A CODE THEORY PERSPECTIVE ON SCIENCE ACCESS: CLASHES AND CONFLICTS

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ABSTRACT

Quantitative measures of student performance fail to provide insight into underpinning constraints and enablements to access in science in higher education. This case study of a science foundation course uses Legitimation Code Theory as a theoretical frame and acquisition of recognition and realisation rules as an analytical frame to provide a depth empirical account of student access and success. Results indicate that access to the powerful science knowledge in the production (science) context is dependent on students recognising and realising the knower code of the learning context, which requires of them to be independent and autonomous learners. Such access is not afforded when students prior (school) learning-context relativist code clashes with the required university learning-context knower code. It is argued that a focus on the learning context could be key in enabling access to students whose educational background does not align well with that of the higher education context.

Key words: code clash, legitimation code theory, realisation rules, recognition rules, science access; science foundation

INTRODUCTION

Statistics on student throughput and retention rates in higher education indicate a system that is failing many of its students, and in the South African context the disparities in performance along race lines are particularly stark (see Scott, Yeld and Hendry 2007; CHE Report 2013). Whilst these quantitative measures are used as a proxy of student 'success' (or not) in the system, they convey little about students' qualitative experiences, processes of student development and learning, or underpinning causal mechanisms for their academic performance. There is therefore an urgent need to develop and use nuanced tools of analysis to conduct depth empirical studies related to teaching and learning in our curricula if we are to respond appropriately to increased calls for decolonised and/or transformed curricula that enable epistemological access to students from a range of socio-cultural backgrounds. As Carey concludes in a report on accommodating student diversity, institutions that are succeeding in this regard 'apply the academic values of empiricist and deep inquiry to their own practices'

(2008, 8). This is one such depth empirical study.

Legitimation Code Theory (LCT), which understands educational practices as being underpinned by social codes, provides a useful broad framework in which to contextualise access and success. In code theory terms access relates to student acquisition of a curriculum code, which can be demonstrated through production of legitimate texts. This study, which is part of a larger project in which access in a higher education science foundation course at Rhodes University in South Africa is examined, draws on these concepts. The course in question, Introduction to Science Concepts and Methods (ISCM), forms part of a year-long foundation programme which aim to enable access to any science course once students enter mainstream. Research in the broader study characterises curriculum and pedagogic practices of ISCM in depth (Ellery 2016). This article provides a close-up examination on how students respond to such practices, drawing on Bernstein's (2000) analytical frame of acquisition of recognition and realisation rules to demonstrate access (or not) to the curriculum 'codes' that are being legitimated. The article therefore aims to better understand constraints and enablements to student access and success through acquisition of legitimated code in ISCM. It also considers how the findings can be applicable in a broader science learning context.

CONCEPTUAL AND ANALYTICAL FRAMEWORK

Conceptually the study draws primarily on Maton's Legitimation Code Theory (LCT) where codes are the organising principles or 'rules of the game' of practices. Code theory is premised on the idea that power and control manifest themselves through the structural and interactional aspects of practices, and therefore have the capacity to include or exclude. Analysing educational practices using code theory enables characterisation of the practices, highlights their underpinning principles (i.e. what is being legitimated), and allows for their effects to be considered (Maton 2014). The desired 'effect' of ISCM educational practices in this study, is students gaining epistemological access to science, or science disciplines, in higher education.

Maton (2014) proposes several dimensions or organising principles useful for understanding practice. This study uses the Specialisation dimension which encompasses epistemic relations (ER; what can legitimately be claimed as knowledge) and social relations (SR; who can claim to be a legitimate knower). These two relations can be represented on continua of stronger to weaker relations (represented by + and – respectively) and plotted on a two-dimensional plane (Figure 1). The resultant four quadrants represent four specialisation codes: a knowledge code (ER+, SR–), a knower code (ER–, SR+), an elitist code (ER+, SR+) and a relativist code (ER–, SR–). Typically, science disciplines legitimate a knowledge code and many humanities disciplines a knower code. A discipline such as music, which requires both good theoretical knowledge (ER+) as well as musical talent (SR+) would legitimate an elitist code (Lamont and Maton 2008). Relativist codes require neither specialist knowledge nor knower dispositions, which could be considered an unlikely scenario in a specialised context such as education.

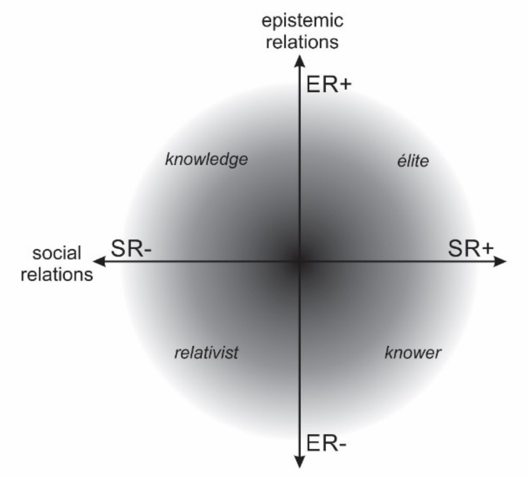

Figure 1: The specialisation two-dimensional plane: Topology of four specialisation codes based on epistemic and social relations (source Maton 2014, 30)

Research done using the Specialisation dimension, and drawing on the concept of cosmologies (Martin, Maton and Matruglio 2010; Maton 2014), indicate that ISCM educational practices reflect two distinct orientations: epistemological and axiological (Ellery 2016). Practices in ISCM with an epistemological orientation are concerned with the production[1] context and focus on scientific knowledge and knower dispositions associated with becoming and being a scientist. Practices with an axiological orientation are concerned with the learning context and focus on students becoming independent and autonomous science learners in a higher education context. Because of ISCMs foundational nature, lecturers pay similar attention to both orientations, resulting in both a *production-context knowledge code* and a *learning-context knower code* being equally legitimated (Ellery 2016).

Examining specialisation codes in educational practices allows for identification of code matches, clashes or shifts over time (Maton 2014, 77). A code clash is defined as a disparity between the code characterising how a participant thinks and acts and the code that underpins the basis for success in the current practice (Lamont and Maton 2008). Empirical studies surfacing code clashes have, for example, allowed comment on low uptake rates of music as a discipline in schools (Lamont and Maton 2008) and learning difficulties for international students in an on-line post-graduate course (Chen 2010).

To characterise the effectiveness with which a student can operate within an educational context, which depends upon her/his capacity to understand and engage with the codes being legitimated and to act appropriately, Bernstein proposes the concepts of recognition and realisation rules. Recognition rules are the way in which 'individuals are able to recognise the speciality of the context that they are in' and to do this a student makes inferences about '*what* meanings may legitimately be put together' (Bernstein 2000, 17, my italics). Even though a student may have recognition rules, they may not be able to produce the legitimate communication, which means that they have not acquired realisation rules. These are the rules that regulate '*how* the meanings are to be put together to create the legitimate text' (Bernstein 2000, 18, my italics). It is worth noting that 'text' is commonly 'measured' through meeting certain criteria in assessment tasks, but can also relate to behaviours and dispositions such as actively participating in class or engaging in self-regulated, independent learning.

Acquiring a coding orientation is facilitated by having the right knower dispositions such as 'aspirations, motivations, values and attitudes' favourable to the context. The students' coding orientation and knower dispositions mutually influence each other for them to produce legitimate text (Morais, Neves and Afonso 2005, 417).

Since epistemological access is about producing required text for a context, the production-context knowledge code and a learning-context knower code legitimated in ISCM require two types of texts. The former is a 'scientific' text that is typically overtly legitimated in assessment tasks, and students are evaluated primarily on propositional and procedural disciplinary and scientific literacies knowledge. The latter is a 'science learner' text that is not assessed directly but instead requires students to be autonomous science learners in an academic context (Ellery 2016). Bernstein's (2000) model of acquisition of recognition and realisation rules and knower dispositions therefore allows for 'operationalisation' of epistemological access according to these two expected texts in relatively concrete terms.

STUDY CONTEXT

The Science Extended Studies Programme (SESP) at Rhodes University in which ISCM is located admits students whose school marks are close to meeting faculty requirements for direct entry into mainstream. Application of other admission criteria means students are also generally working-class, African,[2] first-generation higher education learners whose home language is seldom English.

Despite South Africa being over twenty years into its democracy most African scholars continue to be exposed to a vastly inferior school education compared to their white counterparts. Many school classrooms are characterized by, amongst others, a teacher-centred and spoon-feeding culture, poor academic language proficiency, a slow pace of working, and rote and instrumental learning (Pym and Kapp 2011, 5–6). Similarly, literacy and numeracy scholars speak of learners with an underdeveloped capacity to read independently (Mgqwashu 2012, 240), reproducing verbatim in essays, presenting illogical arguments and claims, describing rather than analysing, being prescriptive or normative when asked to be analytical (Slonimsky and Shalem 2004, 86), shallow conceptual development (CHE Report 2013, 61), and rote performance of measurements and algebraic manipulations (Rollnick, Lubben, Lotz and Dlamini 2002; Engelbrecht, Harding and Phiri 2010).

Being mindful of students' educational background, whilst acknowledging their agency, ISCM lecturers have developed a carefully structured curriculum that is taught both by disciplinary staff (from Physics, Chemistry, Life Sciences and Earth Sciences) in lectures and practical sessions and two 'literacies' staff who focus on scientific and language-related literacies in tutorial sessions. A study of ISCM pedagogic modalities show clear articulation of boundaries of the disciplines, careful selection and sequencing of knowledge, flexible pacing of work, explicit articulation, instruction and feedback related to evaluative criteria, and open communication and dialogue between staff and students – all of which, it is argued, should favour production-context access. Similarly, modalities that relate to being overt about learning expectations, actively modelling expected learning practices (such as consolidating work, accessing appropriate resources, testing their own understanding), and deliberate but explicit scaffolded reduction of such support, should favour learning-context access (Ellery 2016). This study examines whether these modalities do indeed afford such access.

METHODOLOGY

An external language of description, which bridges the gap between abstract concepts and empirical data (Bernstein 2000; Maton and Chen 2016), was developed for both the production-context and the learning-context work in the ISCM curriculum. Empirical data indicating acquisition of production-context recognition and realisation rules were derived from student responses to assessment tasks (tests and examinations) for a period 2010–2014. The tasks encompassed the full range of cognitive complexity from simple recall to comprehension, application, analysis, evaluation and complex creation. However, because learning-context recognition and realisation is seldom assessed directly, data in this regard were instead obtained from student interviews, critical reflections and course evaluations.

Despite a comprehensive external language of description, further analysis was required to surface underpinning enablements and constraints. To this end the coding process described by Maxwell (2012), that uses three overlapping categories, was employed. The *organisational* categories of recognition and realisation were established prior to data collection and did not provide insight into causes. The resultant descriptive *substantive* categories derived from participants' comments and assessment events remained close to the empirical and did not entail theory. The final *theoretical* categories located the data in a more abstract framework of underpinning codes, allowing for identification of a possible code clash and competing code demands.

ACQUIRING PRODUCTION-CONTEXT RECOGNITION AND REALISATION RULES

In terms of a production-context recognition and realisation external language of description for ISCM, *no recognition* (RC(ec)-) indicates a student has no understanding of the context (concepts, values, conventions and procedures) necessary to produce an appropriate text. For example, they may answer a calculation question with a written answer. *Recognition but incomplete realisation* (RC(ec)+/RL(ec)-) indicates they have good understanding of the context but only present some correct concepts and values and apply some appropriate procedures and conventions to produce partially suitable text. A typical example is recognising the need to measure and use ratios in presentation of a scale bar, but using an incorrect choice of scale bar length in the final stage of calculation. *Recognition and realisation* (RL(ec)+) means the student presents correct concepts and values and applies appropriate conventions and procedures to produce a suitable text. For example, this would include not only providing the correct scientific text, such as why large elements are radioactive, but also developing a logical, structured argument in paragraph format.

The analysis of examination questions indicates that students in ISCM are generally able to recognise the context of questions in assessment tasks. This is particularly the case when the task question is framed by clear instructional action (e.g. describe, explain, distinguish, apply) and concept words, and mark allocation or instructions provide an indication of scope of expected answer. Students therefore mostly draw on correct concepts and generally have a good sense of what is required in terms of conventions and procedures associated with writing (e.g. full sentences, logical flow of ideas, acknowledgement of sources) and calculating (e.g. show working, use appropriate units, work to correct significant figures and decimal places). For example, when asked in an interview to explain their understanding of the criteria (phrased as ‘what will get you marks’) for a question related to writing a paragraph with in-text citations based on a scientific article, a student replied:

> I would get marks for the construction of a paragraph ... has an introduction where you start off from a broad thing then goes down to the specific things of what they want in the question ... full sentences ... grammar and spelling ... and if you understood the question ... then the in-text referencing, if you understand you know how it is done. (Student interview, Sandla)[3]

However, despite ISCM students having relatively good production-context recognition rules, they often cannot produce an appropriate text, indicating relatively poor acquisition of production-context realisation rules. In the same mark analysis, poor production-context realisation was not obviously linked at any particular level of cognitive complexity. In other words, as a group they manage equally well (or not) at the lowest level of recall and the highest level of creation, and at all other levels in between.

Poor production-context realisation in ISCM often relates to poor implementation of procedures and conventions. Poor implementation at lower cognitive levels tend to be of a more technical nature, such as making mistakes in calculations, rounding off poorly, using significant figures inappropriately, measuring inaccurately, referencing poorly, and selecting incorrect information. At higher cognitive levels it tends to relate to difficulties in applying, evaluating or being critical.

Poor production-context realisation also relates to incomplete understanding of concepts. In this regard this was often due to the *high cognitive demand* of work:

> I won’t lie, it’s the first subject that I can say it was quite difficult for me ... last year when I was doing my matric, I didn’t see how deep is science but in ISCM I saw how deep is science ... in terms of being critical and put your understanding towards your work (Student interview, Kanelo)

Furthermore, the *abstract nature* of knowledge was especially difficult if it was not contextualised for students:

> Like sometimes there are lectures, it’s all about the theory, there’s no examples ... if there are examples I will understand. (Student interview, Kanelo)

A third aspect of poor production-context realisation that emerged in the interviews is associated with poor *assessment task techniques*. The most common examples of this are running out of time during tests and examinations and not reading the question carefully. In terms of time a student commented:

> ... I don’t think I write slow but the thing is I just have a huge meeting in my mind when I answer questions ... I spend a lot of time thinking. Ja, that’s where I lose most of my time. (Student

interview, Zola)

In terms of reading a question carefully, a student indicates in her comment below that she had registered the words proton and neutron but had not read the need to relate these to forces in the nucleus as required by the question:

> ... what I got I just picked up on the protons and the neutrons in the nucleus what [role] do they play and what do they do, and not the forces ... that's why I answered it this way. (Student interview, Anele)

Bernstein (2000) and Morais, Neves and Afonso (2005) argue that being able to produce legitimate texts requires not only having production-context recognition and realisation but also knower dispositions appropriate for the context. My pedagogic analysis of ISCM indicated that there was both explicit instruction and relatively strong framing of epistemic values and knower dispositions (Ellery 2016). Consequently, student comments in interviews and evaluations indicate understanding of their own ontological development as scientists in a general way:

> This course has taught me many things now I am able to think as scientist, write as one and speak scientifically. (Student written evaluation, 2012)

Nonetheless, despite explicit instruction in the classroom a research project, in which students work relatively independently (although guided through major stages of the process) on a hypothetic-deductive scientific experiment of their choice, appears to play a crucial but more implicit role in developing appropriate epistemic knower dispositions and values. For example, quite a few interviewees commented on getting unexpected results, with some linking this to the epistemic values of being *critical* and *objective*:

> The research ... taught me how to conduct an experiment as a scientist and learn more of how to be a critical thinker and deal with the surprises that one can come across through the research. (Student written reflection, Sanele)

Others linked unanticipated results to the need to be *honest* in their use of empirical data, something that was obviously not necessarily required at school:

> In high school you would lie about your results but with university you have to provide evidence for your findings and conclusion ... you have to be honest when you are conducting an experiment. (Student written reflection, Ntatu)

Others mentioned being *curious* and *interested* in science, which can promote learning and discovery:

> One thing I learnt about Science during this experiment was that Science is not as difficult as

> people perceive it to be but it can be fun and interesting if only you do it out of commitment and curiosity because there is always something new in Science ... and if you do it for marks, you might just give up and lose out a whole lot of information along the way. But when doing it out of interest you might end up discovering new things in Science that no Scientist ever saw before. (Student written reflection, Nokhanyo)

The role of the independent research project in terms of building students' *confidence* and *motivation* in becoming scientists was also commented on by students:

> When we were told we were going to do this research I did not think I can pull this off but the guidelines given to us were very helpful and I had doubt in myself but as time went by I noticed that this is a challenge that I going to overcome. That made me realise I can conduct an experiment in a scientific way. I had never thought that I would be able to ... so this whole process has changed me as a science student and that is in a good way. (Student written reflection, Mncedisi)

The student comments show that whilst at one level ISCM staff can be explicit in terms of articulating epistemic values to assist in producing legitimate texts, at another level the underpinning epistemic values such as being honest, critical, objective, curious and accurate (amongst others) are not simply intellectual and epistemological in nature but also reflect ontological aspects of developing an 'embodied' (Dall'Alba and Barnacle 2007) way of being.

ACQUIRING LEARNING-CONTEXT RECOGNITION AND REALISATION RULES

In the case of learning-context recognition and realisation in ISCM, the external language of description relates to student learner autonomy. *No recognition* (RC(lc)-) means the student has no understanding that they need to be responsible for their own knowledge, work independently and develop their own understanding. A common example is students simply ignoring aspects of the work, especially if they have found it difficult. *Recognition but incomplete realisation* (RC(lc)+/ (RL(lc)-) indicates they have good understanding of the need to be responsible for their own knowledge, work independently and develop their own understanding, but they do not achieve this consistently. A good example is students using past exams and tests to gain a sense of expected questions, but relying on this slavishly and unquestioningly to guide learning. *Good realisation* (RL(lc)+) means students are responsible for their own knowledge, work independently and develop their own understanding. A typical example is a student independently consolidating their understanding by developing links between all different aspects of their work.

A detailed analysis of learning-context recognition and realisation indicates interesting trends. The norms and values underpinning student conduct in a university context are very different from those of a school context. In order to establish levels of recognition in this regard, students are required to articulate their understanding of these differences in a reflective exercise in the first semester of the ISCM course. The differences expressed by students can be grouped into three main categories of expectations. In terms of *knowledge* expectations, whereas students recognise that at school the concepts are relatively easy, seldom applied or requiring judgment, and the pace and work load is relatively low, at university concepts are more difficult, often applied and requiring judgment and the work load and pace is greater. Students also recognise the shift in *responsibility*: at school teachers are responsible for students' knowledge acquisition and therefore work in ways that assist them in this regard, but at university students are responsible for their own knowledge development, which requires them to take notes, attend lectures, ask questions, learn to read cues and work independently. Thirdly, in terms of *learning*, students recognise the need to study consistently and for understanding at university, which they articulate as requiring careful time management, rather than relying on the last-minute rote learning which served them well at school.

By clearly articulating the norms, values and practices of the learning context of the university (and ISCM), as mentioned in the previous paragraph, many students indicate they have good learning-context recognition. As one student commented on recognising they could no longer rely on an authority figure for knowledge, and that they would need to develop understanding at university themselves:

> ... because the lecturer is not like teaching you the school work where they tell you each and every detail but they [lecturers] give you the key notes then you have to go back to the library, or wherever you get the information and try to think what it's trying to tell you ... I think the lecturers are highlighting what you must [know], and everything that is said there is important ... I know that after the lecture I have to go and do the work again. (Student interview, Fezeka)

However, despite this recognition, many have not been able to realise appropriate ways of working and therefore exhibit poor learning-context realisation. Although autonomous learning is essentially about individual work that takes place outside of the contact sessions (lectures, tutorials and practicals), part of it relates to how students engage during *contact sessions* as well. Because tutorials and practicals require active student engagement and allow for opportunities for small group discussions in a mother tongue, students seldom commented on difficulties in these interactions. However, indicating relatively poor learning-context realisation, a number of students commented on problems in lectures related to taking notes, asking questions and on the use of English. In terms of the latter a student stated:

> ... in my school we were taught in English né, but we as learners we couldn't speak English. Like with our teachers we used to speak our mother tongue. Ja so it has been hard to come here and speak [English all the time] ... it's getting better ... but it's hard. (Student interview, Nobuntu)

However, most student comments associated with difficulties in engaging with the course relate to learning *beyond the class context*. Not only is there often insufficient student engagement, but also the type of engagement with course material can be a constraint, indicating relatively poor learning-context realisation. Some students appreciated the need for, but were not in actual fact, *learning for understanding*:

> I did prepare for lectures and the pracs, but sometimes ... I just read for the sake of reading but not understanding exactly what's happening. (Student interview, Lulama)

Others commented on how poor understanding meant poor application in another context:

> ... we did lots of inductive reasoning examples so I learned these examples and not what is in the inductive reasoning. But now I think if I know what is inductive reasoning I would be able to come to with my own understanding and apply it on the questions. (Student interview, Khuselwa)

A number indicated they were *not working with feedback or available resources*. In terms of the latter a student simply chose to ignore a handout that was difficult to understand:

Interviewer:	Did you engage with it [handout on sub-atomic particles]?
Student:	Not really, because I just used my [lecture] notes. But I didn't really understand it [the handout], but I made sure that I at least will have to write something that's in my [lecture] notes, so I used my notes [instead]. (Student interview, Zola)

A contributing component to poor engagement is *misreading requirements of the context*:

> ... 'light-year', I didn't think it was very important. Yes, I heard it in lectures but I didn't think that it was essential. We didn't use it when we were [working] like in practicals or in class, or in tutorials that much. So I thought okay 'light-year' no they won't ask it. (Student interview, Khuselwa)

Like working in an epistemic context, acquiring learning-context recognition and realisation rules requires possession of appropriate knower dispositions and values favourable to the context. In this regard student comments already cited indicate poor acquisition of dispositions and values related to being responsible for developing their own understanding (by rote learning rather than for understanding) and being self-regulated in their work (by not using available resources).

Explanations offered by students as to why they were having difficulty being autonomous learners can be grouped in two categories: aspects of lack of motivation as well as difficulty in changing entrenched study habits. In terms of *lack of motivation*, quite a few students commented on being disappointed or resentful about being in a separate foundation programme, and that this influenced attitude and motivation and therefore performance. As one student stated:

> When I found out I would have to do foundation I was crushed. I thought it a waist of my time and could not understand how it is benfitial to me because I wanted to do the computer route ... I only really started working when I was failing the tuts and the one test. (Student written reflection, Mzingisi)

Many students recognised the need to develop a good work ethic, but some found the social conditions and freedom at university presented them with problems:

> I start watching episodes [of TV series], like just one before I study, but I just click for another and then when you look you see its three in the morning and it's too late [to study] ... (Student interview, Mandisa)

The issue of *difficulty of changing entrenched study practices* was raised by a number of students, and in this regard they commented on volume of work and, often linked to this, difficulty in managing their time:

> I did well at school, very well, I was often first or close in my class ... my pattern was to study very hard just before tests – sometimes for hours ... [but here at university] I always run out of time 'coz there are tests and assignments and homework and stuff and it all takes too much time ... I guess I should be working more consistently like every day like you tell us [laughs] ... (Student interview, Mandisa)

DISCUSSION

Recognition, realisation and knower dispositions for access

Empirical studies focusing on the influence of educational practices on acquisition of recognition and realisation rules in the sciences are usually associated with production-context assessment practices (see Morais, Fontinhas and Neves 1992; Morais, Neves and Afonso 2005; Winter and Linehan 2014). However, because of epistemological and axiological orientations being equally legitimated in ISCM, which give rise to a production-context knowledge code and a learning-context knower code respectively, analysis in this study was conducted at two separate levels.

Legitimate performance at the production-context level in ISCM requires knowledge, practices and dispositions related to being a scientist. The required 'text', generally evaluated through assessment tasks, requires students to recognise and realise both the scientific knowledge and values dimension and the cognitive demand dimension. This study indicates that students in ISCM appear to be relatively successful at acquiring production-context recognition rules and knower dispositions but are less successful at acquiring production-context realisation rules due, in part, to poor assessment tasks techniques, poor use of science procedures and conventions, high cognitive demand, and the abstract nature of knowledge. However, one of the main reasons for students exhibiting poor production-context recognition is linked to the way they are engaging with the curriculum, suggesting that poor learning-context recognition and realisation is a primary constraint to good performance.

Legitimate 'text' that demonstrates acquisition of recognition, realisation and knower dispositions associated with the learning-context in ISCM would be working as an autonomous science learner. In this regard, students in ISCM generally demonstrate relatively good acquisition of recognition rules and knower dispositions through their appropriate articulation of the requirements of the learning context to be successful. However, students are less able to render their recognition into appropriate action and therefore exhibit relatively poor learning-context realisation, a trend that has been recognised in other studies (see Van Etten, Freebern and Pressley 1997; Adendorff and Lutz 2009). Practical difficulties experienced out of class relate primarily to misreading of context such as the need to work independently and consistently, rote learning instead of developing understanding, and lack of or inappropriate use of resources. These signify entrenched study habits from their school background, which students acknowledge are difficult to change, especially since it brought them success previously. Several studies have shown how prior educational practices can make students less predisposed towards acquiring the coding orientations of a new context (see Hoadley 2007; Chen 2010; Niven 2011; Pearce et al. 2015). In LCT terms when students use a code inappropriate to a new context this represents a code clash.

Code clash: Constraints on learning-context realisation

The school learning-context that most ISCM students would have experienced is one of reliance and dependence on an authority figure for knowledge development as well as of rote learning with surface or poor understanding and inconsistent study habits (see Pym and Kapp 2011; CHE Report 2013). This represents weaker learning-context epistemic relations (ER–) as well as weaker learning-context social relations (SR–), thereby embodying a learning-context relativist code. As such, many ISCM students appear to be using their school-based learning-context relativist code, in which they are dependent upon others (the teacher) for their knowledge development, and are not sufficiently realising the learning-context knower code required of ISCM, in which they are expected to be motivated, self-regulated, independent and critical learners dealing with high volumes of intellectually demanding material and developing depth understanding. This represents a code clash at the learning-context level.

I contend that this learning-context code clash is aggravated by ambivalent messages within ISCM itself. Firstly, since both a production-context knowledge code *and* a learning-context knower code are legitimated, this represents competing demands that give rise to code conflict. Students who choose science as a field of study are generally disposed towards a knowledge code which requires working with concrete facts and proceduralised methods, and will likely focus their efforts on epistemic relations rather than on social relations. Furthermore, since epistemic aspects in ISCM are assessed directly and social aspects associated with learner development are not, epistemic demands will naturally take precedence despite what appears to be an explicit pedagogic approach related to learning-context requirements. I therefore suggest students are focusing on the production-context knowledge code and not recognising sufficiently the need to also focus on the learning-context knower code. A possible solution to this would be to better embed learning-context knower code work in assessment tasks – such as regularly scrutinising evidence of individual consolidation processes. Also, activities such as regular but small tests with immediate feedback can significantly affect the quantity and quality of student learning effort (Gibbs, Simpson and MacDonald 2003). However, since a high cognitive load and volume and pace of work can militate against appropriate student engagement (Van Etten, Freebern and Pressley 1997; Adendorff and Lutz 2009; Case 2013) space would need to be created in the curriculum to accommodate such changes.

Secondly, whilst on the one hand ISCM staff offer much support to students in the transitional foundation year, which is a similar approach to that of a school environment and is therefore validating weaker learning-context social relations (giving rise to a learning-context relativist code), on the other hand staff are also attempting to engender self-regulated science learners and are validating stronger learning-context social relations (giving rise to a learning-context knower code). Although staff are aware of this tension between providing support and expecting independence, it is one they have not yet been able to resolve satisfactorily in the curriculum. This tension is recognised too by students, as indicated by their comments in interviews:

> ... we were studying but we knew oh X [ISCM lecturer] is there. She's going to explain things I don't have to go read it up, you know [laughs]. (Student interview, Nomgcobo)
>
> [Lecturers] shouldn't be this helpful to students because some of us really take, I don't want to lie, I did take advantage of it. (Student interview, Siyamthanda)

Broader implications

This article makes a contribution to the study of epistemological access in the sciences. This was made possible by drawing on the realist ontology of LCT, which allowed for identification of narrower disciplinary aspects with epistemological underpinnings and broader learning-context aspects with axiological underpinnings. Furthermore, by moving beyond simplistic quantitative measures to indicate student success, and instead drawing on the framework of acquisition of recognition and realisation rules, the study provides a rich narrative account of student experiences of and responses to ISCM educational practices and assessment tasks. In combination, these two aspects of the study helped develop depth understanding of underpinning causes of constraints to access for ISCM students, and consequently to identify what is required in pedagogic practice to better enable access and success.

Whereas the focus in this study has been on a single science foundation course, I suggest the findings have broader application. A case has been made for the two levels of access identified in this study existing in hierarchy. In other words, since acquisition of realisation rules at a production-context level requires acquisition of realisation rules at a learning-context level, it is difficult to access the powerful epistemic science knowledge in a higher education context unless you are the right kind of science learner. This has important implications for how we teach higher education science, and perhaps even in other fields and disciplines as well.

Mainstream science and science-related courses in higher education overtly legitimate production-context science knowledge and procedures (see Engelbrecht, Harding and Phiri 2010; Case 2013). However, I suggest that an independent, autonomous, responsible knower is also being legitimated in mainstream courses, but this is instead implicit and forms part of the ‘hidden’ curriculum. In other words, students are expected to work in particular ways, without which they will find it difficult to be successful, but this is seldom explicitly articulated nor actively supported in mainstream curricula. As Scott states, if there is insufficient ‘alignment between the assumption of the curriculum and preparedness, capabilities and orientation of the students’ we are creating a limiting environment for such students’ (Scott 2009, 8). Whilst a key function of foundation courses or programmes is attaining appropriate study practices and dispositions (see Grayson 1997; Wood and Lithauer 2005; Davidowitz and Schreiber 2008; Potgieter et al. 2015), this study has shown that, for students whose prior educational experience does not match well that of the higher education context, attaining these is particularly difficult. Though acknowledging the need to focus on epistemic knowledge which is key for success in the sciences, the implication of this study is that there is in all likelihood a need for a much stronger focus on dispositions and habits of the learner-knower than is currently seen in our mainstream science curricula. This requires not only engendering a disposition for successful learning which Barnett (2007) calls a ‘will to learn’, but also overt articulation of expectations and assumptions, explicit assistance through modelling and scaffolding in pedagogic practices, and the creation of sufficient space in curricula and assessment practices for this to be effective.

NOTES

1. *Production context* relates to the context of science and its production. This is distinguished in this study from the *learning context* which relates to the context of science learning.
2. Race categorisations are from the CHE Report (2013): African (black), coloured (mixed descent), Indian and white.
3. Interviewees are referred to anonymously and quotations are verbatim.

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