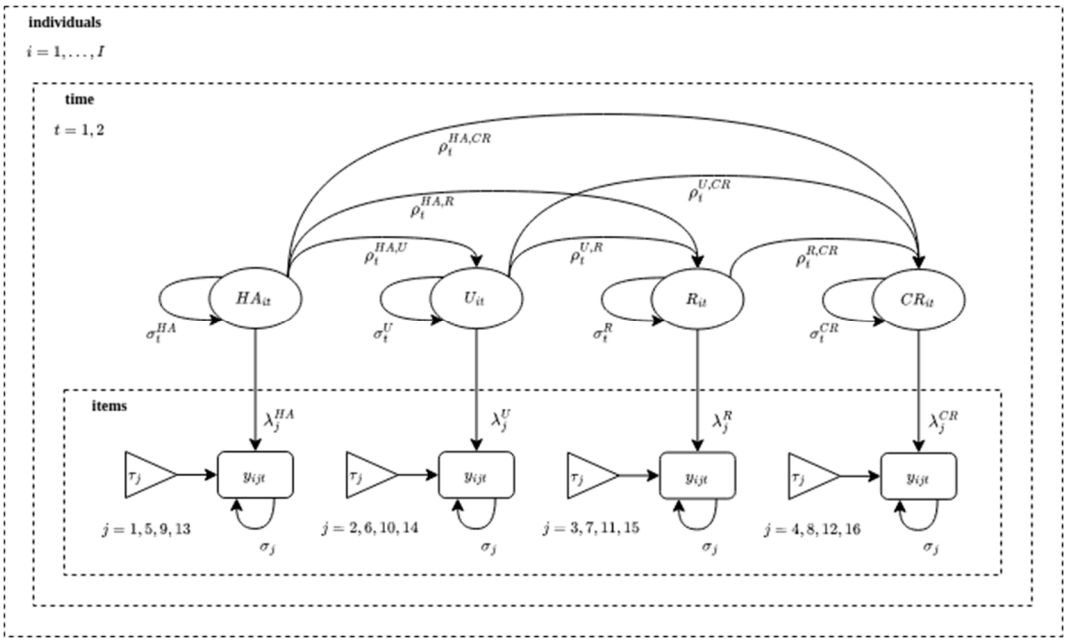

Figure A3. Measurement model of reflective thinking.

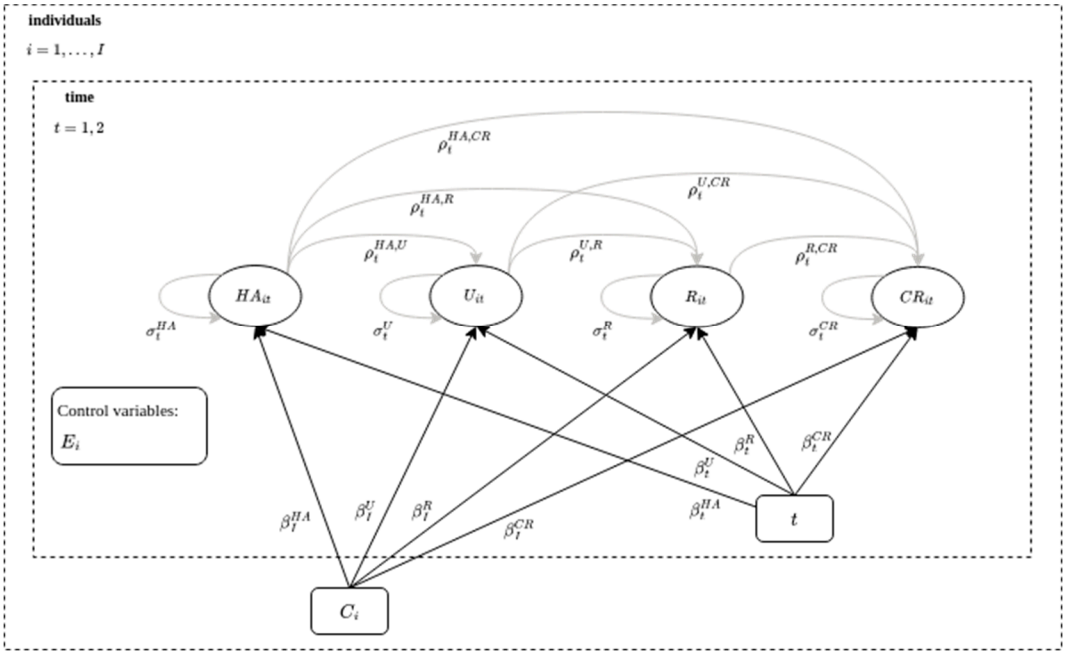

Figure A4. Structural model of reflective thinking.

Appendix D

The measurement (see Figure A5) and structural model (see Figure A6) of teacher efficacy employed an assumption of non-homogeneous–latent–variable-variances.

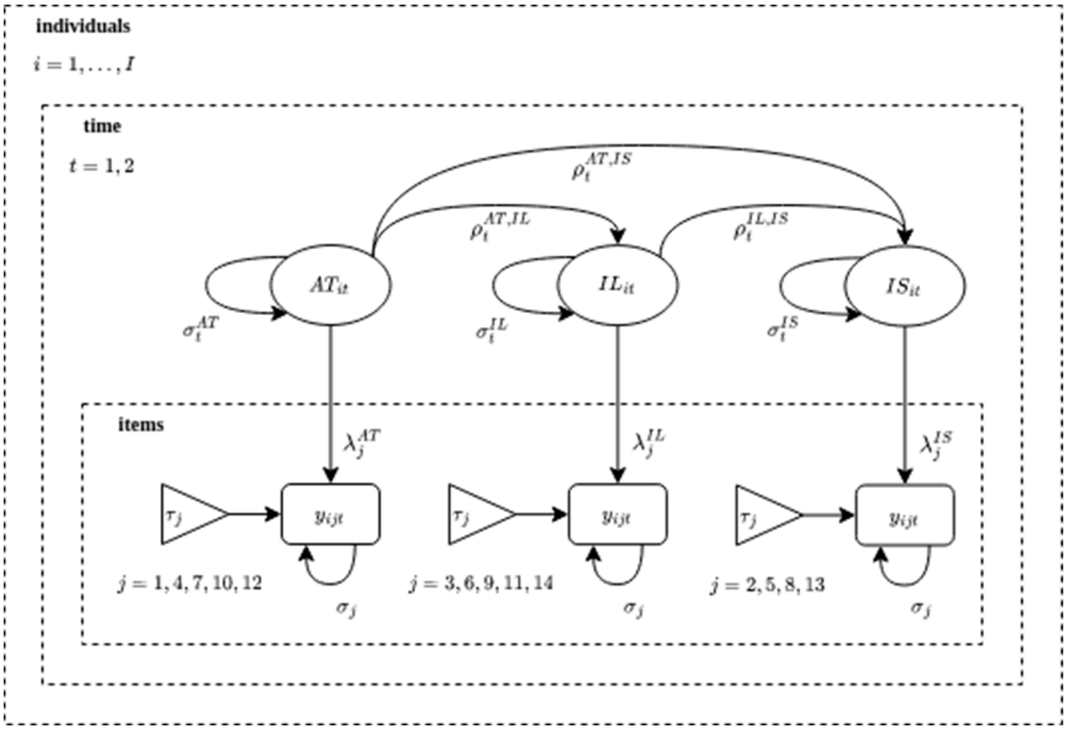

Figure A5. Measurement model of teacher efficacy.

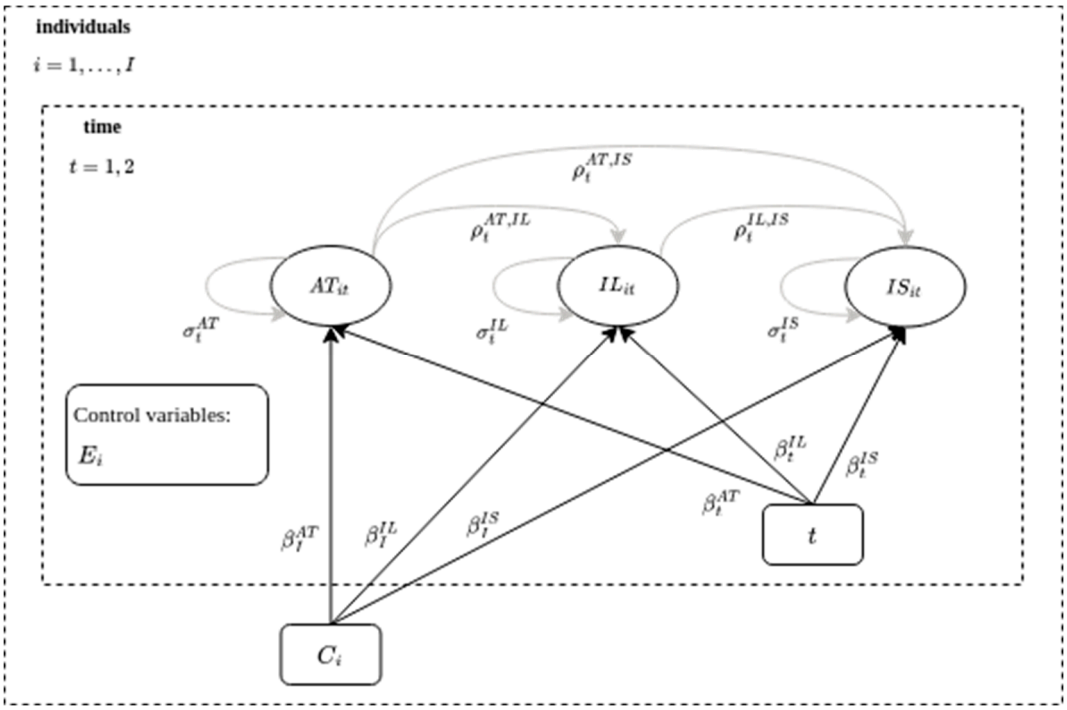

Figure A6. Structural model of teacher efficacy.

Appendix E

The measurement (see Figure A7) and structural model (see Figure A8) of beliefs about learning and teaching employed an assumption of homogeneous–latent–variable-variances.

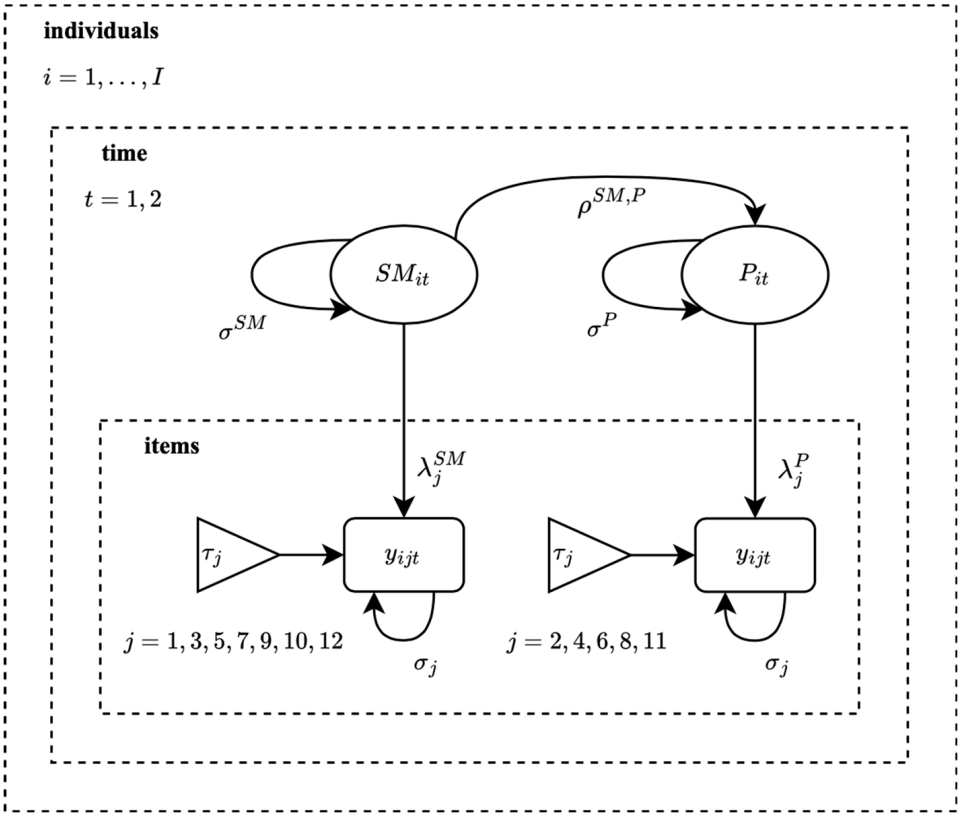

Figure A7. Measurement model of beliefs about learning and teaching.

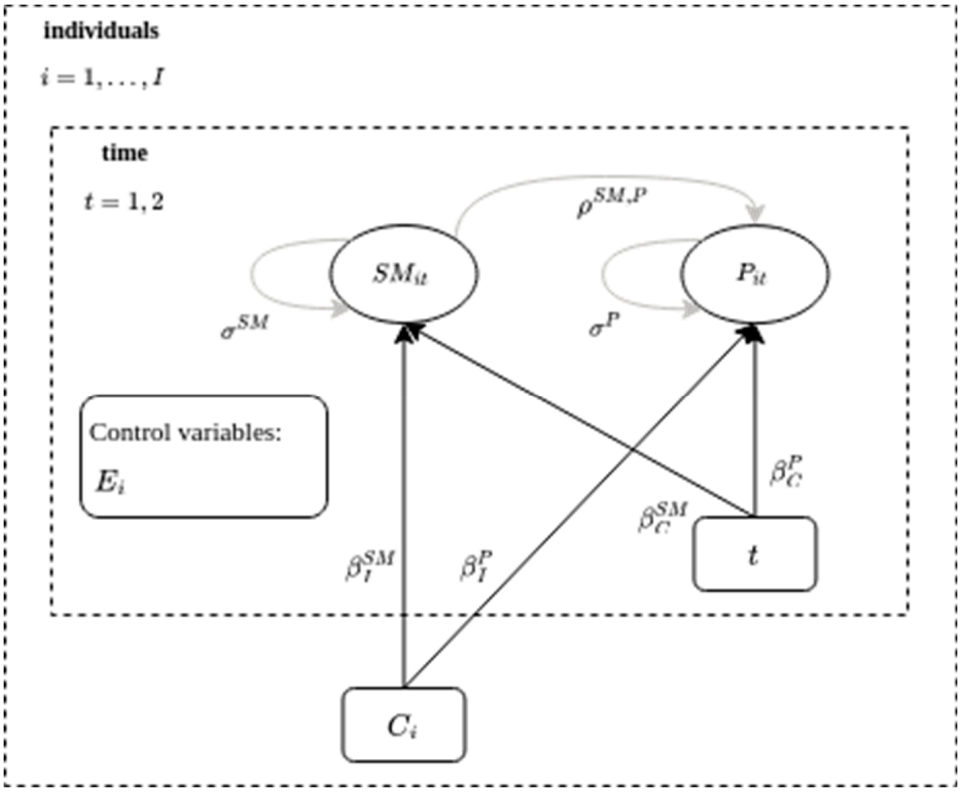

Figure A8. Structural model of beliefs about learning and teaching.

Appendix F

The measurement (see Figure A9) and structural model (see Figure A10) of motivation employed an assumption of homogeneous–latent–variable-variances.

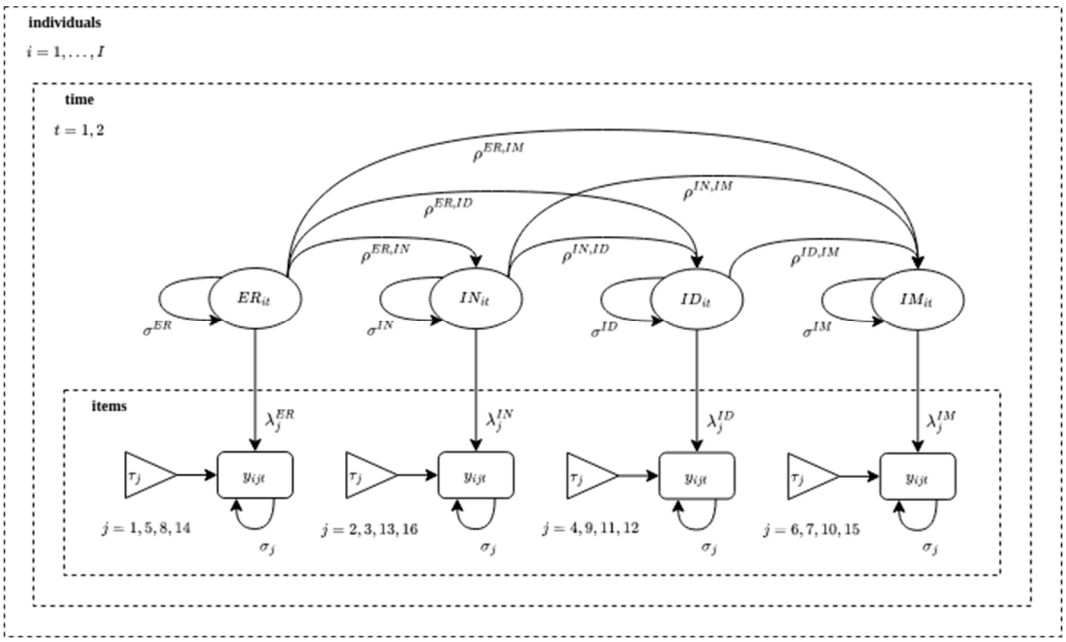

Figure A9. Measurement model of motivation.

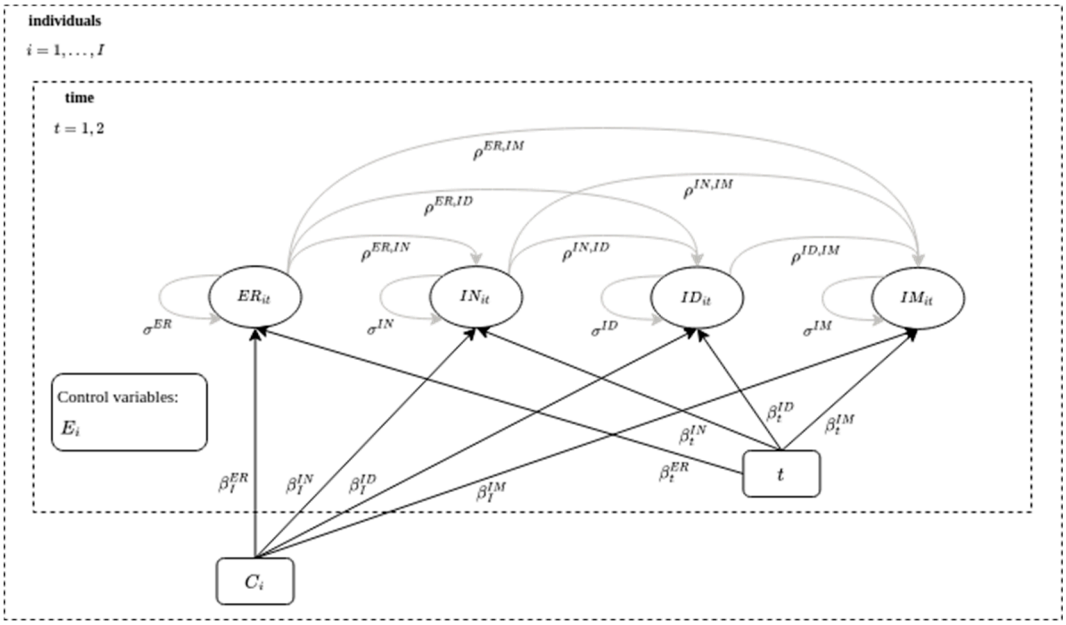

Figure A10. Structural model of motivation.

Appendix G

The measurement (see Figure A11) and structural model (see Figure A12) of collaborative activities employed an assumption of homogeneous–latent–variable-variances.

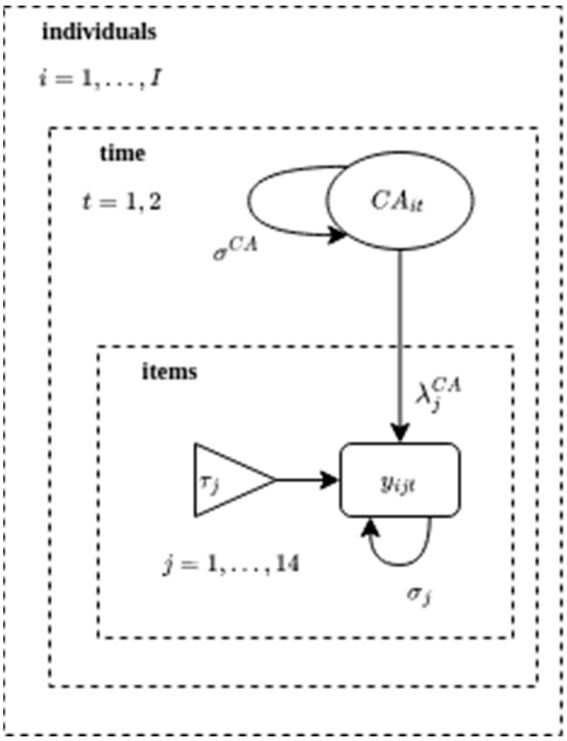

Figure A11. Measurement model of collaborative activities.

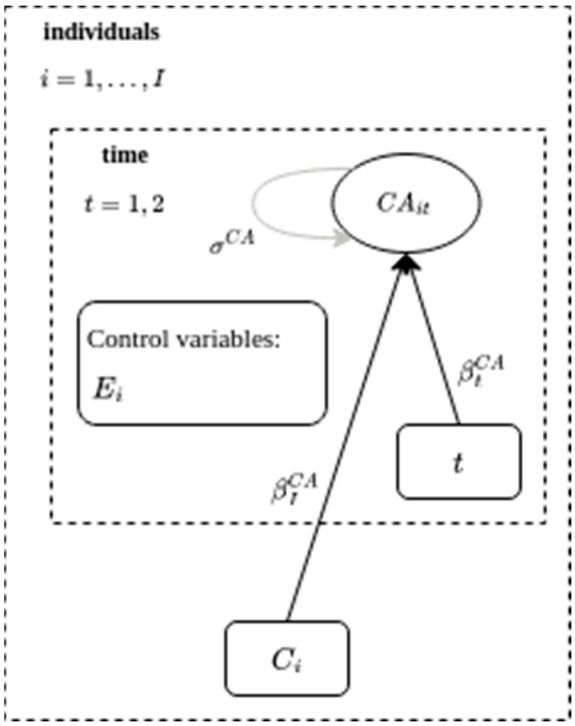

Figure A12. Structural model of collaborative activities.

Appendix H

The WAIC model of learning and regulation activities is shown in Table A1.

Table A1. WAIC model of learning and regulation activities.

	WAIC	SE	dWAIC	dSE	pWAIC	Weight
Model 2B	30,673.72	173.01	0	NA	1239.88	1.00
Model 3B	30,719.70	173.87	45.98	12.84	1281.01	0
Model 1B	30,734.70	172.98	61.00	32.47	1243.60	0
Model 3A	30,769.98	170.75	96.26	57.79	1135.14	0
Model 2A	30,783.38	171.11	109.65	58.75	1127.30	0
Model 1A	30,884.00	170.60	210.20	62.18	1123.60	0

Note. NA = not available.

Appendix I

The WAIC model of reflective thinking is shown in Table A2.

Table A2. WAIC model of reflective thinking.

	WAIC	SE	dWAIC	dSE	pWAIC	Weight
Model 3B	17,866.38	143.38	0	NA	914.25	1.00
Model 2B	17,882.17	143.76	15.80	10.71	910.25	0
Model 1B	17,894.43	144.25	28.05	16.58	902.81	0
Model 3A	17,922.63	142.01	56.26	27.66	893.00	0
Model 2A	17,957.30	141.98	90.92	30.74	882.17	0
Model 1A	17,989.17	142.33	122.79	33.61	876.05	0

Note. NA = not available.

Appendix J

The WAIC model of teacher efficacy is shown in Table A3.

Table A3. WAIC model of teacher efficacy.

	WAIC	SE	dWAIC	dSE	pWAIC	Weight
Model 3B	13,358.25	143.53	0	NA	597.30	0.97
Model 2B	13,365.46	143.47	7.21	7.30	599.69	0.03
Model 1B	13,381.20	144.15	22.95	18.38	575.56	0
Model 3A	13,483.03	140.27	124.78	28.97	370.33	0
Model 2A	13,503.52	140.13	145.27	30.75	365.25	0
Model 1A	13,576.72	140.90	218.47	36.68	350.09	0

Note. NA = not available.

Appendix K

The WAIC model of beliefs about learning and teaching is shown in Table A4.

Table A4. WAIC model of beliefs about learning and teaching.

	WAIC	SE	dWAIC	dSE	pWAIC	Weight
Model 2A	10,265.95	139.39	0	NA	475.49	0.93
Model 3A	10,271.06	139.55	5.11	4.46	478.16	0.07
Model 1A	10,289.91	138.08	23.96	13.53	477.23	0
Model 3B	10,316.86	143.40	50.91	30.34	540.94	0
Model 1B	10,324.72	143.10	58.77	32.04	544.72	0
Model 2B	10,330.58	143.92	64.62	27.53	550.07	0

Note. NA = not available.

Appendix L

The WAIC model of motivation is shown in Table A5.

Table A5. WAIC model of motivation.

	WAIC	SE	dWAIC	dSE	pWAIC	Weight
Model 2B	15,718.07	206.19	0	NA	957.79	0.70
Model 3B	15,719.98	205.81	1.91	4.74	961.17	0.27
Model 1B	15,724.57	206.08	6.50	12.46	948.93	0.03
Model 2A	16,013.63	200.38	295.56	52.72	866.19	0
Model 1A	16,019.30	200.39	301.23	55.60	856.10	0
Model 3A	16,021.24	200.16	303.17	52.61	871.95	0

Note. NA = not available.

Appendix M

The WAIC model of collaborative activities is shown in Table A6.

Table A6. WAIC model of collaborative activities.

	WAIC	SE	dWAIC	dSE	pWAIC	Weight
Model 2A	17,672.30	128.02	0	NA	334.90	0.70
Model 2B	17,675.76	128.07	3.45	4.62	338.75	0.12
Model 3B	17,676.39	128.17	4.08	5.77	340.02	0.09
Model 3A	17,676.51	128.22	4.21	3.25	337.71	0.09
Model 1B	17,900.32	125.84	228.02	34.70	328.28	0
Model 1A	17,974.85	125.28	302.55	37.30	331.92	0

Note. NA = not available.

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