

## ORIGINAL RESEARCH ARTICLE

### Coding, designing and networking: fostering learning through social connections

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Trends in digital technologies and new social practices are calling for innovative models of learning in education. A recent development in the learning sciences, which conceptualises learning activity as networked learning, can offer deeper insight into how digital learning spaces influence the ensuing activity of learners. The networked approach coupled with social semiotics is applied in the analysis of Peep – a computer-based platform with social networking features that supports an undergraduate design course. This article illustrates how the networked learning approach and social semiotics reveal elements of the platform that enable design learning and foster social connections amongst students and lecturers. The article also examines the distribution of students' activity and changes in their patterns of interaction over time.

**Keywords:** educational technology; networked learning; social semiotics; design education

#### Introduction

Design programmes of study often involve students' engagement with different modes of representation, such as visual, verbal and kinaesthetic (D'Souza, Yoon, and Islam 2011) as well as interactions with peers, teachers and professionals. Teaching and learning practices in design education also often adopt the design studio model as a way to offer students a space for creative exploration. Design studios shape future designers' practices through face-to-face encounters with instructors and peers, encouraging master–apprentice type of interaction (Cennamo and Brandt 2012; Schön 1987). Studio pedagogy is characterised as learning-by-doing and reflection-in-action (Adams, Turns, and Atman 2003; Schön 1987) and may include project-based assignments and public presentations, where students' work is critiqued. Design studios are also a social space, where the academic and professional cultures meet, and where students are nurtured in the realities of a profession – a protected space for community-oriented design practices (Barab and Duffy 2000; Cennamo and Brandt 2012). Students' skills and knowledge, their social connections and their perceptions of legitimate design practices (Carvalho, Dong, and Maton 2009) will together form the basis for their own future knowledge creations as designers.

Face-to-face design studio practices currently sit alongside new social practices in higher education (Johnson et al. 2016), and emergent pedagogical strategies (Ham and

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Schnabel 2011; Lloyd 2013), which were prompted by the rise of ubiquitous computing and mobile technology. As such, there is an urgent call for educators to rethink models of learning and knowledge production in design education (Burdick and Willis 2011). New digital learning spaces are offering students opportunities to combine and work simultaneously with different modes of representation, thus increasing in complexity – for example – as students engage with forms of communication that blend two or more multimodal resources, namely, text, image, audio and video (Jewitt 2013). Understanding the impact of emerging technologies on learning and communication is crucial, so that design educators can best integrate technologies in their teaching practices and understand how these are likely to influence students' meaning-making processes (Johnson et al. 2016; Kress and van Leeuwen 2006).

Networked learning offers useful lenses to conceptualise and explore learning activity, foregrounding the use of technology to foster connections, between people and learning resources (Goodyear et al. 2004). This article explores the intersection between digital technologies, social semiotics and social networking practices within the context of design education. A networked learning perspective coupled with a social semiotics approach is adopted to explore connections between elements in a digital space and the ensuing activity of students, through the case study of Peep. Peep is a computer-based platform with social networking features, which was specially designed to support lab-based learning and teaching activity in an undergraduate design course at The University of Sydney, Australia. Elements of the platform that enable design learning and foster social connections are presented. A key feature of the platform is identified, and social semiotics concepts are used to discuss the role of this feature in supporting students' communication about design ideas, their meaning-making processes and social interactions. We then examine the distribution of students' activity as a way to gauge participation and changes in their patterns of interaction over time. The article argues that Peep offers a way of learning about programming that is grounded in the social practices of design communities, enabling networked learning activity within a sheltered space where peer support is encouraged, critiques are practiced and knowledge sharing is nurtured. The main contribution of this article is the application of a networked learning approach, which identifies key elements in a network and connects these to the learner's activity. In particular, the approach helps educators in breaking down complexity by framing crucial components of a network and by theorising the nature of the meaning-making processes students are invited to engage with, within a technology-mediated university context. Although our focus is on design education, the approach could be easily adapted to other contexts where students are invited to engage in social networking practices, use multimodal resources and are encouraged to build and elaborate on each other's ideas. Overall, the approach is useful for those interested in identifying structural elements in the design of a learning network that might encourage knowledge sharing and foster a sense of community.

### **Activity-centred analysis and design framework**

Ideas from architecture and design thinking (Cross 2011) have been gaining currency into education, in what some have called *design for learning* (Beetham and Sharpe 2013; Goodyear and Dimitriadis 2013; Goodyear and Retallis 2010; Laurillard 2012; Luckin et al. 2013). A recent development in this area is the Activity-Centred Analysis

and Design (ACAD) framework (Carvalho and Goodyear 2014a). ACAD conceptualises a learning network as a composition of (1) structures of place (or *set design*), (2) structures of tasks (or *epistemic design*), (3) social structures (or *social/organisational design*) and (4) *co-creation and co-configuration activities*. It suggests that teachers/tutors engage in a type of design activity, as they put together an assemblage of (and make choices about) tools, tasks and social arrangements for a learning situation. These choices include, for example, digital and material tools and resources students will use (set design), for example, pen and paper, a computer and the Internet; considerations about what learners will actually do and how knowledge is paced and sequenced in a lesson (epistemic design); and plans about group arrangements (social design), for example, dyads, groups and scripted roles. Choices made in set, epistemic and social design result in a particular structure of tools, tasks and people, which often supports and shapes learning activity. However, ACAD also acknowledges learners' agency to reconfigure what is proposed at learn time (co-creation and co-configuration activity). In sum, in complex learning situations, there are some elements that can be prearranged (set, epistemic and social design), but the resulting composition is likely to be adapted and reconfigured at learn time (co-creation).

ACAD offers the framing for our analysis of Peep, which foregrounds the 'code editor' as a key element (*set design*) in the network. Social semiotics concepts help us explore the role of the editor in relation to the learning tasks (*epistemic design*) and the social arrangements (*social design*), highlighting its theoretical semiotic potential and the nature of the meaning-making processes students are invited to engage with. We then discuss patterns and the dynamics of students' interaction overtime (*co-creation and co-configuration activity*). Before introducing key concepts of social semiotics that grounded our analysis, we offer an overview of the web-based platform of Peep and the background context of this research.

### **Peep: Peer support for learning programming**

Peep is a web-based platform that supports an undergraduate course in the Bachelor of Design Computing at The University of Sydney, Australia. This is a first semester core subject, with 1-h lectures and 2-h lab tutorials (both face-to-face) on a weekly basis for 13 weeks. The course introduces first-year students to a visually oriented programming language – Processing.js – with an emphasis on its practical application in interaction design and data visualisation. Programming education introduces students to algorithmic ways of thinking as a way of problem-solving (Soloway and Spohrer 2013); however, the course that Peep supports was specifically devised to encourage students to experiment with code as a tool for designing and as a medium of expression in digital media and interaction design. A key difference with other web-based environments for learning programming (e.g. Codecademy, Khan Academy) is that Peep has been designed from the beginning as an environment for a group of students, not for individuals, as it is more commonly the case with online learning environments for computer programming. Underlying assumptions informing Peep's development envisage students *working together*, and that a network of students is created and nurtured, to support their learning. Moreover, Peep supports a course that is part of a 3-year degree, and so it acts also as an introduction for design students about ways of practicing design, for example, when encouraging students to critique the work of their peers. It embodies a view of learning as both physically and

socially situated (Lave and Wenger 1991), where students engage in social networking practices, through invitations to build and elaborate on each other's ideas, knowledge is openly shared, in a space where a sense of community is strongly encouraged.

At the time of this research, Peep had been supporting this undergraduate course for about 4 years. Our research, therefore, was not about evaluating a new development but more so about understanding 'why' and 'how' Peep helped students connect and learn in/about design (see 'Analysis and Discussion' section). Peep web-based platform is accessible at <http://www.peepproject.com>, but parts of the platform and/or access to functionality would require users to login and are restricted to currently enrolled undergraduate students.

### Digital learning spaces of Peep

The design of Peep is based on a generic format for community websites. A front-page provides an overview of current activity – such as recently published portfolio posts and social activity in the forums – together with announcements and updates from the teaching team, for example, deadline extensions, see Figure 1. It also features a large banner animation, based on a similar animation on the Processing.js website, which serves to illustrate what can be achieved using the skills taught in the course. This prominent banner is also the subject of one of the assignments set for students, when they are tasked with designing a new banner that expresses the core values of the Peep environment.

This front-page links to other sections through a menu displayed on this and every page on the website. The *outline* section provides an overview of the course with links to lecture slides and tutorial exercises for each week and brief descriptions of assignments. The *assignments* section provides more detailed information for the

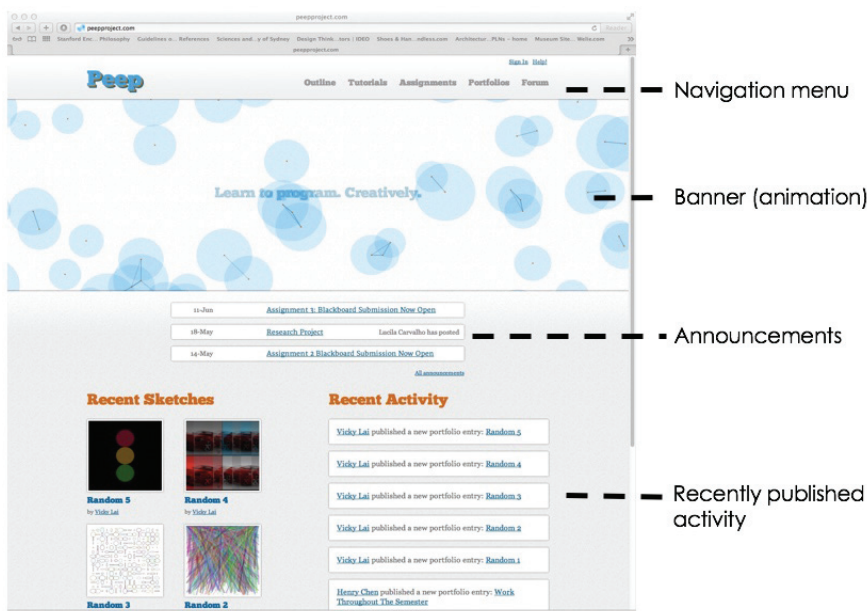


Figure 1. Front-page.

assignments, and it is updated through the semester as the assignments are released. Each assignment description contains links to internal and external resources, for example, portfolio posts or source code that students can use as a guide or starting point for their submissions.

During the first few weeks of the semester, students are expected to spend most of their time in the *tutorials* section (Figure 2), which provides a series of learning tasks that build week by week, starting with a tutorial on how to use the Peep website. Each tutorial is broken up into a series of chapters, with students encouraged to keep track of their own progress. Most tutorials, especially early ones covering basic skills, finish with instructions for students to create a portfolio post, where they expand upon the techniques used in class, by completing some simple exercises. All tutorial pages include a *code editor* accessible at all times, allowing students to experiment with any code given in the tutorial and to complete the learning tasks set within the tutorial screen.

The *portfolios* section contains portfolios of all of the students enrolled, identified by a photo they upload as part of the first tutorial, and allowing students to both find the work of students they may already know and discover new classmates via their

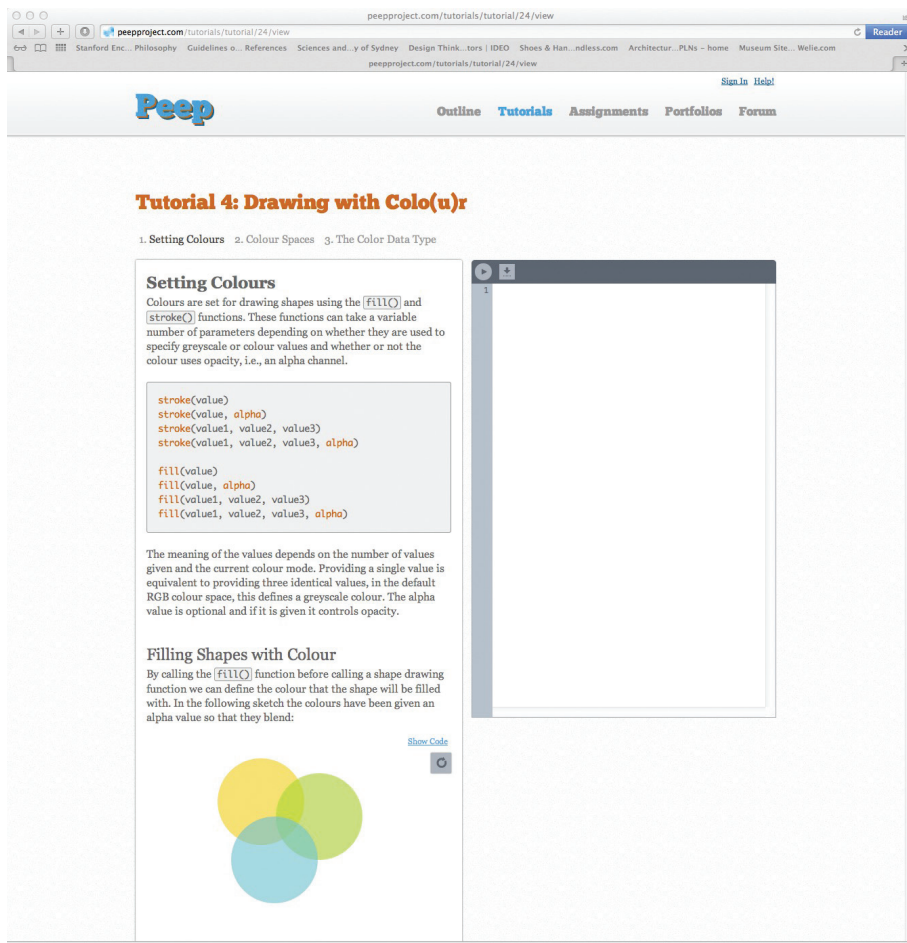


Figure 2. Tutorial.

published work. Published portfolio posts include a comment area where students can provide comments and feedback to the author. Portfolio comments support the posting of code, allowing commentators to expand on code in a portfolio post, encouraging students to expand on published code in ways that benefit the community of learners. Every student can create portfolio posts, but it is their choice whether or not to publish these, even for assignments. This allows students to develop draft posts or complete assignments without other students seeing their work. The *sketchbook* is a private space for experimentation with their designs and a full-featured *code editor*. The *code editor* allows students to experiment with code, and is a key feature, available at various places in the platform. Students might use plain text markup language for formatting or might embed images and code in text. A window where the code sits can be expanded to support runnable code. Figure 3 depicts two views of the code editor – as an image (left) and as code (right).

In the *forum*, students, tutors and lecturers work through specific aspects of the tutorials and provide assistance for students working on assignments. Unlike most learning forums, Peep's *forum* provides access to an integrated *code editor*, which allows students to embed a particular code as part of a discussion thread. The ability to embed and run code facilitates code-based discussions, for example, debugging faulty code, sharing inspiring discoveries or elaborating on ideas presented in tutorials, by eliminating the need to switch between different discussion and coding environments.

Although Peep is a learning resource in the weekly lab tutorials at the university, students and teachers may interact using Peep, at any time, from any location – during and after lessons.

### Social semiotics: understanding communicative resources in Peep

Social semiotics enables the understanding of how a particular ‘resource has been, is, and can be used for purposes of communication’ (van Leeuwen 2005, p. 5). Semiotic

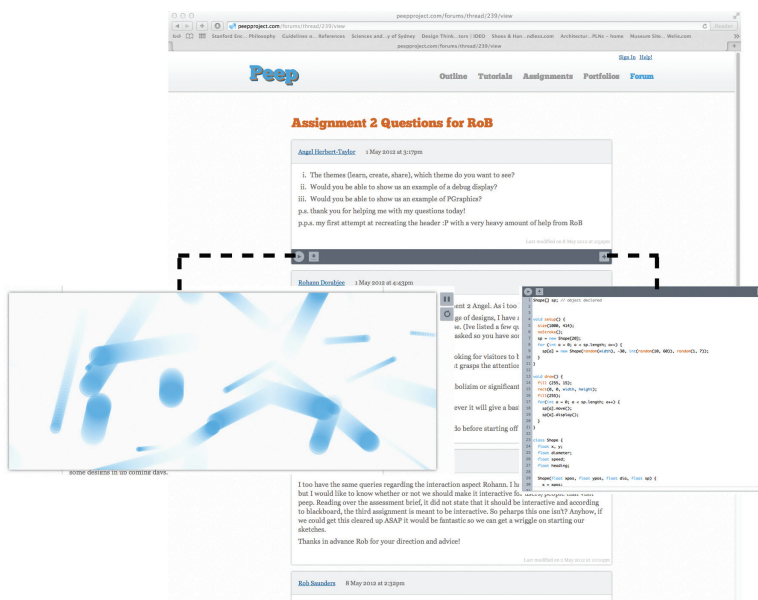


Figure 3. Code editor in forum.

resources can take the form of ‘observable actions and objects that have been drawn into the domain of social communication and that have a theoretical semiotic potential’ (van Leeuwen 2005, p. 4), that is, a potential for making meaning. Essentially, social semiotics is about what people communicate and the set of socially constructed resources they use for making meaning. Social semiotics analyses communicative resources and their potential for meaning-making in social contexts (van Leeuwen 2005).

Our social context involved first-year university students, learning about using programming as a means to design, while interacting within a web-based platform. Students learn skills and knowledge, as well as how to communicate in the *language of design* (Dong 2009) or how to express design ideas through programming. The code editor enables students to navigate between different semiotic systems – textual language, static and moving image – mediating students’ conversations with peers, tutors and teachers, and supporting their development of high-level multimodal competence. Multimodal competence involves knowledge of operations in different modes, and the ability to produce ‘complex semiotic texts’ (Kress 1998, 2010). Overall, Peep facilitates design education through social connections in a technology-mediated scenario, where both the *ability to make meaning* and *to communicate* are essential.

In everyday life, people may make meaning and communicate in many different ways, for example, using language (and the linguistic system of a community), or by reading movements in the body (e.g. kinesics and gestural) or using road signs to convey an agreed speed limit (Unsworth 2006). Systemic functional linguistics (SFL) is part of a social semiotic approach to language (Halliday 1994), supporting the description of language texts in the context of the linguistic systems they realise. It includes both the ‘social role of the text and the predispositions of addresser and addressee’ (O’Toole 1990, p. 185). In SFL, a semiotic resource may serve three meta-functions (Halliday 1983) – ideational, interpersonal and textual. Ideational relates to understanding the environment; it is about how a semiotic text represents aspects of our experiences of the world. Interpersonal function refers to how individuals act to and with others; it is about how semiotic texts manifest aspects of the relationships between the text’s producers and receivers. The textual function alludes to the internal and external coherence of the forms adopted for communication (van Leeuwen 2005). Kress and van Leeuwen (2006) built on these ideas to formulate a ‘grammar of visual design’, through the technical adoption of the SFL meta-functional organisation of meaning-making resources, where:

- Representational (or *ideational*) structures relate to the nature of events, the circumstances involved, including the objects and participants (and these can be verbal or visual structures),
- Interactive (or *interpersonal*) resources influence the nature of the relationship amongst speaker and listener, viewers and what is viewed,
- Compositional (or *textual*) meanings relate to how information is distributed, and the relative emphasis placed on different elements in a text or image.

These concepts are often used to interpret already produced semiotic texts, but we find them also useful to theorise about the types of structures, resources and meanings that design students are dealing with – learning about – as they interact with the code editor and use programming as a tool to design. Design in this context requires that students understand the nature of the objects involved – for example, the text characters that need to be placed together, the lines of codes these characters may

produce – which relate to the *representational structures* above described. Students also need to figure out how to communicate via the semiotic text they are producing in a *viewer/what is viewed* relationship with peers and lecturers, which relates to the *interactive resources*. This involves ways of producing a design work that embodies a desired effect, or the use of a certain element to express an idea. Finally, students need to understand how to bring design elements together in an overall arrangement (with the manipulation of particular elements and the de-emphasising others), resulting in the language/image produced, which relates to the *compositional meanings*.

In the past 10 years, multimodality emerged as an interdisciplinary approach that foregrounds communication and representation beyond language (Jewitt 2013). Multimodality conceives that meaning is realised through iterative connections between the meaning potential of (1) a semiotic artefact/text, (2) the social/cultural environment in which it emerges and (3) the resources and knowledge that people bring to these encounters. While speech and writing are still significant, they are now seen as only part of a broader multimodal assemblage, which acknowledges that representation and communication are likely to involve multiple modes, including visual and aural embodiment, action and interaction, and the relationship between them (Jewitt 2013; Kress 2010). According to Jewitt (2013), ‘the more a set of resources has been used in the social life of a particular community, the more fully and finely articulated it will become’ (p. 141). She points to the idea that a shared cultural sense needs to be present within a community, so that resources can be organised in ways that realise meaning. Meaning may also be orchestrated, through deliberate selection and configuration of modes, in ways that foreground certain interaction between modes. These suggest that communication is ultimately shaped by ‘rules’ and influenced by the interests of people in specific social contexts. As our analysis will reveal, Peep immerses students in a *multimodal ensemble* (Kress 2010) – where different meaning may be allocated to specific modes, and at different times, deployed through different features of Peep. However, an overall structure exists, which is carefully sequenced – or *orchestrated* – to help students navigate their way through the platform, to engage with peers, with the design ideas they encounter and the ideas they generate in this course. What is more, as our analysis will also highlight, over time students seem to ‘take hold’ of the space, and their communication becomes more articulated and tuned to design practices.

In the next section, we discuss the overall research design and data sources. We then delve into the semiotic potential of the code editor through the role it plays in supporting students in making meaning, and the ways it helps mediate conversations in/about design, as students learn skills, problem-solving strategies and exchange views about practicing design.

## Research design

Peep was selected as a case study, to be part of an initial series of 12 cases, in a major study investigating the design of productive learning networks (Carvalho and Goodyear 2014a). The overall aim of the study was to develop ways of analysing and improving the increasingly complex situations in which learning takes place, with a focus on those situations where computer technology plays a strong role. The main study was conducted over a 6-year period (2010–2016) and included case studies of networks in higher education, schools, professional and informal settings, in a range



of disciplinary areas. Essentially, the main study was about understanding how educational design and learning activity connect, and ways of identifying key reusable design elements of productive learning networks. Each case study involved an in-depth analysis of a learning network, and foregrounded learning, design and technology. Each chosen network had an element of ‘productivity’ – which could be characterised as a network that was innovative, different, special and harmonious in some way (to its participants or others who heard and/or were intrigued by its activity). Each case was set out to investigate why and how that specific network was said to work well and what key elements helped in achieving this productivity.

Thus, the focus of this research was on a contemporary phenomenon within a real-life setting, and our interest was on exploring questions related to ‘why’ and ‘how’ (Yin 1994), namely, to understand the connections between the design and functioning of a learning network, which led us to a case study design. Case studies are often used for in-depth explorations of ‘a program, an event, an activity, a process, or one or more individuals’, in situations bounded by time and activity (Creswell 2003, p. 15). They require researchers to gather detailed information and the use of varied data collection and sources overtime. In this article, we report data gathering and analysis conducted in relation to the case study of Peep. Other findings related to the major study (including other case studies) are reported in two edited collections, and various journal and conference publications (see Carvalho and Goodyear 2014a; Carvalho, Goodyear, and de Laat 2017). The Human Research Ethics Committee of the University of Sydney granted approval for the conduct of this research.

### **The case study of Peep**

In the specific case study of Peep, data gathering and analysis involved (1) a collection of screenshots with features of the Peep platform; (2) observations of students’ activity (in class while students interacted with the platform, as well as online interaction); (3) in-depth interviews (with a developer, a student and the designer/lecturer); and (4) log files of a cohort of 63 students using Peep for a period of 13 weeks. Through observations we gauged specific elements that could be of interest for analysis. Screenshots offered opportunity to further examine elements identified through observations – to look closely at a specific feature (set design) or text in the tutorials (epistemic design), or elements that would signal students’ social organisation (social design). Importantly, observations and screenshots allowed us to find, select and capture evidence about the types of artefacts produced by students, and the types of interactions emerging in the co-creation and co-configuration activity (e.g. what students did, how they talked, what sort of questions they asked). Both data gathering mechanisms were used in combination. Emerging insights were then further explored through in-depth interviews. The analysis reported in this article is mostly grounded on evidence from interviews and log files, which are used to illustrate aspects in the design of Peep and in the patterns of interaction in the emergent activity of students. However, these are also connected to our initial observations, complemented by screenshots which captured particular aspects of this learning network (see ‘Peep: Peer Support for Learning Programming’ and ‘Analysis and Discussion’ sections).

ACAD framed our analysis of educational design elements (as per *set*, *epistemic* and *social design*) and their relationship to emergent activity (*co-creation and co-configuration activity*). In the next three sections, we discuss the role of the code editor

in relation to *set*, *epistemic* and *social design*, as a semiotic resource, in supporting students' cognitive efforts in the processing of information, and in mediating communication in design. Research questions that guided this part of our research included:

- What is the semiotic potential of the code editor?
- What role does the code editor play in students' skills development and learning of design knowledge?
- How does the code editor stimulate students' social connections?

## Analysis and discussion

### *A design that encourages experiences through different semiotic systems*

Text is the primary mode of the code editor, but the editor also allows for an image-view (see Figure 3). In navigating between these two views, students are exposed to different representations and supported in establishing connections between their meanings (Carvalho and Goodyear 2014b; Carvalho et al. 2014). They experiment with and learn about what or how certain textual elements/characters, when placed together, form a sequence of code. They are exposed to rules and norms about the order to be followed so that a sequence of code is formed; what text/characters should be typed and in what specific sequence; relationships of how those rules form a class of codes (e.g. 'code a' belongs to the 'class of codes x') and visualisations that show the effects of the code (e.g. a sequence of 'code a' produces 'image b'). Through their exposure to these rules and norms, students are supported in establishing connections between 'code a' and 'image b' and consequently in what code should be used for what effect. Students gain insights into representations that link code-image and image-code and how these are produced, thereby helping the establishment of connections between different modes, how they relate to one another and how they can be used as communicative tools in programming to design. This is strengthened by the format of some of the learning tasks where students are given a 'visual challenge' in the form of an image, and asked to reproduce it using the coding skills being learnt in that tutorial. Some of these tasks require a thoughtful approach to encourage students to apply what they are learning and are intended as a way to break students out of simply performing a series of prescribed actions to complete a task. As such, the code editor is key, in helping students learn how to produce 'complex semiotic texts', as students learn about placing certain characters together, in a specific order, to come up with a valid sequence of code, at the same time checking their effects on the image produced. Through this process, students not only test out the nature of the objects they are dealing with (*representational function*) but also experiment with ways of manipulating certain elements and its effects, as well as how to bring elements in their work together to communicate their ideas and achieve desired results (*compositional function*) (Kress and van Leeuwen 2006).

While the epistemic design envisages students' engagement in *independent* tasks, there is a lot of support provided by peers, lecturer and tutors, via interactions in the forum and comments features. The ability to successfully communicate in the social context of Peep and the use of programming to communicate design ideas is highlighted by the lecturer:

(Peep is) a learning environment where we make code a first-class object of the environment so that it is just as important as discussion, it's just as important as anything else

that's in the online environment, graphics, etc., so that students are always able to put code everywhere on the site, experiment with it, communicate with it, express themselves with it. (Lecturer interview)

### ***A design that supports the processing of complex information***

Lecturer and student interviews highlight a desired function of the code editor, as allowing students to stay in the same screen. This is perceived as potentially aiding students' processing of information, since it avoids having to switch and deal with multiple environments.

They're not switching from one environment to the other. They don't have to – they don't even have to switch between using the mouse and the keyboard in some respects. They can do a lot through the keyboard without having to sort of worry about, you know, everything else. So they can really focus on the tutorial, and in fact that's kind of eerie, because they really do focus and they are very quiet in the early weeks, just completely focused on the tutorials. (Lecturer interview)

This function is perceived as helping students in managing the processing of information, due to reducing the need for context switching in/out, and allowing students to stop and ponder where their attention is needed the most. The presence of the code editor in tutorials (see Figure 2), following along as students scroll down a page, allows for similar functionality – maintaining the object of study in evidence at all times. In addition, by optimising certain processes for students, the code editor facilitates that they concentrate on specific learning areas:

the editor is right there next to the tutorial. It saves their code as they go along for them, it 'remembers' that they're doing it for a tutorial. It takes care of all the housekeeping so they can concentrate on their learning. (Lecturer interview)

[Peep] does a really good job at making [programming] accessible to people who don't necessarily see themselves as programmers, because it's very easy to follow along. The way it's set up makes it – there is a less barrier entry – and a lot of advanced topics get sort of covered without the students even knowing it. For example, the concept of revision control in software... (Developer interview)

Next, we focus on how the code editor supports students to communicate ideas in/about design, and in so doing, begin to form social connections.

### ***A design that encourages social connections and a sense of community***

As any novice entering an established profession, first-year design students need to learn about how to communicate in a new social group – how to produce design knowledge and how to communicate design ideas – according to implicit social rules within this field (Carvalho, Dong, and Maton 2009). Communication is influenced by the nature of the social context (at a macro level – the design profession; at a micro level – design students and teachers), and so it is important that students practice communicating within their immediate network (their cohort), as they enter the design field. Similar ideas have been theorised by scholars in sociology of education, for example, through Bernstein's (2000) notion of horizontal (e.g. every day discourse)

and vertical discourses (e.g. academic discourse), and the notion that learners need to ‘recognise’ relevant meanings in a particular context in order to then ‘realise’ these meanings according to what is expected by a given group. Maton (2014) builds on Bernstein’s theory and proposes ways of analysing ‘legitimate practices’ in intellectual and educational fields – offering lenses to explore the different ‘implicit rules of the game’ that (design) students would need to figure out in order ‘to enter’ their profession. In theorising the nature of the social space of Peep, we also see connections to Gee’s (2005) notion of ‘affinity spaces’ and ‘semiotic social spaces’. Gee uses the term ‘affinity space’ in reference to (virtual or physical) spaces that attract people with shared interests, usually within informal learning contexts. Gee (2005) carefully differentiates ‘affinity spaces’ from ‘community of practice’ (Lave and Wenger 1991), explaining that ‘affinity groups’ are more concerned with how people acquire and attribute meanings to signs, rather than exploring issues associated with membership or belonging. The notion of ‘community of practice’, however, centres around membership, social identities and different levels of participation. A ‘community of practice’ involves people’s engagement in collaborative activities, which, over time, support their development of a shared repertoire of resources, including stories, useful tools, experiences and/or particular responses to problems, as well as involves a degree of active and dynamic negotiations of meaning (Lave and Wenger 1991). We believe both community and affinity groups are relevant for our case study. Gee’s (2005) notion of affinity spaces supports the idea that students are grounding their interactions on ways of communicating and making meaning in design. In that sense, these students are brought together because of their shared interest and they are experimenting with ways of communicating and making meaning in design. But the notion of ‘community of practice’ is also relevant, because as part of their networked activity, students also engage in joint negotiations of meaning, sharing tools, artefacts, comments and experiences. Although learning tasks envisage students working individually, the social design of Peep encourages a community-like atmosphere, through implicit collaboration, offering a space for sharing ideas about what is valuable, in terms of design knowledge and practices. These students would also be interested in a sense of belonging – as they are enrolled in a course to become professional designers. Belonging here is not necessarily attached to a particular person or even to this particular group of students but refers more so to building an identity that eventually acknowledges these students as professionals of this field. Thus, students need to learn how to recognise and realise legitimate design practices (Carvalho, Dong, and Maton 2009), and Peep offers a space where they are given opportunities to explore design ideas and practices, through shared experiences. Not only students communicate ideas in/about design, through various semiotic systems (e.g. textual, image, moving image) (Jewitt 2013), but they are also expected to interact with peers, lecturer and tutors, discussing openly, exchanging perspectives, sharing aspects of their design thinking processes, while helping and supporting others. In these communications, the code editor plays a role as an *interactive resource* influencing the nature of the relationship between speaker and listener, viewers and what is viewed. For example, the portfolios offer students opportunities to see the work of others and to learn about what can be achieved, in a space where students share their own interpretation of a brief.

it’s a really good way of seeing how everyone is progressing, and seeing (...) – all these interesting ways that people think about the assignments. Because the assignments have

like a design brief (...) – the first one was designed like a thing that will create a unique pattern, so every person that wants to buy something from this – like a T-shirt store, or something – every person will have a unique shirt. So we had (...) two things, one was balance and harmony, and one was energy and movement. So everybody had to think of how they interpreted them, showed how they, (...) what they used images, as like inspiration, and then how they actually did that. (Student interview)

Awareness for what constitutes interesting design (within this network and beyond in the ‘real world’ of professional designers) gradually emerges not only through students’ exposure to design creations of peers but also through their expressions of values and opinions about each other’s work. Thus, we theorise that the nature of the space encourages students to communicate *in the language of design* – learning how to express their ideas through the creation of a design artefact, at the same time that they also communicate ideas *about design* – sharing their views of designed artefacts. As such, the code editor has a social role connected to the opportunities it creates for expression of values (commenting on someone else’s work), and conversations about what is interesting in a design. Students reflect, build and elaborate on design ideas, also reusing pieces of code and learning from each other’s experiences. Connections and participation are fostered through a collegial environment, where knowledge is openly shared, and students are encouraged to ask questions and to engage in critique. This ability to comment and elaborate on design works is crucial in design education, where interpretation of critiques is a common practice. ‘Critiques’ are often a form of assessment (Oh et al. 2013) used in the design studio pedagogical model, and so Peep helps first-year students in getting used to this type of practices.

You can also share code on the forums, which is really useful because that way if you do have a problem, people can see exactly where it is, rather than being like oh, I have some code but for some reason, you know, this isn’t working, without any actual examples. And it also can run code on the forums, so like someone could see what their final result might look like if they go down that way. (Student interview)

I think [students] also learn kind of how to help each other. Like I know that for me in high school it was very competitive, like because the end results of high school is (...) all ranked, so we all have to be better than everyone else. [Peep] is such an open way of exploring something that a lot of people haven’t been exposed to, it promotes an open attitude towards learning. (Student interview)

The next section explores emergent patterns of networked activity of 63 students in the first semester of their enrolment in a Bachelor of Design Computing.

### ***Emergent patterns of networked activity***

Finding patterns of networked activity, as per the interaction that occurred between members of the network in a student cohort during a 13-week period provides insights into the emergent activity of students. This part of our analysis was guided by the following research questions:

- How do students participate in the network?
- Does the participation change over time?

Using log files from students' interaction with the platform, we identified Peep web pages that students visited the most and when, how many students commented and contributed to forum posts, how their portfolios views compared with portfolio editing, the time students spent on portfolios versus dedicated sketchbook work.

*Overall activity: where do students go and when?*

Figure 4 shows the overall activity of students during the 13-week period. Students spent the majority of their time working in the sketchbook area – the private space where they create their designs (green). The amount of time spent in sketchbooks increases, as each assignment's due date approaches, fading as the term breaks for holidays. The second major slot of activity (pink) represents time spent looking at each other's portfolios – a similar pattern to the one for the sketchbooks, increasing over time although not as intense. Students' time in tutorials (light blue), forums (red) and commenting (dark blue) are not as pronounced, in comparison with time spent developing ideas in the sketchbook.

*Tutorials and forums*

Figure 5 shows the activity of students in tutorials (red) versus time spent in forum (blue). Tutorial activity is more intense at early stages of the course – which is not surprising. Tasks completed in April and May reflected the course's schedule, sequencing and pacing. Interesting, however, is that students returned to tutorials in June, after they are no longer tasked with tutorial exercises. The graph shows that activity in the forum increases as course progresses, with peak periods near assignment's completion dates.

*Forum edits versus forum views*

As in many online environments, active participation in Peep – or visible participation – is only part of the overall picture. Many students check their peers' pages

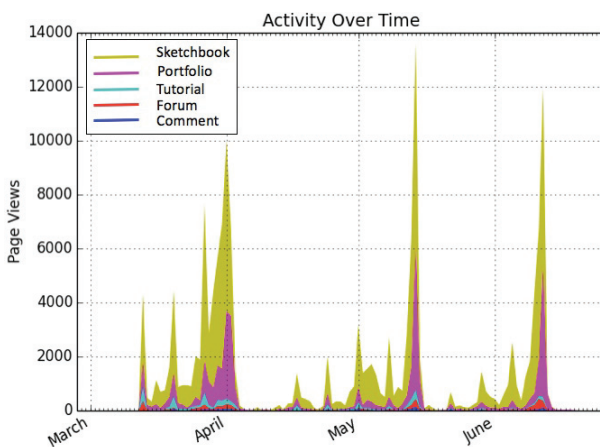


Figure 4. Overall activity over time.

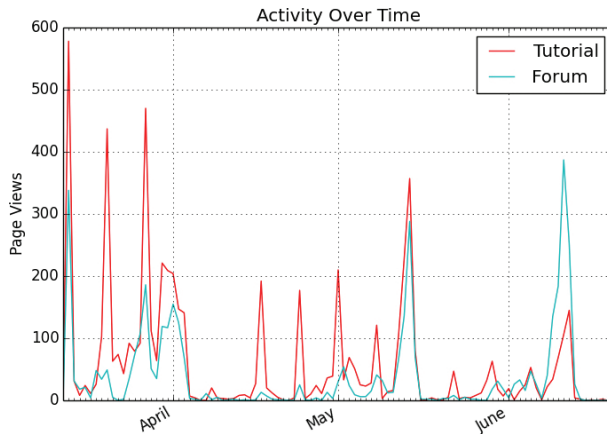


Figure 5. Activity in tutorials and forum.

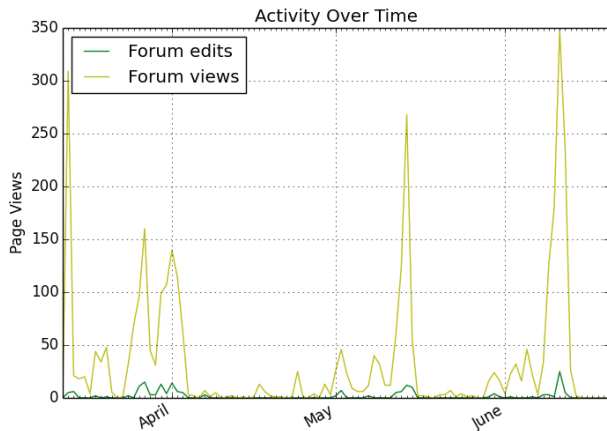


Figure 6. Forum edits versus forum views.

without necessarily offering a comment, and they may read a post in a forum but not leave a response. Figure 6 illustrates this sort of ‘hidden’ activity, through a comparison between forum edits and forum views. Traces of activity detectable through people’s posts, and responses in the forum, are only part of what students are actually doing – the amount of views of a post is much higher than the amount of editing/contribution.

#### *Comments versus contributions to forum posts*

Figure 7 illustrates patterns of text communication between students and tutors, in spaces for comments in the tutorials and forum pages. The graph suggests that activity on the forum increases overtime, again peaking when closer to assignments’ due date.

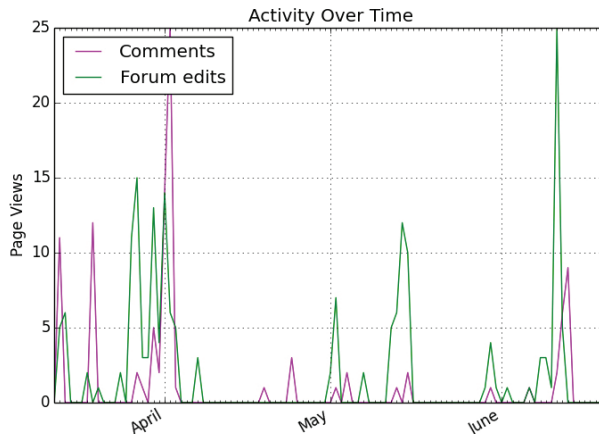


Figure 7. Activity in forum and comment boxes.

### Conclusions and future research

Learning in the 21st Century involves the ability to develop and maintain social connections in networked structures, and this, in turn, is calling for learning and teaching practices that emphasise the co-construction of knowledge, meaning and understanding (de Laat and Dawson 2017). Educators need to understand the impact that networked learning may have on their students and how one can encourage and foster social connections in such spaces. The case study of Peep reveals how the adoption of a networked learning perspective and a social semiotics approach is valuable for understanding the effects of not only technology on learning and communication within design education but also beyond design in other disciplinary settings. Our focus was on how the educational design of Peep (*set, social and epistemic design*) contributes to students learning in/about (in this case ‘design’) knowledge, while fostering a sense of community amongst students. ACAD and social semiotics helped in unveiling relationships between tools, task and people, highlighting the semiotic potential of the code editor. It shows ways the editor – as a key feature – ‘nudges’ students in certain directions, subtly guiding them to focus in certain tasks, and supporting their development of coding abilities, at the same time, facilitating conversations in/about design. The patterns of emergent behaviour from a cohort of students revealed changes in participation over time, with students interacting differently, hanging out in different spaces, checking each other’s contributions and becoming increasingly more active in their forum posts. Over time, students learn about sharing and co-construction of knowledge, and have opportunities to contribute to a conversation in design that seems less individual and more communal.

Our future research will involve a closer look on the behaviour of the network through social network analysis, for example, through the notions of ‘centrality’ and ‘density’. We also plan to further develop and evaluate ways of improving Peep, such as including pre-recorded lecturers for students to study at their own time, allowing the face-to-face lecture time to operate in a ‘flipped classroom’ model and serve as interactive Q&A sessions for students to get specific help on topics. We are also considering how to better facilitate network learning in a blended environment by integrating features from other social networks, for example, ‘like’ badges and other features aimed at strengthening the interaction between students.



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