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Content modules as sites for developing science teacher identity in pre-service teachers: A case of one South African university

Hlologelo Climant Khoza [1*]

[1] University of Pretoria, Pretoria, SOUTH AFRICA

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Abstract

Developing science identity in pre-service science teachers is important as it influences their perceptions about science teaching and learning. Pre-service teachers' science identity can be developed in their specific modules where they obtain content knowledge. Grounded in the notion of pre-service teachers' learning agendas, and identity development, this paper presents an argument pertaining to how science content modules at one South African university contribute to pre-service teachers' development of their identities as science teachers. Data were collected through individual interviews with 13 pre-service science teachers and analyzed using an inductive thematic analysis. The findings revealed four categories of aspects that influenced the pre-service science teachers' identity construction and development. The first is about the nature of the subject matter knowledge taught in the modules. The second is about the context in which this subject matter knowledge is taught. The third concerns how teaching is conducted, and the last comprises the nature of practical work. These findings are discussed, and the implications related to the structure of science content modules in initial science teacher education programs are discussed.

Keywords: content modules, identity development, inductive thematic analysis, learning agendas, science pre-service teachers, subject matter knowledge

INTRODUCTION

Teachers' professional identity plays an important role in how they conduct their teaching (van Lankveld et al., 2016). It is difficult to define the concept of teacher professional identity due to its dynamic and multi-dimensional nature (Rodrigues & Mogarro, 2019). However, it is usually perceived as a process rather than a product as teachers continuously construct ideas on how to act and understand their duties in particular contexts (Song & Shuhua, 2007). Various factors influence how pre-service teachers construct and develop their identity as teachers. These include prior experiences and personal histories emanating from what the pre-service teachers have been exposed to in their schooling (Saka et al., 2013) Another factor is the overall structure of the initial teacher education (ITE) program and opportunities provided within the programs (Avraamidou, 2014). For example, the way in which lecturers conduct themselves would influence what the science pre-service teachers learn about teaching science (Nyamupangedengu & Lelliott, 2016). The current study contributes to the existing literature on how science ITE programs contribute to science teacher identity in science pre-service teachers. Recently, there has been a move towards understanding how pre-service teachers construct their identity in their respective courses where they learn about teaching, such as science methodology courses (Kier & Lee, 2017; Menon & Azam, 2021). However, little has been done to explore how the pre-service teachers construct their identity in content modules. In this article, I focus on the science content modules in the ITE to explore how the modules contribute to science identity development in pre-service teachers. The argument in this paper is that pre-service science teachers' identity is influenced by what, and how they are taught in the ITE content modules. This study was guided by the following research question:

In what ways do science content modules contribute to science teacher's identity development in pre-service teachers?

✉ climant.khoza@up.ac.za **(*Correspondence)**

Contribution to the literature

- Science teacher identity in pre-service teachers can be developed in the science content modules.
- Aspects that contribute to science teacher identity development in pre-service teachers include the nature of the content taught and the context in which this content is taught.
- Findings in this study also indicate that how the content knowledge taught could be a possible factor that influences the pre-service teachers' science teacher identity.

SCIENCE INITIAL TEACHER EDUCATION IN SOUTH AFRICA

As argued above, the science ITE structure influences how pre-service teachers construct their identity as science teachers (Kier & Lee, 2017). There are generally two structures of science teacher preparation in South Africa: the consecutive, and the concurrent (Musset, 2010). In the consecutive structure, students must complete a three-year degree that covers the disciplinary content (e.g., Bachelor of Sciences degree–BSc.). The student would then proceed to the education faculty to do a one- to two-year postgraduate qualification (e.g., postgraduate certificate in education) covering the professional knowledge of teaching (Musset, 2010). This study was based at an institution that follows a concurrent model where the students qualify with a four-year degree by completing both the science content modules, the professional modules (including methodologies), and practical components. Nyamupangendengu (2015) reports on two versions of the concurrent model. In the first version, pre-service teachers complete the science content modules at the science faculty with the science mainstream students, then the professional knowledge modules at the Education Faculty. In the second version, the pre-service teachers learn both the science content modules and professional knowledge at the faculty of education. Anecdotal evidence suggests that variations exist in the second version of the concurrent model in terms of who is teaching the content modules and the methodology modules. In one case, the content modules are taught by the mainstream science lecturers (normally with no teaching qualification), while the methodology modules are taught by those who have some form of teaching qualification. In some cases, a single lecturer would teach both the content and the corresponding methodology module (Nyamupangedengu, 2015). There is currently no literature that strongly supports either of the two models in terms of developing science pre-service teachers' knowledge of teaching (as a factor that influences science teacher identity in pre-service teachers). However, studies suggest that the concurrent model better allows the integration of the content knowledge and how to teach that content (Musset, 2010).

Conceptualizing Pre-Service Teachers' Identity Development

On a basic level, identity is defined as how a person sees themselves, and how they are perceived by others in the work that they do (Gee, 2000). It is a self-attributed notion that is also constructed over time as a person gains knowledge about their profession in particular contexts (Kaplan & Garner, 2018). Pre-service teacher identity is about how the pre-service teachers make sense of their knowledge of teaching and their roles in teaching their subjects (Beijaard et al., 2004). In this case, it is the science subject. There are various conceptions of what constitutes science teacher identity in pre-service teachers. For example, Helms (1998) showed that subject matter is a critical determinant of identity development and illustrated the importance of teachers knowing themselves with respect to their subject matter (Chung-Parsons & Bailey, 2019; Kaplan et al., 2014). The notion of competence in the work that the teacher does is also used as a key concept that defines teacher identity (Lankveld et al., 2017). These conceptions support the point that identity development is situated and constructed in a specific context/s (Kaplan & Gardner, 2018).

Rogrigues and Mogarro (2019, p. 11) describes pre-service teacher identity as a "fragmented, unstable, dynamic, multidimensional, changeable and intersubjective process, which is constantly being interpreted and reinterpreted by student teachers in their continuous discourses and through the relationships they establish within professional contexts". This denotes that identity development is contextual and constructed as an individual engages with those around them. The authors further find that teacher identity is "related to self, it involves agency...and is influenced by personal values, emotions, beliefs, (scientific and didactic) knowledge and (pedagogical) skills. It is also influenced by (past and present) experiences and historical, sociological, and cultural factors" (Rogrigues & Mogarro, 2019, p. 11). The emphasis of this quote is on the idea that the knowledge that pre-service teachers gather should contribute positively to how they view themselves in what they are trained to do. This study draws from the Beijaard et al.'s (2004) definition of knowledge and pedagogical skills. The knowledge in this case is the science content knowledge and the skills include pedagogical practices that are specific to science. For example, be able to

Table 1. The structure of the B.Ed. program

Year of study	Disciplinary modules	Faculty
1st	Science elective modules (content)	Science
2nd	Continuation of science electives (content)	Science
	Methodology of science (general)	Education
3rd	Science 'capping' modules	Education
	Methodology of science (life sciences/physical sciences)	Education
4th	Methodology of science (life sciences/physical sciences)	Education

facilitate practical activities in science. This definition is in line with Feiman-Nemster's (2008) two of the four themes of learning to teach, i.e., learning to know and act like a [science] teacher. The study also draws from the point that pre-service teachers' identity construction is influenced by the kind of social engagements to which they are exposed. This means, for example, that a science pre-service teacher's interaction with the content they are learning (including the instructional materials to which they are exposed), and even simply engaging in discussion with a peer who may have more knowledge of the matter can be a source of defining oneself. As asserted by Kaplan and Garner (2018), social context is one of the domains that influences teacher identity development and change. This is because pre-service teachers have, either consciously or unconsciously, what Loughran (2006) terms 'learning agendas. Learning agendas are the aspects that characterize the knowledge and/or skills that pre-service teachers should learn, and which influence their identity development.

Pre-service teachers' learning agendas

In this study, science pre-service teachers' identity is linked to their learning agendas. Loughran (2006) argues that teaching in ITE should aim to fulfill pre-service teachers' learning agendas. This firstly concerns understanding the content that is taught. In this study, this would be science subject matter knowledge (Shulman, 1986). Pre-service teachers may be learning with, and in the midst of other students training to be scientists (as in the context of this study). However, the subject matter knowledge that they learn should include what they need to teach science in schools in order for them to develop an identity as a science teacher (Chung-Parsons & Bailey, 2019). The second agenda has to do with learning what it means to learn. This involves students being aware of their thinking through metacognition, therefore, questioning their approaches to learning and understanding the subject matter knowledge. The last agenda explores learning about teaching (Loughran, 2006). This is about understanding how to enact and pass on the content knowledge that they gathered to the learners in their classrooms. In a content module, this can be fulfilled by lecturers engaging students in activities that help them imagine their future teaching contexts, and through modelling best practices for teaching (Lunenberg et al., 2007). As the pre-service teachers imagine their future context, they also get to 'see' and feel themselves in practice by imagining the kind of science teachers they would like to be.

Although Loughran (2006) argues that pre-service teachers bring these learning agendas to the methodology modules, Khoza (2020) and Nyamupangendegu and Lelliott (2016) have shown that these learning agendas can be fulfilled in content modules. In this study, my assumption is that these learning agendas would contribute to pre-service teachers' identity as science teachers. Teaching the pre-service teachers, regardless of whether it is through a content or methodology course, should involve using the methods and approaches those teachers themselves are encouraged to use in their teaching. In a study conducted by Montenegro (2020), pre-service teachers expressed that their teacher educators needed to model best practices for teaching, regardless of the nature of the module (content or methodology) as these influences how they further construct their science teacher identities.

METHODOLOGY

This was a qualitative study stemming from an interpretivist paradigm to allow an in-depth analysis of the phenomenon under study (Creswell, 2012). A case study design was used to explore the pre-service teachers' experiences. The aim of this case study is not to create generalizable results, but to gather a more in-depth understanding of how content modules can be sites to develop science teacher identity in pre-service teachers.

Research Context

This study was conducted at an institution that follows a concurrent model, as described above. At the time of writing this, the science content modules are taught at the science faculty, and the methodology modules are taught at the faculty of education for those training to teach science at secondary school level. **Table 1** illustrates the structure of the B.Ed. program for prospective science secondary school teachers.

As can be seen in **Table 1**, the pre-service teachers begin their degree with science content modules at the science faculty. The modes of delivering content in these modules include lectures, practicals, and tutorial sessions. The students complete these modules together

with mainstream students who are studying to become botanists or chemists, for example. However, they still come to the education faculty for their other educational modules. It is only in their second year of study where they do their general science methodology module. This module combines all of the science pre-service teachers, including those who are studying to teach at primary school level. In the third year, the science pre-service teachers complete their subject-specific methodology module at the education faculty. As such, the pre-service teachers only learn how to teach their respective subjects in their third year of study. In addition, the pre-service teachers do what is termed a 'capping module' designed to bridge the gap between the content completed at the science faculty, and the school content. The students then continue with the methodology modules in their fourth year.

Participants

All of the fourth-year science pre-service teachers were invited to participate in this study. These students were chosen because they had experienced the teaching and learning of the content modules in their first and second years and had completed the capping module. Furthermore, at the time of data collection, they had gone to the teaching practice. This means they have had a chance to implement what they are learning at the university. These pre-service teachers were approached through their science methodology modules as they were all enrolled for these. There were 13 registered physical sciences fourth-year pre-service teachers, of which nine agreed to participate in this study. In life sciences, 10 were registered and eight agreed to participate in this study. However, four were found to be in both the physical sciences and life sciences groups as they were majoring in both subjects. These pre-service teachers were marked and interviewed only once to avoid duplication. Therefore, in the end, 13 pre-service teachers were interviewed. I refer to the participating pre-service teachers as participant (P) 1, 2, 3, and so forth, using their preferred pronouns when presenting the findings.

Data Collection

Data were collected through semi-structured interviews, which allowed me to tap into the participants' thinking (Denscombe, 2007). The interview schedule was adapted from Nyamupangedengu (2015) and piloted with two students who were not part of the study. Each participant was interviewed individually to get his or her experiences. Some of the questions included in the interview schedule requested the pre-service teachers to describe a typical science lecture they had had, and their interactions within those lectures and other content delivery methods, like practical sessions. The interviews were audio-recorded and transcribed verbatim. The duration of each interview was between 32 and 46 minutes.

Data Analysis

The data were analyzed using an inductive thematic analysis approach. Clarke and Braun (2006, p. 6) define thematic analysis as "…a method for identifying, analyzing, and reporting patterns (themes) within data." These patterns or themes are identified as they emerge from the qualitative data and are then used to address the research issue under investigation (Maguire & Delahunt, 2017). Data analysis began with reading the transcripts several times alongside the interview audio recordings to familiarize myself with the data and the ideas expressed by the participants. The codes were then allocated to the first transcript, then extracted. To bolster the rigor and validity of the findings, another researcher was invited to code two of the transcripts that were independently using the list of codes from the first transcript. We met and discussed the codes and agreed on our respective findings. It should be noted that there were codes that we both identified from the two transcripts that were not in the list of codes extracted from the first transcript. These were discussed and added to the list. **Table 2** shows some of the codes used in the transcripts.

The next step was to look at the similarities across the codes and the extracts from the data. This led to four categories of descriptions. For example, the codes; 'lecturer's teaching approaches', 'lecturer's use of instructional material' led to the category that pertains to how lectures are conducted in the content modules. These categories are presented in the findings section below.

FINDINGS

The data analyzed yielded four categories that describe and support how science content modules can be sites for pre-service teachers to develop their identities as science teachers. These categories are the nature of the subject matter knowledge taught in the modules; the context in which this subject matter is taught; how lectures are conducted in the content modules; and science practical sessions. These categories are described below.

The Nature of the Subject Matter Knowledge Taught in the Modules

The science pre-service teachers talked about the subject matter knowledge that they were learning at the faculty of science. They expressed how the content seemed irrelevant to them as students of teaching, in particular.

1. **P1:** As a teacher, I would just ask myself, "how would this help me… where am I going to apply

Table 2. Examples of codes developed

Code	Definition	Example of student utterance
Level of content	Description and evaluation of the complexity of the content taught and impact on student learning.	**P2:** "…On a scale of 10, I would rate the difficulty of the content at eight, it was so difficult especially…"
Description of content	The kind of concepts taught and their impact on student learning.	**P4:** "The content was fine but not for us as teachers…"
Lecturer's teaching approaches	Descriptions of how the content is taught, the strategies and techniques.	**P4:** "…we answered questions on clickers that the lecturer posted."
Lecturer's use of instructional materials	Description of how the lecturers used their instructional materials and the impact thereof on student learning.	**P11:** "There was extensive use of PowerPoint presentations and reading off from the slides."
Lecturer's description	Any students' mention of how they saw the lecturer as not just a lecturer.	**P2:** "I sometimes felt like I was not being taught by a teacher. It was a few that taught like teachers."
Practical activity	Description of the activities that they did in their science practicals.	**P10:** "The practical investigations were fine…sometimes we were given worksheets."

this?" I would imagine what the kids have to learn, then be like "nah…this is not for me".

2. **P5:** The content did not necessarily prepare me to become a science teacher because most of the concepts we did are sort of detached from the school content.
3. **P8:** The knowledge was more focused on the BSc students rather than me as a future science teacher.

As can be seen above, the three pre-service teachers alluded to the same aspect. P1 expressed that she always had to ask herself questions when she was learning the subject matter knowledge. This meant that during the learning process, she did not see herself as a science teacher. Instead, she saw herself as a scientist. This was also noted by P12, who explained, "Whenever I was in class, the content did not 'speak' to me as a science teacher". He did not feel catered to, and this had implications for how he identified himself during teaching practice. He further stated, "When I was doing my teaching practice, I felt like I was just too much of a scientist for my learners". On the other hand, P5 noted that what he learnt at the faculty of science did not seem to be aligned with what he needed to teach in school. P8 argued specifically regarding the differences between her and the BSc students, specifically that the subject matter knowledge was not tailored for her needs a pre-service teacher. She felt as if she was left out due to the content taught and could not see herself as a teacher when learning the content. She ended up conforming to what she was taught and seeing herself more as a BSc student than a science teacher.

Some of the pre-service teachers enjoyed the knowledge, but still shared the same sentiments as those above in terms of developing themselves as science teachers.

1. **P2:** I enjoyed the modules because I am inquisitive, but I struggled with some of the content I had to teach to Grade 10s… when I have to teach, I always draw from what I was taught in high school rather than what I learnt in varsity.
2. **P9:** As much as it was nice to understand the science, I still needed to learn in a capacity of a science teacher. I enjoyed the content, like biology, on an individual level.

P2 and P9 noted that they enjoyed the modules on an individual level because they were inquisitive in nature. Although this may be seen as desired, P2 expressed that she was unable to understand herself as a teacher when she took part in teaching practice. P9 made a bold statement that he needed to acquire knowledge as a science teacher, which would in turn contribute to his identity as a science teacher. However, the content he was learning did not seem to unleash and develop that identity.

Other pre-service teachers were specific and provided examples in terms of the nature of the subject matter knowledge that they had learnt at the faculty of science. For example, P6 said, "I learnt new things, but not useful for me, to me as a science teacher…like we studied insects in depth, and I could not see 'insects' in the school curriculum". P6 further explained, "It was a problem for me when I was at teaching practice because I had to start from scratch and read the content…that is when I started feeling like a teacher". This denotes that P6 did not identify himself as a science teacher when doing the science modules. It was only when he went to teaching practice that he reflected on what he had learnt in the modules, and how that became less useful to him as a science teacher. Similarly, P4 expressed the following:

1. **P4:** I was doing a module that was mainly catered for Zoology students majoring in entomology and did not necessarily give a thought that there were education students, even if we are few, how it was presented in terms of the examples and concepts.

Examples are part of subject matter knowledge. Although he was not specific, P4 reported that due to

most of the examples used in zoology module, he did not see himself as a teacher. Most of the examples that were used catered to the zoology students. Hence, P12's sentiments were that "we were studying science and not education or science education".

The Context in Which the Content is Taught

Context, in this case, has to do with where the pre-service teachers learn content–attending the same lectures as the BSc students.

1. **P1:** I felt like a science student in my first two years. I even forgot that I was doing teaching. It was only in my third year where I started feeling like I was actually studying to become a teacher.
2. **P3:** In my first year, the reason I struggled is that I was struggling to find myself as a teacher in a big class full of core science students.
3. **P5:** When I am at that side [the science faculty], I just learn concepts and I feel like they are not related to my field.
4. **P6:** I just feel like a normal student at X campus [the science faculty], but this side, I feel like a teacher. It is kind of hard to settle in when you do not relate to people around you.

The pre-service teachers raised the fact that they were struggling to identify themselves as science teachers when attending content modules with other science students at the science faculty. P1 and P5 expressed that they did not feel like science education students in their first two years. This was due to where the knowledge was being taught, and the careers to which these modules catered. Learning the subject matter in this manner resulted in P3 struggling to understand himself as a teacher. This also applied to P6 as she admitted, "It is kind of hard to settle when you do not relate to people around you". She particularly viewed the people around her during the learning process as contributing to how one develops an identity as a science teacher. P9 alluded to this by stating, "I felt lonely in the classroom as a student of teaching," and further expressed that this was because she was studying with the BSc students. Not only did the pre-service teachers express their concerns about the context in which the science content modules are taught, but they also suggested the following:

1. **P2:** I think if education students were taught alone, it would have made me relate
2. **P13:** I would be happy if all our modules are here because I registered for teaching and I want to breathe teaching from the onset so that I can teach better.

P2 and P13 claimed that they could possibly relate to the knowledge if it were only education students in the classroom. P13 specifically noted that this would not delay his development as a science teacher because he would start to "breathe teaching from the onset", meaning that his identity construction as a science teacher would have begun in his first year.

How Lectures are Conducted by the Lecturers

This category highlights that it is not only the content that is taught, the context in which it is taught, but also how this content is taught that develops teacher identity:

1. **P11:** I gained some demonstrations and methods of teaching, and I could see myself using them in my teaching. Some I used during teaching practice but did not work out.
2. **P3:** I would say I picked up quite a few things, even if they were not explicitly exhibited. I will make an example of a zoology lecturer, that instead of us reading the parts of an insect, we were required to make a poster then presenting that to the rest of the class. It is one of the things that I picked up about how I can steer my lessons, even if it is not the same topic.
3. **P7:** Other lecturers were inspiring in how they taught, and I would sometimes wish to imitate them.
4. **P8:** The issue was on the presentation of content and assessment. For me, a good teacher, it is not about the content. It is about how the students perceive the content. Like Prof. X, he was really good, and even paid attention to how he wrote his notes, how he communicates.

As seen in the pre-service teachers' utterances above, when attending lectures, they listened and took note of how the lecturers taught the content and took on multiple identities (e.g., as students and/or science teachers). In this case, they took a step further and though of ways in which whatever the lecturer was saying and doing could be used when they embarked on their teaching careers. For example, P11 said she used some of the methods that her lecturer used in the lectures, while P3 was thinking of doing the same in his teaching. P7's wish to imitate his lecturers indicated that he saw himself as a particular kind of a science teacher through paying attention to how his lecturer did things. Similarly, P8 seemed as if she had adopted or would like to adopt Prof. X's teaching approaches and his ways of compiling notes for students. This suggests that her identity as a science teacher was influenced by how Prof X taught, and how he conducted himself in the lectures. P13 shared a similar experience, "Sometimes when I teach science, I see my chemistry lecturer at play, and I realize this at a later stage". This denotes that she was unconsciously teaching like her chemistry lecturer, thus, influencing how she constructs her science teacher identity.

Some of the pre-service teachers expressed their concerns in terms of how they had to gather the messages useful for teaching that influenced their

identity. For example, P3 said, "We usually had to pick up messages about teaching on our own and that was a bit problematic for me". The fact that P3 noted this aspect shows that he needed the lecturer to explicitly tell them why they were teaching in a certain manner. In this regard, the pre-service teachers would have consciously developed certain identities as science teachers. Similarly, P4 explained, "I know they [the science faculty lecturers] are teaching the science, but they also need to know the methods in a way that it shows us how to teach the content boldly".

Science Practical Sessions

All of the pre-service teachers interviewed in this study referred to their practical work sessions, and how this influenced how they saw themselves as science teachers and how they were seen by others. The following pre-service teachers' responses reveal this point.

1. **P2:** The practical component of the modules helped me to understand science better as a scientist. The practicals were too complex, unless I had learnt how to bring it down to the level of students
2. **P5:** We always used complex apparatus and when I got to the school, there was none. I struggled to teach as I was in a township… the variation of practicals was absent, like for us who will teach in the disadvantaged schools.
3. **P7:** I found the practical activities worth my time as a science student because I also developed the scientific reasoning skills.

The pre-service teachers expressed the necessity for practical activities in their profession as science teachers. However, instead of adopting such practical activities, they would rather adopt the necessary skills because the practical activities did not help them understand themselves as science teachers. P2 said that she took on a scientist identity instead of that of a science teacher largely due to the kind of practical investigations conducted. P5 made an interesting point, revealing that he usually took on the identity of a science teacher by thinking of his future context when in practical sessions. However, he suggested that what might have contributed to his development as a science teacher is a variety of practical investigations that are more complex, and those that can also be conducted in schools that do not have resources.

Similarly, P7 noted how the practical work made him feel like just a science student, thus contributing to a scientist identity. This is evident as he specifically used the words "as a student". When he was probed on the matter, he further shared, "I cannot deny that I always did the practicals as a scientist, plus, I have BSc. friends who talked the scientist language…" to denote that his science teacher identity was not encouraged. P6 stated, "I believe that practicals should have had a huge impact if they gave us relevant experiments," thus arguing that practical activities are what should help them to learn about what it means to be a science teacher.

DISCUSSION

In this article, the findings presented highlight what the various aspects that could contribute to the development of pre-service teachers' identity as science teachers in content modules. Firstly, the nature of the content taught was determined to be a major factor. The science pre-service teachers expressed that the subject matter they were taught in the first two years of their degree did not relate to them as science teachers. Chung-Parsons and Bailey (2019) also found similar results, as the pre-service teachers in their study considered the scientist identity as 'core'. This is problematic as these students are studying to become science teachers and not scientists. Literature that looks at the nature of science content knowledge suggests that there is a difference between academic content knowledge, and teaching-related content knowledge (Deng, 2007). Although, according to Deng (2007), while the relationship between the two is dynamic and complex, what is taught to the pre-service teachers should develop them in ways that allow them to become better science teachers. The academic science content, as the parent of school science subject matter knowledge, should provide a frame of reference for what the science pre-service teachers need to know. In this study, the findings suggest that a distinction is not made, despite the fact that it is necessary. According to Chung-Parson and Bailey (2019) and Kaplan et al. (2014), teachers should also be able to identify themselves within their subject matter as different subject matters have specific norms. As argued earlier, knowledge (the science content knowledge in this case) that the pre-service teachers gather when learning about teaching is important for identity development (Beijaard et al., 2004). According to Aydeniz and Hodge (2011), the development of a scientist identity in pre-service teachers is desired, however it should not take priority over the development of the teacher identity. As such, it can be posited that prospective teachers need not learn the pure academic science content that is learnt by those studying to become scientists as this will propel them to view themselves as scientists only.

Secondly, the pre-service teachers' construction of their identity as science teachers could be influenced by the context in which the science knowledge is taught. As mentioned earlier, Kaplan and Garner (2018) have identified social context as one of the factors that influences teachers' identity development. Indeed, the discourses that the science pre-service teachers participate in contribute to how they later on act as science teachers (Menon & Azam, 2021). A study conducted by Nghia and Tai (2017) shows that pre-

service teachers' identities are shaped by teacher education programs and the interactions that the pre-service teachers engage in with their peers. Similarly, Tucker (2020) also finds that interactions with peers can greatly contribute to pre-service teachers' identity development. When individuals engage in actions and social conversations in particular social contexts, this allows them to reflect on the kind of people they are. This was the case in this study, where the pre-service teachers were subjected to a social context full of BSc. students. It is expected that if people share the same values and norms, their interactions will illuminate those values and norms. Indeed, the science pre-service teachers in this study noted that the 'language' and conversations they held with the BSc. students made them feel like scientists instead of science teachers. Therefore, for the pre-service teachers to develop their science teacher identities, a sense of belonging in a community with like-minded individuals is desired. This community would also provide the pre-service teachers with a sense of appreciation and connectedness where they also recognize each other's competencies (van Lankveld et al., 2017). However, mixing the BSc students with teaching students in content modules does not seem to provide this opportunity for pre-service teachers.

It is not only the interactions in lectures that contribute to the development of pre-service teachers' identity as science teachers, but also the activities performed. In this study, the activities performed included practical work activities. The pre-service teachers in this study expressed their concerns on how the practical activities did not speak to them as science teachers. Just like the beginning science teachers in Wei et al.'s (2019) study, the pre-service teachers' explanations and responses in this study are an indication that they perceived practical work as what should be part of their identity as science teachers. However, they were denied the opportunities to consolidate that understanding through the activities carried out in their practical sessions. Practical investigations and the language used in those sessions should be a window to seeing themselves as science teachers. However, what became useful for them as prospective science teachers were how the sessions were conducted–gaining the skills of facilitating practical work only, yet, according to Wei et al. (2019), teacher preparation should provide students with opportunities that develop their identity for teaching science with practical work.

Thirdly, the pre-service teachers' learning experiences revealed how the content knowledge taught could be a possible aspect that led to them developing as science teachers. The literature on lecturers as role models suggests that prospective teachers are likely to see themselves and teach in the ways in which their lecturer has been training them (Lunenberg et al., 2007). Timmerman (2009) argues that lecturers who are involved in the education of teachers should also be teachers because they might have an impact on the pre-service teachers' perceptions of teaching. This study has shown that, indeed, pre-service teachers do take note of and pay attention to how they are taught and, consciously or unconsciously, come to perceive that as how they should be teaching in schools. This would then define them as science teachers. As such, lecturers need to model good teaching practices, such that pre-service teachers can develop identities that allow them to become effective science teachers (Nyamupangedengu & Lelliott, 2016). Harrell-Levy and Kerpelman (2010, p. 77), support this, emphasizing that teachers have to be "identity agents". The findings in this study suggest that the lecturers of content modules also need to be identity agents in the sense that they model behaviors that foster pre-service science teachers' identity development.

CONCLUSION, IMPLICATIONS, AND FUTURE RESEARCH

The data presented in this study have shown that modules where pre-service science teachers learn their subject matter knowledge can potentially influence (both positively and negatively) the development of the science teacher identity in pre-service teachers. As other recent studies have shown that science teacher identity development in pre-service teachers is influenced by the ITE programs (e.g., Kier & Lee, 2017; Menon & Azam, 2021), it is important to rethink the practices in these programs. As such, the results of this study have certain implications for the science ITE programs and content modules:

1. The question that can be asked here is, 'do pre-service science teachers need the same subject matter knowledge as the BSc. students?' There seems to be a need to rethink the subject matter knowledge taught to pre-service teachers in terms of the concepts (the depth and breadth). It is important that pre-service teachers can relate to the knowledge taught and be able to identify themselves as science teachers rather than pure scientists. This then suggests that the practical activities and ways in which they are conducted be rethought.
2. The pre-service science teachers' attendance of content modules with BSc. students is questioned. If it is indeed a fact that social context does contribute to teachers' identity development, as in Kaplan and Garner's (2018) model, then attending science content modules with BSc. students need to be reconsidered. The interactions that pre-service teachers have with BSc. students leads to them identifying themselves as scientists rather than science teachers.
3. Regardless of who is teaching the content modules, the results in this study suggest that

how the subject matter knowledge is taught contributes to pre-service science teachers' identity development. As such, messages about teaching need to be explicitly portrayed to these students. As such, the issues of the subject matter knowledge taught, and the context in which the pre-service teachers are taught, need to be resolved first.

The findings in this study are not generalizable. However, this study can also be done in other contexts to begin a conversation around the development of science teacher in pre-service teachers in content modules. Given that identity development is complex and influenced by a range of factors including teacher educators' practices (Kaplan & Garner, 2018), future studies can look into describing how and what lecturers teach in both content and methodology modules influence the science teacher identity development. This can also include looking at the link between the teacher educator knowledge and science pre-service teacher identity development.

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