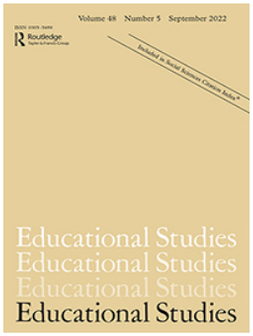

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Cognitive demands and opportunities for access in school curricula from mainland China: an integrated analysis based on specialisation codes

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ABSTRACT

Educators have long questioned why some students can experience achievement more easily in some school subjects/curriculum, but not in others. We argue that learners cannot ignore navigating two key features inherent within every curriculum–– its cognitive demands as well as its opportunities for access to knowledge that are the twin foci of this study. We adopt Specialisation codes from Legitimation Code Theory to examine the epistemic and social relations of intended learning outcomes from secondary science- and arts-based curricula in mainland China. The results showed that science curricula coded predominately with knowledge codes, but the latter possessed mainly elite codes. Compared to science, the Chinese arts curriculum is therefore more challenging for learners because achievement here is largely dependent on possession of specific attributes, dispositions, or qualities that can potentially restrict access. Implications for improving teaching and learning in these two types of curriculum in this region are discussed.

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Intended curriculum; Legitimation Code Theory; Specialisation codes

Introduction

What makes learning and achievement easier to accomplish in one school curriculum, but appear as very distant, almost out-of-reach goals in another? What are the factors that make disciplinary knowledge within a curriculum more accessible to learners, while that in another seem much like a tall, unscalable mountain? Although these are perennial concerns of governments, testing agencies, and educators, they too have often been articulated in parallel ways by students. The latter seek advice as to which subjects in school should they study and, more importantly, if any of these might be easier to pass or to excel. Most answers to these quotidian, but pragmatic queries will likely invoke teacher factors, the varying levels of difficulty of the examinations or the role of personal interest, motivation, industry and so forth.

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However, we argue that successful achievement in school subjects cannot ignore navigating two key features inherent within every curriculum––its cognitive demands as well as its opportunities for learner access to knowledge that are the twin foci of this research. In this paper, we will equate curricula with school subjects and use these terms interchangeably. We also assume that learning or achievement in a curriculum means that students here should understand disciplinary knowledge promoted within it rather than just obtaining high test scores. We next describe how psychological and sociological insights have recently been integrated to analyse the forms of specialised, disciplinary knowledge required for academic success in school, and which kinds of students can meaningfully participate in studying a curriculum. The significance of simultaneously interrogating these important concepts together will assist educators to understand "what is possible for whom, when, where and how, and who is able to define these possibilities, when, where and how" (Maton 2014, 18).

The cognitive demands of a curriculum

We begin by unpacking cognitive demand, which can be defined as the "degree to which tasks require more complex knowledge and skills for students to respond correctly and comprehensively" (Perie and Huff 2015, 120). It is the range of mental or intellectual processes/skills and knowledge that learning subject matter or performing practical tasks require. This psychological construct has long been used to measure how demanding are school curricula, textbooks, and examinations (e.g. Lee et al. 2017; Lee, Kim, and Yoon 2015; Lee and Wan 2022a; Wan and Lee 2021). For educators, knowing what are the cognitive demands within intended curricula are essential because they directly influence teaching and learning in classrooms, especially in regions with a centralised system of education. Curricula, moreover, have a strong bearing on assessment and testing; any misalignments between the intended curriculum and assessment are detrimental to finding out with accuracy what students actually know and can do.

Cognitive demands are oftentimes used to mean difficulty, but these two constructs can be separated, though not perfectly in the literature. Difficulty is associated with the statistics empirically derived from assessment/examination outcomes, whereas demand is linked with the professional judgements of evaluators regarding how "hard" are curriculum, textbooks, test items, and other educative resources (Pollitt, Ahmed, and Crisp 2007). Presently, a number of tools/frameworks are used to classify psychological levels of demand such as revised Bloom's Taxonomy, Webb's Depth of Knowledge, and the SOLO (Structure of Observed Learning Outcomes) Taxonomy although each has acknowledged their strengths and flaws. The concept of difficulty is best regarded as a post-assessment characteristic of examinations that is sample-dependent in contrast to cognitive demand that is a pre-test construct related to, but not identical to, its difficulty. The reason is that test items that are demanding are usually difficult, but the reverse is not necessarily true due to the mitigating effects of content exposure, repeated practice or training, and provision of resources that can either lower or increase item difficulties in the classroom (Organisation for Economic Co-operation and Development [OECD] 2019, 108). During the analysis of the intended curriculum such as in this study, however, the cognitive demands will remain unchanged as these are its intrinsic features that are unaffected by any variability in its implementation in the classroom.

We also know that curriculum-makers will transform disciplinary knowledge into appropriate forms to help learners become part of a disciplinary community. Learners can, over time, appreciate what questions are possible for inquiry, learn how to create adequate explanations or knowledge products as well as justify new knowledge claims among other valuable practices. There are many terms that describe this process; for example, students can be described as assuming both constructor and critiquer roles in order to master the conceptual, epistemic, and social learning goals of a school subject (Duschl 2008). As the quotation below shows, learning disciplinary knowledge through a curriculum involves knowing its logical structures of knowledge as well as its procedures for inquiry as a community that also constitute part of its overall cognitive demands.

> [D]isciplines [are] sites of knowledge production that vary on the basis of two interconnected dimensions: how knowledge is constructed (i.e. an epistemological dimension) and how knowledge communities interact socially (i.e. a social dimension) . . . . disciplines typically have a core content or knowledge base, which we refer to as the conceptual dimension. School and university assessments of learning often focus disproportionately on content, with less attention to other aspects of disciplinarity. (Quinlan and Pitt 2021, 3)

Opportunities for learner access in a curriculum

The above quote also reminds us that handling the cognitive demands alone is insufficient for learners to fully experience success and achievement in a curriculum; a social dimension is involved to gain access to knowledge, but this is oftentimes ignored. Hence, we need to ask if all learners have equal access to disciplinary knowledge within a curriculum or if different curricula afford different levels of access for learning, which the latter constitutes the second feature of all curriculum that we want to highlight. The point we are making is subtle: We are not concerned whether a subject is inherently engaging/interesting or if it can be made to be so by an instructor. Neither are we concerned about the extent of content coverage nor about the appropriate pedagogies associated with a subject. Neither is the quality of instruction adopted by a teacher at stake here, although we do acknowledge that these are all important and supportive conditions for quality learning to take place. It is also a common misconception to equate faithful school attendance with gaining access to a curriculum; this relationship is actually tenuous as the substantive structures of a curriculum can remain opaque to students even with the passage of time. Increased hours spent in school do not translate into better learning outcomes (Angrist et al. 2020).

Instead, we want to assert that some curricula strongly anticipate (indeed demand) an ideal type of learner who has certain kinds of attributes or dispositions and who can access or take advantage of its opportunities more fully for learning (Muller 2014). From this sociological perspective regarding knowledge, success in some curricula is also partly dependent on the possession of specific innate qualities (e.g. having artistic perception, linguistic gifts) or certain social positions (e.g. as cultural insiders, as native speakers of a language). Failure to satisfy these conditions, learners might experience repeated obstacles in their quest for deep understanding and meaning in the discipline. These individuals can be denied access to specialised knowledge, although not for reasons regarding the cognitive demands found inside a curriculum. So while most sociologists

are keen to discover the range of "external" social factors that facilitate or inhibit access in education (e.g. inequality, questions about race, class, gender), we want to examine the opportunities for access to knowledge that are "internal" to a curriculum that can profoundly affect the learning of certain types of students. Indeed, it has been argued that educational sociology, and education as a whole, is strangely "knowledge blind" where fundamental questions of what counts as knowledge or who has access are downplayed over concerns about pedagogy and learning (Maton 2014). As we will explain later, all learners with respect to a curriculum can therefore be distinguished by belonging to one of the four code types: "what and how they know (a knowledge code), by who they are (a knower code), by both (an elite code) or by neither (a relativist code)" (Shay 2016, 777).

Research question

Normally, researchers who examine educational success and achievement in schools take their standpoints either from educational psychology or sociology, but not from both. Thus, either psychological factors are examined, or access to education is studied, but not with equal devotion to both even as both offer much wisdom. In this study, we apply a new theoretical framework that merges insights from both disciplines at the same time––four Specialisation codes that are derived from Legitimation Code Theory (LCT). We use Specialisation to examine the learning outcomes (LO) of the intended curriculum to determine their: i) *epistemic* relations between knowledge and its object of study (i.e. its cognitive demands), and ii) *social* relations between knowledge and its agents of implementation (i.e. opportunities for learner access). We explain the meanings of these complex technical terms in the following sections, but our research question can now be phrased as thus: Based on the four Specialisation codes, what are the cognitive demands and opportunities for learner access among selected junior and senior secondary science- and arts-based curricula from mainland China?

Although we code our LO from curricula in mainland China with implications for classroom instruction here, international researchers can be inspired to conduct similar analyses of their own education systems to determine which of their school subjects afford greater chances of success and achievement for learners. In what follows, we briefly review the literature on cognitive demands and access surrounding science- and arts-based curricula at the secondary level from mainland China, followed by explaining the theories behind Specialisation codes and LCT.

Cognitive demands and access in mainland Chinese school curricula

In this section, we briefly review the literature on cognitive demands and opportunities for access to secondary-level science- and arts-based curricula from mainland China. It will be seen that these two constructs have been analysed separately, if they have even been studied at all. So while it is universally acknowledged (by students and teachers) that studying science subjects is difficult, few researchers have empirically examined their cognitive demands in this country. It was recently reported that higher-order cognitive processes based on revised Bloom's Taxonomy

in the 2018 senior secondary chemistry curriculum have slightly increased compared to previous eras (Wei 2020). Using the same coding scheme, Wei and Ou (2019) found that the cognitive demands in the intended general science curricula from Chinese junior secondary levels were not challenging; they emphasised the memorisation of factual and conceptual knowledge. In terms of access, official science curriculum documents have, however, mentioned about learning emotional goals related to personal attributes, dispositions, opinions, and qualities, such as cultivating students' social responsibility, and scientific attitude and spirit (Ministry of Education [MOE] 2017). International research has reported that many difficulties confront science teachers who wish to teach these norms and values in their classrooms (Corrigan et al. 2020).

Early in the new millennium, art and music education in mainland China shifted from its double-base focus (i.e. learning basic knowledge/theory & skills) to concentrate on learning aesthetic principles. This meant that teachers should help students personally enjoy, experience, and participate in the arts rather than just mastering skills and concepts in the curriculum (Zhou 2020). A decade later, Xue (2013) found that the Chinese art curriculum emphasised students' active participation and investment in the subject, and combined students' life experience and emotional experience besides the learning of artistic skills. Moreover, she believed that the curriculum had paid attention to the accumulation of experience gained by students in the process of observation, experiences, and feelings to eventually develop their emotional or moral experience and artistic sensibility here.

This priority on cultivating aesthetics in the school curriculum has been similarly echoed in the official music curriculum (Ministry of Education [MOE] 2017) and by numerous music education researchers in the country too (e.g. Chen 2018). For example, a leading music curriculum developer believed that besides aesthetic perception, artistic expression and cultural understanding were the core qualities of senior school music as a discipline (Editorial Department of Basic Education Curriculum 2018). Being literate in these three pillars allowed students to deeply understand and grasp the auditory characteristics, expression, artistic forms, and unique emotion of music as an ennobling facet of human culture. Nonetheless, music as a compulsory school subject at all grades has often been marginalised in favour of more "academic" subjects (e.g. mathematics, languages) that can open doors to higher education (Xie and Leung 2011). Unless students showed proficiency in the music exams outside of school contexts then they may enjoy special priority in university admissions by passing the entrance examination of art/music majors held by some universities. What is interesting is that the music curriculum has recently been described as still too knowledge-centred "towards the promotion of knowledge, with a focus on the subject matter … on the aesthetics of music education" (Yu and Leung 2019, 193). According to these authors, this curriculum has remained bounded in terms of its scope and sequence of prescribed theoretical concepts for learning. As far as we know, studies that empirically examine the cognitive demands of arts-based curricula using established psychological frameworks have yet to be conducted. We next explain the theoretical frameworks and concepts that we adopt in this study that combine ideas from psychology and sociology at the same time for curriculum analysis.

Theoretical framework

Legitimation Code Theory

Legitimation Code Theory (LCT) is an evolving theoretical framework that seeks to investigate two focal areas: i) the structures or forms of knowledge, and ii) the agents involved in this process of knowing. It grew from pioneering work by Karl Maton, whose intellectual heritage can be traced back to Basil Bernstein and Pierre Bourdieu as well as ideas from Systemic Functional Linguistics (Maton 2014, 2020; Maton et al. 2020). To understand LCT, we first must realise that within all social fields like education, the practices of knowledge within them are both structured and are structuring. That is, people are constrained in what they can or cannot do just as they can potentially change these social practices too. As LCT also takes its philosophical stances from Social Realism, researchers here dialectically regard knowledge as both real (i.e. reflective of objective reality that can be known) and social (i.e. influenced by culture-historical values & contexts). Because of this philosophical position, we believe that it allows the formation of a vital connection between psychology and sociology, which is the position that we wish to adopt here (Lee and Wan 2022b).

Why is knowing such information about the structure of knowledge in a social field so critical? For novices, learning and gaining appropriate mastery or success must assume demonstrating legitimate or correct ways of showing expertise, which are regarded as (knowledge) codes. Demonstrating what these usually tacit organising principles or "rules of the game" in Pierre Bourdieu's language will hence enable one to move from peripheral towards central and legitimate forms of participation. On the other hand, failure to master, demonstrate or simply be aware of the actual basis of achievement can be highly detrimental. For example, failure can either deny entry into these social fields or even prevent one from attaining higher levels of success here. In other words, social mobility in a broad sense may be hindered. This then is one of the chief purposes of adopting LCT in educational research: Once these normally hidden codes are uncovered in a systematic way, they can be critiqued and therefore improved upon within these social fields. In addition, access to these practices can now be enhanced and opened up for others. It is therefore said that knowing the "what" of knowledge as an object of study in its own right should be prioritised over questions of pedagogy or motivation of learners as significant as the latter are for educational success (McPhail 2020; Rata, McPhail, and Barrett 2019).

As LCT is being actively developed internationally in many domains other than in education (e.g. the arts, law, management, architecture), there are currently three main dimensions of legitimation codes in its conceptual toolkit. These are Autonomy and Semantics, but in this paper, we wish to focus on LCT codes that concerns what knowledge students must know and what kinds of persons they must be––the Specialisation dimension as developed by the Sydney school of LCT (Maton et al. 2020). The different codes within this dimension of LCT will enable us to determine the potential differences in learning achievement and success (through its cognitive demands & opportunities for learner access) among selected secondary school subjects from mainland China.

Two Specialisation relations

At its heart, Specialisation acknowledges that people know, believe and act upon something based on their state of knowledge in all the social fields (such as a curriculum) that they participate in (Bertam 2022; Maton and Chen 2020). Two concepts belong to this LCT dimension: epistemic relations (ER codes) and social relations (SR codes). First, we need to recognise that there are interconnections between people and objects called knowledge-knower structures, which reveal "how practices specialize identity, consciousness and relations" (Maton 2014, 66). Put differently, all practices are about something or oriented towards some object/phenomena by persons. These structures determine "what counts" in a social practice (Luckett and Hunma 2014) that can be analytically separated into epistemic relations (written as ER codes). Epistemic relations describe the relationships between knowledge and their object or focus––what are the forms of acceptable or legitimate knowledge or skills (i.e. *what* counts legitimately as knowledge) and how can these be known (i.e. *why* questions regarding the principles or procedures for justification). These are similar to the two aspects of cognitive demands of a curriculum that was explained earlier (i.e. the logical structures of knowledge & procedures for inquiry in a knowledge community). Hence, we can use ER+ codes to denote specific objects/problems where specialised knowledge or skills are strongly required for their successful enactment. For example, ER + codes would definitely characterise the curriculum of physiotherapy because these workers require extensive training in general aspects of science and specifically in physiology, anatomy, and disease. Without possessing these kinds of disciplinary knowledge or procedures and being able to judge what counts as new knowledge, they would never qualify as true professionals.

Second, social relations (denoted as SR codes) in Specialisation focus on the relationships between knowledge and their agents/subjects of implementation as the basis for achievement. The fundamental concern here is who can claim to be a legitimate knower: Who is enacting the practice and is there access to these practices? Legitimacy with respect to social relations can be acquired through: 1) being born into a field of practice or which is something naturally innate (e.g. having a keen ear for rhythm as a musician); 2) cultivating the requisite attributes, dispositions or sensibilities through instruction; and 3) through adopting standpoints or social positions consistent with a certain theoretical framework (e.g. class-based or feminist dispositions) according to Maton (2014). Dispositions are implicit and foundational ways of thinking and being that form a habitus and thus enable a person to effectively function or progress within a social field. Therefore, opportunities for access to a specific curriculum might be dependent on having the right dispositions or standpoints; the absence of such individual qualities might therefore make it much harder to achieve learning or to derive meaning. Through research methods such as documentary analysis, interviewing, and questionnaires, ER and SR codes of Specialisation can usefully describe knowledge practices across a "national curriculum, a subject area, specific aspects of a subject's curriculum, particular tasks within that area, and so on" (Lamont and Maton 2008, 271) because they specify i) what has to be known (c.f. cognitive demands) and ii) who is doing this knowing (c.f. opportunities for learner access).

Four code modalities of Specialisation

If these two Specialisation relations are represented in a 2 × 2 matrix as shown in Table 1, it forms a useful heuristic to visualise the four code modalities of knowledge practices that we now describe in turn (Maton 2014). Note that LCT researchers prefer to speak of a Specialisation plane as the ER and SR axes vary along a continuum of strengths rather than just being dichotomous, that is, no practice is regarded as completely ER/SR or not. Nonetheless, visualising the four Specialisation codes as quadrants in Table 1 does not detract from the theoretical argument that we are making. In quadrant 2, *knowledge* codes (ER+/SR-) describe a range of practices that have little need of awareness of one's social standing or development of one's personal attributes/dispositions––being a certain type of knower does not matter in this practice. Since social relations such as possession of personal attributes/qualities are downplayed here (i.e. there is more access to all), the code is thus denoted as SR-. This still stands true even though science learners, for example, are constantly exhorted to be objective, sceptical, honest, logical among many other typical attributes expected of a scientist: the "assessment criteria are always linked directly to epistemic relations" (Ellery 2019, 219). At the same time, specialised knowledge of specific objects is required and indeed privileged (i.e. high cognitive demand to achieve success), thus epistemic relations are denoted as ER+. Knowledge codes have often been used to describe knowledge practices found in mathematics or the hard sciences, where this field of practice underscores the significance of having disciplinary knowledge, including how it is constructed, communicated, and evaluated. In these contexts, it matters less who is making these claims, but the depth and inquiry practices backing this knowledge matters greatly.

The opposite condition occurs in quadrant 4 where *knower* codes are found (i.e. ER- SR +). Instead of emphasising the possession of specialised knowledge like in knowledge codes (ER+/SR-), the types of learners with their relevant attributes, sensibilities, and dispositions are paramount in legitimising the knowledge practices here. When a practice is coded this way, a strong social relations code would either point to having innate genius/ability, cultivated taste (e.g. through lengthy exposure to great artistic/literate work or extended apprenticeships), or stances based a knower's social position (e.g. class identity from standpoint theories). For instance, hip-hop and rap artists from urban America, who have an embodied feel for rhythm, movement, and poetry would be

Table 1. Epistemic and social relations that interact to describe the four Specialisation code modalities.

		Social relations (relationships between practices and their agents)	
		SR- (little need to be aware of social position or develop one's attributes/ dispositions)	SR+ (must be aware of social position or develop one's attributes/ dispositions)
Epistemic relations (the relationships between practices and their object or focus)	ER+ (must possess specialist knowledge of specific objects of study)	Quadrant 2: *Knowledge codes*	Quadrant 1: *Elite codes*
	ER- (little need to possess specialist knowledge of specific objects of study)	Quadrant 3: *Relativist codes*	Quadrant 4: *Knower codes*

prime examples of the possession of knower codes, whereas most scientists and engineers would generally be characterised by knowledge codes. The opportunities for access in quadrant 4 are therefore very restricted even though the cognitive demands are not high in this particular code modality. In South Africa, it was found that some disadvantaged undergraduates needed to shift towards having knower codes that could enable them to become more independent and autonomous learners as they stepped into higher education, which encompassed the metacognitive skills so vital for executive functioning (Ellery 2017).

In quadrant 1, the Specialisation codes here (ER+ SR+) can be described as *elite* that indicate practices requiring both specialised knowledge and being a "right" type of person. Such practices can describe the professional work of connoisseurs who are defined by the online Oxford English Dictionary as people "well acquainted with one of the fine arts, and competent to pass a judgement in relation thereto; a critical judge of art or of matters of taste". It is obvious that not everyone can be a connoisseur even if they aspired to; professional sommeliers come to mind as they balance being well educated about wine and its culture, and possessing a highly discerning palate. Passing written exams alone, clearly, is insufficient to gain entry into these exclusive circles as it requires certain innate qualities too that are not easily taught. ER+SR+ codes can therefore represent curricula where both its cognitive demands are high and access rewards only certain kinds of learners. And in certain social practices where having neither knowledge nor being certain types of persons (i.e. knower attributes) are consequential for achievement or success ("anything goes"), we find what is known as *relativist* codes as seen in quadrant 3 in Table 1.

Through these four Specialisation codes, it is possible to understand the ways in which knowledge practices for success/achievement in a curriculum can be organised that comprise the "rules of the game" (Bertam 2022). For example, Lamont and Maton (2008) was an early adoption of Specialisation codes in LCT curriculum research. It was found that the early stages of the British music curriculum emphasised musical knowledge (knowledge codes) or the musical dispositions of knowers (knower codes). Upon reaching senior levels, however, learning music in preparation for the examinations shifted towards more elite codes in the curriculum. It was a "code shift" that young learners both recognised and avoided, leading to the widespread unpopularity of senior music as an official school subject. This was felt to be a pity as the epistemic relations that are to be found when learning music can serve as a source of powerful knowledge for young people throughout their lives (McPhail 2017).

With the intent of seeing whether university courses provided epistemic access to disadvantaged learners in post-apartheid South Africa, Luckett and Hunma (2014) sampled the curriculum and exam papers from four foundation courses at one university. They found that the psychology course was defined mainly by knowledge codes (ER+SR-), whereas the courses in the Humanities there seemed to favour cultivated knower codes (ER-SR+). Finding what these Specialisation codes were showed the implicit relations/dispositions among the courses and could potentially assist new students navigate the particular rules of the game in each discipline. If students managed to do so, they thus would have gained achievement and success in the discipline. Indeed, it was these kinds of fears about potential "code clashes" or shifts required by learners, such as those reported by overseas Chinese students studying in Australia (Maton 2016; Maton and Chen 2020) that prompted this study in the first place.

Although we have devoted much space in explaining the theoretical basis for our study, we are just motivated to simultaneously examine the cognitive demands as well as the opportunities for learner access to disciplinary knowledge in a curriculum. To accomplish this task, we now examine a mix of learning outcomes (LO) from mainland Chinese curricula through ER and SR codes from the Specialisation dimension of LCT.

Sample & methods of coding

We first need to understand that in mainland China, with a few exceptions, junior (Grades 7–9) and senior secondary (Grades 10–12) education each lasts 3 years. Junior secondary education is part of compulsory education and is thus universally offered to all, but entering senior secondary education is different. Here, there is a selection process where students can choose between attending general education or vocational school. Although non-compulsory, the gross enrolment at this stage in the country has now reached 91.4% of which enrolment in general senior secondary school education is around 50% in 2021 (MOE 2022). Given the large population sizes in mainland China, curricula at the secondary level are thus highly influential as so many leaners are exposed to them.

Our sample consisted of curriculum LO from junior and senior secondary levels of the same subject from mainland China (see Table 2). We chose school subjects that are commonly believed to be as divergent as possible––the sciences and the fine arts. Hence, we examined the LO from eight science-based curricula (chemistry, earth science, biology, & physics) and four arts-based curricula (music & art). These LO were translated into English and coded separately by the researchers based on the four modalities of Specialisation codes in Table 1. Interrater reliability values were found to be excellent when coding for science-based subjects achieving nearly 100% agreement for both ER and SR codes, while they ranged from 66% to 85% for ER codes and 63% to 73% for SR codes for arts-based subjects. All coding disputes were then resolved to reach a final consensus on the coding.

We set some rules in order to improve consistency in our analysis. For example, LO often contained multiple phrases that detailed the command verbs, procedures or activities for learning, and of course, the learning goals themselves. For such complex representations, if an LO contained both the positive and the negative aspects of either ER/SR codes, we always recorded it as the positive case (+). This decision recognises that formal school instruction is typically necessary for learning the content/skills or certain personal attributes/dispositions are called for, which are both harder or less routine conditions for learning to be fulfiled that we wanted to foreground. Another useful rule

Table 2. Sources of learning outcomes from the official curriculum documents from mainland China used in this study.

Title of Publication	Data	Publisher	Year of release
Compulsory Junior School Geography/ Physics/Chemistry/ Biology/Art/Music Curriculum Standards (Grades 7–9) (total of six books)	Learning objectives in the section of content standards	Beijing Normal University Press	2011
The General Senior Secondary School Geography/Physics/ Chemistry/Biology/Art/Music Curriculum Standards (Grades10-12) (total of six books)	Learning objectives in the section of content standards	People's Education Press	2017

we adopted was that any kinds of knowing that is located in everyday life, or which does not require any kind of specialised knowledge by the learner would be coded as ER-. It is to be remembered that the intent of LO from national curricula is to specify what students ought to know and do as a direct consequence of receiving formal instruction. Since these are all forms of specialised knowledge (i.e. ER+), ER- codes were therefore found to occur at low frequencies within our data.

Table 3 shows selected examples of our coding of mainland Chinese LO using the four modalities of Specialisation codes. For example, the LO "Able to find connections between music, art, drama, dance and other works that express the same kind of emotion" (Junior Art) was coded as ER+SR- because only conceptual knowledge was required here to find connections between these stated art forms (ER+) without mentioning any need for having personal traits or dispositions (SR-) for success. Likewise, "Experience cultivating a plant" (Junior Biology) wanted science learners to go through the process of growing a plant (ER+), again without any mention of personal attributes being involved here (SR-). On the other hand, learners encountering LO such as "Able to express one's emotions using artistic elements and formal laws" (Junior Art) or " Have a sense of sustainable development for the development and utilization of energy" (Junior Physics) needed specialised knowledge (ER+) as well as certain personal traits/dispositions (SR+) in order to learn meaningfully here. Thus, both of these LO are typical of elite codes that are located in quadrant 1 of Table 1. The LO "Explore various sounds in nature and life and can imitate different sounds in different ways" (Junior Music) and "Able to experience the joy of exploration activities and the joy of learning success" (Junior Chemistry) are good examples of knower codes where specialised

Table 3. Examples of the coding for mainland Chinese LO based on four Specialisation codes.

ER+SR- (Knowledge Codes)	ER+SR+ (Elite Codes)
能够找出表达同一类情感的音乐, 美术, 戏剧, 舞蹈等作品之间的相通之处 Able to find connections between music, art, drama, dance and other works that express the same kind of emotion (Junior Art)	能够运用艺术要素和形式规律表达自己的情感 Able to express one's emotions using artistic elements and formal laws (Junior Art)
	能够简单表述音乐对于情绪的影响, 并能运用合适的音乐进行自我调节 Able to express the influence of music on emotions and use appropriate music to self-regulate (Junior Music)
学习变声期嗓音保护的知识, 懂得嗓音保护的方法 Learn knowledge about voice protection during the voice change period and understand the methods of voice protection (Junior Music)	拒绝毒品 Refuse drugs (Junior Biology)
体验一种常见植物的栽培过程. Experience cultivating a plant (Junior Biology)	了解家乡的发展规划, 关注家乡的未来发展, 树立建设家乡的志向 Understand the development plan of one's hometown, pay attention to the future development of the hometown, and establish the ambition to build the hometown (Junior Geography)
	对于能源的开发利用有可持续发展的意识 Have a sense of sustainable development for the development and utilisation of energy (Junior Physics)
	具有控制实验条件的意识 Have awareness when controlling experimental conditions (Junior Chemistry)

Table 3. (Continued).

ER-SR- (Relativist Codes)	ER-SR+ (Knower Codes)
–	至少能接触或学习欣赏10部与文化密切相关的经典艺术作品 Able to at least be familiar with or learn to appreciate 10 classic works of art that are closely related to culture (Junior Art)
	探索自然界和生活中的各种音响, 能够用不同的方式模仿不同的声音 Explore various sounds in nature and life and can imitate different sounds in different ways (Junior Music)
	能体会到探究活动的乐趣和学习成功的喜悦 Able to experience the joy of exploration activities and the joy of learning success (Junior Chemistry)
	与他人交流讨论时, 既敢于发表自己的观点,又善于倾听他人的意见 When communicating and discussing with others, will dare to express one's own opinions and will be good at listening to others' opinions (Junior Chemistry)

knowledge is downplayed (ER-), which aligned with our earlier coding rule about unspecialised everyday knowledge that cannot be taught or experiences that are accrued outside of formal instruction such as the home. However, finding success by virtue of being a certain kind of person (SR+) with the "right" personal attributes are key features of knower codes in this particular quadrant. Finally, based on our coding scheme, there were no occasions of any relativist codes (ER-SR) among this sample of science- or arts-based LO from mainland China.

Findings

Tables 4 and 5 shows the coding of secondary science- and arts-based LO from mainland Chinese curricula based on the four modalities of Specialisation codes.

Table 4 shows that among the science-based curricula in our sample, both at junior and senior secondary levels, the predominant code was for knowledge (ER+SR-). This ranged from 82.1% in junior chemistry to 100% in senior geography with most science-based curricula garnering more than 93% knowledge codes, which was expected (Maton 2014). The cognitive demands here were high, but the social relations aspect was downplayed that facilitated access to disciplinary knowledge for more learners. It also showed that geography or earth science was heavily focused on learning generalisable knowledge and conceptual ideas, and not just gaining personal or arbitrary experiences specific to a particular field location as some people might think (e.g. Maude 2020). A small number of science LO were elite codes (ER+SR+) especially from the chemistry curriculum; it reached a high of 16.1% in junior secondary levels and dropping to 6.1% in senior chemistry, which was still considerably higher compared to the other science subjects that had few of such codes. Why was this curriculum (and to a smaller extent physics) such an

Table 4. Coding profiles showing the number of learning outcomes (LO) from the four science-based curricula (junior & senior secondary) in mainland China based on Specialisation codes.

	Junior Geography LO (n00A0=00A0100) (% in brackets)	Senior Geography LO (n = 141) (% in brackets)
ER+SR+ (elite)	1 (0.1)	0
ER+SR- (knowledge)	99 (99.9)	141 (100)
ER-SR+ (knower)	0	0
ER-SR- (no knowledge)	0	0
	Junior Biology LO (n = 107) (% in brackets)	Senior Biology LO (n = 120) (% in brackets)
ER+SR+ (elite)	2 (1.9)	3 (2.5)
ER+SR- (knowledge)	105 (98.1)	117 (97.5)
ER-SR+ (knower)	0	0
ER-SR- (no knowledge)	0	0
	Junior Physics LO (n = 116) (% in brackets)	Senior Physics LO (n = 258) (% in brackets)
ER+SR+ (elite)	6 (5.2)	3 (1.2)
ER+SR- (knowledge)	110 (94.8)	255 (98.8)
ER-SR+ (knower)	0	0
ER-SR- (no knowledge)	0	0
	Junior Chemistry LO (n = 112) (% in brackets)	Senior Chemistry LO (n = 147) (% in brackets)
ER+SR+ (elite)	18 (16.1)	9 (6.1)
ER+SR- (knowledge)	92 (82.1)	138 (93.9)
ER-SR+ (knower)	2 (1.8)	0
ER-SR- (no knowledge)	0	0

Table 5. Coding profiles showing the number of learning outcomes (LO) from the two arts-based curricula (junior & senior secondary) in mainland China based on Specialisation codes.

	Junior Art LO (n = 18) (% in brackets)	Senior Art LO (n = 51) (% in brackets)
ER+SR+ (elite)	13 (72.2)	34 (66.7)
ER+SR- (knowledge)	1 (5.6)	14 (27.5)
ER-SR+ (knower)	4 (22.2)	3 (5.9)
ER-SR- (no knowledge)	0	0
	Junior Music LO (n = 46) (% in brackets)	Senior Music LO (n = 47 (% in brackets)
ER+SR+ (elite)	30 (65.2)	37 (78.7)
ER+SR- (knowledge)	13 (28.2)	7 (14.9)
ER-SR+ (knower)	3 (6.5)	3 (6.4)
ER-SR- (no knowledge)	0	0

outlier with respect to this code? LO coded with ER+SR+ were those that pertained to the proper conduct of scientific inquiry and to environmental conservation issues where personal feelings, judgement, and taking responsibility were essential (see also Table 3). For example, in junior chemistry and physics, we find examples of LO that required specialist knowledge and having the right kind of personal dispositions to ensure success in learning such as:

- *Able to conduct experiments independently or in cooperation with others*
- *Be able to process and organise facts and evidence, and make preliminary judgements on the relationship between factual evidence and assumptions*

In senior chemistry, some examples of these elite codes were related to learning about environmentalism and healthcare that mentioned taking personal stances or having a certain kind of identity:

- *Establish safety awareness and environmental protection awareness*
- *Establish the concept of "green chemistry" and form the consciousness of comprehensive resource conservation and material energy recycling*
- *Experience/Feel the importance of the development of chemistry science for the synthesis of drugs, and initially establish awareness of analysing health problems based on the properties of substances*

There is a complete absence of ER-SR- codes because these are, after all, LO that are meant for teaching purposes. There are also two rare examples of knower codes (ER-SR+) in junior chemistry LO as seen in Table 2. Here, personal attributes (e.g. joy, confidence, empathy) were the target of learning, while specialist knowledge was downplayed. Overall, there were no significant changes in the frequency of codes moving from junior to senior levels in the science curricula except for chemistry, although it experienced a drop in elite codes at the same time. On the whole, the data from these science-based curricula from mainland China aligned with what was reported in the literature about Specialisation codes.

Table 5 shows that among the arts-based curricula, both for junior and senior secondary levels, there was a very different pattern. Now, the predominant code were elite codes (ER+SR+), which ranged from 65.2% in junior music to 78.7% in senior music. This profile was quite similar from junior to senior art with a slight decrease in elite codes, but the jump for this code in music was a massive 23% increase! What this means is that in the arts-based curricula in mainland China, success here requires both specialist knowledge (high cognitive demand) and the right dispositions or attributes (that constrain access to knowledge), which is a tall order by any account to achieve among learners. Knowledge codes (ER+SR-) were the next most common category, reaching nearly 30% in junior music and senior art curricula, which emphasised possession of knowledge and de-emphasised personal attributes for success. Knower codes (ER-SR+) were the next most represented with 22.2% in junior art, but only around 6% in the other three arts-based curricula. A good example was the LO in junior art "Able to at least be familiar with or learn to appreciate 10 classic works of art that are closely related to culture" that emphasised personal taste and appreciation, qualities that are rather difficult to impart through formal instruction. The LO "able to express one's emotions using artistic elements and formal laws" would again be hard to teach because of the personal nature of expressing deeply felt emotions. Like science, there is a complete absence of ER-SR- codes again because these are all LO found within an instructional curriculum.

In sum, Chinese science-based curricula focused primarily on scientific knowledge and skill/inquiry process and less on elements such as scientific attitudes to cultivate the requisite attributes, dispositions or sensibilities of individuals. Knowledge codes (ER+SR-) were accordingly the most frequent Specialisation code to be found in Table 4 regardless of subject and grade levels. In contrast, LO from Chinese arts-based curricula in Table 5 were strongly characterised by elite codes (ER+SR+) as the basis of achievement that predominated across all grade levels.

Conclusion & discussion

As teacher educators, we wanted to know why was it easier to experience learning and achievement in some school subjects/curriculum, but not in others. What were the causes for these differences putting aside reasons due to student characteristics such as interest, motivation, and hard work? These are all weighty questions that have been debated time and time again within the education community without clear resolution. We argue that we cannot ignore the nature of disciplinary knowledge as expressed within curricula as an object of study (Maton 2014). But, educators who rely on theoretical concepts from psychology alone might concentrate on scrutinising the cognitive demands of curricula. This is undeniably critical work, but also incomplete in its answers. Adopting lenses from sociology, on the other hand, might compel educators to investigate a variety of large-scale or intergenerational social factors that can affect access to education in general. Whether these factors are difficult to examine is not really the point, they involve looking at variables and constructs that extend beyond the actual curriculum per se while ignoring its opportunities for access to knowledge among learners.

In this paper, we have adopted a new theoretical framework that integrates insights from both disciplines at the same time, which is Legitimation Code Theory, specifically from its Specialisation dimension. In other words, LCT enables researchers to jointly address the twin pitfalls in education regarding "relations with knowledge" (i.e. the cognitive perspective) and "relations to knowledge" (i.e. the sociological perspective) as well as what counts as success in a social practice (Maton et al. 2020). Specialisation consists of Epistemic and Social relations whose combination allowed us to characterise the learning outcomes of secondary school science- and arts-based curricula from mainland China. By doing so, we can empirically understand the internal factors within these curricula with regard to their i) cognitive demands, and ii) opportunities for access to knowledge for learners (Table 1). Together, these two inherent features of knowledge within a curriculum inform us which school subjects can potentially afford greater chances of success to learn disciplinary knowledge for learners.

Let us review our findings as we concurrently discuss some implications for their teaching and learning in the classroom in mainland China. Among science-based curricula, the most frequent code found here were knowledge codes (ER+SR-) regardless of grade level that ranged from 82% to 100% among the eight curricula in our sample (see Table 4). This implies that learning science is cognitively challenging at the secondary level, but academic achievement is now a matter of receiving good instruction that has less to do with possession of personal dispositions. The small number of elite codes found here (ER+SR+) does not disrupt this assertion; these few LO were concerned with deeper meanings associated with the practice of scientific inquiry and environmental/health issues. While they certainly involve identity formation and developing social responsibility as competent scientists, they only occupied a very small frequency and therefore do not severely limit the overall opportunities of access to learners. In other words, science is still very accessible to all learners in mainland China; strong social relations codes (SR+) do not really matter in these curricula. Conversely, one new British A-level (i.e. senior secondary) Geography topic places a strong emphasis on knower codes (ER-SR+) compared to the previous iteration where relativist (ER-SR-) codes were more common, which therefore increased the difficulty of learning for students (Vernon 2021).

On the other hand, elite codes were the visibly predominant feature among the arts-based curricula in mainland China that spanned from 65.2% in junior music to 78.7% in senior music. This profile, as shown in Table 5, was maintained in both junior and senior levels, but there was a large jump in this code for music in the senior secondary grades by 23%. While there were some knowledge (ER+SR-) and knower codes (ER-SR+), these were but a minority. It is thus possible to infer that learning the arts is actually harder to achieve success because of the need for certain personal dispositions and qualities (i.e. SR+) as possible basis for achievement. We are also struck by the high cognitive demands as well as restricted opportunities for access in junior art. This subject has a high number of both elite and knower codes, which might make this *the* most challenging curriculum for learning among the four arts-based ones from mainland China! However, it can be argued that art becomes more manageable moving up the grades due to the decrease in elite and knower codes with large rise in knowledge codes. Interestingly, when British Grade 9 students studying music were asked about their perceptions of doing well in this subject compared to other subjects like science and mathematics, elite codes were overwhelmingly favoured (Lamont and Maton 2008). This code was similarly used to describe the practices of graduate choral music educators in training, which suggests its prevalence too at higher levels of education as well as among professional musicians (Howard 2020).

For learning the arts at the secondary level in mainland China, not only must learners be knowledgeable they must also possess certain kinds of personal qualities in order to succeed here. This claim appears to have support from the literature review, which highlighted how the arts-based curriculum is focused on aesthetic knowing (Ministry of Education [MOE] 2017) as well as being knowledge-centred (for music) (Yu and Leung 2019). Teachers in these domains are therefore urged to find creative ways to overcome the strong stress on SR+ codes, such as through sustained apprenticeships to cultivate desired personal attributes among students. Compared to science, the arts curriculum is therefore more challenging for learners to access disciplinary knowledge and to find success. Curriculum-makers and teachers in the arts from this region would be well advised to consider the pedagogical implications of our findings.

A number of conundrums continue to confront all educators such as whether learning an "easy" subject make it less worthy? Or is art and music necessary for a full and comprehensive education that is the entitlement for everyone? Or is learning the sciences more important for future career advancement? Which school subject(s) do learners find relevant and fulfiling or should they stick to pragmatic choices? Our study of the cognitive demands and opportunities for access to disciplinary knowledge in a school curriculum is therefore one piece of a larger and more complex puzzle that points us back to reconsidering the philosophy and aims of education. Based on our starting hypothesis that science- and arts-based curricula are the most divergent, our results provided preliminary evidence to support this claim, although this will only hold true when more school subjects are compared this way. It was also found that science LO are much more numerous than arts-based ones in our sample, which might moreover skew the claims that we are making. Another limitation is that this study only analyses the intended curriculum for its likely Specialisation codes that may be different from the actual cognitive demands and opportunities for access that are expressed during everyday teaching, which is known as the enacted curriculum. So even though our coding scheme is agnostic to which discipline an LO belongs to when coding, an LO does not indicate its

effort or duration for the learning goals to be achieved by a teacher. This might be the situation with respect to learning the arts-based subjects; fewer LO might actually point to more time and effort devoted to learning compared to the sciences. Perhaps, the biggest obstacle is that Specialisation and indeed LCT, which is its parent theoretical framework, often seem overly complex to understand, especially when concepts here cross the traditional boundaries of canonical methods of investigation within psychological and sociological research. Still, we are enthusiastic about using them because they offer an integrated perspective into the many difficult questions that our study has raised. Above all, it allows for the empirical analysis of demands and access in curricula through a relatively objective manner to find knowledge, knower, relativist, and elite codes, which we hope will form the core of an active research agenda for the future.

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