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ORIGINAL PAPER

Accounting for preservice teachers' constructivist learning environment experiences

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Abstract The article reports the findings of a study conducted to inform a teacher preparation program of the extent to which they were providing students with experiences consistent with the program goals. The Constructivist Learning Environment Survey (CLES) was administered three times to participants in a 1-year program for graduate students seeking licensure in mathematics and science. These data were compared to program course syllabi and participant reflections to generate an *account of institutional practice*. From this account, observations about the program and a subsequent hypothetical learning trajectory were generated. It is recommended that the program find additional ways to explicitly integrate constructivist learning environment components into coursework and field experiences, specifically in the area of Critical Voice. Furthermore, the program should continue to structure programs components differently for mathematics and science and continue to offer a year-round field experience.

Keywords Constructivism · Learning environment · Mathematics education · Mixed methodology · Program evaluation · Science education · Teacher preparation programs

Introduction

What does it mean to say that a teacher preparation program is successful? How can a particular program gauge its own level of success? There are many types of measures that could potentially address these questions. A simple analysis of successful job placement of graduates might be one place to start. Depending on how one defines successful job

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placement, this seemingly narrow analysis might need to take into account the type of jobs that the graduates are doing, whether they are doing well in their placements, and how long they actually stay in the teaching profession. Initially simple measures quickly become more complex and perhaps too complex to be useful. Another way to quantify 'success' might be to look at teacher preparation program accreditation results from organisations such as the National Council for Accreditation of Teacher Education (NCATE). However, in the same way that no single assessment that can measure all of the abilities of a particular child, most institutions would agree that the NCATE accreditation process does not tell the entire story of a particular program. Additionally, simple questions of what works best are inappropriate tasks for the field of education research (Schoenfeld 2000). The complexity of the contexts and the processes in teacher preparation mean that new program evaluation tools are needed to replace simple measures such as job placement rates and accreditation results.

Teacher preparation programs that involve preservice teachers in becoming 'reflective practitioners' and constantly 'inquiring into their own practice' have shown great promise in the development of new teachers (Cochran-Smith and Lytle 1999; Schon 1987). It seems clear that the same process of inquiry and reflection would benefit the programs that prepare these teachers. A teacher preparation program that is truly attempting to improve and develop should reflect on and inquire into its own practice as a way to measure its success. Feiman-Nemser (2000) has argued that the key to success in education is success in preparing good teachers, and has identified the professional learning continuum from initial preparation to the early years of teaching. When asked to identify the characteristics of an effective teacher preparation program, Feiman-Nemser cites *conceptual coherence* as the primary component of any such program. Conceptual coherence means that an institution establishes a clear conceptual framework around which all pieces of the teacher preparation program are assembled. The impact of a coherent conceptual framework can be seen in the way in which courses are designed, the type of professional culture that is presented, and the types of pedagogical and assessment choices that are made by staff. Lastly, Feiman-Nemser points to the program's conceptual framework as one tool for gauging 'success'.

Statement of the problem

Considering that the conceptual framework can be the most important characteristic of a teacher preparation program, institutions face a unique challenge when developing this framework. Professional preparation programs are simultaneously attending to the learning of the adult student (the preservice teacher at the university) and the young student (the child in the field). The complexity of these tasks points to a need for identifying a theory of learning that is relevant for learners of a variety of ages, learning a variety of subjects, and learning in a variety of environments.

Another challenge faces the teacher preparation program and distinguishes it from other types of professional learning environments. Unlike most professions, students in education programs arrive with significant experience (12–15 years) in watching 'experts' in action. This 'apprenticeship of observation' means that teacher candidates enter the university with significant preconceptions about what it means to be an effective teacher and a learner (Grossman 1990; Lortie 1975). During this apprenticeship of observation, preservice teachers might have developed strong preconceptions about teaching, and watched significant amounts of instruction that did not facilitate the types of teaching called for by

education reform (National Council of Teachers of Mathematics [NCTM] 2000). Even though preservice teachers might not have had direct instruction in how to teach during their previous schooling, informal apprenticeships that lack explicit instruction can still lead to significant learning and ideas about what it means to be a master practitioner (Lave and Wenger 2006). In light of these constraints, teacher preparation programs must develop a conceptual framework that attends to both adult and child learning, while accounting for the pre-conceptions of the teacher candidates.

As teacher preparation programs staff struggle to identify a conceptual framework that meets the challenges outlined above, preservice teachers must also negotiate their new positions while balancing the potentially mixed signals that they are receiving from their coursework and field experiences (Guyton and McIntyre 1990). Preservice teachers often view their field experiences as the most valuable part of their preparation (Feiman-Nemser 2000; Guyton and McIntyre 1990). However, the realities of placing large numbers of preservice teachers each year into field experiences mean that university personnel cannot always be selective in the choice of placements. As a result, many preservice teachers cannot count on regular opportunities to observe, practice and reflect on the kind of teaching that is advocated in the preparation programs. To further confound the situation, "…cooperating teachers often feel the need to protect preservice teachers from 'impractical' ideas promoted by education professors who are out of touch with classroom realities" (Feiman-Nemser 2000, p. 12). However, it is precisely the explicit integration of coursework and field work that helps preservice teachers to connect theory and practice (Szabo et al. 2002).

Preparation programs must begin to reflectively analyse the experiences that they offer to teacher candidates. This analysis should involve the experiences at the university, as well as those that take place in the field. In order to be reflective practitioners of their own programs, institutions need to ask about the framework around which they structure their program. Based on our framework, is this program a success? How do we measure our success? What data can we collect to support our claims? Finally, how can this inquiry into our own practice inform the program's future?

Purpose of the study

The purpose of this study was to inform a university-based professional teacher licensure program about the extent to which the program components are allowing preservice teachers to experience learning environments that are consistent with their goals. The institution in this study offers a 1-year graduate program that leads to a Master of Science degree and state teacher licensure in mathematics or a science content area for Grades 3–12. This program is offered by a department of science and mathematics education that is housed in a college of science. The instructors who teach the licensure coursework are from three populations: educational researchers who hold doctorate degrees in education; clinical staff who hold Master degrees and have significant experience as K–12 educators; and graduate students with K–12 experience who are currently working toward doctorates in mathematics or science education. Clinical staff and graduate students typically supervise the preservice teachers in their field experiences.

Field experiences occur in K–12 public schools that are in close geographic proximity to the university. The field experiences range from heterogeneous, self-contained elementary school classrooms to tracked, single-subject, secondary school classrooms. A pool of cooperating teachers is repeatedly called upon from year to year to work with the

institution's preservice teachers. Many of the cooperating teachers have built long-term relationships with the department. Each year, new cooperating teachers are also solicited. Additionally, some of the cooperating teachers are graduates of the program.

Preservice teachers entering the teacher preparation program at this institution hold an undergraduate degree in either mathematics or a science-related field. The cohort in this study includes 31 preservice teachers. Six are seeking primary certification in advanced mathematics, 1 in basic mathematics, 14 in Biology, 2 in Chemistry, and 3 in Physics. Approximately half of the cohort entered the program immediately following their undergraduate education, while the others had spent intermediate time working or in other graduate education. Eighteen of the preservice teachers are female, while 12 are males. One preservice teacher speaks English as a second language. During the study, 3 preservice teachers left the program for personal reasons and 1 preservice teacher took a medical leave of absence. One preservice teacher arrived late to the program and was not present for the entire study.

An analysis of the program goals for classroom instruction revealed they were consistent with constructivist theories of learning (Bransford et al. 2004; Fosnot and Perry 2005). The institution in the study does not identify constructivism explicitly in any of the course objectives, but this theory of learning is consistent with the stated goals and course objectives of the program.

Review of the literature

For the institution in this study, Shulman's (1986) conception of pedagogical content knowledge (PCK) was chosen as the conceptual framework around which the program is built. However, for the program, no particular learning theory was chosen. A preliminary analysis of program materials revealed constructivism as consistent with the program goals. Constructivism is a theory of knowing that emphasises that knowledge is actively constructed by the learner as he/she reorganises prior knowledge in the light of new experiences (Bransford et al. 2004; Fosnot and Perry 2005). Rather than representing some isolated body of facts, von Glasersfeld (1995) claims that knowledge represents something that we can do in our experiential world, the successful ways of dealing with the objects that we call physical, and successful ways of thinking with abstract objects. Von Glasersfeld (1995) singles out three essential components of constructivism: (1) learning is dependent on prior knowledge; (2) cognition is aimed at viability; and (3) language is weak as a way to co-construct meaning. These three components are also applicable to teacher learning. Preservice teachers' learning is strongly dependent on their prior knowledge, especially their apprenticeship of observation. Preservice teachers' cognition is aimed at what will be viable to them in the classroom, what they see as 'best practices'. And, finally, language itself is inherently at the centre of any teaching experience.

There have been critiques of constructivism that highlight ways in which it fails to account for the impact that non-cognitive influences, like socioeconomic background, have on learning processes. Specifically, some have argued that any comprehensive learning theory must account for social, historical and cultural influences that affect the learner (Vygotsky 1986; Wertsch et al. 1999). Still others contend that constructivism fails to account for the marginalisation of certain populations and the ability of some cultural and social groups to construct knowledge more effectively in the formal school environment (Boaler 2002).

These non-cognitive influences, including the environment in which learning takes place, can impact on the way in which a person learns (Taylor et al. 1994b). This has led

some researchers to incorporate a critical theory perspective into the constructivist framework (Taylor et al. 1995; Watts and Jofili 1998). Within *critical constructivism*, as this is called, "…cognitive constructive activity of the individual learner occurs within, and is constrained by, a socio-cultural context" (Taylor et al. 1995). Critical constructivism is a social epistemology that addresses the sociocultural context of knowledge construction and serves as a potential representation of cultural reform. Combining radical constructivism with critical theory, this approach focuses on the cultural myths of the classroom that distort social roles and discursive practices. Finally, with critical constructivism, every 'knower' is influenced by his/her own culture and all knowledge is mediated by social experience (Taylor 1996). Most significantly, this theory acknowledges that, while the teacher has the power to design any type of learning experience, the learner always has the power to reject the new information according to constructivist theory. The contradictory nature of the power in this relationship, which involves each agent holding some power, dictates the need for a critical approach to this theory of knowing (Watts and Jofili 1998).

While many educators would agree with the basic tenets of constructivism, a teacher's practice in the classroom does not always correspond to his/her beliefs about student learning (Taylor et al. 1994b). This gap between the theory and its practice is further widened by the notion that constructivism is a theory of learning and not a theory of teaching. However, there are certain pedagogical strategies that can be employed when looking to provide an environment conducive to constructivist learning in which students can succeed (Naylor and Keogh 1999; Taylor et al. 1994b, 1995). Some of these ways to be a 'constructivist teacher' include (1) providing an environment where the individual constructs knowledge, (2) allowing learners the opportunity to conceive a personal understanding of content through exposure and (3) promoting, modelling and engaging students in constructivist learning experiences (Cannon 1995).

In 1995, Taylor et al. identified five components of a critically constructivist learning environment as follows:

1. *Personal Relevance*: the extent to which subject matter (mathematics or science) is connected to students' outside-of-school experiences.
2. *Student Negotiation*: the degree to which opportunities exist for students to explain and justify their ideas, to listen and reflect on other students' ideas, and to reflect self-critically on the viability of their own ideas.
3. *Shared Control*: the extent to which students control, along with the teacher, the learning environment, their own learning goals, design and the management of learning activities, and development and use of assessment criteria.
4. *Critical Voice*: the extent to which a social climate has been established so that students can question the teacher's pedagogical plans and methods, and express concerns about impediments to their learning.
5. *Uncertainty*: the amount of opportunities that are provided for students to experience subject knowledge as arising from theory-dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally and socially determined.

Taylor et al.'s (1995) framework for constructivist learning environments has been utilised by a number of educational researchers. Constructivist learning environments have been shown to have a strong connection to student achievement (Dorman et al. 2002) and to have a strong influence on curriculum choices (Bukova-Guzel and Alkan 2005; Chang 2006). The previously mentioned studies focused on the perceptions of student learners in the classroom. Other work has looked at the perceptions of the teacher and adult learner

Table 1 Mapping of program standards to constructivist categories

Components of constructivist learning environments	The institution's corresponding program standard
Personal Relevance	4.0 Students as learners, cultural diversity and exceptionalities
	9.0 Curriculum
	10.0 Social context
Student Negotiation	11.0 Reflection
Shared Control	3.0 Inquiry and problem solving
	7.0 Assessment
Critical Voice	5.0 Pedagogy
	6.0 Learning environments
Uncertainty	1.0 Content/subject matter
	2.0 Nature of science and nature of mathematics

regarding constructivist learning environments (McClure et al. 2000; Nix et al. 2005). This body of work has served to validate the variety of uses of this framework and point to its usefulness in a wide range of situations.

This framework for constructivist learning environments has been applied to a variety of research contexts. However, it seemed necessary to judge the framework's appropriateness to this particular institution's program. To further ascertain the suitability of this framework to the particular teacher preparation program in this study, the standards directing the professional teacher education program were mapped to the components of a constructivist learning environment. Table 1 illustrates how 10 of the 12 program standards address the spectrum of categories identified as promoting critically constructivist learning.

For example, Standard 6.0 Learning Environments reads: "The program will ensure that teachers of science and mathematics can design and manage safe, secure and stimulating learning environments that meet the needs of all students." This was found to correspond to the Shared Control component of constructivist learning environments because it would most likely address the level to which students control, along with the teacher, the learning environment, their own learning goals, and design and the management of learning activities. However, Standard 8.0 Technology was deemed too general to address any of the specific components of a constructivist learning environment. While "…skills in using technologies and can engage students in learning science and mathematics using appropriate technological resources to expand the science and mathematics knowledge" could include some elements of Personal Relevance, that connection would require inferences that were deemed too large for a direct match. The results of this mapping indicated that the critical constructivist framework was an appropriate tool from which research questions could be developed.

Questions and/or hypotheses

The questions that directed this study were first asked by the licensure programs' staff in an informal way. Conversations during staff meetings centred on potential ways in which the 'success' of the program could be measured. Taking into account that most felt intuitively that the program was effective, this claim needed to be supported by rigorous research. The

staff were uncertain about what types of questions should be asked, what types of evidence should be collected, and what kind of analysis should be undertaken. Two researchers were asked to begin the task of inquiring into the program's practice. Research questions were framed in order to analyse the way in which the two targeted sources of PCK, teacher education and classroom experience, contribute to the preservice teacher's experiences with constructivist learning environments. Taylor et al.'s (1995) framework for critically constructivist learning environments was foundational to the development of the research questions, the selection of data sources, and in the analysis of the results.

Research question 1: Creating an account of practice

How do our program goals and preservice teachers' perceptions of field placements contribute to their experience with constructivist learning environments as defined by Taylor et al. (1994b)?

- Are course objectives consistent with the components of a constructivist learning environment?
- Do the preservice teachers perceive aspects of a constructivist learning environment in their field experiences?

Research question 2: Building the hypothetical learning trajectory

Can we identify opportunities for enhancing preservice experiences with the categories assessed by the Constructivist Learning Environment Survey (CLES; Taylor et al. 1995) categories?

- Which aspects of our program to provide experience with categories encompassed by the CLES?
- Which types of field experiences contribute most to positive preservice teacher responses on the CLES?

The design—methods and procedures

Research on educational practice is most often led by outsiders interested in questions about teaching and learning. Educational practice, on the other hand, is enacted by teachers and students in a real context. Educational practice and the research that surrounds it need to be mutually supportive, not hierarchical (Fenstermacher 1987). No practice is perfect and no research is comprehensive, so both have much to learn from and offer the other. There is no single right way to approach teaching and learning, and avoiding a hierarchy means moving away from positivist ideas about research. Rather than approaching the research questions in this study from a positivist perspective, the goal of this project was to be educative, not condemnatory. As Fenstermacher (1987) advocates, the knowledge gained during this research process, and detailed below, is meant as a component for consideration in the analysis and possible revision of the institution's practice.

Today, a lot of effort is being expended by education researchers in moving towards mutually supportive research. The design for this particular study is in alignment with one such effort, *accounts of practice methodology* (Simon and Tzur 1999). Generating accounts of practice is one possible way to address this problem of the hierarchy of research over

practice. An account of practice methodology is an approach that allows for the understanding of practice in the context of current reform research. "An account of practice is an adaptation of the case study methodology and is the researchers' explication of a teachers' practice" (Tzur et al. 2001, p. 233). The model emphasises a shift from the evaluative deficit model, in which researchers focus on what is *not present* in the teacher's practice, knowledge base, or abilities. Instead, accounts of practice attempt to describe what *is present*, and offer a potential learning trajectory for the teacher (Simon and Tzur 1999). Simon and Tzur's methodology is a conscious attempt to bring the teacher's voice into the research. It abandons the notion that the researcher has all the answers, and instead attempts to offer one possible answer.

Accounts of practice have two primary components: the development of the conceptual framework and the use of this framework to trace practice (Simon and Tzur 1999). The creation of an account of practice calls on the researcher to choose a framework through which to view the teacher's practice. This framework then drives the data collection and analysis and the development of the Hypothetical Learning Trajectory (HLT). The HLT should not be thought of as an 'answer' or prescription, but rather as a possible path that might lead towards the goals outlined by the researcher. The goals and the conceptual lens of the researcher might or might not be the same lens through which the research participants view their own practice. By acknowledging this up front, the teacher's perspective becomes distinct and as important as the researcher's perspective.

In the same way that Simon and Tzur (1999) view research on teacher practice, the methodology in this study involved not evaluating but rather describing what is present in the institution's program and providing a possible trajectory that is consistent with the program's goals. In other words, creating an account of institutional practice seemed best suited to meeting the goals of the researcher and the needs of the institution. For this study, a conceptual framework, critical constructivism (Taylor et al. 1995), was selected by the researcher as the foundation for the research questions and the data collection and analysis. Critical constructivism was selected based on the emic perspective of the researcher and on the analysis of the program's standards. However, we do not assert that critical constructivism is the 'solution' for this program. Rather, critical constructivism is one possible lens through which to view the program's practice.

As a result of this analysis, a HLT was created for the institution. Again, this trajectory is not a prescriptive 'solution', but a set of suggestions for reflection and further inquiry. Accounts of practice methodology have been typically applied to teacher practice (Barrett et al. 2002; Simon and Tzur 1999). However, the challenges faced by a researcher in analysing teacher practice are similar to those of the researcher analysing a program's level of success. In order to avoid the tendency towards deficit-model evaluations and researcher-imposed frameworks, research should be modelled as an account of practice. Figure 1 details the accounts of institutional practice framework that was used in this study.

Sampling

In the professional teacher licensure program, there are three significant timeframes in which preservice teachers are involved in both coursework and field work. Table 2 illustrates each of these three phases. Phase I occurs from August until the end of September. This first phase begins with 3 weeks of full-day coursework that introduces common themes of teaching, including unit and lesson design, learning theories, professionalism and classroom management. This phase concludes with 1 month in their field placement.

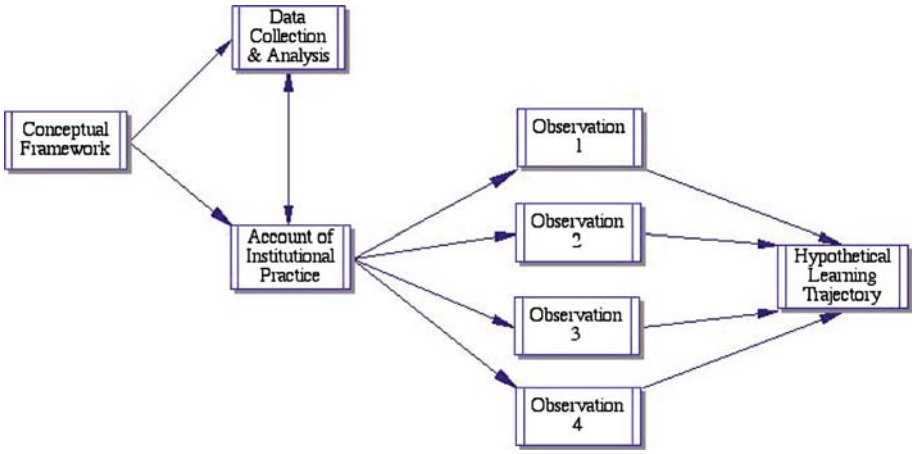

Fig. 1 Framework for account of institutional practice

During this month, the preservice teacher will teach between one and five lessons in the classroom under close supervision of the cooperating teacher. For most preservice teachers, this first field placement occurs in a middle or junior high school.

Phase II includes coursework and field experiences and occurs from October until early December. For these months, the teacher candidates are in their initial field placement in the morning and in coursework in the afternoons. Their coursework includes separate classes that address methods, pedagogy, subject matter and adolescent psychology. In their field placement, the preservice teachers plan and teach a seven-lesson work sample. This work sample is prepared with the guidance of both the cooperating teacher and the university supervisor.

Phase III includes coursework and field experiences and lasts for 11 weeks from April until June. During this time, the preservice teachers are in a second field placement. For most preservice teachers, this placement occurs in a high school. In this phase, preservice teachers plan and teach a 2-week work sample with the guidance of both the cooperating teacher and the university supervisor. The preservice teacher will also assume up to half of

Table 2 Description of activities in each program phase

Characteristic	Activities in each program phase		
	Phase I August 1–October 1	Phase II October 1–December 10	Phase III April 1–June 15
Field experience description	Placement I: full time in September	Placement I: daily in mornings	Placement II: full time school day
Field experience responsibility	Teach 1–5 lessons, assist teacher	Teach 7 lesson work sample, assist teacher	Teach 10 lesson work sample, assume ½ teacher load
Coursework description	Introductory course: full time in August	Methods, pedagogy, subject matter: full time in afternoons and evenings	Weekly seminar meeting
Coursework responsibility	Write lesson plans, journal, reflections	Prepare first work sample, other course assignments	Prepare second work sample

the cooperating teacher's teaching load. Coursework in this phase includes a weekly seminar meeting during which issues related to diversity, equity, classroom management and professionalism are addressed.

Instrumentation

To investigate the preservice teachers' perceptions of their field experiences, the CLES was administered at the end of Phases I, II and III. The CLES was developed to enable teacher-researchers to monitor their development of constructivist approaches to teaching school science and mathematics (Taylor et al. 1995). Modified from a previous version (Taylor et al. 1994b), the new CLES was developed to "…encourage emanicipatory interest and develop critical discourse about cultural myths" (Taylor et al. 1997, pp. 295).

The CLES consists of 30 items with frequency response options (Almost Always, Often, Sometimes, Seldom, Almost Never). Items in the instrument are grouped into five categories corresponding to each of the components of a constructivist learning environment outlined above (Taylor et al. 1995). Within each group, six questions serve to inform the researcher about each category. Because the surveys were modified to be specific for a mathematics or science classroom, the language for both versions of the instrument was the same, with the exception of the words 'mathematics' and 'science' when relevant. Example items for each category are listed in Table 3.

Considering that Likert scales prevent certain types of statistical analysis, the instrument is structured in such a way as to allow for the assignment of a scale score to each of the five CLES categories. The response Almost Always is assigned a score of 5, while Almost Never scores a 1. Each scale, therefore, has a range of possible scores from 6 to 30. These scale scores can then be used in quantitative analysis. After extensive testing, the instrument has been shown to have construct validity and reliability in a number of learning environments (Taylor et al. 1995, 1997). While originally developed in Australia, the CLES has been shown to be adaptable to a number of learning environments. It has been used by adult and child learners and has been translated and modified for use in Turkey, Taiwan, Canada and England (Bukova-Guzel and Alkan 2005; Chang 2006; Nix et al. 2005).

The CLES developed by Taylor et al. (1994a) was used in this study. This 30-item instrument consisted of five scales, each with six items, modified for teachers. Johnson and McClure (2000) analysed the 30-item CLES for inservice and preservice teachers at the middle and high school levels. Their reported α coefficients for the five scales ranged between 0.80 and 0.91 ($n = 290$). Beck et al. (2000) also used the 30-item CLES and

Table 3 Sample item for each CLES scale

CLES scale	Sample item
Personal Relevance	In this class, I observed that…students learned how science [mathematics] can be part of their out-of-school life
Student Negotiation	In this class, I observed that…students talked with other students about how to solve problems
Shared Control	In this class, I observed that…students helped to assess their learning
Critical Voice	In this class, I observed that…it was OK for students to express their opinions
Uncertainty	In this class, I observed that…students learned that science [mathematics] is influenced by people's values and opinions

reported α coefficients ranging between 0.56 and 0.96 ($n = 203$). Lastly, internal consistency for this study ($n = 28$) was estimated by computing α coefficients for each subscale (Personal Relevance = 0.70, Student Negotiation = 0.77), Shared Control = 0.88, Critical Voice = 0.92; Uncertainty = 0.90).

Data collection

Data collection spanned the entire program duration (10 months) for one cohort enrolled in the teacher preparation program. In order to prepare the institutional account of practice, data were collected to inform the researchers about both the coursework and field experiences. These data came from three sources: (1) the CLES; (2) required course syllabi; and (3) student reflections. The three data sources provided insight into, respectively, the preservice teachers' perceptions of their field experience, the program's coursework requirements, and the preservice teachers' perceptions of their own practice. By synthesising these three data sources into the account of institutional practice, all aspects of the programs were represented. Figure 2 details the data sources that informed this process.

To inform the researcher about the types of environments that were present in the field experiences, the CLES was administered at the end of Phase I, Phase II and Phase III of the program as described above. During the Phase I administration, the total population consisted of 31 preservice teachers, 23 in science and 8 in mathematics. Because of some minor attrition among preservice teachers, the total population consisted of 27 preservice teachers, 21 in science and 6 in mathematics by the Phase III administration. Surveys were distributed to the entire population during each phase and response rates were relatively strong for both science and mathematics (Phase I: science $n = 23$, mathematics $n = 8$; Phase II: science $n = 21$, mathematics $n = 7$; Phase III: science $n = 18$, mathematics $n = 6$). Participant responses were recorded and paired. After all three administrations, there appeared to be complete data from all three phases for 21 preservice teachers, 15 in science and 6 in mathematics. In other words, 21 preservice teachers had completed the survey at each of the three administrations.

To inform the researchers about the types of environments that occurred in the coursework, the 16 course syllabi and the department mission statement were examined.

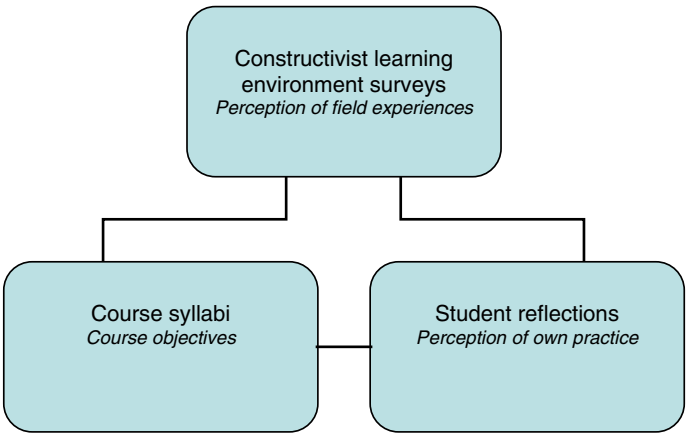

Fig. 2 Data collected to inform account of institutional practice

These documents were collected in order to understand the department's goals for the program. Qualitative data analysis was completed to determine how the mission statement and course objectives related to the five components of constructivist learning environments. Objectives for course syllabi do not always translate directly into classroom instruction. As stated earlier, what a teacher claims to believe and how those beliefs play out in practice might not always be aligned (Taylor et al. 1994b). However, course syllabi represent the official stance of the department and are intended to encourage consistency from year to year as instructors come and go. For this reason, they were chosen for analysis.

To further substantiate the survey and syllabi data, the preservice coursework was analysed. It was hoped that this analysis might provide insight into the level to which preservice teachers might be internalising aspects assessed by the CLES. Data collected for this purpose included reflections that the preservice teachers provided as a part of their work sample requirements. A reflection was collected from each preservice teacher at the end of Phase I, Phase II and Phase III. At the end of Phase I, the preservice teachers were asked: "How have your beliefs about teaching and learning changed as a result of this experience?" Their Phase II reflection asked: "How are you, as a preservice teacher, different from the teacher you were a month ago? What ideas and practices have changed? What have you learned and what are you doing better? Finally, what are your goals for your continued growth as a teacher?" Their final reflection challenged them to "reflect on the professional growth that you have experienced to date. Include evidence gathered throughout the term, including previous reflections on your videotaped lessons." The 21 preservice teachers who completed all three administrations of the CLES were sampled. These 21 preservice teachers were divided into two groups, one for mathematics and one for science. One-third of the population from each group was randomly selected for analysis (mathematics $n = 2$; science $n = 5$). Qualitative data analysis was completed for all three reflections from each of the sample preservice teachers to locate statements that corresponded to the five categories of the CLES.

Data analysis

Analysis of the institution's practice

The analysis of the institution's practice consists of two parts. The first is an overview of the institution's program and how it aligns with the critical constructivist framework applied by the researcher. This section also includes a summary of the results of the data analysis. The second part is an account of institutional practice. It is presented with the purpose of reconciling the conclusions made from the data analysis.

The preservice teachers perceive a number of opportunities to experience constructivist learning environments in the field experience component of the program as well. The preservice teachers ($n = 21$) reported the strongest positive scores for Personal Relevance (Phase II $M = 22.4$; Phase III $M = 23.1$), Shared Control (Phase II $M = 21.1$; Phase III $M = 24.2$), and Uncertainty (Phase II $M = 21.8$; Phase III $M = 24.8$). The less positive scores occurred for Student Negotiation (Phase II $M = 17.4$; Phase III $M = 17.9$) and Critical Voice (Phase II $M = 13.7$; Phase III $M = 16.9$).

These data suggest that there is a difference in the types of experiences in the first and second placement. There is strong evidence to suggest that there was a statistically significant ($p < 0.05$) increase from Phase II to Phase III in the mean positive responses of preservice teachers for Personal Relevance, Uncertainty, Critical Voice, Shared Control

and Student Negotiation (Wilcoxon Signed rank sum test). When these data were separated across the subjects of mathematics and science, there was strong evidence to indicate a significant increase from Phase II to Phase III for science preservice teachers in Shared Control and Student Negotiation (Wilcoxon Signed rank sum test). There was weak evidence to indicate an increase from Phase II to Phase III for science preservice teachers in the areas of Personal Relevance and Uncertainty. These data do not indicate any statistically significant increases in CLES scores for the mathematics preservice teachers over the different phases. These conflicting results led the researchers to separate these data across subject lines for further analysis.

Means of each CLES scale from each administration were graphed separately for mathematics and science preservice teachers. The graphs (Figs. 3, 4) appeared to indicate that the means of the five scales are different.

The means for Student Negotiation and Critical Voice appeared to be different from the means of Personal Relevance, Shared Control and Uncertainty. A further analysis of these data indicates that the means of the five categories are different for both mathematics and science in both the Phase II and Phase III administrations (One-way Kruskal–Wallis ANOVA, Phase II mathematics $p = 0.028$, Phase III mathematics $p = 0.022$, Phase II science $p < 0.001$, Phase III science $p < 0.001$).

The graphs also seem to indicate that the means might fall into a lower cluster and higher cluster. It appears that Student Negotiation and Critical Voice are potentially related and have lower means than for Personal Relevance, Shared Control and Uncertainty. To assess the significance of these clusters, contrasts were undertaken. Accounting for unequal variances, these two clusters seem to explain the variation for both mathematics and science in both the Phase II and Phase III administrations (Contrast Test, Phase II mathematics $p = 0.001$, Phase III mathematics $p = 0.004$, Phase II science $p < 0.001$, Phase III science $p < 0.001$).

The institution involved in this study provides a number of experiences that align with the components of a constructivist learning environment. In the coursework component of the program, 13 of the required course syllabi address at least one of the CLES categories. These 13 syllabi include 41 objectives that deal directly with one of the five components (Personal Relevance: 4 objectives, Uncertainty: 10 objectives, Critical Voice: 5 objectives,

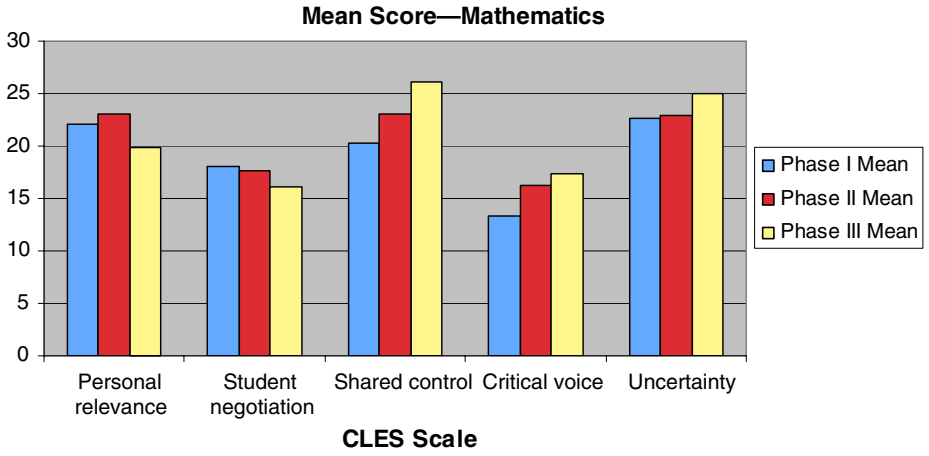

Fig. 3 CLES scale means for each phase—mathematics

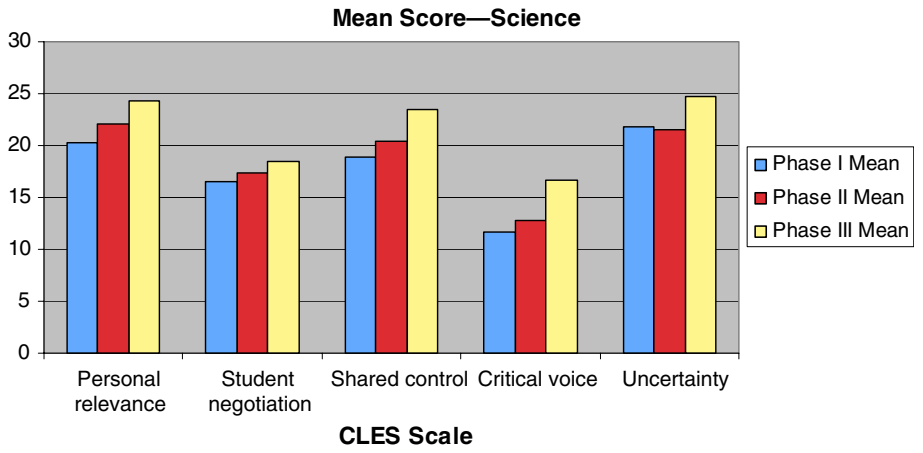

Fig. 4 CLES scale means for each phase—science

Shared Control: 9 objectives, and Student Negotiation: 13 objectives). While each constructivist learning environment category is addressed in some way, Uncertainty, Shared Control and Student Negotiation seem to be more emphasised. All five categories are addressed by objectives across a wide spectrum of courses, with no course containing more than four objectives that match the categories.

Although these data illuminate opportunities to experience constructivist learning environments in the coursework and perceptions of these environments in the field experiences, additional data were collected about the extent to which preservice teachers are internalising the categories in their professional learning. Based on results of the Wilcoxon rank sum test, preservice teacher reflections were divided into two groups: mathematics and science. One-third of the mathematics ($n = 2$) and one-third of the science ($n = 5$) participants were randomly selected for analysis. A total of 21 reflections (three reflections from each sampled participant) were included in the analysis. Pseudonyms were assigned to all of the reflections. Coding of the reflections from Phase I, Phase II and Phase III revealed that preservice teachers did use language that is consistent with the five categories when reflecting on their own practice. Personal Relevance and Student Negotiation were referenced most often by the preservice teachers in their reflections (Personal Relevance: 27 instances, Student Negotiation: 24 instances). An example of one of these instances is Janet's comment about the importance of Personal Relevance in her future teaching of science:

> In the future…I want to take their interests and tie them into what we are doing in class. It seems to me that these students lack relevance and, since science seems to have no importance to their lives, they do not care to learn it. [*Janet* (Summative Reflection, Phase III)]

Ted, a mathematics preservice teacher, reflected on his attempts to challenge students with thought-provoking questions in order to promote more complex thinking. This is an example of the Student Negotiation in action:

> In the spring, I would ask higher-order questions occasionally and would encourage students to slow down and think hard about an answer, clearly indicating the importance of the questions. [*Ted* (Summative Reflection, Phase III)]

The categories of Uncertainty, Critical Voice and Shared Control were also referenced in the reflections, but to a lesser extent (Uncertainty: 3 instances, Critical Voice: 10 instances, Shared Control: 7 instances). While these categories appeared less often, it is important to note that the preservice teachers were not taught explicitly about these components. Furthermore, because they did not learn specifically about critical constructivism, it is noteworthy that there were 71 references that correspond to the five components of a constructivist learning environment, and that each component appeared at least three times in the 21 reflections. This observation is striking, especially because the reflection prompts did not direct the preservice teachers to focus on these ideas specifically. Doug, a science preservice teacher, reflected on how he is beginning to see the role of Uncertainty of Science and how this impacts on his teaching:

> I am beginning to learn that an in-depth understanding of selected topics is preferable to a superficial understanding of numerous topics. Scientific knowledge is expanding exponentially, and it is impossible to teach everything. [*Doug* (Summative Reflection, Phase II)]

Janet described an instance when she solicited student opinions before making pedagogical decisions. Based on the students' input, or Critical Voice, she adjusted her plans:

> I talked to many of my students about their beliefs on note taking, and I found that they held many of the same ideas as I do.…I want to continue to find ways in which I can involve my students into the content. [*Janet* (Summative Reflection, Phase III)]

Finally, we saw examples of Shared Control in the questions that Julie, a science preservice teacher asks herself. These questions illustrate a desire to allow student needs to direct her pedagogy, and a belief that these desires lead to more effective teaching:

> What are the needs of my students? Do they truly understand the content? By understanding the individual needs of the students and understanding the class as a whole, I feel that my teaching can be more effective. [*Julie* (Summative Reflection, Phase III)]

During the coding of the reflection data, references to the five CLES aspects of a constructivist learning environment were coded to indicate whether the reference was to the in-service teacher's practice (IT), the preservice teacher's practice (PT), or to a theoretical practice or belief about future teaching (FT). Of the 71 references in the reflections, the vast majority were about the preservice teacher's own practice or their desire to practice this way in the future (PT: 40 references, FT: 28 references). A very small minority of the references related to the practice of the in-service teacher (IT: 3 references). Because the prompts for the reflections dealt specifically with the preservice teacher's own practice, it is not surprising that these data are skewed in this way. The results of the reflection analysis seem to indicate that these data complement, rather than duplicate, data collected from the CLES. Additionally, the large number or references to the preservice teacher's own practice point to a possibility that, while the components were not taught explicitly, they have been internalised implicitly by the students in the institution's program.

Account of institutional practice

A summary description of the institution's practice appears in Table 4. Each piece of the program (coursework, field experience, preservice teacher reflections) that was analysed can be compared across the five categories of constructivist learning environment. Using

Table 4 Number of objectives, cohort field experience mean in Phases II and III, and number of preservice teacher reflections for each CLES category

CLES category	Number of course objectives	Cohort field experience *M*		Number of preservice teacher reflections
		Phase II	Phase III	
Personal Relevance	4 objectives	22.4	23.1	27 instances
Student Negotiation	13 objectives	17.4	17.9	24 instances
Shared Control	9 objectives	21.1	24.2	7 instances
Critical Voice	5 objectives	13.7	16.9	10 instances
Uncertainty	10 objectives	21.8	24.8	3 instances

this table and the analysis of the institution's practice as stated above, four observations were generated from the account. These observations should be treated as items for questioning and discussion, not as evaluative claims.

Observation 1: Shared Control and Uncertainty are experienced across the program, but are mentioned the least by the preservice teachers in their reflections.

Nine course objectives address the idea of Shared Control in the classroom (i.e. the level to which the student, together with the teacher, controls the learning environment, assessment and design of activities in the classroom). Preservice teachers reported perceiving these practices in their fall and spring placements. Shared Control deals directly with classroom management. These data suggest that the classroom teachers have internalised this component. Perhaps there is something specific about this idea that makes it difficult to internalise early in one's experience with teaching. Additionally, it can be hoped that, with a foundation of experiences in this area, the preservice teachers will be able to adopt this practice as their time in the classroom increases.

Uncertainty addresses the content in the classroom more specifically, especially that science and mathematics are not based on cold reason but, rather, they have evolved based on human experiences, values and ideas that are culturally and socially determined. These data suggest that the preservice teachers are experiencing the idea of Uncertainty in both their coursework and field experiences. However, it does not appear to be a focal point in the reflections. There are a number of reasons that possibly could explain why this is happening. Perhaps the preservice teachers have not been able to overcome their experiences from past science and mathematics classes that were not taught from the stance of Uncertainty. New curriculum in the field experiences might be presented from an inquiry stance, although it is unclear whether preservice teachers' previous ideas about the nature of the content can be changed so quickly.

Observation 2: Critical Voice is experienced least often during the program and is not mentioned as often by the preservice teachers in their reflections.

Critical Voice focuses on whether students feel that they may advocate for their own learning either by questioning ideas or challenging things that impede their own learning. Constructivism in its many forms has neglected this idea that students should have a critical voice (Taylor 1996). It is for this reason that Taylor (1996) saw a need for reform of constructivism to include an equality of opportunity for all to assume dialogical roles.

Others who have advocated for a critically constructivist perspective hoped that this move would lead to an awareness of culturally influenced norms that move towards a liberation, rather than a taming, of learners (Watts and Jofili 1998).

The idea that constructivism should be integrated with a critical theory perspective is relatively new. It is not surprising to see that Critical Voice is the category that is least represented in institution's practice. The other categories seem to address ideas that are perhaps less 'controversial'. While the ideas around Critical Voice take hold at the university and in field experiences, it is unclear whether future research might show changes in the institution's practice.

Observation 3: The field experiences for preservice teachers in mathematics and science seem to differ.

During the analysis phase, the course syllabi were investigated as a total including both mathematics and science. A separate analysis revealed that companion courses (i.e. Mathematics Pedagogy and Science Pedagogy) emphasised critical constructivism in similar amounts. These data indicate that the coursework component of the institution's practice did not differ along subject lines. However, during the analysis of the CLES data, statistically significant changes were evident between Phase II and Phase III for the science teachers' perceptions of the field experiences, while none appeared for the mathematics.

There are a limited number of courses that separate the cohort along subject lines, for the most part, but the institution has equivalent requirements for licensure regardless of certification area. However, the CLES results indicate that the overall experience does differ depending on the subject studied. With the exception of Personal Relevance, the mean scores for the CLES were higher for mathematics than for science at every phase. The mathematics preservice teachers' CLES data indicate that the field experiences were perceived to be more aligned with critically constructivist environments and that this experience was consistent over the length of the program. For the science preservice teachers, these data indicate that the field experiences were perceived to have less alignment, but that this alignment improved over time.

Analyses that were resistant to sample size were used to frame this investigation. However, it is difficult to ignore the variation between population sizes for mathematics and science. Additionally, the science preservice teachers are grouped as 'science', but they are in field experiences that include biology, physics, chemistry and earth science. The mathematics preservice teachers, however, share a much more common experience with one another. It is unclear from these data whether this variation in the diversity of the groups' experiences would influence the results. Finally, while the nature of mathematics and science content shares some commonalities, there are important differences. Considering that none of these questions can be answered by these data, it does point to a possibility that the institution should look at the science and the mathematics preservice teachers' experiences as separate entities.

Observation 4: Perceptions of Critical Voice and Uncertainty seem to change most from November to June.

Building on the comments presented above in Observations 1 and 2, Critical Voice and Uncertainty have unique components that could lead to these results. There are a number of reasons why this might be the case. Between Phase II and Phase III of the program, the preservice teachers have 11 weeks of coursework that addresses Critical Voice and

Uncertainty. This coursework includes both educational theory and content courses. As their professional knowledge base increases, preservice teachers might be more able to recognise components of Critical Voice and Uncertainty in their field experiences.

Between Phase II and Phase III, the classroom teachers had additional time to build up the classroom climate that is so central to Critical Voice. Additionally, the idea of the Uncertainty around a subject might be developed over time and, therefore, more present in the field experiences as the school year progresses. While it is unclear from these data why these two components change the most over time, it does point to a need to offer preservice teachers the opportunity to be in a field experience throughout the year.

The hypothetical learning trajectory

The reader is again reminded that the purpose of this account of institutional practice is not to serve as an evaluation or judgement. Instead, the researchers' own conceptual framework has been used as a lens for viewing this practice. This viewing resulted in several observations about the practice, and these observations serve as a foundation for the HLT. The purpose of the HLT is to offer suggestions for further development (Simon and Tzur 1999). The following suggestions are intended as items for discussion and questioning, rather than required steps. These ideas were developed based on the account of institutional practice and the institution can accept or modify this trajectory based on its own goals:

1. Analyse courses for which critical constructivism is not emphasised or less emphasised and determine whether there are appropriate ways to integrate the categories into the syllabi.
2. Modify coursework and field experience assignments so that preservice teachers focus explicitly on components of a constructivist learning environment and their manifestation in the K–12 classroom.
3. If a comprehensive experience with all of the components of constructivist learning environments is desired, find ways to increase the emphasis on ways that students' Critical Voice can be solicited and heard in both the university coursework and K–12 field experiences.
4. Continue to teach courses that address preservice teachers' specific needs according to their subject matter because their field experiences appear to differ.
5. Continue to offer a year-round field experience component that offers a more complete experience, especially for those in science fields.

Coursework and field experiences in this program seem to offer complementary approaches to the categories of the CLES. Through participation in coursework and field experiences, preservice teachers gain a more comprehensive experience with constructivist learning environments. It is when field experiences are linked closely to coursework in terms of assignments and theoretical stance that preservice teachers have the best opportunity for growth (McIntyre et al. 1996). Preservice teachers often struggle with balancing their theory-based university courses with their practice-based field experience (Duquette 1996). Data from this study suggest that the components of constructivist learning environments manifest themselves differently in the coursework and in the field experiences. Personal Relevance is the least mentioned component in the syllabi, but is the most frequently perceived element in the field experience. If comprehensive attention to each category is desired, then it seems that a continued balance between coursework and field experiences is necessary. Explicit integration of the two experiences would allow for the most connections (Szabo et al. 2002).

Field experiences that occur throughout the program's duration also help preservice teachers with transition into the teaching profession (Graber 1995). Additionally, programs that include a program-long field experience component help preservice teachers to develop their PCK, an explicit goal of the institution's program (Jones and Vesilind 1996). Data in this study points to a specific need for a year-round field experience for the preservice teachers in science fields most specifically.

Significance of the study

In recent years, researchers have moved away from analysing classroom practice in deficit studies, and have begun to take an inquiry stance on the practice of teachers (Barrett et al. 2002; Simon and Tzur 1999; Tzur et al. 2001). The result of this work has been a movement that acknowledges the distinction between and the equal value of the teacher's perspective and the researcher's perspective. This philosophical view of research can be applied to the analysis of varied educational contexts, including teacher preparation programs. No single study and no finite set of data can completely describe something as complex as an institution's practice. However, a rich description of an institution's practice, including quantitative and qualitative data about both coursework and field experiences, can initiate the reflective inquiry process. This inquiry process is one tool that might guide an institution along a trajectory of increased effectiveness.

Any research on a teacher preparation program must acknowledge the difficult position that preservice teachers are in when they attempt to balance the theory from their coursework with what they are seeing in the field. In this study, we looked at this balance and how each component of a program can complement the other. Field experiences that are in line with theories advocated in university coursework will feel more like laboratory experiences than some disjointed and unrelated 'real world' (McIntyre et al. 1996). These are precisely the experiences that institutions should be facilitating for their preservice teachers. By distinguishing what the field experience offers from what the coursework provides in our study, the institution is given an opportunity to enhance both components. Areas of the critical constructivist framework that are less emphasised by the program can become targets for enhancement. This account of institutional practice gives the institution a place to begin.

This study is only a start in this direction, but one must begin somewhere. If student learning needs to improve, then schools need to improve. Schools cannot improve without the presence of effective teachers and effective teachers should start their careers with a strong preparation program. Feiman-Nemser (2000) argues that all strong programs have at their foundation a strong conceptual framework. This is followed by purposeful design and use of field experiences, including the use of reflections, weekly cohort meetings, individual conferences with preservice teachers, and diversity of placements.

This study is in response to a direct request from the program so that they might start moving in the direction that Feiman-Nemser (2000) describes. Based on the needs of the institution and the observations made from the data, a HLT was created. This HLT serves as items for inquiry and reflection and not as a comprehensive 'to do' list. It is intended that this HLT will guide, not dictate, progress. The institution should consider analysing courses in which critical constructivism is not emphasised or is less emphasised, and then determine whether there are appropriate ways to integrate the constructivist categories into the syllabi. The institution might also consider focusing specifically on the components of a constructivist learning environment. This is especially significant for the Critical Voice

component, because it is currently the least emphasised component. Additionally, the program should consider continuing to separate some coursework around subject lines because field experiences for both groups seem to differ.

As Guyton and McIntyre (1990) advocate, this account of institutional practice includes both field experiences and university coursework in the analysis. However, it should be emphasised again that the account is built upon a conceptual framework that was chosen by the researcher. This framework aligns directly with the institution's standards, but it is the researchers' framework nonetheless. Based on this framework, it is intended that this account of practice and the resulting HLT will support the inquiry process at the institution in the study. Additionally, the methodology described in this study could guide the inquiry process of other institutions interested in improving their own practice.

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