

# Assessing Patterns of Students' Attainment of Professional Standards in Higher Education

Abhinava Barthakur<sup>1</sup>, Jelena Jovanović<sup>2</sup>, Ryan Baker<sup>3</sup>, Vitomir Kovanović<sup>4</sup>, Christopher Charles Deneen<sup>5</sup> and Shane Dawson<sup>6</sup>

## Abstract

It is widely recognized that higher education (HE) graduates require a broad range of professional skills and abilities to succeed in their future careers. However, despite this acknowledgement, assessment practices in HE remain focused on content-based knowledge. This narrow emphasis limits the capacity to effectively and holistically evaluate a student's professional competency and readiness for employment. This issue is particularly acute for HE degrees that require graduates to demonstrate attainment of externally regulated professional standards. While the curricula are mapped to professional standards for accreditation purposes, demonstrating a student's attainment of these standards is not straightforward and has mostly been done through self-reported surveys. This study offers a novel curriculum analytics method for mapping assessment grades to the attainment of professional standards across a Teacher Education program. Specifically, we present an approach that uses psychometric modelling and learning analytics to identify distinct patterns in learners' acquisition of professional standards. This method does not alter current assessment practices in HE. Instead, the approach offers a scalable, automated means to infer a learner's attainment of documented professional standards, complementing current measures of academic success, such as GPA. The study underscores the advantages of complementing the current HE assessment practises with an outlined curriculum analytics approach, providing a holistic representation of a student's learning progress.

## Notes for Practice

- There exists a notable discrepancy between the professional standards higher education graduates are expected to cultivate and those that are actually assessed within academic assessments.
- This study introduces a curriculum analytics approach that connects students' performance on existing assessments to specific professional standards, allowing for quantifiable tracking of standards attainment across an entire program.
- The paper provides nuanced insights into the relationship between conventional academic success and demonstrated professional readiness by comparing students' standards-based profiles with their GPAs.
- Educational stakeholders can use the standards-based profiles to pinpoint areas of curriculum improvement and to tailor support for students with differing competency development needs.

**Keywords:** Higher education, professional standards, academic success, distinct achievement patterns, curriculum analytics

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Corresponding author <sup>1</sup>Email: [abhinava.barthakur@adelaide.edu.au](mailto:abhinava.barthakur@adelaide.edu.au) Address: Centre for Change and Complexity in Learning, Adelaide University, 61–68 North Terrace, Adelaide SA 5000, Australia. ORCID iD: <https://orcid.org/0000-0002-2437-6892>

<sup>2</sup>Email: [jeljov@gmail.com](mailto:jeljov@gmail.com) Faculty of Organizational Sciences, University of Belgrade, Jove Ilića 154, 11010 Belgrade, Serbia; Centre for the Science of Learning & Technology (SLATE), Faculty of Psychology, University of Bergen, Christies gate 12, 5015 Bergen, Norway. ORCID iD: <https://orcid.org/0000-0002-1904-0446>

<sup>3</sup>Email: [ryanshaunbaker@gmail.com](mailto:ryanshaunbaker@gmail.com) Address: Centre for Change and Complexity in Learning, Adelaide University, 61–68 North Terrace, Adelaide SA 5000, Australia. ORCID iD: <https://orcid.org/0000-0002-3051-3232>

<sup>4</sup>Email: [vitomir.kovanovic@adelaide.edu.au](mailto:vitomir.kovanovic@adelaide.edu.au) Address: Centre for Change and Complexity in Learning, Adelaide University, 61–68 North Terrace, Adelaide SA 5000, Australia. ORCID iD: <https://orcid.org/0000-0001-9694-6033>

<sup>5</sup>Email: [chris.deneen@adelaide.edu.au](mailto:chris.deneen@adelaide.edu.au) Address: Centre for Change and Complexity in Learning, Adelaide University, 61–68 North Terrace, Adelaide SA 5000, Australia. ORCID iD: <https://orcid.org/0000-0003-2860-2073>

<sup>6</sup>Email: [shane.dawson@adelaide.edu.au](mailto:shane.dawson@adelaide.edu.au) Address: Centre for Change and Complexity in Learning, Adelaide University, 61–68 North Terrace, Adelaide SA 5000, Australia. ORCID iD: <https://orcid.org/0000-0003-2435-2193>

## 1. Introduction

Capabilities-oriented teaching and learning have recently become a critical point in contemporary higher education (HE) discourse (Ajjawi & Boud, 2023; Barthakur et al., 2023). This focus underscores the imperative of assessing a comprehensive range of learner achievements, thereby aligning assessment practices with professional and generic competencies that graduates are expected to acquire upon completion of their studies. However, while teaching practices have evolved, models of assessment in HE remain largely unchanged (Swiecki et al., 2022). The focus remains largely on content-based knowledge, commonly understood as the recall and reproduction of subject-matter information, definitions, and routine procedures from course materials (Pellegrino et al., 2001). Subsequently, student success is evaluated and communicated through GPAs and transcripts (Ajjawi & Boud, 2023). Although professional degree programs within HE have embraced work-integrated learning (such as placements, internships, and industry projects), there is still a lack of systematic measurement and program-level reporting of students' broader capability attainment (Barthakur, Jovanović et al., 2024). This is a significant gap, given that graduates must demonstrate readiness for complex, real-world roles that go beyond mere mastery of content-based knowledge.

Professional degree programs within HE institutions must comply with accreditation standards set by regulatory bodies. Such programs must explicitly demonstrate where specific professional standards are taught and assessed in the curriculum (Holmes et al., 2018) and provide evidence that graduates have attained a specific set of academic and professional skills or standards. For example, within the Australian context, the Tertiary Education Quality and Standards Agency (TEQSA) oversees the accreditation of all university degree programs to ensure they meet rigorous academic and professional standards (Brawley et al., 2015). At a more granular level, providers of Initial Teacher Education (ITE) programs in Australian universities are mandated to substantiate that learners have fulfilled all accredited teaching standards to graduate and attain eligibility for registration as professional teachers. This requirement mirrors the expectations of numerous other professional accrediting bodies, which seek evidence that graduates have met mandated standards (Holmes et al., 2018).

Professional standards are often linked to various elements of the curriculum and visually represented through curriculum mapping. While mappings of professional standards to learning activities and assessments are documented for accreditation purposes, the measurement and reporting of students' attainment along the directions defined in these standards are complex and, to date, are rarely completed. The measurement of graduates' attainment of professional standards has to date been very limited. Grade point average (GPA) is commonly used as a standardized measure of a student's overall academic performance across multiple courses. While a few studies have attempted to measure attainment of professional standards using self-reported pre-test/post-test questionnaires (e.g., Hudson & Grove, 2009; Kaļķe et al., 2022), such approaches lack objectivity and are prone to response bias. On one hand, GPA offers a broad and scalable indicator of academic performance. On the other hand, self-reported surveys bring deeper insights but are inherently subjective and prone to bias. This tension highlights the need for a robust, objective, and scalable method for assessing students' professional standards.

The relevance of monitoring and reporting learners' progress against standards has sparked interest in applying learning analytics to provide a comprehensive representation of learners' achievements, including the development of broader competencies (Barthakur, Jovanović et al., 2024; Barthakur et al., 2023; Khosravi et al., 2023). Substantial evidence highlights the complexity and variability inherent in learners' competency development, underscoring that this process rarely follows a linear or uniform trajectory (Barthakur, Jovanović et al., 2024; Poquet et al., 2021). Learning analytics enables the identification of unique student pathways, including the various factors such as personal experiences, contextual factors, and varying degrees of effort required to develop these professional capabilities (Barthakur, Jovanović et al., 2024). Such recognition allows educational institutions to tailor interventions and design more responsive support systems using learning analytics, ultimately enhancing graduate preparedness and contributing to ongoing improvements in educational programs.

To contribute towards addressing this challenge of measuring students' attainment of professional standards, this paper proposes a curriculum analytics (Dawson & Hubball, 2014) approach (a sub-field of learning analytics that utilizes statistics and machine learning to support decision-making and enhance curriculum) that relies on the measurement and reporting of attainment (e.g., evidence derived from existing assessment outcomes), rather than the design of assessment tasks themselves. It makes use of assessment grades from all courses of an ITE program through a two-step process: i) by mapping assessments to professional standards and determining the attainment of standards based on the assessment grades, and ii) by identifying latent learner profiles based on the distinct patterns of student achievements across professional standards. The ITE program studied in this paper is offered at an Australian HE institution. It aligns with the Australian Professional Standards for Teachers (APST) as defined by the Australian Institute for Teaching and School Leadership (AITSL, 2011). The proposed approach enables a comprehensive investigation of learners' attainment of multiple professional teaching standards across the entire ITE degree program, using a combination of psychometrics and learning analytics techniques. In this manner, the proposed methodology provides empirical evidence that students exhibit distinct and individualized patterns in mastering professional standards. The adopted methodology builds on the method used in a comparable prior investigation (Barthakur, Jovanović et al., 2024) that assessed the development of general capabilities within an ITE program through learner profiles. The current study extends the adopted methodology by comparing the identified profiles with traditional measures of academic

achievement, such as GPA, to provide a more nuanced understanding of how students demonstrate their teaching readiness. The study’s methods and findings enhance our understanding of the assessment and representation of learners’ attainment of professional standards, thereby providing a foundation for evaluating the effectiveness of professional degree programs, such as ITE, in preparing students for specific professions.

## 2. Background

### 2.1. Professional Standards for Teachers

A professional standard is a set of well-established criteria or benchmarks that define the knowledge, capabilities, attitudes, and behaviours required for effective performance in a specific profession or occupational field (Call, 2018). Such standards outline the essential knowledge and capabilities that professionals need to perform their work proficiently and meet the expectations of employers, clients, and the broader professional community (Sachs, 2003). By providing a clear, agreed-upon framework, professional standards inform and even guide the design and development of educational programs, curricula, and assessment practices. Importantly, because professional standards are articulated as demonstrable capabilities and performance expectations, they function as anchor points for competency-based education (CBE), in which progression is contingent on demonstrated mastery rather than time spent in class (Gervais, 2016). In CBE terms, standards specify the competencies to be mastered, thereby directly translating into learning outcomes, performance descriptors, and authentic assessments that evidence competence (Frank et al., 2010). These standards facilitate the recognition and validation of learning by establishing common benchmarks for evaluating and accrediting individuals’ professional skills and knowledge. In this manner, professional standards enable educators to align learning outcomes and assessments with the industry expectations of a given profession.

Professional standards for teachers are commonly used in HE. The application of professional standards aims primarily to enhance the quality of teaching and thereby improve learning outcomes (Call, 2018; Sachs, 2003). International interest in professional standards for teachers stems from the recognition of the positive impact high-quality teaching can have on student outcomes (Hattie, 2003). Within this context, a distinction is often made between professional standards and more generic graduate competencies. Generic competencies, such as critical thinking or teamwork, are transferable across disciplines.

In contrast, professional standards (such as those in [nursing](#) and [engineering](#)) are grounded in the knowledge, dispositions, and practices of a specific career domain. They are often tied to regulatory or accreditation requirements (Bravenboer & Lester, 2016). In ITE programs, for example, professional standards are interpreted as developmental benchmarks, with attainment understood not as complete mastery of classroom practice but as evidence that students are progressing toward readiness for professional entry (Hudson & Grove, 2009).

An important dimension of applying professional standards in HE is ensuring the validity of assessment practices. Validity refers to the degree to which assessment outcomes appropriately reflect the knowledge, skills, and dispositions specified by professional standards (Messick, 1995). Central to validity is the alignment between assessment tasks and the intended standards, often conceptualized as constructive alignment (Biggs, 1996). Constructive alignment requires that all assessment tasks are explicitly linked to the standards they are designed to measure, thereby ensuring that evidence of student learning is both relevant and defensible. Curriculum maps play a critical role in this process by making visible the connections between professional standards, intended learning outcomes, and assessment practices. Such alignment not only supports valid judgments of student attainment but also strengthens program coherence and accountability (Webb, 2007).

**Table 1.** An Overview of the Seven Australian Teaching Standards and Their Domains

Domain of teaching	#	Standard
Professional Knowledge	1.	Know students and how they learn
	2.	Know the content and how to teach it
Professional Practice	3.	Plan for and implement effective teaching and learning
	4.	Create and maintain supportive and safe learning environments
	5.	Assess, provide feedback and report on student learning
Professional Engagement	6.	Engage in professional learning
	7.	Engage professionally with colleagues, parents/carers, and the community

Curriculum mapping in teaching degree programs, based on teachers’ professional standards, is often mandated by government regulatory bodies or discipline-specific professional associations (Holmes et al., 2018). These mappings ensure that students acquire the necessary skills and knowledge to succeed in their future professions (Bravenboer & Lester, 2016; Holmes et al., 2018). For example, in the case of ITE programs in Australia, universities must demonstrate that students have met the APST standards, as defined by the AITSL(2011), to graduate and be eligible for registration as professional teachers.

The APST framework (see Table 1) covers three domains. It provides sufficient flexibility for Australian HE to design different learning and assessment activities within their programs to support learners' attainment of professional standards. The program's accreditation explicitly requires that each course in each year is aligned with the APST, noting how each specific standard is taught, practised, and assessed. Collectively, all seven standards are addressed and assessed across the entire program (coursework and placements), with appropriate sequencing to support attainment by graduation. While this study specifically focuses on assessing students' attainment of the APST, the curriculum analytics method presented in this paper is framework-agnostic. It can be applied in any country that defines professional standards for teachers.

## 2.2. Challenges of Professional Standard Measurement

The measurement of students' attainment of professional standards is more complex than more traditional measures of content-based knowledge (Joksimović et al., 2020) and has therefore often been ignored. In the absence of objective methods, some research initiatives have relied on self-assessment surveys to gauge students' development of these professional standards (Hudson & Grove, 2009; Kałke et al., 2022, among others). This practice is also prevalent in ITE programs, whereby the measurement of latent teaching constructs (in our case, the seven teaching standards listed in Table 1) has predominantly relied on surveys. For example, Hudson and Grove (2009) implemented a pre-test/post-test study design to investigate how second-year pre-service teachers perceived their development toward teaching standards. The study relied on an introspective survey based on the Queensland College of Teachers' professional standards. Similarly, Kałke et al. (2022) developed and evaluated a teacher professional competence assessment questionnaire based on the knowledge, skills, attitudes, and competencies defined in Latvia's Teacher Professional Standards. In another study, Sweeney and Nielsen (2017) piloted an assessment rubric to facilitate pre-service teachers' self-reflection on their professional development and classroom readiness. The authors outlined three levels of professional proficiency (novice, emerging, and intermediate) to differentiate among pre-service teachers who required distinct levels of intervention and support. While these and similar studies demonstrate the usefulness of the proposed tools (e.g., questionnaires) for self-assessment, the issue of subjectivity remains. There is a need for alternate approaches that are more objective and scalable, and capture the development and progression of the professional standards beyond binary outcomes of *achieved/not achieved*.

There are broader concerns regarding the measurement of professional standards in HE that are particularly important for this study. First, there is a disconnect between what is being measured and reported as learning outcomes, on the one hand, and what relevant stakeholders expect students to have achieved upon graduation, on the other. While many HE degree programs focus on the development and evaluation of content-based knowledge, which constitutes the conceptual foundation of the discipline in which learning occurs (Barnett, 1994), certain disciplines, such as engineering, ITE, or health sciences, integrate skill-based assessments more explicitly. However, within these disciplines and more broadly, tensions tend to persist between what is currently being communicated about graduates' achievements in academic programs (often reduced to the level of attainment of content-based knowledge), the expectations of HE institutions of their graduates, and the external standards set by professional organizations (Ajjawi & Boud, 2023). While GPA, as a measure of academic success, is widely accepted, the extent to which it fully captures the nuances of students' attainment of professional standards remains unexplored. Empirical evidence highlights the complexity and variability inherent in learners' competency development, underscoring that this process rarely follows a linear or uniform trajectory (Barthakur, Jovanović et al., 2024). Addressing this alignment issue is particularly critical to adequately supporting students in HE, especially in disciplines where professional preparedness depends significantly on practical, transferable competencies.

The second issue stems from HE institutions often failing to properly integrate program-level considerations into the curriculum mapping process, which affects how students' achievements are evaluated and reported (Armatas & Spratt, 2019). The lack of alignment between assessments and overall program objectives stems from the tendency to define assessments and learning outcomes within a comparatively narrow course context (Fielding & Regehr, 2017; Ruge et al., 2019). Assessment planning, execution, and communication often occur within the scope of individual courses, without sufficient alignment with the other courses in the same study program or with the broader intended learning outcomes of that program (Charlton et al., 2022). There is often inadequate communication of learning outcomes across courses and of how students build on their knowledge and skills as they progress through a study program. It is often unclear how their achievements within individual courses contribute to the development of the overall intended set of capabilities, academic knowledge, or professional standards they are expected to have upon graduation. Finally, the course-level considerations lead to a lack of understanding of the longitudinal development of these standards.

## 2.3. Existing Approaches for Professional Standard Assessment

There have been several prior attempts to measure students' attainment of professional standards beyond self-reported surveys. Different forms of evidence, such as digital credentials, have been proposed to comprehensively and transparently represent and recognize learning achievements (Ajjawi & Boud, 2023; West & Cheng, 2022). However, due to difficulties associated with their integration into the ecosystem of HE, their use has been largely limited to informal and non-formal educational settings (Varadarajan et al., 2023).

Innovative curriculum designs have also been used to both develop and assess specific professional standards. For example, by adopting a constructivist approach, Lator et al. (2015) introduced a portfolio-based assessment in a course on assessment within a teacher-training degree program. The students were required to reflect on their learning and to engage in learning tasks that replicated authentic professional scenarios, that is, to take on the role of assessment designers, markers, and self- and course-evaluators. While this and similar initiatives aimed at creating an authentic experience for the development and (formative) assessment of professional competencies are well-accepted and appreciated by students, they are still far from being broadly adopted in HE (Cañadas, 2023). Therefore, there is a need for more automated and scalable approaches to measuring students' attainment of professional standards in HE.

Distinct and scalable curriculum analytics (Dawson & Hubball, 2014) techniques have been proposed as viable alternatives for measuring the attainment of professional standards. These studies have relied on curriculum-related data and assessment grades to evaluate professional competencies. For instance, Shtymak et al. (2020) introduced a method that uses fuzzy sets and rules to determine the levels of professional standards among HE graduates, building upon their assessment scores. Though the approach holds promise, the authors did not report on its effectiveness. Motivated by the need to quantify attainment of professional standards based on students' assessment grades, Barthakur, Jovanović et al. (2024) proposed a curriculum analytics approach that combined Cognitive Diagnostic Models (CDM; Rupp & Templin, 2008) and learning analytics to estimate seven graduate attributes across an entire ITE degree program. The authors demonstrated the application of CDMs to measure the development of Graduate Attributes in an ITE program. They identified four different groups of learners demonstrating distinct patterns of competency development. However, their study focused on measuring graduates' general capabilities and did not address the development of professional teaching standards. Therefore, there is currently a lack of understanding of how graduates acquire teaching standards and how curriculum analytics approaches can facilitate scalable, automated assessment.

### 3. Research Questions

The above literature review highlights that, while HE maps professional standards to the curriculum for accreditation purposes, the extent to which students attain these standards is rarely systematically measured and reported. To address this gap and enable semi-automated, objective assessment of students' professional standards, the current study aims to advance HE assessment practice by enabling measurement of students' attainment of these standards. To that end, we rely on a systematic curriculum mapping between assessment objectives defined in the curriculum and requirements defined in teacher professional standards (the mappings were validated in our previous study, Barthakur, Kovanović et al., 2024). Using this curriculum mapping and the students' assessment grades as its inputs, the current study employs a curriculum analytics methodology to investigate the measurement and representation of learners' attainment of professional standards in an ITE program. In particular, this exploratory study is driven by the following research questions:

**RQ1:** How can curriculum analytics measure learners' attainment of professional standards?

The literature also suggests that learners' competency attainment (development) is complex and non-linear, shaped by several factors. It is also unclear to what extent GPAs capture this attainment. Thus, the following two research questions are designed to investigate distinct patterns and the relationship between GPAs and the attainment of professional standards.

**RQ2:** What are the common patterns of professional standard attainment?

**RQ3:** How well does a student's GPA relate to their standards profile? Does the latter allow for a more nuanced distinction in the attainment of professional standards?

By investigating these questions, we aim to examine the efficacy of the proposed curriculum analytics approach in providing a holistic representation of the students' attainment of professional standards and identifying areas requiring further development.

### 4. Methods

#### 4.1. Study Contexts

Assessment grades of pre-service teachers from an ITE program at a large Australian public university were collected for analysis. The investigated ITE program is a four-year honours degree that requires learners to develop and demonstrate seven teaching standards across three domains of teaching as defined in the APST framework (AITSL, 2011) (see Table 1). These standards cover different aspects of professional preparedness and require learners to demonstrate them to complete the ITE program. For accreditation and quality assurance purposes, curriculum developers and course and program directors within the university were required to map their teaching and learning activities and assessments to the seven standards. This mapping was used in our analysis (see Table 2).

The performance of all enrolled students was evaluated across standards 1–4 (Table 1). The remaining standards (5–7) were assessed based on students' performance in professional experience courses and two regular courses within the study

program, primarily reported as overall assignment grades and GPAs. The former group of assessments used binary grading (non-graded: pass or fail), and because students were allowed multiple attempts, the vast majority (94%) eventually passed the assessments and the courses. Regarding the latter assessment group, the grades on these two assessments across the two courses showed little to no variability in learners’ performance. Therefore, Standards 5–7 were excluded from analysis.

**4.2. Data Analysis**

A total of 15 core courses, from a maximum of 24 core and elective courses, were included in the study. The program’s elective courses comprised any university course that contributed to specialist knowledge (e.g., the specialization in Health and Physical Education) and might not have directly contributed to the ITE. The elective courses are not mapped onto the professional standards during the accreditation process and were not considered in our analysis. A total of 31 assessments out of 43 assessments from the 15 (core) courses were mapped to the standards. Of the 31 assessments, ten were allocated to the professional experience courses to measure Standards 5–7 and were graded on a binary pass/fail basis. Because each assessment can be mapped to more than one standard (Table 2), the pass/fail grade does not directly correspond to any single standard. Hence, a total of 21 assessments were included in our study. Student assessment grades were collected from the cohort of 178 learners who commenced the ITE program in 2019 and completed all core courses by the end of 2022. The numerical grades for these learners on 21 assessments were converted into five ordinal levels based on the university’s grading system—49 and below: Fail (F), 50–64: Pass (P), 65–74: Credit (C), 75–84: Distinction (D), and 85 and above: High Distinction (HD). These grade conversions were done to prepare the data for the psychometric model (described below) used to calculate attainment of the professional standards.

**Table 2.** Mapping Between the Assessments and the Teaching Standards

Assessment	Standard 1	Standard 2	Standard 3	Standard 4
1A_Cont Assessment	0	1	0	0
1A_Pamphlet	0	1	0	0
1A_Project	0	0	1	0
1B_Presentation	0	0	0	1
1C_Play Plan	0	0	0	0
1D_Presentation	0	1	1	0
1D_Report	1	0	0	0
1E_Assessment 1	0	0	1	0
2A_Research Folder	0	1	0	0
2B_Assessment 1	0	0	0	1
2B_Assessment 2	0	0	1	1
2C_Case Study	1	0	0	0
2C_Project	0	1	0	0
2D_Assessment 1	0	0	0	0
2D_Cont Assessment	0	0	0	0
2E_Assessment 2	1	0	0	0
3A_Assignment 2	1	0	0	0
3B_Case Study	0	0	1	0
3C_Presentation	1	0	0	0
4A_CA Workbook	0	0	0	0
4B_Critical Analysis	1	0	0	0

*Note: Table 2 lists all the assessments used in the study. The assessment names start with an alphanumeric course code followed by the assessment description. The first character refers to the year of study in which the course was delivered, while the second character denotes a particular course in that year. For instance, an assessment 2A\_Research Folder was an assessment in a second-year course, and the research folder refers to the assessment description.*

The mapping between the assessments and the teaching standards of the APST framework (Table 2) was developed by program coordinators and teaching staff for accreditation. The assessment validity and constructive alignment of the mapping between the assessments and the first four standards were checked using item response theory (IRT) models in our earlier work (Barthakur, Kovanović et al., 2024). The IRT models are commonly used to analyze the relationship between latent constructs and responses to assessment items (Wu et al., 2016). In our previous study, IRT was used to provide item (assessment) analysis, including estimates of item difficulty and item discrimination. The models use the same data (assessment grades and mappings

in Table 2) as in the current study to calculate the quality of each item and the extent to which an item can estimate learners’ latent skills. In this study, the revised mapping (see Barthakur, Kovanović et al., 2024) was first examined using a confirmatory factor analysis. The goodness of fit measures (root mean square error of approximation = 0.033, comparative fit index = 0.985, Tucker-Lewis’s index = 0.982, and standardized root mean square residual = 0.059) indicated a good model fit and were well supported by the data (Finch & French, 2015). Therefore, we proceeded with this mapping to calculate learners’ attainment of professional standards.

The first research question (RQ1) was addressed using a psychometric model, namely the generalized cognitive diagnostic model (CDM; Rupp & Templin, 2008), to calculate the probabilities of attainment based on assessment grades. CDMs are diagnostic models that assign learners to multidimensional skill profiles based on their assessment grades. This study opted for CDMs over other latent-variable models, such as IRT or latent factor analysis models, because they provide fine-grained diagnostic information about students’ attainment of latent skills (Rupp & Templin, 2008). We built a CDM model using the mapping between assessments and standards, along with learners’ assessment grades, as inputs. The model’s output provides probabilities (on a scale of 0 to 1) indicating the extent to which the latent constructs (skills or standards) are attained. High attainment (probabilities closer to 1) represents that students have provided evidence of attaining the standard. In comparison, low attainment (probabilities closer to 0) represents that students have not provided evidence of attaining the standard. The labels “higher” and “lower evidence of attainment” refer to *relative* differences among students inferred from latent learner profiles of assessment outcomes; they should not be interpreted as determinations that a student has satisfied all focus areas within a Standard or achieved capability beyond the APST *Graduate* level.

The model also provides a categorization of learners into 2n groups, where n indicates the number of latent constructs. In our case, latent constructs are the four standards (Table 1), and the model would provide 16 learner groups. However, investigating 16 groups of learners and identifying meaningful differences in their attainment of teaching standards would be difficult. Also, the exponential increase in learner groups as these latent constructs (i.e., the number of standards) grow would make it a formidable task for instructors to incorporate this information into their instructional strategies, provide pedagogical support, or improve learning experiences for future cohorts. Therefore, we adopted a hierarchical clustering algorithm to group learners and provide meaningful interpretations of the variations in learners’ attainment of the professional teaching standards (RQ 2). We used a dendrogram and a silhouette plot to determine the number of learner groups and visualize the clusters, thereby enhancing our understanding of the groups. The analysis was done in R using the CDM package (George et al., 2016) and cluster package (Maechler et al., 2013).

To address the third research question (RQ3), we conducted a one-way analysis of variance (ANOVA; Field et al., 2012) to determine whether the mean GPAs of the different learner groups differed significantly. The ANOVA analysis was followed by the post hoc Tukey test to detect pairwise differences in GPAs among students in distinct learner groups (i.e., clusters obtained in addressing RQ2). This analysis compared the mean GPAs of two groups at a time and indicated if there were any statistically significant differences. The ANOVA and Tukey’s analyses were implemented using the built-in aov and Tukey functions in R, respectively.

Ethics approval was obtained from the university where the data were collected and analyzed. The ethics application ID number is 205808.

## 5. Results

### 5.1. Assessing Students’ Attainment of Professional Teaching Standards

To address the first RQ, we implemented a CDM using assessment grades across all courses in the ITE program, along with the mapping between assessments and the teaching standards (Table 2). The model output included probabilities of attaining the teaching standards, as illustrated in Table 3. For instance, student #1001 had a high probability of attaining Standard 1 and Standard 3, while demonstrating low attainment in the other two standards. Student #1002 and student #1004 had higher probabilities of attainment across all four standards, while student #1003 had low attainment across all four standards. The average level of attainment for Standard 1 was 0.86 (*SD* = 0.33), Standard 2 was 0.59 (*SD* = 0.43), Standard 3 was 0.68 (*SD* = 0.40), and Standard 4 was 0.50 (*SD* = 0.42).

**Table 3.** An Example of CDM-Based Estimation of Learners’ Attainment of the Teaching Standards

Student ID	Standard 1	Standard 2	Standard 3	Standard 4
1001	1.00	0.10	0.98	0.03
1002	1.00	1.00	1.00	0.96
1003	0.03	0.00	0.01	0.00
1004	1.00	0.98	1.00	0.96

### 5.2. Identifying Learner Groups and Distinct Patterns of Standards Attainment

To analyze the different groups of learners based on standards attainment and support decision-making, we identified latent groups using a hierarchical agglomerative clustering algorithm based on the probabilities of attainment across the four standards. The dendrogram (Figure 1) and the silhouette analysis (silhouette widths were 0.67, 0.57, 0.65, 0.52, and 0.30, respectively) suggested five groups of learners with distinct patterns of standard attainment.

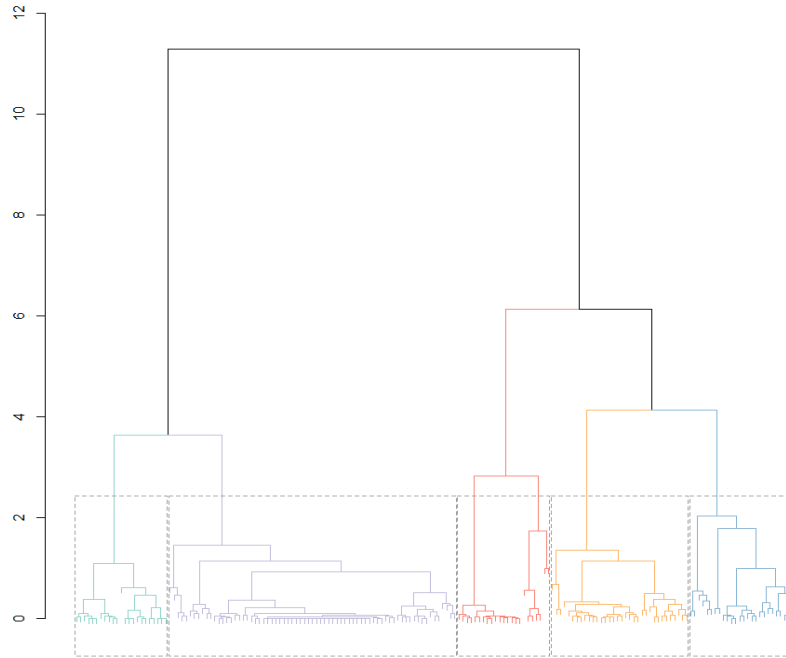


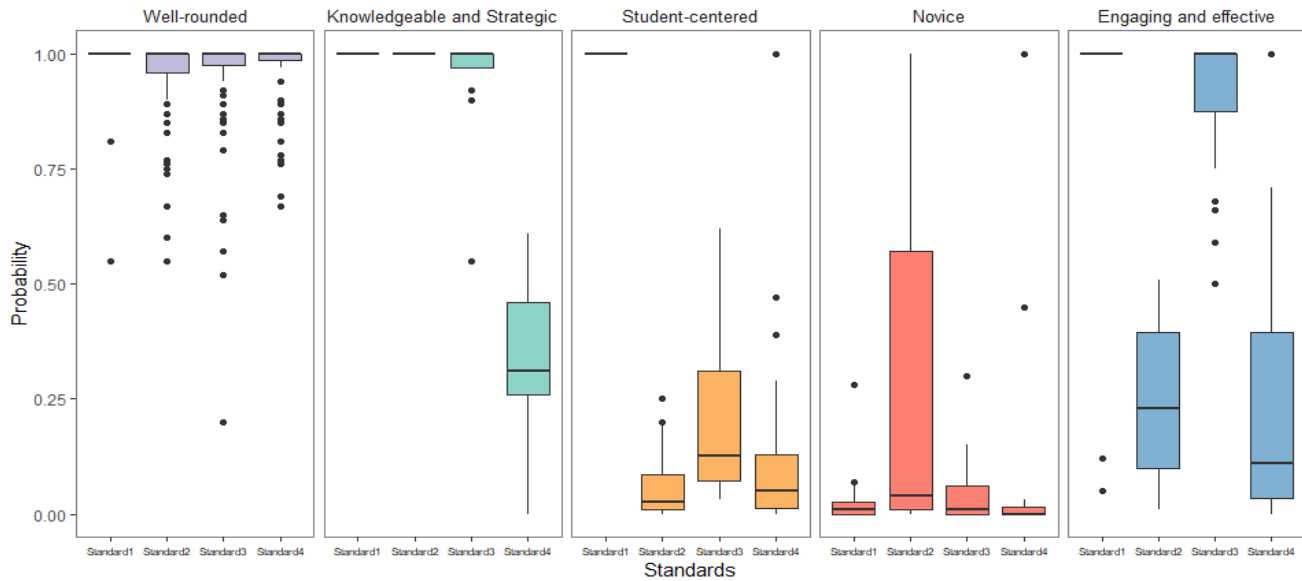
Figure 1. Clustering Dendrogram Plot

Table 4. Average (Standard Deviation) Attainment of the Standards by Students in Different Clusters

Cluster	Standard 1	Standard 2	Standard 3	Standard 4
Well-rounded	0.99 (0.058)	0.95 (0.110)	0.94 (0.135)	0.96 (0.084)
Knowledge and Strategic	1.00 (0.000)	1.00 (0.000)	0.96 (0.096)	0.34 (0.190)
Student-Centred	1.00 (0.000)	0.06 (0.065)	0.19 (0.164)	0.12 (0.191)
Novice	0.03 (0.059)	0.29 (0.432)	0.04 (0.072)	0.11 (0.295)
Engaging and Effective	0.93 (0.244)	0.24 (0.165)	0.90 (0.152)	0.24 (0.284)

Based on the cluster analysis (Figure 2, Table 4) and using the definition of the teaching standards (Table 1), we labelled the clusters to aid our understanding and interpretation of the different latent learner groups:

- **Well-rounded** (71 learners): This group was by far the largest one. Overall, learners in this group demonstrated high levels of attainment across all four standards.
- **Knowledgeable and strategic** (23 learners): This group of learners demonstrated high attainment across the first three standards but lower attainment in the standard on creating and maintaining a safe learning environment (Standard 4). While this group is very similar to well-rounded learners, there is potential for future growth in creating a supportive and safe learning environment.
- **Student-centred** (34 learners): While learners in this group had a strong command of concepts related to knowing their students (Standard 1), the majority had low levels of attainment across the other three standards.
- **Novice** (23 learners): Learners in this group demonstrated low attainment across all four teaching standards. However, there was some variation in the attainment rate for understanding the content and the teaching strategies.
- **Engaging and effective** (27 learners): This group of learners demonstrated higher attainment levels across the first and third standards, which focus on knowing learners and planning effective teaching and learning, respectively. At the same time, these learners demonstrated low attainment in knowing their content and maintaining supportive learning environments.

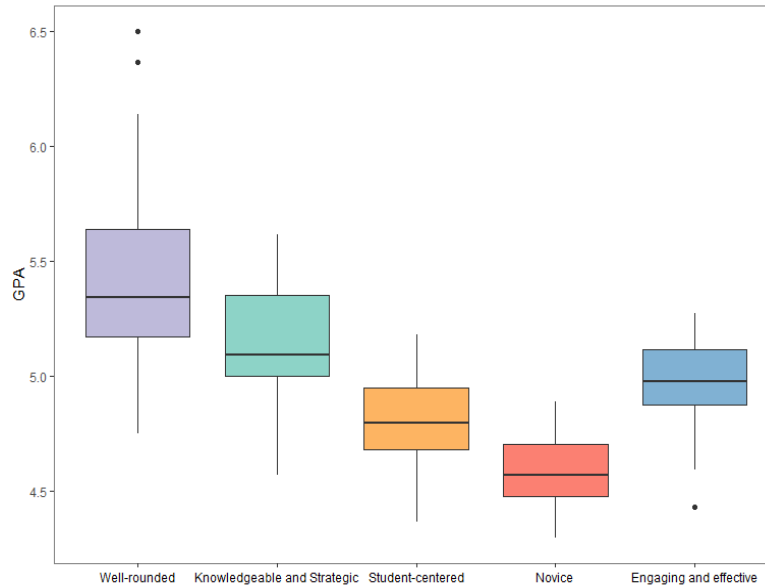


**Figure 2.** Cluster Representations Based on Learners' Attainment of the Standards

*Note: The figure shows the distribution of the probability of standard attainment for learners across the different clusters.*

### 5.3. Relation of Students' GPA and Their Attainment of Professional Teaching Standards

The final analysis in this work investigated the relationship between learners' program GPA and their attainment of the teaching standards. A comparison of GPA distributions across the five distinct learner groups (Figure 3) suggests that the groups differ significantly in their average GPAs. For instance, the Well-rounded group had the highest average GPA, while the Novice group had the lowest. There was a significant difference in GPAs at the  $p < 0.05$  level for the five learner groups,  $F(4, 173) = 51.44, p = 0.000$ .



**Figure 3.** Distribution of the Average Program-Level GPA of Students Across the Five Clusters

To investigate differences between group pairs, a post hoc Tukey's test was conducted. The plot presented in Figure 4 is a graphical representation of the results of Tukey's analysis and can be interpreted as follows: if the result of a pairwise comparison crosses the vertical dotted line (the zero line), the result is not significant (denoted by the red lines), meaning that there is no difference in average GPA between the two groups; otherwise, average GPAs of the two compared groups do differ. Specifically, the following three group pairs do not differ in GPA: a) the **Engaging and effective** group and the **Knowledgeable and strategic** group, b) the **Novice** group and the **Student-centered** group, c) the **Engaging and effective** group and the **Student-centered** group.

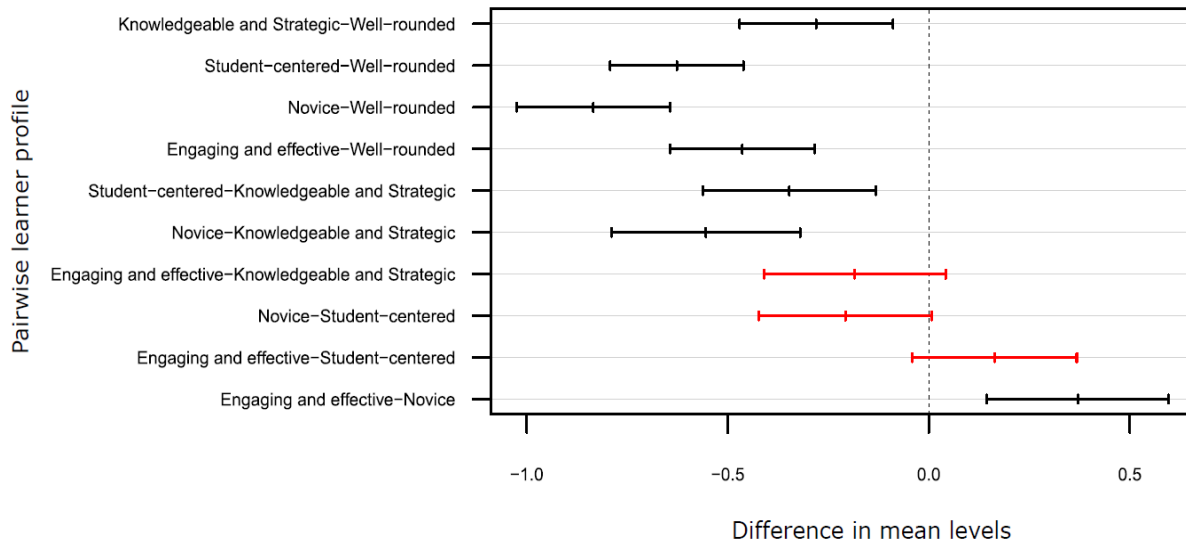


Figure 4. Tukey's Analysis

Note: Pairwise comparison of the average GPA of the different groups of pre-service teachers.

## 6. Discussion

Assessing graduates' attainment of professional standards is an important yet complex and challenging process. The ability to measure and gauge student progress and attainment of professional standards is particularly important in the context of professionally oriented programs, such as teaching and nursing. In professional programs, graduates are assessed and supported in developing capabilities established by external professional bodies, which are required for registration and, consequently, employment. Read through a CBE lens, professional standards function as explicit competency statements and performance expectations; they support criterion-referenced judgments and mastery-based progression rather than time-based accumulation (Frank et al., 2010; Gervais, 2016). Hudson and Grove (2009) noted that university coursework and related assessments can serve as indicators of attainment of professional standards. Accordingly, our study contributes to quantifying and scaling the measurement of the student's attainment of professional standards by taking a program-level consideration of the assessments and operationalizing these into professional standards that learners need to demonstrate upon completion of the degree program. It is also important to note that the choice of focus does not imply that profession-specific standards are more important than generic competencies; both are important and merit work.

We demonstrate our curriculum analytics approach by using assessment grades from an ITE program at a large public university in Australia. To provide a comprehensive interpretation of how pre-service teachers were performing across the standards, we identified five latent groups (clusters) based on their estimated levels of standards attainment. We have also validated our approach through a comparative analysis of the five latent learner groups based on their average GPAs. The findings indicate that the latent groups are consistent with the GPA data. It is important to note that several nuances and variations in the learners' attainment of the standards were not adequately captured by their GPAs. Our methodology is domain-agnostic and can be generalized and extended to other programs that establish a link between assessments and professional standards or general competencies (as shown in Table 2). This is also evident in Barthakur, Jovanović et al. (2024), who used a similar methodology to measure generic graduate qualities across courses of an HE degree program.

### 6.1. Assessing Students' Attainment of Teaching Standards and Identifying Distinct Patterns

Our study findings echo those of the existing LA study by Barthakur, Jovanović and colleagues (2024) and demonstrate that the largest of the five pre-service teacher groups achieved **Well-rounded** attainment. This is evidenced by the high levels of success across the four professional standards and is similar to the CBE's *competent* or *ready to practise* profile (Frank et al., 2010). Conversely, a small group of students, termed **Novice** learners, demonstrated limited attainment of the standards. The second-largest group of pre-service teachers, the **Student-centred** group, were well acquainted with the standards related to *knowing their students and what they know*. However, this group also demonstrated below-average performance across the other program standards and components. The remaining two groups, namely the **Knowledgeable and strategic** group and the **Engaging and effective** group, exhibited varying degrees of proficiency in both professional knowledge and practice. Notably, these two groups demonstrated disparate attainment levels across *Standard 2—Know the content and how to teach it*. According to Baumert et al. (2010), the significance of teachers' content knowledge directly influences instructional quality and, subsequently, student progress. Therefore, identifying these distinct attainment patterns is crucial and aligns with CBE's emphasis on targeted interventions that specifically address the diverse learning needs of each group.

The majority of pre-service teachers clustered into the **Well-rounded** group, demonstrating high attainment across all professional standards. This group relates to the graduate level defined by Sweeney and Nielsen (2017), who are capable of planning and carrying out complex teaching responsibilities, attending to diverse student needs, and demonstrating comprehensive classroom readiness. This result suggests that this professional degree program likely develops broad capabilities, at least among this subset of learners, enabling them to transfer their learning and succeed as in-service teachers. In contrast, **Novice** pre-service teachers possess limited subject-matter knowledge and basic skills, requiring guidance to implement effective teaching strategies (Sweeney & Nielsen, 2017). Comprehensive support can facilitate the acquisition of essential skills, knowledge, and pedagogical practices, enabling them to deliver effective instruction and cater to diverse students' needs. The other three groups—**Student-centred**, **Knowledgeable and strategic**, and **Engaging and effective**—resemble the emerging level in Sweeney and Nielsen's (2017) study; students in these groups have demonstrated higher proficiency in certain aspects of their professional development while lacking significantly in others.

The study's findings align with existing LA research (Barthakur et al., 2024) that reports learners' varying patterns of attainment across different graduate capabilities. Our results similarly indicate non-uniform attainment across the four standards. Specifically, except for the **Novice** group, the rest of the students mastered *Standard 1—Know students and how they learn relatively easily and demonstrated high levels of attainment*. Conversely, attaining Standard 4—Create and maintain supportive and safe learning environments—proved more challenging for the students. Clapper (2010) argued that developing and articulating professional practice associated with creating safe learning environments is more complex and nuanced. An alternative or complementary explanation may lie in how well the standards are scaffolded and covered throughout the program. In Barthakur, Jovanović et al. (2024), we noted a significant discrepancy in the distribution of standards-related assessments throughout the program. This observation reinforces our earlier assertion that assessments in HE courses are rarely evaluated cohesively across the entire curriculum, which, as indicated by Dawson et al. (2023), leads to suboptimal learning outcomes. Henceforth, our previous study provides empirical evidence of inadequate curriculum mapping and underscores the necessity for more rigorous, analytics-based methodologies to enhance this traditionally manual process (Barthakur, Kovanović et al., 2024). Such improvements are vital for fostering more effective educational programs to better support and prepare students in their respective professions.

## 6.2. Association of the GPA With the Latent Learner Groups

The extant literature argues that GPA is a reliable indicator of academic performance and a valid measure in the admissions process for educational institutions (Soh, 2010). We show that the average program GPA of the **Well-rounded** and **Novice** groups aligns with their attainment of professional teaching standards. However, the intricate nuances of attaining the professional standards for the other three groups were not adequately captured in their GPAs. The three groups demonstrated distinct and varying levels of attainment across the four professional teaching standards.

Academic scores or GPAs are very limited in their ability to predict learners' success and progress beyond the classroom (Edwards & Edwards, 1999; Paek et al., 2021) and to serve as a measure of employability suitability. Reliance on a single grade measure can be misleading about a student's abilities and future capabilities (Paek et al., 2021). Our findings complement GPA and allow for more nuanced measurement, representation, and communication of academic success. For instance, when the attainment of teaching standards differed significantly between two groups of learners (such as the **Well-rounded** group and the **Knowledgeable and strategic** group), the corresponding GPAs also differed significantly. However, when there were subtle differences in the attainment of standards (such as between the **Novice** group and **Student-centred** groups), there was no corresponding differentiation in GPA, but the latent groups identified by our method did capture those differences.

We argue that the current study, therefore, provides a step towards the development of learner profiles. The findings support the recommendations of other LA researchers (Barthakur et al., 2023; Dawson et al., 2023), who argued for a shift from assessment-centric evaluations to a more development-oriented mindset that encompasses a broader spectrum of learner capabilities. While Dawson et al. (2023) discuss new conceptualizations of assessment in relation to feedback, this study advances that perspective by advocating for programmatic assessments that capture a holistic representation of a graduate's employability readiness. Adopting a holistic representation can address some of the critical views and the prevailing scrutiny of the quality of graduates from ITE programs (Bourke & Ryan, 2023) and further enhance transparency in the evaluation process. Embracing a more holistic approach to learner evaluation can also help instructors tailor instructional strategies and support systems, ultimately fostering a learning environment conducive to individual growth and development.

## 6.3. Limitations and Future Work

Multiple limitations constrain the current study and its findings. First, we were unable to include assessments that measure all the standards, and more specifically, we left out assessments for the final three standards (for the reasons stated in the Methods section). Hence, we cannot provide a complete representation of the learners' professional preparedness and the abilities required to be successful in-service teachers. However, as we have demonstrated throughout the paper, by even considering four standards, we can provide a richer picture of students' standards attainment than a simple GPA score or individual assessment grades. Secondly, our study analyzed the attainment of professional standards for a single learning cohort. Related

to this is the limited sample size ( $N = 178$ ), which may further affect the generalizability of our results. Therefore, to establish generalizability, we need to analyze the assent grades and attainment of the standards in the future offerings of the degree program, as well as in other programs. The third limitation stems from variability in the number of assessments per standard, arising from the mapping process described in the Methods section. This variation may have influenced the attainment probabilities calculated across standards for all learners.

Furthermore, due to the constraints of the program's curriculum design and assessment structure, specifically, how certain courses and assessments were graded and mapped, assessments from the elective courses were not included. As discussed in detail in the Methods section, the decision to focus on the core courses and exclude the pass/fail or unmapped assessments was necessary given the program's requirements, but it may have omitted potentially valuable information. Additionally, we categorized the numerical scores into discrete grades. While this is necessary to fit the CDM model, we must acknowledge that there is an information loss associated with such a data transformation. Fifth, our methodology relies on the curriculum map developed by the HE administrators and academics. While realistically, updates to these mappings are expected to be minor and less frequent (given that regulatory bodies need to approve the changes), any changes in the mapping would require the model to be re-run. Finally, while our study takes a program-level approach to the assessments and operationalizes the four professional standards at the study program level, there is an opportunity to evaluate these standards at the level of each year of the degree program. This could allow instructors and program coordinators to monitor students' progress toward the standards and provide adequate support. Additionally, systematic mapping of assessments to focus areas and criteria-referenced rubrics calibrated to the seven APST standards, while out of scope for the current study, can provide more fine-grained information about learners' preparedness as teaching professionals and is a valuable direction for future work.

## 7. Implications and Conclusions

The official representation and recognition of students' learning achievements in the HE context are currently reliant on GPA and associated course transcripts (grades) and often focus on representing students' content-based academic performances (Ajjawi & Boud, 2023). While these are credible measures of students' academic success, little is often communicated about graduates' job readiness. While some previous work used pre-/post-test measures to evaluate graduates' professional standards, the analytics-based approach presented in this study offers a viable solution to address these limitations. By mapping assessment results to specific professional teaching standards, the presented curriculum analytics approach complements the conventional forms of recognition. It provides a more holistic representation of individuals' professional development levels. Qualitative approaches (such as focus groups or interviews to gauge students' understanding of the different standards) and teacher evaluations (supervisor ratings and artifacts explicitly aligned to focus-area descriptors) can offer an alternative and complementary perspective, providing a more nuanced understanding of the patterns of standards attainment.

Furthermore, our methodology can be linked to the emerging concept of digital credentials, enabling a more comprehensive and granular representation of students' capabilities and achievements. Additionally, in future work, the use of generative AI can aid in transforming the attainment of professional standards (as illustrated in Table 3) into textual summaries more suitable for human interpretation. Such advancements have practical implications for academic pursuits, including facilitating the transferability aspect of the student's achievements among different systems.

Program coordinators and managers in HE institutions can benefit from the presented standards-based learner profiles (Barthakur et al., 2023). These profiles, identified in our current study, offer valuable insights into the attainment of pre-service teachers' professional standards within the ITE program. In future offerings of the degree program, the methodology can be applied to calculate students' attainment of standards at any specific point in their program (e.g., Semester 3) using assessment mappings and grades attained before that point, and matching them against the five identified profiles. Such information enables targeted interventions and adjustments to the curriculum and pedagogical strategies, enhancing the program's ability to prepare pre-service teachers for the demands of the modern workforce. There are also opportunities to provide personalized, targeted support to the learners based on their profiles rather than merely auditing them. For instance, learners in the **Knowledgeable and strategic** group can be provided with more opportunities to develop and demonstrate their capabilities in creating and maintaining safer learning environments (Standard 4). By understanding students' performance in relation to specific professional standards at the program level, HE administrators (coordinators and managers) can engage in reflective practices to assess the effectiveness of the ITE study program. Appropriate interventions at the curriculum level can be implemented (e.g., in response to an increase in the number of students with "low-achievement" profiles). The proposed approach facilitates evidence-based decision-making, enabling more informed discussions of curricular improvements and alignment with external mandates and professional regulatory bodies. This study thus provides an opportunity to streamline quality assurance and accreditation processes at scale. Specifically, the presented approach provides program directors and educators with a strong empirical foundation for clearly examining program quality and adherence to professional standards. The use of learning analytics-based approaches can lead educators to engage in more data-informed practices. In turn, this can

foster an environment of continuous improvement that ensures programs not only meet but also inform the further advancement of standards of professional practice.

## Declaration of Conflicting Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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