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Foregrounding knowledge in e-learning design: An illustration in a museum setting

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The nature of knowledge, and the various forms knowledge may take, is a neglected aspect of the development of e-learning environments. This paper uses Legitimation Code Theory (LCT) to conceptualise the organising principles of knowledge practices. As we will illustrate, when it comes to the design of e-learning, the organising principles of the knowledge comprising the subject area, matters as much as the content. Drawing on one dimension of LCT, *Specialisation*, we show how to identify and apply organising principles of knowledge, in two successive stages, through an example of our own recent work developing an e-learning environment called Design Studio. First, an *analytic* stage explored knowledge practices within four design disciplines, engineering, architecture, digital media, and fashion design, in terms of their organising principles. Second, a *generative* stage involved the creation of content for the Design Studio software as well as its look and feel, and interaction design elements, all of which were designed to be consistent with the output from the analytic stage. Design Studio was then pilot-tested by 14 high school students. The paper concludes with some general observations about how LCT can improve the creation of other e-learning environments.

Introduction

E-learning environments involve the use of various combinations of digital content, platforms, tools, tasks, and interface and interaction design to support learning and teaching (Carliner & Shank, 2008; Luckin, Puntambekar, Goodyear, Grabowski, Underwood, & Winters, 2013). In such environments, one typically finds a number of proposed learning tasks on a given topic (represented in the subject content), and learners' activities are often mediated by interactions with the subject content and visual and navigational features. Knowledge thus plays a significant role in these environments in terms of both the subject content and skills that students are intended to obtain, and the form of knowledge (e.g. readings, simulations, quizzes, etc.) conveyed. Part of the work of e-learning designers involves finding ways to articulate this knowledge so as to maintain its integrity. However, the organising principles of knowledge in a given field and their influence in the design of e-learning have received relatively little attention in educational technology research (Howard & Maton, 2011). This article explains why it is important to bring knowledge more firmly into the picture and, using Legitimation Code Theory (LCT) to do so, illustrates how the organising principles of knowledge practices within different fields can be incorporated into e-learning design. Three main issues are addressed in this article: (i) how LCT can be used to explore the organising principles of knowledge practices in diverse intellectual fields; (ii) how these principles were identified in the field of design (focusing on engineering, architecture, digital media, and fashion design); and (iii) how these identified principles were then embedded within an e-learning environment.[1]

In the next section of this paper we discuss issues related to the absence of knowledge in e-learning design and why it is important to take the organising principles of knowledge practices into account. Second, we introduce concepts from LCT, a framework that provides the analytical lens for our research. Third, we discuss how we used LCT to analyse the organising principles of knowledge in the field of design. Fourth, we discuss how this analysis underpinned the creation of Design Studio, an e-learning environment developed to support informal learning in a museum setting. Lastly, we discuss how educational designers can practically apply these ideas.

[1] The fact that we have been working on the design of an e-learning environment for learning about design complicates the expression of our argument. We have tried to remove all ambiguities about the use of the term design.

Getting deeper into knowledge

E-learning design usually involves a team of experts working on task analysis, problem-solving, and testing, while taking a range of stakeholders' (e.g. students, teachers, managers in an educational institution and others) interests into account (Gagné, 1992; Hakinnen, 2002). Educational designers carefully examine students' learning needs and liaise with various stakeholders in order to develop, revise and re-write content, create media to support learning tasks, develop assessment tasks, and so on. In order to produce the functionality and visual displays of content and learning tasks, educational designers take many factors into account, such as user experience, learning needs, and instructional strategies. They have however tended to neglect the role of the organising principles underlying the knowledge to be learned, that is, the rules of the game, for what counts as significant and interesting within a particular field (Maton, 2014). These principles shape how knowledge is expressed or communicated in a field. Thus, while an important aspect of the work of educational designers involves dealing with ways of expressing content, considerations of the organising principles that generated that content are often missing. As a result only a surface picture of knowledge is embraced, focusing on subject content at the expense of what lies beneath it (the organising principles that generate that content).

The absence of engagement with such principles is illustrated by well established models used to guide the creation of learning resources, such as ADDIE or Instructional System Design (ISD) and 4C/ID (e.g. Clark, 2014; Grafinger, 1988; Molenda, 2003; van Merriënboer, Clark, & Croock, 2002). ADDIE and ISD offer systematic ways of breaking the design process into phases – analysis, design, development, implementation or delivery, and evaluation – with the analysis phase emphasising the importance of needs assessment (Clark, 2014; Hakkinen, 2002). Two of these phases – *analysis of needs* and *evaluation of design* – could potentially address the organising principles of a field. In the *analysis phase,* the established models suggest that designers should break down the identification of the learning problem, goals, and audience needs. However, there are no references to understanding the nature of knowledge or to strategies by which designers could identify the organising principles underlying the practices of the field that generate its knowledge. Indeed, these phases are generic to any design project, and not specific to e-learning. This means that ways of expressing knowledge as reflecting the broader social context of a particular environment are not explicitly articulated during the design process. Similarly, the 4C/ID model rightly suggests that "concrete, authentic, whole-task experiences" (van Merriënboer et al., 2002; p. 43) are central elements to complex learning and that it is important that learners are offered "nontrivial, realistic and increasingly more authentic task classes and learning tasks" (p.58). However, the 4C/ID model does not provide principles for what constitutes realistic or authentic tasks within a field, nor does it indicate different ways of expressing such principles through e-learning design. The rules of the game for what constitutes realistic or authentic tasks are likely to take different forms in different fields as fields may have different organising principles underlying their knowledge. The design of a realistic task would perhaps require the learner to see knowledge in relation to the broader social context that generated that knowledge so as to understand how knowledge became legitimated within the field of learning. Neither of these issues is addressed in the *evaluation phase* of these models. Even when subject matter experts (SMEs) are brought into these design teams, their role is often seen as having a review purpose, as someone who may bring "some ideas to use during class, some 'examples from the trenches'" (Piskurich, 2006; p. 6), and verify the veracity of the content. While content expertise is important, content knowledge in itself does not fully support the process of bringing knowledge into the picture. Being an experienced participant within a field and having expert knowledge about the content do not necessarily translate into having the ability to analyse and describe the organising principles for knowledge in that field.

Why should the organising principles of knowledge practices be given a more central place in e-learning design? There are two main reasons. First, the creation of e-learning environments occur within social contexts (Merchant, 2012); they are not isolated entities but rather connected to broader social practices, including the intellectual fields giving rise to their content. Within and between intellectual fields, differences over the basis of claims to legitimate knowledge occur and change over time (Maton, 2014). People working in a field often become enmeshed in competing ways of determining legitimate knowledge and consequently can become entrained to a set of organising principles. They may then transfer those principles when designing e-learning environments for another field without recognising that those organising principles would be inappropriate in that field. This situation can produce a *code clash* between two competing ways of understanding legitimacy, which we explain below. Second, people who are entering such a field can benefit from greater awareness of the nature of knowledge and knowing within the field – from greater *epistemic fluency* (e.g. Goodyear & Zenios, 2007). Our research claims that in order to learn about a subject area, in addition to domain content, one needs to understand the organising principles underlying its knowledge – the rules of the game. Learners, as newcomers to an intellectual field, need to recognise what is considered meaningful in that context and the specific ways in which legitimate knowledge is practiced and communicated amongst those who claim to possess knowledge. However, determining legitimate knowledge may be particularly challenging for learners who are just starting their socialisation into the field.

It is necessary, then, that we bring knowledge more firmly into e-learning design. In order to devise ways of supporting learners, it is important that e-learning designers acknowledge that knowledge takes various forms, and that these forms are dependent on the organising principles for that knowledge rather than simply arbitrary. These are critical points for educational designers to determine appropriate forms of knowledge to incorporate into e-learning environments. We therefore turn to LCT, an approach that offers useful conceptual tools for identifying the organising principles for knowledge in social fields, both within and beyond education.

Analysing knowledge practices: Legitimation Code Theory (LCT)

LCT is an analytical framework that enables knowledge to be seen as an object of study and its organising principles to be conceptualised along a number of dimensions. LCT assumes that knowledge is both socially constructed and real in the sense of having effects (Maton, 2014). LCT views educational contexts as fields of struggle in which practices embody competing claims for legitimacy or measures of achievement active in the field. LCT offers a multi-dimensional conceptual toolkit for analysing these rules of the game.[2] One widely-used dimension is *Specialisation* or ”what makes actors, discourses and practices special or legitimate” in a given context (Maton, 2007; p. 98). All knowledge is about something and by someone, establishing relations to objects and subjects. Thus, one can analytically distinguish *epistemic relations* (ER) to objects of knowledge, and *social relations* (SR) to subjects, authors, or actors. These relations highlight questions of: what knowledge can be legitimately described as, for example, design (epistemic relations); and who can legitimately claim to be producing legitimate design (social relations). In positing different measures of legitimacy, practices emphasise these relations to different degrees, from stronger (+) to weaker (–), generating a range of *specialisation codes* (ER+/–, SR+/–). These continua of strengths are visualised in Figure 1 as a topology with infinite capacity for gradation and four principal specialisation codes:

- *knowledge codes* (ER+, SR–), where possession of specialised knowledge is emphasised as the basis of achievement, and the attributes of actors are downplayed;
- *knower codes* (ER–, SR+), where specialised knowledge is less significant and instead the attributes of actors as knowers are emphasised as measures of achievement;
- *élite codes* (ER+, SR+), where legitimacy is based on both possessing specialist knowledge and being the right kind of knower; and
- *relativist codes* (ER–, SR–), where legitimacy is determined by neither specialist knowledge nor knower attributes – anything goes.

The specialisation code describes the rules of the game or dominant basis of success of a social context; in the four codes, what matters is what or how you know (knowledge codes), the kind of knower you are (knower codes), both (élite codes) or neither (relativist codes). A specific code may dominate as the (typically

[2] The conceptual architecture of LCT has been elaborated through a series of publications by Maton and various colleagues over the past 15 years. See Maton (2014) for a systematic introduction to two dimensions of LCT, and Maton, Hood and Shay (2015) for a primer and further examples of studies. See also http://www.legitimationcodetheory.com

unwritten) rules of the game, but may not be transparent, universal or uncontested. Not everyone may recognise and/or be able to realise what is required; there is typically more than one code present, and there are likely to be struggles over which code is dominant. One can thus talk of degrees of code clash and *code match*, such as between: learners' ways of thinking and being and the educational context (Chen, Maton, & Bennett, 2011); different approaches to knowledge practices within a field (Carvalho, Dong, & Maton, 2009; Dong, Maton, & Carvalho, 2015); or goals of educational policies and ways of working of subject areas (Howard & Maton, 2011). As well as clashes, the dominant code may also change, such as between subject areas, classrooms, and stages of a curriculum. These *code shifts* change the rules of the game (Lamont & Maton, 2010).

As a growing number of studies are showing (e.g. Maton, Hood, & Shay, 2015), LCT concepts may be used to analyse all kinds of practices (curriculum, pedagogy, beliefs, etc.) at different levels of analysis (from national curriculum to individual texts) using a range of methods (documentary analysis, surveys, interviews, etc.). Empirical studies applying LCT conceptual tools can be found in educational technology (Carvalho & Goodyear, 2014a, 2014b; Howard & Maton, 2011), engineering (Wolff & Luckett 2013), history (Matruglio, Maton, & Martin, 2013), journalism (Kilpert & Shay, 2013), music (Lamont & Maton, 2010), physics (Georgiou, Maton, & Sharma, 2014) and many other fields. In the rest of this article, we use the concepts to explore the organising principles of four disciplines of design – engineering, architecture, digital media, and fashion – through the analysis of interviews and survey with designers. We go on to explain how we embedded these principles within an e-learning environment.

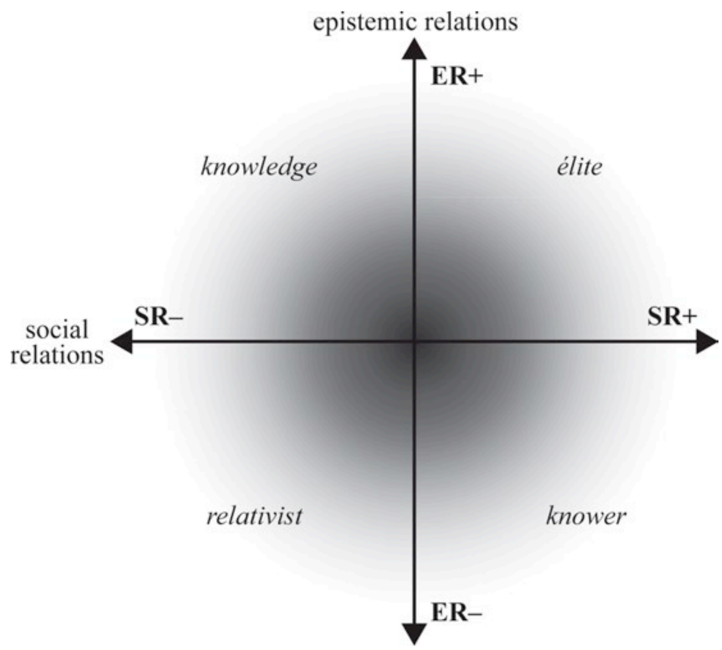

Figure 1. The specialization plane (Maton, 2014; p. 30).

Analytic phase: Exploring knowledge in the field

The first phase involved analyses of knowledge practices in engineering, architecture, digital media and fashion (Carvalho, 2010; Carvalho et al., 2009). The research design used a mixed methods approach with a sequential exploratory strategy (Creswell, 2003) in two stages. In the qualitative stage, a semi-structured interview protocol was used with engineering, architecture, digital media and fashion designers, and with two other participants who work in a museum of design. The quantitative stage used an online survey (mainly multiple choice questions) with professionals, academics, undergraduate and postgraduate students from the four design areas. Four pilot studies were conducted prior to producing the final survey protocol (Carvalho, 2010). Questions in the final protocol gathered background information, and contained a total of 6 tasks exploring participants' perceptions of design disciplines (tasks 1 and 2), perceptions of designers (tasks 3 and 4), and strategies used by designers (tasks 5 and 6). Task 3 replicated an instrument created and used by Lamont and Maton (2010), and task 6 was an open-ended question (see Table 1 below and Appendix A for more information). Both the interview and survey protocols investigated the same thematic categories: knowledge practices in the area of design, perceptions of designers, and strategies for identifying legitimate practices in the respective areas. An "external language of description" (Bernstein, 2000; p.132) – a means of translating between concepts and data – was created to show how the LCT concepts were enacted in the analysis of the interviews (see Table 2) and for the survey (examples are shown in Table 1 and results are presented in Appendix A).

Table 1
Enactment of LCT concepts in survey questions

	Survey Task	Question	LCT	Examples from options appearing in the protocol
Task 1	Participants completed a sentence using three words to describe design disciplines	Engineering design is ...	**ER**	scientific, technical, methodical, systematic, objective, procedural, skillful, driven by knowledge, others
			SR	social, empathic, driven by taste, fancy, glamorous, individual, influential, elegant, others
Task 3	Participants completed a sentence using three words to describe designers	An engineering designer is …	**ER**	a scientific person, a technical person, a procedural person, a methodical person, an objective person, a problem solver
			SR	a social person, a tasteful person, an empathic person, a glamorous person, a sensitive person, an artist
Task 4	Participants read a sentence of a fictitious profile and then chose to what discipline(s) they thought that person would be associated.	The statements below relate to fictitious people. Please tick the box that you think corresponds to the design profession the person might work in (you can tick as many boxes as you wish).	**ER**	X. is a very technical and methodical person. That is why s/he chose this sort of work. X. is a highly skilled person who has developed skills by studying and working really hard.
			SR	X. really understands other people's feelings. S/he can easily put her/himself in other people's shoes. X. recognises the value of beauty. In her/his profession one certainly needs a great sense of taste.
Task 5	How often designers in your discipline do "x"	Read the statements below and then please place a tick on the box that better describes how these statements apply to designers in YOUR design discipline." Likert scale (frequency)	**ER**	Designers in my discipline … … consult scientific journals … participate in conferences to listen to ideas … read technical books on the subject
			SR	Designers in my discipline … … use their personal experiences as inspiration for their design work … participate in conferences for social networking … develop an *eye* for the job through their design practice

Table 2
Enactment of LCT concepts in interview

Concept	Description of Concept	How concept manifests in current study	Example
ER+	Knowledge, skills, procedures or techniques are strongly bounded and controlled	Emphasis is placed on knowledge within own discipline. Designers refer to the application of design knowledge. Designers focus on how a solution meets a proposed problem and how the technical challenges are overcome so that the designed product could be generated.	"Where the real originality in that project is, is not necessarily the bridge itself, it's just the application. It is taking that type of bridge and putting it where it is to solve a problem which was about rocks falling off the face of the cliff. Again it is about the solution to what was probably a geotechnical issue which was slope stability was down by a bridge." (engineering designer 1)
ER–	Knowledge, skills, procedures or techniques are weakly bounded and controlled	Emphasis is placed on exchanging ideas with other design disciplines, and/or learning from other unrelated disciplines. Experiences from outside own discipline are valued, and designers use of multiple channels to acquire knowledge.	"I find ideas … is from everywhere, you know, Alfred Hitchcock once said ideas come from everywhere and I think that's really true and when I'm sort of stuck on an idea I'll get up from the office and I'll go for a walk or I'll take myself out and do something else like I'll go and see a film" (digital media designer 1)
SR+	Emphasis on the subject as the author	Designers' characteristics or background are emphasised. Real-life experiences and/or feelings are emphasised.	"There's something inside of you that says you can't live without this thing, if you can't, if somebody took that away from you you'd be as good as nothing, that you'd be as good as dead probably." (fashion designer 1)
SR–	The subject as author is downplayed	There is less emphasis on persons' characteristics or on designer as an author. The designer may be seen as an object (as a *resource*) rather than a person.	"If you're being employed and for me here I'm seen as a resource, so I come into projects, give my consultation or do my work on it and then leave again." (digital media designer 2)

Results from the analysis of these interviews (N=10) and survey (N=139) suggested that different disciplines in the field of design have their own rules of the game characterised by different organising principles (Appendix A). As Figure 2 illustrates, legitimacy in engineering was more likely to be perceived as based on technical and objective attributes (a knowledge code), whereas achievement in fashion was often described as reliant on the designers' dispositions (a knower code). Architecture and digital media were perceived as emphasising both procedures and skills and attributes of the knower, such as dispositions (élite code). These results are discussed in greater detail in Carvalho (2010).

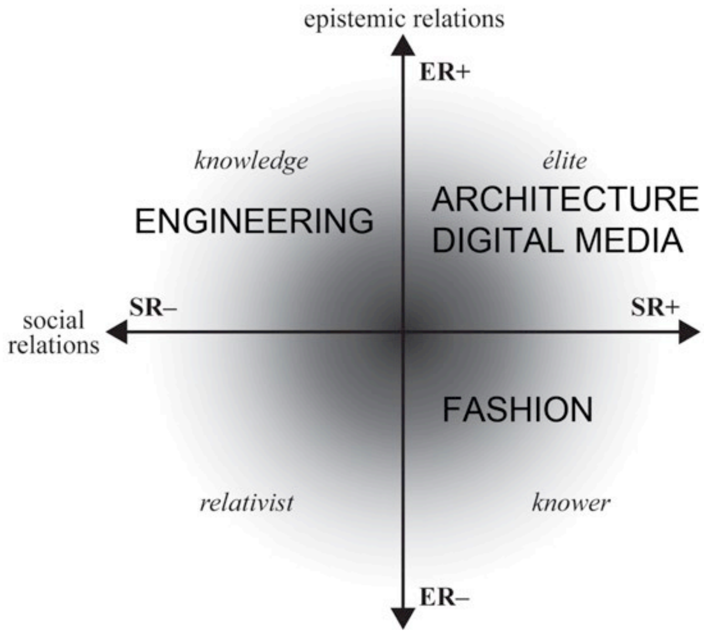

Figure 2. Specialisation codes of the four design sub-areas.

These results indicate that learning in the field of design requires awareness that disciplines within the field are characterised by different organising principles. An e-learning environment designed according to the specialisation code of engineering would not be appropriate for architecture, regardless of similarities or differences in content. Consider, for example, the form of knowledge an e-learning designer would create to help the learner solve an architectural or engineering design problem. Should the designer create a visual library of reference solutions, textbooks, chat capabilities to connect the learner to practitioners, and so on? Of the various possible forms of knowledge, which are more appropriate? Our research suggests that forms of knowledge that support producing a particular *vision* are more likely to be emphasised in architectural design, whereas forms of knowledge conveying procedures and methods would be more suited to engineering design (Carvalho, 2010: Carvalho et al., 2009). For example, our survey results indicate that while 66% of architecture designers reported drawing on personal experiences in their design work, only 39% of engineers referred to this strategy. In contrast, while 93% of engineers reported to follow methodical procedures in their practices, only 48% of architects acknowledge using such strategy. These differences are manifestations of the organising principles for knowledge in these fields, and not solely to the intrinsic nature of the design problem. Both architectural and engineering design problems can, for example, share the characteristic of being *wicked* problems with no clear solution and path to the solution. The specialisation code identifies which form of knowledge is more likely to be appropriate.

Having identified the specialisation codes of the four design disciplines, the next step of our research was to devise ways of shaping the content of the e-learning environment (e.g. tasks proposed, information about design) according to the appropriate specialisation codes. The aim was to create an environment that would help people learn about design according to the forms of knowledge taken by practitioners in engineering, architecture, digital media and fashion, that is, allowing students to explore design knowledge according to the underlying principles of legitimation in the field (Figure 2).

Generative phase: Embedding knowledge in Design Studio

Design Studio is an e-learning environment created and implemented at the Powerhouse Museum in Sydney, Australia. The concept behind Design Studio was inspired by approaches and systems designed to enable learners' self-directed inquiry such as SCI-WISE (White, Shimoda, & Frederiksen, 1999), ECOLAB (Luckin & du Boulay, 1999) and the Guided Learner-Adaptable Scaffolding (GLAS) (Jackson, Krajcik, & Soloway, 1998) and others (Hall & Bannon, 2006; Hsi, 2003; Quintana, Zhang, & Krajcik, 2005; White et al., 2002). Mobile devices commonly utilised in museums act as visit guides, and are often used to nurture informal learning (Sung, Hou, Liu, & Chang, 2010). Design Studio software displays a series of learning tasks and information offering learners opportunities to design an object while inquiring into the forms of knowledge considered legitimate within the four design disciplines. It offers guidance through virtual design coaches (advisors) that support learners in completing activities related to the design of eight types of objects (a house, a chair, a car, a train, an icon, a 3D character, a dress, or footwear). Four sets of two objects were chosen to represent each of the four design areas in our study (e.g. dress and footwear could be associated with fashion, 3D character and icon with digital media, and so on). The specialisation codes drove the following design decisions: (1) the content of the screenplays of design advisors who would assist the learners in the design activity in the museum; and (2) the content of instructions to the learners as they engage in the design process. Museum visitors select a specialisation code implicitly when choosing their preferred advisor or when requesting that the system allocate an advisor based on their selection of a particular object. In addition, one could also choose to go through tasks with no guidance at all. We describe in further detail below how the specialisation codes identified in the analytic phase influenced the user experience in Design Studio.

Developing screenplays of four advisors

Four types of characters (advisors) provided guidance through the activity, with their profiles representing each of the four specialisation codes. Learners choose the type of character they would like as an advisor. Each character has a male and a female version (Figure 3): Roger/Rachel (knowledge code), Christopher/Christine (knower code), Alexander/Alexandra (élite code), and Nicholas/Nicole (relativist code).

Figure 3. Design Studio screen shot: Choosing advisor.

Each advisor proposes tasks and provides guidance according to the associated specialisation code they represent. In other words, while the thematic content of the screenplay for each of the characters is the same, both the language that the characters use to communicate the content and their suggestions for approaches to design tasks reflect the different specialisation codes (see Table 3). For instance, one common activity in design is *need-finding*, and the common thematic content is to have all learners talk to other museum visitors as a strategy to explore the features that would be essential in the design of a certain object. However, a learner who is being guided by Roger/Rachel (knowledge code) will be recommended a more methodical way of approaching this task such as the use of templates for interviewing museum visitors. On the other hand, the guidance of Christopher/Christine (knower code) reflects a more personal approach, such as encouraging the participants to explore people's feelings and their own dispositions toward a certain designed object (see Table 4). In this case, no templates are offered.

Table 3
Enactment of LCT concepts in script

Advisor and specialisation code	**Characteristics**	**Example from Design Studio script**
Rachel or Roger ER+, SR– (knowledge code)	Methodical, practical, go direct to the point Likes: puzzles, following instructions Dislikes: talking about feelings	Designers must always be aware of standard practices in their field. They need to keep up to date with what is going on and they often do that by reading and researching the topic, and exchanging ideas with their peers.
Christine or Christopher ER–, SR+ (knower code)	Feelings, how one experiences object, people's person Likes: creative things, art Dislikes: following rules, methodical people	Designers often need to imagine how people would experience the object they are designing. Designers need to think about what feelings such an object would evoke. It is also important to consider that different people like different things and have different ideas.
Alexandra or Alexander ER+, SR+ (élite code)	Combination of refined "eye" and technical knowledge Likes: scientific programs about the universe, art, and original movies Dislikes: anything common place	Designers must always be aware of standard practices in their field. They need to keep up to date with what is going on and they often do that by reading and researching the topic, and exchanging ideas with their peers. Designers also often need to imagine how people would experience the object they are designing. It is important that designers think about what feelings such an object would evoke.
Nicole or Nicholas ER–, SR– (relativist code)	Average, common person Likes: sports, beach, BBQ Dislikes: Philosophy, nerds or sensitive people	Different people have different ideas. By talking to others or having a look at similar objects you can be reminded of things you didn't think of.

The examples above illustrate how the various ways of practicing design were incorporated according to the organising principles underlying knowledge in the respective design discipline. In other words, when it comes to the presentation of the knowledge, it is the specialisation code that matters, not the content alone. The goal of these options was to offer learners opportunities to establish connections between knowledge and ways of obtaining knowledge according to the methods valued within engineering, architecture, digital media and fashion design.

Table 4
Enactment of LCT concepts in need-finding tasks and strategies

Specialisation code	**Summary of advisor characteristics**	**Extract from Design Studio script: UNDERSTANDING THE DESIGN PROBLEM – TASK 1**
ER+, SR– (knowledge code)	Methodical, practical, careful, follows procedures and impersonal rules.	In this task you will need to list questions that you think are important and related to the design of the OBJECT. First you will consider what should be taken into account in the design of the OBJECT. In this step you need to open your mind and list as many things as you can think of. *Ideas to ASK other people:* Define a set of questions to ask other museum visitors or the teachers of your workshop. Make sure you ask the same question to at least 3 people, so you can see and compare how others may have different ideas. Record their answers in a notebook, and try to record as they talk, so you don't forget what exactly they said. (The original text included a link to a template for asking questions)
ER–, SR+ (knower code)	Design as personal expression, learning through intimate inter-personal relationships, intuition, developing an 'eye'.	In this task you will need to place yourself in the shoes of someone using the OBJECT and think how it would feel like. You need to brainstorm some ideas and come up with questions that you think are important and related to the design of the OBJECT. Try to consider what you should take into account in the design of the OBJECT. In this step you need to open your mind. *Ideas to ASK other people:* Ask someone to close their eyes and think about their favorite house or building. Then, ask them to describe it to you, and what do they like about the place and why?
ER+, SR+ (élite code)	Combines technical knowledge and talent or intuition, following procedures and 'refined eye'.	In this task you will need to list questions that you think are important and related to the design of the OBJECT. Consider what you should take into account in the design of the OBJECT. Place yourself in the shoes of someone using the OBJECT. In this step you need to open your mind and list as many things as you can think of. *Ideas to ASK other people:* Define a set of questions to ask other museum visitors or the teachers of your workshop. Make sure you ask the same question to at least 3 people, so you can see and compare how others may have different ideas. Record their answers in a notebook. Make sure to record as they talk, as you might forget what exactly they said if you leave it for later on. (The original text included a link to a template for asking questions) Ask someone to close their eyes and think about their favorite house or building. Then, ask them what do they like about the place and why?
ER–, SR– (relativist code)	Average person, anyone can do design, nothing special needed, work not specialised.	In this task you will need to list questions that you think are important and related to the design of the OBJECT. It may help to think about similar objects out there in the world. *Ideas to ASK other people:* Talk to your friends or museum visitors about their preferences in relation to similar objects. Explain what sort of OBJECT you are thinking of designing and exchange ideas with them. Talk about features they like, or don't, what would they change and how.

Instructions based on the organising principles for knowledge

Results from the analytical study (see Figure 2) were enacted when learners chose to have an advisor assigned instead of making a choice themselves. In this case, a learner who chose to design a dress but was uncertain about which advisor to follow would be assigned the character corresponding to the specialisation code for fashion design identified by the analytic phase (Christine/Christopher – knower code).

Results associated with designers' strategies to identify legitimate knowledge were also incorporated into Design Studio. For example, our survey results indicate that fashion and architecture designers were more likely to draw on personal experiences in their design work than, for example, engineers. Within the environment, these results are embodied and expressed through the types of strategies proposed by Christine/Christopher (knower code) and Alexandra/Alexander (élite code). This is done, for instance, by suggesting that learners reflect about their previous experiences (e.g. when in contact with similar objects, what they liked or disliked about a particular object they have seen either in real life or in a film and so on). Neither Rachel/Roger (knowledge code) nor Nicole/Nicholas (relativist code) suggests that visitors draw upon personal experiences, reflecting the weaker social relations of these codes. Table 4 presents extracts from the scripts of advisors as they explain one of the learning tasks (e.g. produce a list of questions about what may affect the design of their chosen object) and suggest ways of gathering information about it. These examples illustrate how elements in Design Studio expressed the different forms of knowledge taking into account the respective specialisation code (see examples of *Ideas to ask other people*). Through interactions with Design Studio and the museum surroundings, learners practice design in various disciplines, and at the same time they are exposed to the different forms of knowledge emphasised in the respective design discipline.

Implementation and evaluation

Design Studio was installed on MacBooks and pilot-tested by 14 Year 10 students during a design activity at the Powerhouse Museum in Sydney, Australia (Carvalho, 2010). Students came from a private inner city secondary school, and were selected by their Design and Technology Head Teacher to participate in the workshop. Most students were 15 years old, with only one being 16 years old. There were 7 females and 6 males. Participants interacted with both Design Studio and museum surroundings as they went through an inquiry process connected to the design of an object of their choice.

We explored how Design Studio shaped their museum experience and the extent to which the students' engagement with design followed the respective specialisation codes. The museum activity started with participants gathering in a lab room, equipped with desktop computers and two large screens (within the museum premises). Students were introduced to the learning task and shown how to use Design Studio. They were then put into pairs and asked to explore their design ideas through interactions with each other and with other museum visitors, as well as with Design Studio and museum objects and exhibits. Participants were asked to return to the lab after one hour. In interaction with Design Studio the pairs were invited to choose one type of object to design from eight options (each object is associated with a specialist area of design in our study, e.g., a *car* representing engineering design, a *dress* reflecting fashion). Once students completed the activity, they returned to the lab and completed a short survey (10 minutes). The survey collected information about participants' choices of object and advisor, reasons for choosing that advisor and the frequency of advice selected. It also included a short evaluation section with 10 multiple choice statements (using a 5-point Likert scale) and 2 open questions about the best/worst aspects of their design activity. A total of 13 valid responses were collected. This was followed by a 20 minute group discussion and debriefing session, which was audio taped and transcribed for analysis. The group discussion provided an opportunity for participants to openly share their perceptions of the activity with each other and the researcher, if they desired to do so.

Survey results from this small qualitative study show that 8 out of the 13 students followed the specialisation code of the design discipline corresponding to their chosen object, in accord with the survey results in the empirical study (a code match). This was the case in relation to objects associated with architecture (2), digital media (2) and fashion (4). Four of these participants went through the design experience being guided by the élite code oriented advisor and four by the knower code oriented advisor (see Table 5).

Table 5
Advisor and choice of object

	Advisor	**Specialisation code**	**Object**	**Discipline**	**Code match?**
Participant 1	Alexander	ER+, SR+	Chair	Architecture	Yes
Participant 2	Alexandra	ER+, SR+	Dress	Fashion	No
Participant 3	Alexandra	ER+, SR+	3D	Digital Media	Yes
Participant 4	Alexandra	ER+, SR+	3D	Digital Media	Yes
Participant 5	Alexandra	ER+, SR+	Dress	Fashion	No
Participant 6	Alexandra	ER+, SR+	Car	Engineering	No
Participant 7	Alexander	ER+, SR+	Chair	Architecture	Yes
Participant 8	Christine	ER–, SR+	Dress	Fashion	Yes
Participant 9	Christopher	ER–, SR+	Dress	Fashion	Yes
Participant 10	Christopher	ER–, SR+	Dress	Fashion	Yes
Participant 11	Christine	ER–, SR+	Dress	Fashion	Yes
Participant 12	Roger	ER+, SR–	Dress	Fashion	No
Participant 13	Roger	ER+, SR–	Dress	Fashion	No

However, when asked to justify their choice of a design advisor, from the 8 participants who expressed a code match, 4 students reported that their reasons laid on the advisors' appearance rather than the advisors' message, and 2 students justified their choices with a "no special reason". Only 1 student reported his/her selection of the design tutor was connected to being "the right type of advisor" according to their chosen object, but this response was by a participant who was not part of the code match group. These results are summarised in Table 6. (Please note that each participant could give more than one reason.)

One possible interpretation for this data is that participants had some intuitive understanding of knowledge practices of design (and thus 8 of them experienced a code match), but they were less sure how those practices were realised, and so they were not able to explicitly recognise connections between their choices of an object and the advisors' expressions of design ideas. Another interpretation is that participants just wanted to try out a specific way of experiencing design. We would like to emphasise that the combination of an advisor and object, which we refer as expressing a code match, was not the only possibility for the students design trajectory. Participants would design a fashion object in accord with the rules of the game in fashion when, for example, they requested that the software assign an advisor to them according to their choice of object. They would also follow this path if they were able to recognise the discipline's code and opted to experience the design of the object with their corresponding advisor. However, Design Studio also offered other opportunities to explore designing an object under a different code orientation. The idea was not to dictate a unique path to experience design according to the discipline's code. Instead, we wanted to highlight that there are different ways of practicing and expressing design knowledge. Epistemic and social relations may be emphasised and/or downplayed on a certain design discipline, but they are not necessarily absent. Epistemic oriented practices still exist in a knower-oriented discipline, albeit downplayed. Thus it is possible that participants might have found it interesting and chose to experience designing a dress under a knowledge code orientation, that is through methodical and systematic processes such as the choices made by Participants 12 and 13 (Table 5). We cannot necessarily ascertain whether this would per se translate into a code clash experience. Similarly, a potential code clash may only be cautiously inferred, not definitively concluded, when analysing the responses of Participant 6 (Table 5), who chose to design a car under the guidance of the élite code advisor and justified his choice by stating that this advisor was "the best suited advisor considering my choice of object".

Table 6
Reasons for choosing advisors

Reasons for choosing advisor	Code match group (8 participants)	No code match group (5 participants)	All 13 participants
Because of his/her looks	4	2	6
Because of his/her personality, likes and dislikes	2		2
No special reason, just chose one by chance	2	2	4
Because of his general ideas about how to design an object	2		2
It was the best suited advisor considering my choice of object		1	1
Other	1		1

Figures 4 and 5 illustrate the results from the evaluation questions. Participants were asked about their choice of advisor and object, the guidance received, usefulness of the content, and whether they felt supported during the activity and learned from the experience. In the code match group, 6 participants reported that they were happy with their choice of advisor, 5 were happy with the guidance received, and 6 felt supported (Figure 4). From the 5 participants in the no code match group, 4 reported that they were happy with their choice of advisor, 3 were happy with the guidance received, and 3 felt supported (Figure 5).

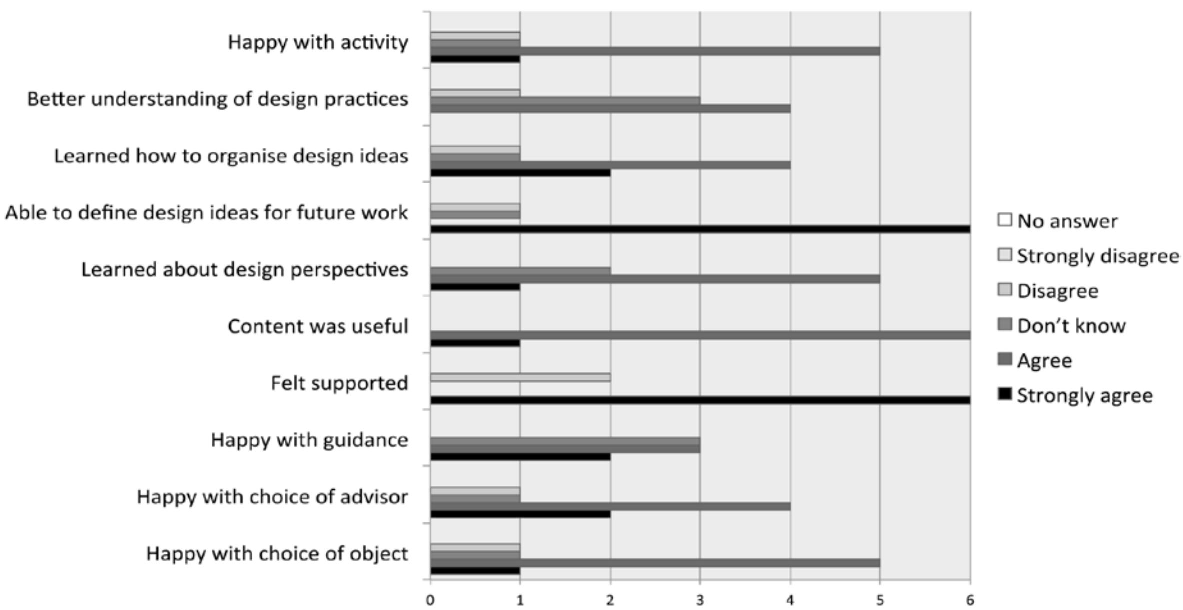

Figure 4. Evaluation of design activity: Code match group.

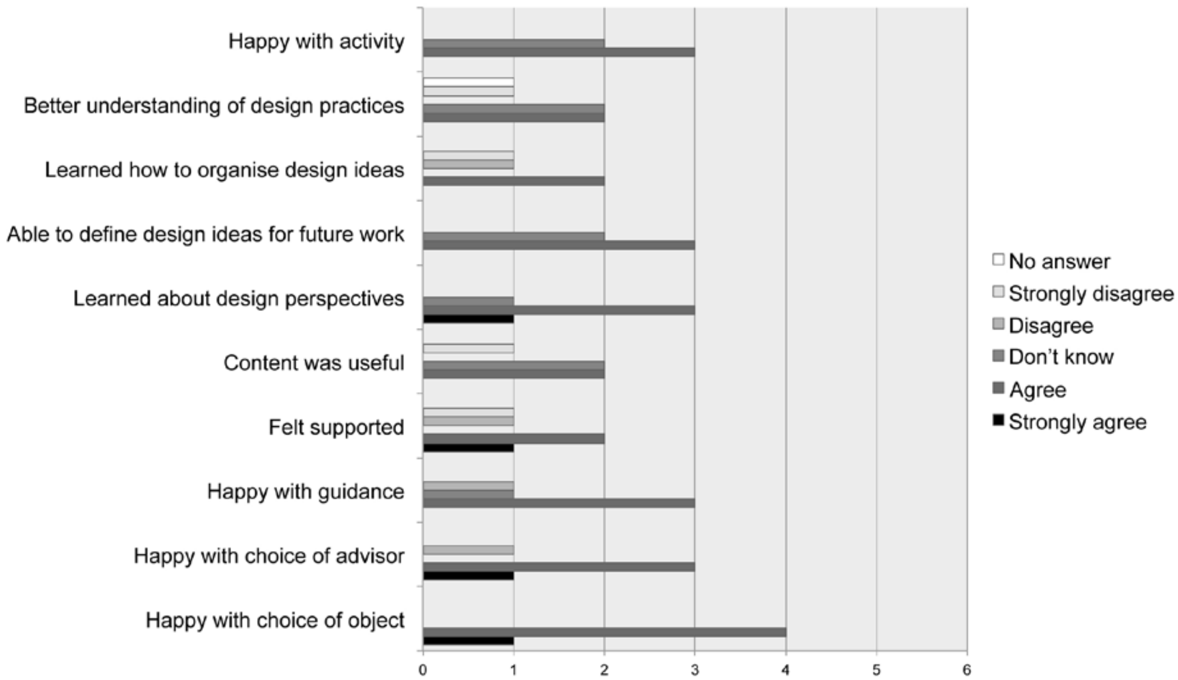

Figure 5. Evaluation of design activity: No code match group.

Results in Figure 4 and 5 indicate that both groups found the experience worthwhile. A closer examination of these figures also suggests that those who experienced a code match seemed more likely to find the content useful, and reported having a better understanding of design practices and how to organise and define ideas for future work. These findings point to relationships between the ways knowledge was foregrounded in the design of the environment and the learners' experiences. The use of LCT to facilitate the design and content of educational technology seems promising, particularly for those interested in figuring out how to better support students' learning of domain knowledge.

Results from the open questions in the survey and debriefing session seemed to reinforce the idea that students enjoyed the museum visit when guided by the e-learning environment and appreciated the suggestions of which exhibits and objects to visit, as well as the idea of using the museum collection to obtain insights for their own designs. Students enjoyed working in partners and found it useful to share different viewpoints with others. The following quotes from participants in both the code match and no code match groups, illustrate their positive impressions:

- [The best was] the general concept for the design and our original ideas. Being able to work with a partner was also really enlightening as we had two opinions of which we could work off. (Participant 7, code match group)
- Being able to come up with an initial design and using the program, which assisted me. (Participant 8, code match group)
- We learned a lot more about the design process and how to choose ideas. (Participant 6, no code match group)
- To experience new things and be in a museum with interactive activities. (Participant 13, no code match group)

Negative aspects of the experience related to usability (e.g. lack of a back button) and technology factors.

Conclusions and implications for e-learning designers

This paper illustrates the application of an analytic framework, LCT, to the development of an e-learning environment, with the aim of enabling knowledge to be more clearly brought into e-learning design. Design Studio foregrounds knowledge practices in design according to the specialisation code of its constituent intellectual fields. The specialisation code drives design decisions relating to the manipulation of aspects of the learning tasks and the allocation of different possibilities and choices in the ways instructions are expressed.

E-learning designers may incorporate our approach into their development process by taking two main steps, which may be used as an extension of needs analysis and/or evaluation process models. First, it is important to identify the organising principles of knowledge in a field from which the content is drawn, such as through surveys and interviews with professionals. These responses can then be examined through specialisation codes from LCT. Second, once these principles are identified, designers can explore ways of expressing a field's rules of the game, or how these organising principles may be translated into features of the learning environment. Embedding pathways through the learning tasks and explaining the background of the field may also be of help to those who are new to a specialised field (Carvalho, 2010). The use of this approach may be of particular value to learners who need a better understanding of the bases of knowledge in a field, and how professionals within the field inquire about and extend its knowledge. E-learning designers may also benefit from this approach, in particular those designers who value theoretical contributions relevant to their work, but who struggle to understand how abstract theoretical representations can inform contextualised design problems (Yanchar et al., 2010).

To be clear, we are not advocating the replacement of established models of instructional design, such as ADDIE, ISD or 4C/ID. Rather, we argue for the extension of these models with practical ways of revealing the organising principles of knowledge practices in different fields, and of embodying those principles within e-learning environments. As pointed out by van Merriënboer and colleagues (2002), the 4C/ID model focuses on the transition from the design phase to the development phase, and does not provide detailed guidance for the development phase of e-learning. As the authors state, "important elements such as overviews of content structure, summaries, transitions and so forth are not dealt with" (van Merriënboer et al., 2002; p. 58). Drawing on LCT-informed analyses of knowledge practices can offer significant contributions to existing e-learning design approaches so as to focus not only on content but also on the organising principles underlying that content.

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Appendix A

Summary of Survey

Sample and Sampling

A total of 139 respondents participated in our study. A purposive sampling with a snowballing strategy was used. Participants were contacted via email and invited to participate in an online survey, which they could access via a link. They were also asked to distribute the survey link amongst designers and design students in their own institutions. Participants were recruited from Universities, Tertiary Educational Institutions of Design, and Design companies, comprising 50 undergraduate students, 53 postgraduate students, and 44 professional designers who were a staff member of a design company and/or a university/tertiary institution. Designers and design students from four disciplines participated in the survey, being 28 from engineering, 65 from architecture, 30 from digital media, and 16 from fashion design. There were 77 males and 61 females, and 74 participants reported having less than 5 years of experience in design, while 65 reported being in the field for more than 5 years.

Survey Tasks and Summary of Results

In Task 1 participants completed a sentence (e.g., Engineering design is…), choosing three words to describe engineering design out of a drop down list, or alternatively, they could type in their own words. The list presented in the survey instrument contained 16 options of words. Eight of these were associated with an ER emphasis (e.g., driven by knowledge, methodical, objective, etc) and eight with an SR emphasis (e.g. driven by taste, elegant, empathic). Participants were asked to describe their own design discipline as well as the other disciplines in the study.

Mean values were calculated for all participants' use of ER and SR words to describe each discipline. Mean values closer to 3 or 0 show a high level of agreement between respondents toward or away from, respectively, ER or SR words. Mean values closer to 3 show that respondents tend to emphasize one of the relations, ER or SR. For example, M = 2.78 for all participants' use of ER words to describe engineering denotes an emphasis on epistemic relations (ER+). Mean values closer to 0 show that one of the relations (ER or SR) is downplayed. Thus, M = 0.15 in relation to all participants' use of SR words to describe engineering shows that social relations are downplayed (SR–). Together the specialisation code associated with the results for engineering would be a knowledge code (ER+,SR–). Mean values closer to 1.5 show that both types of words were used in the description of the discipline; thus, there is higher variance in responses. Mean values closer to 1.5 were seen in the descriptions of architecture and digital media. Table A1 shows results for Task 1. Percentages in bold refer to the ways designers described their own profession. (For a detailed discussion of this analysis see Carvalho, 2010.)

Table A1
Survey results: Task 1

Task 1 – Results										
		Described Profession								
			ER Words				SR Words			
Participants' profession		n	EN	FA	AR	DM	EN	FA	AR	DM
	EN	28	**89.6%**	2.6%	36.9%	37.3%	**10.3%**	97.3%	63.0%	62.0%
	FA	16	91.4%	**22.8%**	54.8%	40.0%	8.0%	**77.1%**	45.1%	60.0%
	AR	65	97.0%	12.3%	**38.9%**	47.5%	2.9%	87.6%	**61.0%**	52.0%
	DM	30	98.7%	14.8%	67.5%	**47.1%**	1.2%	85.1%	32.5%	**52.8%**
	All	139	94.7%	12.1%	44.9%	44.1%	5.2%	87.8%	55.0%	55.8%
	M		2.78	0.35	1.29	1.28	0.15	2.56	1.58	1.64
	SD		0.47	0.58	0.85	0.85	0.40	0.71	0.86	0.87

Task 2 explored designers' perceptions of the four design disciplines in the study, replicating an instrument developed by Lamont and Maton (2010). Participants were asked: "In your opinion how important are the following for being good at (design discipline)". A 4-point Likert scale with values from 1 to 4 was used: 1 - *not at all*; 2 - *not very*; 3 - *quite* and 4 - *very*. Participants had three items to complete (i) Skills, techniques and specialist knowledge, (ii) Natural born talent and (iii) Taste, judgment or a developed *feel* for it. Item (i) relates to epistemic relations, and items (ii) and (iii) relate to social relations.

The analysis assigned values (minimum of 1 and maximum of 4) to respondents' answers about skills (item (i)), and to the combined results for the questions referring to taste and talent (items (ii) and (iii) combined). A mean was calculated in relation to all the design disciplines, and values above the mean were considered as denoting stronger (ER or SR) and those below the mean were considered as denoting weaker (ER or SR). For example, looking at all results for the importance of *skills* in engineering, 3.81 is above the mean value of 3.44 for all, which suggests an emphasis on epistemic relations (ER+), while the result of 2.56 for the importance of *taste and talent* in engineering is below the mean value for all of 3.06 (SR–). According to these results the combination of ER+ and SR– suggests that engineering is a knowledge code. Table A2 illustrates the results for all participants combined, and each separates groups by discipline.

Table A2
Survey results: Task 2

Participants' profession			Skills	Taste + Talent	ER	SR	Specialisation Code
	All (*N* = 139)	EN	3.81	2.56	ER+	SR–	Knowledge
		FA	3.02	3.44	ER–	SR+	Knower
		AR	3.54	3.26	ER+	SR+	Élite
		DM	3.38	2.99	ER–	SR–	Relativist
		Mean for all	3.44	3.06			
		Standard Deviation	0.32	0.38			
	Engineering participants (*n* = 28)	EN	3.89	2.69	ER+	SR–	Knowledge
		FA	2.82	3.62	ER–	SR+	Knower
		AR	3.42	3.48	ER+	SR+	Élite
		DM	3.17	3.08	ER–	SR–	Relativist
		Engineering mean for all	3.33	3.22			
	Fashion participants (*n* = 16)	EN	3.81	2.59	ER+	SR–	Knowledge
		FA	3.37	3.40	ER–	SR+	Knower
		AR	3.68	3.15	ER+	SR+	Élite
		DM	3.68	3.06	ER+	SR+	Élite
		Fashion mean for all	3.64	3.05			
	Architecture participants (*n* = 65)	EN	3.82	2.45	ER+	SR–	Knowledge
		FA	3.04	3.36	ER–	SR+	Knower
		AR	3.55	3.26	ER+	SR+	Élite
		DM	3.36	2.81	ER–	SR–	Relativist
		Architecture mean for all	3.44	2.97			
	Digital media participants (*n* = 30)	EN	3.72	2.67	ER+	SR–	Knowledge
		FA	3.55	3.08	ER+	SR–	Knowledge
		AR	3.44	3.25	ER+	SR+	Élite
		DM	3.00	3.48	ER–	SR+	Knower
		Digital media mean for all	3.43	3.12			

Task 3 explored participants' perceptions of designers. In Task 3 participants were asked to complete a sentence (e.g. An engineering designer is …) using three words. Similar to Task 1, participants could use their own words or select words from a list set in a drop down menu containing 14 options. Seven words were associated with an ER emphasis (e.g., a methodical person, a problem, solver, a procedural person) and seven words with an SR emphasis (e.g., a glamorous person, a sensitive person, a social person). Participants completed sentences describing designers in each of the disciplines in the study. Table A3 shows results for Task 3. Percentages in bold refer to the ways designers described designers in their own profession.

Mean values were calculated for participants' use of ER and SR words to describe designers. Mean values closer to 3 or 0 show a higher level of agreement between respondents. A mean closer to 3 shows an emphasis on the ER or SR. For example, the *M = 2.87* for the use of ER words to describe engineering designers suggests an emphasis on epistemic relations (ER+). A mean closer to 0 shows that either ER or SR is downplayed. In the engineering example, *M* = 0.06 in relation to the use of SR words to describe engineering designers suggests that social relations are downplayed (SR–). The combined ER and SR results for the descriptions of engineering designers by all participants would reflect a knowledge code (ER+,SR–). Mean values closer to 1.5 show that participants use both types of words (e.g., descriptions of digital media and architecture designers).

Table A3
Survey results: Task 3

Task 3 – Results									
Designer Described									
Participants' profession		**ER Words**				**SR Words**			
	n	**EN**	**FA**	**AR**	**DM**	**EN**	**FA**	**AR**	**DM**
EN	28	**98.7%**	2.7%	34.6%	31.0%	**1.2%**	97.0%	65.3%	68.9%
FA	16	95.1%	**33.0%**	74.1%	57.8%	4.8%	**66.3%**	25.8%	42.1%
AR	65	98.7%	7.4%	**36.3%**	50.6%	1.0%	92.5%	**63.6%**	49.3%
DM	30	94.2%	10.9%	57.9%	**39.7%**	5.7%	89.0%	42.0%	**60.2%**
All	139	96.6%	10.0%	43.1%	43.0%	3.3%	89.9%	56.8%	56.9%
M		2.87	0.29	1.27	1.22	0.06	2.63	1.69	1.67
SD		0.44	0.55	0.79	0.95	0.28	0.70	0.82	1.01

In Task 4 of the survey participants were asked to read profiles of fictitious designers (e.g., X. is a very technical and methodical person. That is why s/he chose this sort of work) and then select in which design profession(s) the fictitious designer was most likely to work, if any. The survey instrument displayed a total of 14 profiles, seven of these profiles were associated with an ER emphasis and seven profiles associated with a SR emphasis. Each profile could be associated with more than one discipline. Results related to Task 4 are summarised in Table A4.

Table A4
Survey results: Task 4

Task 4 – Results			
		ER Profiles	SR Profiles
All participants (N = 139)	Associated with engineering designers	72.8%	27.1%
	Associated with fashion designers	16.0%	83.9%
	Associated with architecture designers	39.1%	60.8%
	Associated with digital media designers	45.7%	54.2%
Engineering participants (n = 28)	Associated with engineering designers	78.6%	21.9%
	Associated with fashion designers	7.1%	67.8%
	Associated with architecture designers	41.3%	57.5%
	Associated with digital media designers	33.6%	39.7%
Fashion participants (n = 16)	Associated with engineering designers	78.5%	23.2%
	Associated with fashion designers	28.5%	67.8%
	Associated with architecture designers	57.1%	58.0%
	Associated with digital media designers	48.2%	48.2%
Architecture participants (n = 65)	Associated with engineering designers	72.0%	15.1%
	Associated with fashion designers	10.0%	54.5%
	Associated with architecture designers	40.4%	65.4%
	Associated with digital media designers	36.4%	25.4%
Digital media participants (n = 30)	Associated with engineering designers	56.6%	18.0%
	Associated with fashion designers	9.0%	55.2%
	Associated with architecture designers	26.6%	40.4%
	Associated with digital media designers	36.1%	42.8%

In Task 5, participants read 26 statements about how designers obtain knowledge (e.g., Designers in my discipline participate in conferences to listen to new ideas in the field) and reported the frequency of the strategies identified in the statements in their own design discipline. A 5-point Likert scale was used: 1 - *always*, 2 - *frequently*, 3 - *not sure*, 4 – *rarely*, or 5 - *never*).

Table A5
Survey results: Task 5

Task 5 – Results		
	ER-Oriented Strategies	SR-Oriented Strategies
Strategies used by engineering designers	Frequently – 42.8% Always – 31.5%	Frequently – 31.5% Always – 9.3%
Strategies used by fashion designers	Frequently – 30.2% Always – 30.2%	Frequently – 41.8% Always – 35.5%
Strategies used by architecture designers	Frequently – 38.2% Always – 16.4%	Frequently – 40.0% Always – 18.4%
Strategies used by digital media designers	Frequently – 32.8% Always – 18.4%	Frequently – 34.1% Always – 20.0%