High Educ (2017) 74:915–931
DOI 10.1007/s10734-016-0085-x

Conceptualising knowledge for access in the sciences: academic development from a social realist perspective

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Published online: 26 November 2016

Abstract Whilst arguing from a social realist perspective that knowledge matters in academic development (AD) curricula, this paper addresses the question of what knowledge types and practices are necessary for enabling epistemological access. It presents a single, in-depth, qualitative case study in which the curriculum of a science AD course is characterised using Legitimation Code Theory (LCT). Analysis of the course curriculum reveals legitimation of four main categories of knowledge types along a continuum of stronger to weaker epistemic relations: disciplinary knowledge, scientific literacies knowledge, general academic practices knowledge and everyday knowledge. These categories are 'mapped' onto an LCT(Semantics) (how meaning relates to both context and empirical referents) topological plane to reveal a curriculum that operates in three distinct but interrelated spaces by facing towards both the field of science and the practice of academia. It is argued that this empirically derived differentiated curriculum framework offers a conceptual means for considering the notion of access to 'powerful' knowledge in a range of AD and mainstream contexts.

Keywords Academic development · Epistemological access · Knowledge · Legitimation Code Theory · Social realism

Knowledge in the academic development field

Academic development (AD) initiatives worldwide, both as a field of study and as a domain of practice, are generally aimed at improving teaching and learning practices. As such, AD in higher education institutions only emerged in the mid-twentieth century, largely in response to contemporary challenges of massification and widening participation (Clegg 2009). Although AD can relate to student learning, curriculum considerations, professional staff development or

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institutional development in various ways, in this paper, it refers specifically to engagement with (science) curricula and student learning.

Pedagogy in the AD field in the sciences has been influenced primarily by two opposing understandings of meaning-making based on differing views towards reality of knowledge. The empiricist approach, with its realist ontology and objectivist epistemology, views knowledge as being objective, de-contextualised and certain. Knowledge therefore tends to be seen as an authoritative view on the world, rather than a system of knowledge about the world (Maton 2014a, p. 5). This view is common in science disciplinary courses. The interpretivist approach, with its relativist ontology and (social) constructivist epistemology, associated more commonly with AD practices that have a stronger concern for learning processes, views knowledge as being individually (or socially) constructed in particular contexts and is thus only visible in relation to an individual's cognition (or, socially, in a community of practice). In this view, knowledge is reduced to *knowing*. In both of these stances, the intrinsic properties and powers of knowledge itself are ignored (Muller 2000, p. 57), which precludes any consideration of 'knowledge as a category in its own right' (Young 2008a, p. 19). This creates, as Maton terms it, a 'knowledge-blindness' (Maton 2014a, p. 7).

In contrast, social realism, with its ontological realism and epistemological relativism, lies between the two extremes of empiricism and interpretivism along the continuum of what can be considered 'real'. Social realism is a practical explanatory social theory that has, as its focus, social phenomena (Archer 1998), and in the educational field, it calls particularly for a focus on knowledge as an object of study. To quote Maton and Moore (2010, p. 10; original italics):

> Knowledge is the very basis of education as a social field of practice; it is the production, recontextualisation, teaching and learning of *knowledge* that makes education a distinct field…social realism puts *knowledge as an object* centre-stage in thinking about education.

Social realism offers a way of looking at knowledge that overcomes the knowledge-blindness mentioned earlier. It recognises the *social* nature of knowledge production but also allows for knowledge to have an *objective reality* and thus cannot be completely reduced to the social. Knowledge viewed in this way allows it to be an object of study that has structure, emergent properties, tendencies and powers of its own, all of which can have consequences for learning (Archer 1998).

Calls for a stronger focus on knowledge in curricula have been made by a number of social realist scholars both in the South African (in which this study is located) and in the broader context (see Muller 2000, 2014; Moore 2000; Maton 2000, 2014a; Moore and Maton 2001; Young 2008a; Wheelahan 2010). An underlying premise for these calls is that not all knowledge is equal. For example, theoretical knowledge, which is produced and acquired differently and has a different basis for validity compared with everyday knowledge, is a more socially powerful knowledge. The social power of theoretical knowledge, which relates to the intellectual power it gives to those who have it (Young 2008b, p. 14), lies in its abstract nature which allows us to think beyond current context and personal experience to think the 'unthinkable' and the 'yet to be thought' (Bernstein 2000, p. 30). It also allows us to make connections between seemingly unrelated events or objects and to predict the future (Young 2008a, pp. 41–42). Theoretical knowledge is thus important as it provides access to 'society's conversation about itself' (Wheelahan 2010, p. 2), and students of higher education should certainly be contributing to and ultimately driving these conversations. Wheelahan argues that in order to do this, students need to develop 'disciplinary styles of reasoning' on how knowledge is used and on what basis arguments are made (ibid. p. 2).

From the above arguments, it is clear that access to powerful theoretical knowledge is a matter of distributional social justice (Wheelahan 2010). Only through attaining such access will the educationally disenfranchised be able to join society's conversations and also have the capacity to disrupt existing power relations (ibid. p. 145). Based on this reasoning, it can be argued that the 'progressivist' approaches of foregrounding of skills, outcomes, practical work and activity and of backgrounding of knowledge that were established to increase inclusion and access for the diverse masses (Muller 2015) may, in fact, have had the opposite effect. 'Knowledge' scholars thus propose that theoretical knowledge should be central to all higher education qualifications and courses (Wheelahan 2010; Shay et al. 2011; Muller and Young 2014). In this regard, AD courses, which traditionally do not have strong allegiance to any particular discipline, should pay particular attention to theoretical knowledge if their primary purpose is inclusion and epistemological access.[1]

A key question emerging from these arguments is *what kind of knowledge may be useful in enabling epistemological access*? This paper, which is based on a close-up empirical case study of a science course in the South Africa higher education AD context, attempts to address this question. It does so by developing a conceptual framework of a differentiated curriculum that takes into account theoretical, literacies and academic practices knowledge types. Prior to analysis, the paper briefly outlines (a) the context of the study, (b) the conceptual framework of knowledge differentiation that is utilised in the study and (c) the social realist Legitimation Code Theory (LCT) analytical framework that underpins the study.

Academic development in the South African context

AD initiatives in South Africa were initially, and essentially still are, premised on a social justice agenda to enable access and success to students who have been exposed to poor-quality schooling (Boughey 2007). Despite the removal of the apartheid system over 20 years ago, which ensured whites[2] had a superior education compared with other race groups, an inequitable system that privileges white and middle-class students still exists today.

In an attempt to address systemic inequities in the higher education sector in South Africa, the state has funded extended curriculum programmes (ECPs) since 2004. These programmes extend the 3-year degree by a year with courses, primarily in the first year, being designed to align better with students' educational backgrounds and to allow for more time on task in both structured and independent studies in a supportive environment.

Rhodes University has three ECPs, one each in the Commerce, Humanities and Science faculties. The Science Extended Studies Programme (SESP) offers a year of pre-mainstream study to selected students who do not meet the Science Faculty direct-entry requirements. Because of a range of other admission criteria, SESP students are usually African, from poor socio-economic backgrounds, have attended poorly staffed and under-resourced schools, are first-generation university learners and do not have English as their first language. In the programme, students take three year-long courses: mathematics, computer skills and Introduction to Science Concepts and Methods (ISCM).

ISCM is a multi-disciplinary course designed to develop students' understanding of scientific knowledge and concepts and to introduce them to methods, practices, competencies

[1] Becoming and being a successful participant in an academic practice (Morrow 2009).

[2] Race, as a social construct, continues to be a defining feature in the South African society. Terminology in this regard is in keeping with the standard report such as the CHE Report (2013): African (black), Indian, coloured (mixed descent) and white.

and literacies needed to communicate and construct knowledge in the sciences. It currently focuses on the four main disciplinary areas of physics, chemistry, earth sciences and life sciences. Two permanently employed staff work with the development of scientific- and language-related literacies[3] and academic practices (study skills) throughout the year in tutorials, whilst disciplinary input is provided by mainstream staff in lectures and practicals. The stated aims of ISCM are (a) to present the concepts, literacies and academic practices required by first-year students in a science degree and (b) to prepare students for success in mainstream (SESP Review Report 2011).

Conceptualising knowledge: a conceptual framework

Gamble (2006) develops a conceptual dichotomous model of different forms of knowledge in which the first distinction is based on knowledge having two fundamentally different kinds of meaning: that which is not linked to a specific context and that which is. She refers to these as *context-independent* (or general or theoretical) and *context-dependent* (or particular or practical) knowledge (Table 1). Other authors have used similar knowledge distinctions: sacred and profane (Durkheim 1959 [1912]), abstract and concrete (Vygotsky 1962) and esoteric and mundane (Bernstein 2000).

Within each of these two categories, both principled and procedural knowledge types are recognised at the second level of distinction (Table 1). We are familiar with the ideas of principled (often called propositional) and procedural knowledge in a theoretical academic context, and the terms used by Shay et al. (2011) of 'conceptual' and 'proceduralised conceptual' knowledge respectively (Table 1) capture this distinction well as they indicate that procedures are based on underpinning conceptual knowledge.

Gamble (2006) argues that the distinction of principled and procedural knowledge also occurs in practical knowledge (Table 1). Using the example of craft workers, she suggests that the production of a craft article (such as a wooden cabinet) is a tacit process requiring an understanding of the relationship between parts of the whole and the 'essential principle of arrangement' (Gamble 2004, p. 196). In other words, craft work (and other works associated with practical knowledge), which is highly proceduralised, is underpinned by principles derived from practice and they are usually tacit and embodied. The principles are the codification of practice. Again, the terms of Shay et al. (2011) (Table 1) of 'principled procedural' and 'procedural' knowledge capture these two concepts well. This study draws on this knowledge differentiation framework but adapts it for use in an AD course context in which academic and literacies practices form an important part.

Conceptualising knowledge: an analytical framework

In a project spanning more than a decade, Maton has developed theory around knowledge, practices and actors' dispositions. Central to his work, similar to that of Bernstein's, is the concept of legitimation. In this regard, when an actor engages in a practice, they are, either

[3] The approach to scientific and language literacies is informed by the New Literacy Studies movement (see Gee 2012) which acknowledges that literacy is a social practice and that there are multiple literacies in society and within an individual's repertoire.

Table 1 A conceptual model of forms of knowledge (adapted from Gamble 2006, p. 92)

First level of distinction	Second level of distinction
General/theoretical (context independent)	Principled (conceptual[a])
	Procedural (proceduralised conceptual[a])
Particular/practical (context dependent)	Principled (principled procedural[a])
	Procedural (procedural[a])

[a] Terminology from Shay et al. (2011)

explicitly or tacitly, making a claim for the legitimacy of the practice and, more specifically, for the organising principles that underpin that practice (Maton 2014a). Practices can thus be understood as *languages of legitimation*, and the underpinning principles of the practice are regarded as *legitimation code* (ibid. p. 24). The legitimation code is thus the currency used or proposed by actors to define the practice. In this study, the practice of concern is the ISCM curriculum and two LCT dimensions (organising principles) are used to unpack the underpinning codes: specialisation and semantics.

The first dimension, specialisation, is the basis for differentiation in intellectual and educational fields or practices. In other words, it is what specialises the field or practice or is the key organising principle (Maton 2000, 2010, 2014a). The specialisation dimension uses two concepts for analysing the organising principles: epistemic and social relations. Epistemic relations (ER) refer to relations between knowledge claims and the object of study—in other words, *what* can legitimately be claimed as knowledge (Maton 2014a, p. 29; original italics). Social relations (SRs) refer to relations between knowledge claims and the subject (person) who is making the claim—in other words, *who* can claim to be a legitimate knower (ibid. original italics).

Bernstein's (2000) concepts of classification (relative strength of boundaries between contexts; +C, −C) and framing (locus of control within a context; +F, −F) can be used to unpack epistemic and social relations. For each of ER and SR, there can be weaker and stronger classification (−C, +C) as well as weaker and stronger framing (−F, +F). In an educational field or practice, if the relations between the knowledge claim and object of study show stronger classification and framing, then the practice exhibits relatively strong epistemic relations (ER (+C, +F) or simply ER+). Science is a good example of a field with stronger epistemic relations and therefore has what is called a knowledge code, and a field or discipline with stronger social relations (SR+) exhibits a knower code. The focus of this paper is on the epistemic relations, and the social relations are considered more fully in a separate study.

The second dimension used in this study is that of semantics (Maton 2009, 2011, 2014a). This dimension comprises two aspects, based firstly on issues of context dependence and secondly on condensation of meaning in a particular field or practice. *Semantic gravity* (SG) refers to the degree to which meaning relates to its context—which may be social or symbolic (Maton 2011, p. 65). Where semantic gravity is relatively stronger (SG+), meaning is more closely related to its context; where weaker (SG−), meaning is less dependent on its context. *Semantic density* (SD) refers to the degree to which meaning is condensed within symbols (terms, concepts, phrases, expressions, gestures, etc.). Where semantic density is relatively stronger (SD+), symbols have more meaning condensed within them; where semantic density is weaker (SD−), symbols condense less meaning.

The two concepts can be represented on a two-dimensional plane (Fig. 1). Since there can be a strong interdependence between the two concepts, an educational practice with a weaker semantic gravity (SG−) is likely to have a stronger semantic density (SD+). For example, an educational practice such as a physics course with a strong theoretical base (SD+) that is somewhat removed from context (SG−) could be expected to be located in quadrant 4 (rhizomatic code; Fig. 1). The opposite is also true, and a practice with stronger semantic gravity (SG+) would likely exhibit weaker semantic density (SD−). For example, an educational practice such as a plumbing course with a practical base (SD−) is well rooted in context (SG+) and would probably be located in quadrant 2 (prosaic code). However, the concepts can also vary independently, giving rise to other code combinations. Vocational curricula based on both theory (stronger semantic density, SD+) and practice (stronger semantic gravity, SG+) could be located in quadrant 3 (Shay 2013; worldly code). Shay (ibid.) also suggests a generic curriculum would be located in quadrant 1 with weaker semantic gravity (SG−) and weaker semantic density (SD−; rarefied code). This two-dimensional plane is used to identify semantic codes used in the ISCM curriculum.

Methodology

The overall approach used in this study was qualitative case study research in which the knowledge types and knowledge practices of the ISCM curriculum were examined. The primary source of data was current course documents (course and semester outlines; readings; resource materials; lecture, practical and tutorial handouts; assessment tasks and rubrics; from 2013 data) and, to a lesser extent, critical self-reflection since I also coordinate and teach in ISCM.

In order to bridge the 'discursive gap' between the abstract, the dense theoretical concept of epistemic relations and the empirical data held in course documents, it was necessary to develop an 'external language of description' (Bernstein 2000; Maton and Chen 2014). The external language developed in this study emerged through iterative processes of movement between data and theory, drawing initially on the four knowledge

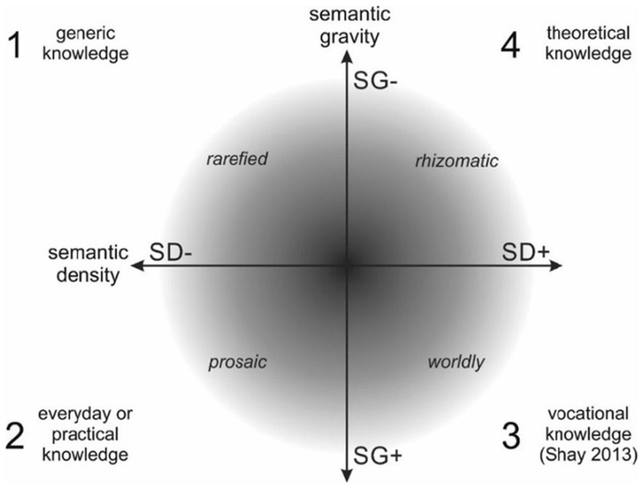

Fig. 1 The semantic plane. Topology of four codes (rarefied, prosaic, worldly and rhizomatic) based on concepts of semantic density and semantic gravity (source Maton 2016, p. 16). The knowledge categories are from Shay (2013)

categories of Gamble and Shay as outlined earlier. The final external language of four knowledge categories and eight sub-categories was influenced by the fact that ISCM is both a science course and an AD course in a higher education context. The knowledge categories were then mapped onto the LCT semantic plane.

Conceptualising knowledge in ISCM: epistemic relations

Epistemic relations are relations between practices and their object of focus which, in this study, was knowledge and knowledge practices. It is acknowledged that initially, it was difficult to 'see' knowledge in much of the course documentation as many ISCM tutorials were focused on practice-oriented work such as writing, reading or accessing information. However, by making the assumptions that (a) all practices and procedures are themselves a form of knowledge and (b) practices and procedures are underpinned, either tacitly or overtly, by some form of principled or contextual knowledge, a relatively nuanced breakdown of knowledge types and practices was possible.

It is standard practice to use a simple dichotomous characterisation of epistemic relations: relatively stronger epistemic relations (ER+) for specialised knowledge and procedures that are strongly bounded (+C) and framed (+F) and relatively weaker epistemic relations (ER−) for less specialised knowledge that has less clear boundaries (−C) and is weakly framed (−F). In this study, I refer to these as epistemic (conceptual) knowledge (relatively strong; ER+) and non-epistemic (contextual) knowledge (relatively weak; ER−), respectively (Table 2). However, as in the case of work by Gamble (2004, 2006, 2009) and Shay et al. (2011), this simple dichotomy proved inadequate to describe knowledge in the ISCM curriculum, and categories, each exhibiting relatively stronger or weaker epistemic relations along a continuum, could be distinguished.

Four main knowledge categories are identified. At the one end of the continuum, there is disciplinary knowledge (DK) associated with science disciplines which, because of relatively stronger classification and framing, has an ER++ categorisation (Table 2). Whilst there can obviously be some overlap, knowledge in this category is usually associated specifically with a particular discipline. For example, kinetic motion is clearly a physics concept and the theory of plate tectonics a geology one. Also legitimated in the ISCM curriculum is more general science knowledge that has an epistemic base, but since it is less strongly classified and framed than disciplinary knowledge, it has an ER+ categorisation. This refers primarily to science knowledge, procedures and values that are recognised in most science disciplines such as the valuing of empirical evidence and the use of a generalised approach in experimental design and even in report writing (Table 2). Drawing on Street's concept of literacies as neither technical nor neutral skills but instead a set of multiple social practices that are embedded in socio-cultural contexts which have 'socially constructed epistemological principles' (Street 2006, p. 2), this second knowledge category is referred to as a scientific literacies knowledge (SLK).

Two categories of non-epistemic knowledge are legitimated in ISCM, the first being academic practices knowledge (APK). This refers primarily to the generic 'study skills' work that can be quite dominant in AD courses such as ISCM, and relates to, amongst other things, students' learning to access information, take notes in class or consolidate work out of class (Table 2). The second category of non-epistemic knowledge that is legitimated in ISCM is everyday knowledge (EK), which represents the informal knowledge and practices acquired outside of educational settings. Because classification and

Table 2 Characterisation of knowledge in ISCM using LCT (specialisation): external language of description and examples of empirical evidence for epistemic relations

Theoretical concept	External language of description		Empirical data from course documents
Epistemic (conceptual) knowledge	**Disciplinary knowledge (DK) is valued**	**ER++**	**Principled knowledge—students need to know/understand**
			Stoichiometry
			Limiting reagents
			Chemical equilibrium
			Procedural knowledge—students need to
			Perform titrations
			Balance equations
			Calculate limiting reagents
	Scientific literacies knowledge (SLK) is valued	**ER+**	**Principled knowledge—students need to know/understand**
			Scientific concepts: standard units of measurement; significant figures; independent and dependent variables; hierarchies and connections
			The value of and need for empirical data; careful observation; use of significant figures; honesty in reporting; randomisation in experiments
			Basis upon which knowledge claims are made (tentative claims; use of data)
			How scientific knowledge is constructed (inductive and deductive reasoning, experimentation, observation, measurement)
			Procedural knowledge—students need to
			Design and conduct experiments; present results in scientific poster and orally
			Work with quantitative and qualitative data
			Measure accurately and precisely
			Write scientific laboratory reports, essays
			Read and think critically in the sciences
			Evaluate sources
Non-epistemic (contextual) knowledge	**Academic practices knowledge (APK) is valued**	**ER−**	**Contextual (rules) knowledge—students need to know/understand**
			Organising principles of library, Internet, dictionary, words (prefix, suffix), paragraphs, essays, textbooks, learning context
			Academic practices—students need to
			Technical practices: access information (library, Internet, dictionary); organise (notes; use diaries; manage time)
			Read/write/listen practices: read (anticipate, headings, pictures); write (paragraph: topic sentence, supporting information; essay: introduction, body, conclusion); listen (cues, repetition); take notes (shorthand, leave gaps for later work)
			Study practices: prepare; review; consolidate; ask questions

Table 2 (continued)

Theoretical concept	External language of description		Empirical data from course documents
			Assessment techniques: time management, unpacking questions
	Everyday knowledge (EK) is valued	**ER——**	**Contextual knowledge—students need to know/understand**
			No data
			Procedural knowledge—students need to
			Draw on home-based practices related to growing of plants (to conceptualise independent research project)

framing are, relatively speaking, more weakly classified and framed in the everyday context, everyday knowledge is categorised as ER—— and academic practices knowledge as ER−.

Further sub-categorisation was possible, with both disciplinary and scientific literacies knowledge types exhibiting principled and procedural knowledge (Table 2). In contrast, the academic practices and everyday knowledge types instead have 'contextual' (which may be principled) and procedural knowledge. As such, these eight sub-categories make up the principled/contextual and procedural knowledge types that are legitimated in the ISCM curriculum. These are described in more detail below, using empirical data from the ISCM course documentation to illustrate them.

The first of the eight sub-categories is that of *disciplinary principled knowledge*. This draws on disciplinary theory, and examples from chemistry are the concepts of stoichiometry, limiting reagents and chemical equilibrium (Table 2). The second sub-category is *disciplinary procedural knowledge*, which is procedural knowledge that has a strong theoretical base such as, again, using chemistry as an example, performing titrations, balancing equations and calculating limiting reagents. Since ISCM has a disciplinary focus (related to physics, chemistry, earth sciences and life sciences), the identification of both disciplinary principled and procedural knowledge types in the curriculum is not unexpected.

However, the following sub-categories relating to scientific literacies and academic practices knowledge types require a bit more explanation as they form the contribution of this paper in finding a theoretical and analytical home for such knowledge in the epistemic relation continuum. This is because literacies and academic practices work is usually 'process' oriented and has not, to my knowledge, been analysed using epistemic relations in this way.

In analysing course documentation, it was clear that a large portion of procedural work done in ISCM had an epistemic base but was of a more general scientific nature rather than being associated with a specific discipline. The *scientific literacies procedural knowledge* sub-category was based on procedural knowledge and includes what scientists *do* (e.g. design and conduct experiments; work with quantitative and qualitative data; write laboratory reports; present scientific arguments; evaluate sources) and how they *act* (e.g. work accurately and precisely; observe carefully; report honestly; Table 2). However, this procedural knowledge is underpinned by *scientific literacies* *principled knowledge*, which relates to what scientists *know* (e.g. standard units of measurement; significant figures; independent and dependent variables; hierarchies and connections) and what and how they *value* (e.g. empirical data; randomisation in experiments; careful observation; tentative claims; basis upon which knowledge claims are made; critical thinking).

Unlike the scientific literacies knowledge sub-categories, which are embedded in the norms and values of science and therefore have an epistemic base, the academic practices knowledge sub-categories have no epistemic underpinnings, hence an ER− categorisation (Table 2). The dominant one in ISCM is the *academic practices procedural knowledge* sub-category, which is referred to simply as *academic practices* (or study skills). Students in ISCM need to be able to perform a range of generic tasks in order to be successful in an academic context, and these relate firstly to the various *conventions* and *techniques* that can be addressed in acontextual ways such as accessing information, working with new terminology and vocabulary, writing a paragraph, unpacking questions and managing time in tests. Secondly, they relate to *organisational, study and learning practices* that students are expected to develop in an academic context. These relate to developing organisation procedures such as filing, using diaries and managing time, working appropriately by preparing in advance of learning (lectures, practicals) interactions, consolidating after learning interactions, asking questions and taking good notes. The *academic practices contextual knowledge* that underpins the academic practices, such as the organising rules and principles of libraries, Internet, textbooks and words, tends to be fairly implicit. However, attempts are made in ISCM to make them explicit through direct teaching.

The final two sub-categories, *everyday contextual knowledge* and *everyday procedural knowledge*, refer respectively to contextual and procedural knowledge that is firmly embedded in particular everyday contexts (Table 2). An example of the latter in ISCM is where students are required to draw on home-based practices related to growing plants to help them conceptualise their independent research project, which examines experimentally the effect of an environmental factor on the growth of pot plants.

Although the four main knowledge types are represented as distinct categories, they, in fact, exist on a continuum and categorisation of data is not always as obvious as has been presented here. For example, writing a scientific laboratory report, with its conventions on report structure, basis for making claims and for referencing is categorised in this study as scientific literacies procedural knowledge (Table 2). However, such a report would also, of necessity, draw on disciplinary principled and procedural knowledge related to the topic of the report. In another example, the context in which something is taught influences categorisation. As such, if writing a coherent paragraph is taught in an acontextual manner based on generic 'rules', such as the use of logical connecting words, it would be categorised as an academic practice as there is no epistemic base. However, if paragraph writing is taught in the context of building an argument in science, it would be categorised as scientific literacies procedural knowledge because of the epistemic underpinnings of the approach. Similarly, note-taking in lectures can be addressed simply as a technical exercise of using good short-hand notation, good use of headings and writing sufficient information, which would be classified as an academic practice. However, when underpinning scientific values such as recording empirical data from given examples are discussed, this would be classified as scientific literacies procedural knowledge.

The next conceptual move was to map the four distinct knowledge types or categories of the ISCM curriculum onto the semantic plane.

Conceptualising knowledge in ISCM: LCT(Semantics)

The semantic mapping resulted in analytical separation of each of the different knowledge types and practices, thus creating a space for consideration of how they may be useful in an AD course. The rationale for the 'mapping' is as follows (Fig. 2).

Quadrant 4

Since quadrant 4 represents theoretical knowledge, it follows that the disciplinary principled and procedural knowledge (DK) of the ISCM curriculum would be placed in this quadrant. As such, for the disciplinary knowledge in ISCM, meaning and principles are derived from explicit theories, concepts and empirical referents linked to the specific discipline, resulting in a relatively strong semantic density (SD+). However, because meaning and principles are not linked to particular specific contexts, semantic gravity is relatively weak (SG−). For example, geology knowledge and practices in ISCM draw on principled knowledge such as mineralogy to understand rock types and rock origins (SD+) but this is generalised knowledge that can be applied to any rocks in any setting (SG−). This aspect of the ISCM curriculum, where legitimacy is based on context-independent and conceptually dense meanings, would therefore be classified as a *theoretically based curriculum* with a *rhizomatic code* (Fig. 2).

Quadrant 2

As mentioned previously, in an educational context, quadrant 2 can represent practical knowledge that, in Shay's (2013) work on vocational curricula, is derived from

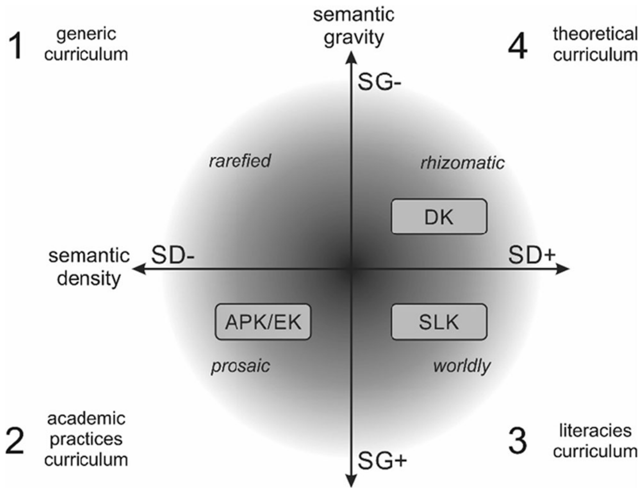

Fig. 2 Semantic codes for ISCM based on curriculum documentation (adapted from Maton 2016, p. 16). *DK* disciplinary knowledge, *SLK* scientific literacies knowledge, *APK* academic practices knowledge, *EK* everyday knowledge

workplace contexts. Through curriculum recontextualisation,[4] the workplace practical knowledge becomes codified in the curriculum into a set of rules, principles or guidelines for the practice. An example used by Shay (ibid.) is of a journalistic workplace in which the practice of interviewing is taught through a set of procedurally based guidelines. Since the practice of interviewing is related to the journalistic workplace context, semantic gravity is stronger (SG+) and since the guidelines are derived from practice and not theory, semantic density is weaker (SD−).

Drawing on the above reasoning, I have located APK in quadrant 2. In this case, the practical knowledge relates to the academic learning context rather than to the workplace practical context. The practices associated with the academic learning context could be note-taking in class, note-making from resources, consolidation of lectures, preparation for practicals, developing own understanding, locating sources of information or using feedback, all pedagogic activities legitimated in the ISCM curriculum. These practices, expected of students in an academic context, have become organised into a set of learning context principles or guidelines in the ISCM curriculum recontextualisation process. For example, when modelling the process of consolidating a lecture in a tutorial, the lecturer initially works with principles of identifying the overall theme of the lecture, drawing out the main points, summarising information and seeing links with other aspects of the course. Since the practice of consolidating a lecture is located firmly in an academic learning context, semantic gravity is stronger (SG+). However, since the principles are derived from practice and not from theory, semantic density is weaker (SD−).

The APK in the ISCM curriculum, where legitimacy is based on context-dependent practices with simpler meanings, would therefore be classified as an *academic practices curriculum* with a *prosaic code* (Fig. 2). Since EK is such a small part of the curriculum, it has not been considered in-depth here but the principles and coding as outlined for APK would also apply to EK, which would therefore also locate it in quadrant 2.

Quadrant 3

In Shay's (2013) work, she places professional or vocational knowledge, and hence professional or vocational curricula, in quadrant 3. This quadrant is different from quadrant 4, as the 'logic of the curriculum is the demands of the practice', and is different from quadrant 2, as the 'principles informing the practice are derived from theory' (ibid. p. 575). Shay uses a mechatronics design project as an example in which the workplace practice of design guides the direction of the project (hence is grounded in context; SG+), but students are expected to draw on theoretical knowledge from a range of electrical, mechanical and information technology disciplines which exhibit stronger condensation of concepts (SD+). In her analysis, the curriculum in quadrant 3 therefore draws on the practice elements of quadrant 2 and the theory elements of quadrant 4.

Based on the above reasoning, I have placed scientific literacies principled and procedural knowledge (SLK) in quadrant 3. The values and meanings in scientific literacies are based on theoretical (scientific and epistemic) principles and concepts, resulting in a relatively strong semantic density (SD+). Examples of relevant scientific values drawn on in ISCM are the basis upon which knowledge claims are made, and the valuing of empirical data, objective

[4] The process of transforming original knowledge (usually produced at universities, but in this case, at the workplace) to taught knowledge (usually in a curriculum; Bernstein 2000).

approaches and inductive and deductive reasoning—which were classified as scientific literacies *principled* knowledge in the original epistemic relation analysis. However, since scientific literacies work is based on academic practices such as writing appropriate texts, reading texts critically, listening constructively in lectures and arguing critically—classified as scientific literacies *procedural* knowledge—the principles and guidelines are derived from these academically based practices, representing relatively strong semantic gravity (SG+).

Previously, it was indicated that the task of consolidating a lecture could be located in quadrant 2. However, it does not take much to shift what appears to be a generic academic context task to become a scientific literacies task that draws on scientific knowledge and values. In ISCM, the first two or three times the process of consolidating a lecture is modelled, it is done as a generic task based on the principles derived from practice that were mentioned earlier (such as overall theme, summary, main points and links). However, later modelling involves interrogating how lecture consolidation in sciences may differ from other fields. For example, the fact that science values precise definitions, factual information (as opposed to opinions), empirical data (preferable to say 10 kg instead of 'quite heavy') and mathematical and graphical condensation (as opposed to longer descriptions) would considerably influence the lecture consolidation process. In this context, students would still draw on principles derived from academic practices (SG+), but they would also draw on the scientific value base (SD+) for effective consolidation. Other ISCM tutorials use similar logics to promote scientific literacies practices such as writing texts or reading resources critically and would also be located in quadrant 3.

The SLK of the ISCM curriculum, where legitimacy is based on context-dependent academic practices as well as theoretical underpinnings, would therefore be classified as a *scientific literacies curriculum* with a *worldly code* (Fig. 2).

Quadrant 1

As in Shay's work (Shay 2013), ISCM appears to have no data related to quadrant 1, which represents a *generic curriculum* with a *rarefied code* (Fig. 2). Shay (2013, p. 575) suggests this could represent a curriculum that focuses on developing general graduate attributes such as problem-solving, critical thinking and professional communication, which are neither rooted in context nor have conceptually dense meanings. In its current form, because ISCM is a foundation course preparing students for work in mainstream science disciplines, all curriculum work is rooted in the context of particular science disciplines or academic practices. It is conceivable that generic graduate attributes could form a part of mainstream curricula later in the students' degrees.

To conclude this section, the *extent* to which each of the knowledge categories is valued in ISCM was calculated on a percentage time basis in a separate study (Ellery 2016). Results indicate that SLK (worldly code) dominates throughout the year. However, there is also a strong focus on the APK work (prosaic code) initially, but this declines with a concomitant increase in legitimation of DK (rhizomatic code) as the year progresses. The appropriateness of this differentiation for a science AD course is deliberated below.

Implications for epistemological access

The fine-grained account of four major knowledge types identified in the epistemic relation analysis opened the space for a detailed and nuanced account of the ISCM curriculum using

LCT(Semantics), drawing primarily on the curriculum differentiation work of Shay (2013, 2016). Mapping of ISCM knowledge types on a two-dimensional plane that represents typologies of semantic gravity and semantic density indicates a differentiated curriculum that draws on theoretical, scientific literacies *and* academic practices knowledge types.

The overall purpose of any course, and its resultant curriculum structure, has implications for student access and success (Gamble 2006; Muller 2009; Wheelahan 2010; Shay 2016). ISCM staff seem to have interpreted the dual function of ISCM of developing conceptual understanding as well as preparing students for mainstream as facing inwards towards *disciplines* (and the field of science) and outwards towards an *academic practices learning context*, drawing on a range of differentiated knowledge types to achieve this. This is similar to Bernstein's (2000) notion of a 'region' that faces both inwards towards disciplines and outwards towards professional or workplace practice. Whilst this use of 'academic practices learning context' is a somewhat unconventional interpretation of the 'practice' component of a region, I believe it serves the same function: it regulates the practice part of the curriculum that shapes academic learning and some of the literacies work—which in the case of ISCM is scientific literacies work.

I argue that any higher education course, but particularly AD courses, should have a two-way focus, both towards the field or discipline and towards the learning in a higher education context in order to enable epistemological access. What I suggest below is that this dual focus necessitates a broad-based, differentiated curriculum that operates in at least three of the four quadrants on the semantics plane. The extent to which a course or curriculum draws on each of the quadrants would depend on the purpose of the course and, possibly also, on the background socialisation contexts of students.

A curriculum that operates primarily in quadrant 4, as do many traditional content-dominated science courses, would expose students to powerful theoretical knowledge. However, as has been shown in numerous studies, this does not necessarily give students the tools or means to access the tacit framework of norms and values and practices necessary for understanding the abstract context (Maton 2014b). Conceivably, however, a curriculum located mainly in quadrants 3 (SLK) and 4 (DK), with the scientific literacies work serving to make the underpinning epistemic logics overt, could achieve this. This is supported by the notion that working across the range of semantic gravity (as do quadrants 3 and 4) has the potential to promote effective student conceptual and cumulative development (Humphrey and Robinson 2012; Macnaught et al. 2013; Clarence 2014). The examination of likely 'semantic waves' (recurrent shifts in context dependence and condensation of meaning; Maton 2014b, p. 181) would be a useful close-up addition to the work done in this study in terms of understanding knowledge building and achievement in the ISCM context.

Nonetheless, I suggest that, taking into consideration both the process nature of learning and the home and school backgrounds of many higher education learners today, a developmental approach that also draws on knowledge and academic practices located in quadrant 2 is appropriate. For ISCM learners, their school classrooms were characterised by, amongst other things, a teacher-centred and spoon-feeding culture, a slow pace of working with low cognitive loads, and passive, rote and instrumental learning (Ellery 2016). This is diametrically opposed to the high pace, volume and cognitive load, as well as the expectation of student autonomy and responsibility for own understanding in higher education institutions today. Despite these almost universal expectations, the principles related to academic learning practices are seldom explicitly stated in higher education. For example, knowledge on how to take notes in a lecture or how to locate a source of information is assumed by many lecturers. Similarly, scientific literacies work located in quadrant 3 is underpinned by knowledge that has been internalised by the lecturer and can often operate at an unconscious level and therefore remain tacit (Jacobs 2007, p. 75). I therefore suggest that explicit discussion, modelling and scaffolding of expected academic and literacies practices should form a part of higher education curricula, particularly AD curricula, to provide a platform for students becoming the 'right' kind of learners in an academic context. In order to become participating, contributing members of scientific academic practices in higher education, students are taking on new identities, which takes time and requires continued support (Ellery 2016).

It is worth noting that the academic practice work of quadrant 2 can form a foundation and entry point to some of the scientific literacies work in quadrant 3. Hence, drawing on generic academic practices provides a base and some initial structure to the scientific literacies work (for example, using generic rules for writing before drawing on epistemic procedures). It is important, however, that an AD course such as ISCM does at some stage make the shift from weaker to stronger semantic density in order to contextualise the work in a disciplinary context and to increase the cognitive complexity as is required in higher education.

Conclusion

One of the main contributions of this paper, based on close-up empirical work of a single case, has been to bring together aspects of *knowledge* and practice-oriented *knowing* under the same conceptual umbrella. In this regard, the social realist assumptions that all practices are themselves forms of knowledge and are underpinned by principled or contextual knowledge provided the necessary conceptual move to accommodate practice work (such as academic and literacies practices) in a knowledge framework. In a sense, I am working in the opposite direction of the academic language and literacies scholars such as Freebody et al. (2008) and Jacobs (2013), who argue for placing knowledge at the centre of language and literacies work, and am instead saying that academic literacies and practices are, in fact, forms of knowledge practices and therefore can be an object of study like any other form of knowledge. I have therefore brought practice-oriented AD work, which has traditionally been viewed through an interpretivist (and (social) constructivist) lens, squarely into a social realist knowledge framework.

Another contribution has been to conceptualise AD work as facing two ways. By drawing on both theoretical (disciplinary or science) knowledge, which in LCT terms, has stronger semantic density and weaker semantic gravity, and academic practices knowledge, which has weaker semantic density and stronger semantic gravity, a third curriculum space of academic (in this case, scientific) literacies, with both stronger semantic density and stronger semantic gravity, becomes central in holding these opposing knowledge requirements together. This idea of finding curriculum spaces that bridge the gap between polarised views of theoretical knowledge and practice-oriented knowledge or knowing has been mooted by others (see scenario 3 Muller 2015; Shay 2016), as it allows us to consider what it means to enable access to 'powerful' knowledge. In other words, knowledge that permits access, such as academic and literacies practices knowledge, is as important as the powerful theoretical knowledge that we value so much. This study therefore concludes that curricula that draw on knowledge types and practices that indicate clearly, and provide support for, the pedagogic and epistemic needs of any particular disciplinary context are key in enabling success for the diverse group of students who are entering higher education today.

Despite the parochial context of the work, I suggest that the empirically derived differentiated curriculum framework from this study offers a sufficiently conceptually robust approach for examining both AD and mainstream curricula in a range of contexts. As such, this study should contribute to current conversations in the global higher education sector relating to curriculum reform processes concerned with student epistemological access and success.

Acknowledgments Professor Chrissie Boughey is sincerely thanked for her contribution to this work. The study was supported in part by funding from the National Research Foundation (Grant no: 92685) and Rhodes University.

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