Article:

Collinge, W.H. orcid.org/0000-0003-3387-1649 (2024) Issues of Interpretation and Understanding: Social Semiotic Framework to Inform Teaching of Civil Engineering and Project Communications. Journal of Civil Engineering Education, 150 (2). 04023012. ISSN 2643-9107

https://doi.org/10.1061/JCEECD.EIENG-1913

EI1913

Issues of Interpretation and Understanding: Social Semiotic Framework to Inform Teaching of Civil Engineering and Project Communications

William H. Collinge[1]

[1]School of Civil Engineering, University of Leeds, Leeds. LS2 9JT.United Kingdom. w.h.collinge@leeds.ac.uk

Abstract

Civil engineers and project managers must control and manage the project management discourse with the client and other stakeholders or risk slippages to time, cost and programme. This paper explores how communicative choices and the representation of project requirements and engineering issues is intrinsic to effective civil engineering work. Using a social semiotic framework, the paper contributes to civil engineering learning by revealing how various engineering communications (e.g. schematic drawings; visual images) function in civil engineering contexts. The research builds upon civil engineering communication scholarship, highlighting the significance of representational choices for affecting engineering work. The social semiotic and multimodal informed analysis clarifies processes of cognition, interpretation and understanding at play when civil engineers interact with project stakeholders. The findings inform civil engineering education and the teaching of communication skills: communication composition being intrinsic to effective civil engineering work.

Practical Applications

The paper presents a framework for assisting and guiding civil engineers and project management professionals in the formulation and review of communicative resources (e.g. visual images; drawings; schematics) used in civil engineering and project management work. The social semiotic framework, validated through case study evidence from a hospital construction project, informs the teaching of civil engineering communication skills: communicative choices and the representation of project requirements and engineering issues being intrinsic to several aspects of civil engineering work, including risk management, stakeholder engagement and planning and control. The theoretical insights address the role of authors and readers of sign communications in civil engineering work, and clarify the processes of cognition and interpretation at play when engineers interact with other professionals and project stakeholders with various communicative resources. The paper adds to the body of knowledge concerning communication in civil engineering contexts and informs the teaching of communication skills for professional civil engineers.

Keywords: communication; stakeholder management; cognition; social semiotics; multimodality; design work; cognition.

Introduction

Effective communication has long been recognised as essential for civil engineering and project management success (ASCE 2019). Industry codes of practice (e.g. CIOB 2022; ASCE 2019) highlight communication as critical to processes and practices: communication being linked to effective stakeholder engagement and management (Turkulainen et al 2015). The

UK Chartered Institute of Building (CIOB) (2018) notes communication as a core standard for project management learning, whilst in the United States, the American Council for Construction Education (ACCE) (2021) has similar stipulations, noting that written communications and oral presentation skills be taught that are appropriate for civil engineering and project management disciplines. However, the significance of routine methods of communication used by civil engineers (e.g. schematic drawings; visual images) often escapes notice despite their importance to effect the civil engineering discourse. Additionally, whilst academic work has highlighted the importance of communication, for example, Ninan et al. (2020) highlighting the significance of social media and information communications technology (ICT) for external stakeholder management on megaprojects, and Datta et al. (2020) identifying the centrality of communication in addressing the "knowing-doing gap", little research into how civil engineering resources function in an engineering project has been conducted.

Such an empirical enquiry is important because in civil engineering projects, communication occurs not just from person-to-person, but also from project resource to person: interactions between humans and resources also being legitimate instances of communication. This paper explores how project resources carry intention and meaning from the originator to the reader/viewer through their composition; an issue which may be understood clearly through semiotics. The significance of semiotics for understanding project communications has been noted previously (c.f. Gluch and Raisanen, 2009; Collinge and Harty, 2014). This paper extends such work by utilizing a social semiotic framework of analysis to examine and critique resources used in the civil engineering project management discourse: social semiotics being the analysis of sign constructs used in social situations. A social semiotic informed analysis enables a deeper and more reflective understanding of the role of signs in social situations, the implications of sign deployment and the motivational drivers underlying their formulation (Kress, 2010).

Clarification of the interpretive and cognitive processes at play when communication resources are mobilised reveals how issues such as stakeholder management, risk management and planning/control are effected by communicative resources. Several contributions are made. Firstly, social semiotics and multimodality are presented as valid analytical approaches for the review and formulation of resources used in civil engineering work. Secondly, theoretical contributions are made concerning issues of interpretation and cognition: particularly how resources trigger cognitive interpretive codes and lexicons of knowledge (Eco 1979). These theoretical contributions inform existing understandings of the teaching of communication skills required of civil engineers. Thirdly, civil engineering communication is revealed as inherently social semiotic: everyday resources impacting work significantly through their communicative properties. Such an insight is valuable for civil engineers active in the profession as the deeper understanding of communicative processes contributes to civil engineering education scholarship.

The paper has the following overall research questions:

- How do communicative choices affect the civil engineering discourse?

- How can various communicative resources be understood conceptually and theoretically?

- How can processes of cognition, interpretation and understanding be better understood when civil engineers communicate?

Background and Paper Organisation

Civil engineering projects are complex, information-intensive collaborations (ICE, 2020) where communication is central to effective work execution (Winch and Kelsey, 2005). In the iterative cycles of communication (Emmitt and Gorse 2007), varieties of resources are used to propel the process forward (e.g. sketches and drawings; physical models; bills of quantities; digital images). Whilst such resources are integral to civil engineering work, they are less well understood conceptually or theoretically. Additionally, as resources are often disseminated and shared with multiple stakeholders, appreciation of how project resources are interpreted and understood from a cognitive perspective is also merited.

Civil engineering resources are important for the communication and relationship building process, being semiotic devices (being composed of sign constructs). For example, a project brief will communicate client needs and requirements in words and numbers (e.g. costs; dimensions); an image of a building may communicate architectural aesthetics via color and graphics in a landscaped environment; a Gantt chart will communicate project timeframe and work package connections through colors, lines and words. Whilst Lloyd and Busby (2001) highlight the importance of language and word exchange in social design interactions (i.e. designers using words and language to articulate their thoughts as opposed to architects, who prefer to use drawings and sketches), Bogers et al. (2008) reflect how designers often use images to clarify concepts. More recently, the study of Datta et al. (2020) into how 4D visualisations help project teams identify risks highlighted the significance of interpretation and representations of project work.

The paper examines civil engineering communications using social semiotics. Semiotics is the study of signs used in communicative interactions (Cobley, 2010); the overarching aim of semiotics being to study the production and comprehension of sign constructs as manifesting in human and non-human spheres (Danesi, 2010, p.135). Social semiotics is oriented towards understanding the role of signs in social situations, the implications of sign deployment and the motivational drivers underlying their formulation (Kress, 2010). Arguably, deeper understandings of communication are needed to explore different aspects of civil engineering work. For example, whilst planning and control is recognised as important for establishing shared understandings of objectives and risks (Winch and Kelsey, 2005), analysis of how civil engineering resources impact such processes has been limited. Similarly, if civil engineers are tasked with monitoring time, cost and quality, then understanding the impact (real or potential) of the resources used on those parameters is informative for future civil engineering work. Moreover, if we accept that project control is beyond the capability of one individual – control existing at a number of levels in a number of places (APM, 2019) – then understanding the role of civil engineering resources in the planning, risk and control process is important. Such findings should also inform the teaching and understanding of civil engineering communications pedagogy.

The paper begins by reviewing the teaching of civil engineering communications and social semiotics/multimodality theories of communication. A methodology section reviews the empirical work undertaken and presents an analytical framework used to examine various civil engineering resources. The paper proceeds to examine a number of resources drawn from a hospital construction project in the UK: these resources being used successively to inform various stakeholders, communicate ideas, control the discourse and influence the trajectory of cost, risk and quality. A following discussion explores issues of interpretation and cognition more closely, relating the findings to current civil engineering educational thinking on communication. A closing conclusion draws the insights of the paper together.

Teaching of Civil Engineering Communication

The ASCE Body of Knowledge (2019) notes communication as an essential professional skill for civil engineers: the text providing a review of cognitive domain and affective domain levels of achievement (p.42-43). As noted by the ASCE (2019):

"Successful civil engineers communicate effectively and persuasively using appropriate interpersonal skills with technical and nontechnical audiences in a variety of settings. Effective communication conveys information clearly, correctly, and succinctly and includes not only the skills to transmit information, but also to verify that the receiver has correctly understood the information." (p.43)

The ASCE BoK (2019) goes on to note:

"Persuasive communication shapes, reinforces, or changes the response of the receiver. Although all communication can persuade, it is important that civil engineers know how to communicate in a manner intentionally designed to persuade others. Persuasive communication leads to a noticeable response and action by the receiver. Not all communication by civil engineers is intended to be persuasive, but when persuasion is needed, civil engineers must be adept in the skills of persuasive communication, while maintaining the highest ethical standards." (p.43)

Professional associations such as the CIOB (2018), the ASCE (2019) and ACCE (2022) highlight the importance of teaching communication skills to engineering and project management students and professionals. Although not noted in the ASCE Bok (2019), semiotics is intrinsic to all instances of communication (Cobley, 2010), civil engineering communications also being inherently semiotic in nature.

As noted in the ASCE Bok (2019),

"An appreciation of the receiver's perspective is also essential for the communication to be effective and persuasive. This appreciation is particularly important when communicating with diverse stakeholders and communicating technical issues to nontechnical audiences." (p.44)

This recognition of the importance of persuasion and how others will interpret and understand communications in time-constrained and pressured civil engineering contexts should not be under-estimated.

In detailing typical pathways for the fulfilment of the communication skills outcome, the ASCE BoK (2019) notes that in the cognitive domain, the communication outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience (p.45), with self-development being advised to address communication outcomes in the affective domain. The excellent guidance, whilst valid, does not proceed to offer any deeper theoretical or conceptual explanations to clarify how effective and persuasive civil engineering communications may be achieved. For example, the ASCE Body of Knowledge (2019) does not address the semiotic nature of communication or direct any readers to any relevant theories to explain the processes of interpretation and understanding occurring. It is the intention of this paper to make a further contribution to the civil engineering community in this respect.

Social Semiotics and Multimodality

Social semiotics and multimodality have evolved as disciplines of enquiry over a short time period (cf. Veltri 2015; Jewitt et al. 2016). The interest is partly due to the growth of digital technologies for both work and leisure, and recognition of the visual and multimodal as legitimate fields of enquiry (cf. Boxenbaum et al. 2018). The concepts underlying social semiotics, multimodality and visual semiotic studies are closely shared (see Van Leeuwen (2005) for an exhaustive review): each being oriented towards understanding the role of signs in social situations. Social semiotics and multimodality are appropriate and valid for understanding civil engineering communications as projects are recognised as social processes where communication is central to design development (Chiu 2002): multiple modes of communication (i.e. written text, numbers, images, verbal dialogue) often being used in combination to convey information to others. Whereas both social semiotics and multimodality examine the role of signs in social situations, multimodality examines how different modes of communication work in combination.

In the built environment field, a number of scholars have engaged with multimodality and social semiotics. Ravelli and McMurtrie (2016) examined a variety of built structures (e.g. libraries; shopping centres; tower blocks) as forms of multimodal texts "to be read" as meaning-making resources in the landscape. Such works examine how buildings communicate in non-verbal ways (cf. Barthes 1979; Rapoport 1990). Semiotics has also been referenced in works clarifying the distribution of meaning in architect's communications (Medway 1996), that view construction as a complex of signs (Medway and Clark 2003) and work recognising physical built environments as reflecting the representations of other semiotic modes (Markus and Cameron 2002). Collinge (2019; 2017; 2015) noted how construction project engineering and design may be understood as a social semiotic practice, where the representational transformations of requirements over time may be examined and understood using semiotics and multimodal theories of analysis. The adaptability and flexibility of semiotics and multimodality for academics was noted by Hiippala (2017): semiotic enquiry being an adaptable and amenable approach for researchers investigating issues of cognition in various domains. The analytic framework (Figure 1) references scholarly work that has previously applied semiotic analytic techniques to the architecture and built environment fields.

The framework combines theories of semiotics, visual social semiotics and multimodality, proposing a methodological alignment so that project resources of different materiality (i.e. drawings; digital images, objects) can be analysed using the same concepts as, "no semiotic mode can be considered without attention to its material" (Bateman and Wildfeur 2014, 182). The framework (figure 1) distinguishes text from visual image sign communications (multimodal being a combination of the two). The relevant analytic concepts for each semiotic are noted in the figure, together with relevant academic works using them. It should be noted that although semiotic analysis uses a certain terminology, it provides an effective suite of techniques, as Harrison (2003, p.154) notes,

"The method is quite complex and introduces a great deal of new terminology which can appear pedantic to the outsider…but the method is effective in bringing out hidden meanings."

The concepts within the figure 1 framework are detailed below the figure.

Coded/non-coded signs

Non-coded signs are easy to understand compared to those requiring specialised knowledge (coded signs) (Barthes 1967). Coded signs are used amongst communities or professions to facilitate quicker communication (e.g. sign language); coded signs requiring a higher degree of cognitive knowledge, often necessitating the initiation of educational activities from one party to another. In projects, the client may need to be "educated" about issues through the sharing of coded languages (e.g. schematic drawing scales), whereas non-coded signs require no explanation, simplifying the communicative interaction considerably. Whether a sign is coded or non-coded depends upon the cognitive knowledge of individuals interacting with a sign (i.e. their interpretive knowledge).

Denoted/connoted signs

A denoted sign gives a direct, uncomplicated message to be understood. Connoted, or "second-order meanings" are cultural. First level significations (denotations) act as a basis for second level significations (connotations), as Barthes (1967, 1977) states,

"The first system (denotation) becomes the signifier of the second system (connotation) … the signifiers of connotation are made up of the signs of the denoted system."

In civil engineering and project management work, a rough sketch and a digital image may both depict a room, but whether the representation is "professional" or "amateur" in connotation may influence how a client reacts towards it.

Linguistic/iconic signs

Barthes (1977) notes that language often accompanies iconic signs (e.g. diagrams) to function as either anchorage or relay. As anchorage, words (which may be denotative or connotative) label that which is depicted: as relay, text complements an image by adding further meanings. In such cases, text (as a semiotic resource) adds meaning to another semiotic resource (e.g. image; diagram). Iconic signs resemble their object in some way (e.g. photographs, maps, diagrams), having a physical connectivity with an object and are used extensively in construction project work. Penn (2000) notes that linguistic and iconic signs work in different ways, text being a more "laborious" medium than visual imagery, where meanings are conveyed concurrently. Such issues are significant when linguistic and iconic signs are combined as the compositional choice effects how readers relate to and comprehend representations.

Open/closed signs

One method by which sign authors can determine reader interpretation is through the employment of "open" or "closed" signs. Eco (1979) describes "open-texts" (e.g. poems; impressionist paintings, modernist sculpture) as having greater interpretive possibilities than "closed-texts" (e.g. instruction manuals; acts of law). Authors of signs in project management interactions may well consider how "open" or "closed" they are to interpretation as such issues could conceivably affect the project management process.

Visual social semiotic concepts

Visual social semiotic concepts (Kress and van Leeuwen 2006) are employed to examine what an image represents and the nature of the representation. Distinctions can be made between narrative and conceptual visualisations: narrative images "telling stories" about events or situations; conceptual images "defining" or "classifying" people, places or things. As Jewitt and Oyama (2001) state, the choice is important since the decision to represent something in narrative or conceptual form provides a key to understanding the discourse which mediate their representation. Visual social semiotic work also employs a number of concepts (representational; interactive; compositional) to expose how visual images make relationships between viewers and authors of signs, with semiotic choices reflecting the intention, motivations and narrative strategies of sign authors: visuals being examined from a “grammatical” perspective.

Multimodality

Multimodality (Jewitt, Bezemer, and O’Halloran 2016) clarifies how communication is characterised by the co-deployment of multiple sign resources concurrently, combinations of signs cohering and interacting to convey meanings together. Multimodal ensembles of signs (e.g. text, color, image) can be used to convey meanings collectively (Kress 2010) with meanings being distributed across different semiotic modes concurrently (Jewitt and Kress 2003). Whilst separate semiotics may be analysed individually, multimodality examines what modes combine together and their relational coherence (Kress 2010): the distribution and weighting of semiotic resource use being critiqued through a multimodal analysis (c.f. Bateman 2014; Hiippala 2015).

Interpretation and Understanding

Signs connect the social world of their use with the cognitive understandings of people, the principle being embodied in Eco`s (1979) Model Reader concept (figure 2). The Model Reader indicates how effective communication depends upon shared interpretations and understandings between sign authors and readers. As a referential model, the Model Reader highlights how shared interpretations and understandings are critical for effective communication: signs and semiotic resources being the vehicles and mechanisms of meaning.

Eco`s Model Reader (1979) highlights shared interpretations and understandings as critical for effective communication: signs and semiotic resources being the vehicles for the achievement of understanding between parties. Eco (1979) contended that although authors of signs align them to the imagined interpretative schemas of readers, sign receivers have the potential to understand in their own way, referencing their own interpretive schemas. Barthes (1968) referred to personal levels of knowledge that readers possess as "lexicons of knowledge". Both "codes" and "lexicons of knowledge" refer to the cognitive, but in different ways: whilst readers must possess interpretive codes to interpret signs effectively, these codes invoke certain levels of understanding (or lexicons of knowledge). The Model Reader (figure 2) demarcates how authors and readers extrapolate meanings from communicative exchanges by referencing shared interpretive codes and lexicons of knowledge.

Whilst Eco (1979) describes the process of interpretation as being a continuous, complex, interconnected cognitive "coming and going" by the reader (p.36), in civil engineering and project management, layers of meaning are generated that have a cumulative effect. For example, a proposed design schematic reviewed by a project team will be discussed, questioned and critiqued, adding further meanings to the schematic.

The paper now proceeds to describe the methodological approach adopted to explore the above issues further.

Methodology

A study into communications on a National Health Service (NHS) civil engineering hospital project in the UK examined a series of project resources, interviewing NHS representatives and project/civil engineering professionals in order to understand the communication processes occurring; NHS hospital projects being recognised as complex and challenging for engineers and project management professionals (Collinge, 2015). A series of 21 semistructured independent interviews were conducted with the researcher. The 21 interviews were a representative sample for the study as all had direct experience of hospital engineering and project management work. Additionally, the interviewees had interacted with or co-created the resources analysed in the paper. Table 1 details the interviewees by professional occupation. The interviews were recorded by the researcher, transcribed and then examined in detail by the researcher working alone; interviews being supplemented by the collection of project resources (e.g. schematic drawings, PowerPoint slides, visual images of the proposed hospital) which interviewees referred to when explaining their insights. In the selection of materials, the contention of Prior (1997) was followed, who states,

“Qualitative research can not only start with the investigation of things (rather than persons), but can also examine links and connections between objects that cannot speak, yet nevertheless bear messages.” (77)

The relational link between the various resources examined was hospital patient room and ward design and visioning. The researcher analyzed each resource separately, but in sequence, as used on the hospital construction project itself using the social semiotic analytic framework (figure 1). The analysis of each resource was completed independently by the researcher, with interviewee insights complimenting the independent analysis of each resource. Treating separate civil engineering resources as a form of discourse for analysis (Bateman and Wildfeur 2014) is valid as civil engineering resources are produced successively through a project: requirements shifting in semiotic form as successive resources are produced for interpretation and discussion (Collinge, 2017). The analysis of the changing semiotic forms of project requirements enables a visually expressed narrative to be discerned.

Whilst interviewees reflected on each separate resource and provided insights into project communication practices, it was clear that civil engineer and project professional efforts to ‘understand’ and ‘engage’ with NHS stakeholder interests often equated to how their designs would be understood and interpreted. It was evident that NHS interviewees engaged and related to a project via the designs presented to them, interpreting them against personal cognitive understandings of a fully functional and operational hospital facility.

Empirical Analysis

The paper now proceeds to examine a series of project resources used on an NHS hospital project using the social semiotic framework (figure 1), supplementing the analysis with interviewee views and opinions of the resources as communicative devices.

Project Brief

“We have a huge job at the start of a project to go through all of their written requirements. And they can be quite specific…” (Medical Planner 1)

Every project begins with a project brief. On hospital construction projects, patient room design is significant, with visioning and observation of patients being important. The importance of getting patient room design correct was noted by an interviewee who commented,

“If you get one ensuite room wrong, you have got 600 wrong, haven`t you? We don`t want any mistakes.” (NHS Head of Planning)

Patient room requirements are initially presented in briefing documentation using text statements, such as,

"The location of washing and toilet facilities should be ensuite. Washing and toilet facilities should be positioned such that they maximise visibility into the rooms."

"Privacy and dignity of patients should be assured wherever possible and space allowances around patients should be sufficient to provide for this. This could include space for visitors to sit with patients and adequate space between chairs and seating."

Such statements may be examined using concepts from the framework of analysis (figure 1). The text statements are non-coded sign constructs as no specialized knowledge is required to understand the English language used. They are also direct and instructional, being denotative in meaning: direct messages are conveyed to design teams on what they should provide. No background history or organisational detail accompany the requirement statements, so connotative meanings are minimized. This is a deliberate decision of the hospital as author of the text: the minimalist statements giving no insight into organisational culture of the client. Their minimalist nature prompts designers to question and probe the client, as an interviewee noted,

"The documents may be written months or years before the bid comes to market…so the documents often don`t have the full story behind them. We often have to tease out the drivers behind the requirements." (Project Director)

Medway (1996) notes how written texts can be used to mask emotions and associated feelings people may have regarding certain subjects, which spoken, face-to-face communications would reveal. Therefore, as well as being official statements of need, the statements also mask any personal feelings towards requirements; the text being a strategically neutral medium of communication.

The hospital also does not prioritize any of these requirement statements, but the onus is upon designers to tease out preferences and opinions once briefing dialogue begins. As an interviewee reflected,

“It is a process of communication…so we would interpret the brief, do some design work and have our meeting with them and challenge some of the notions: why is there a need for 100% in-patient single rooms? It is about challenging and questioning some of the requirements.” (Medical Planner 1)

Initial designs

“It will start with a 2 dimensional, just a plan. Whatever the brief is, I have sketch plan without any visual features of any kind and that will be depending on the scale and nature of it.” (NHS Manager)

Initial design work produces sketch drawings of room spaces that meet spatial requirements; designers transforming text and numeric specifications into schematic drawings. An immediate representational shift occurs from the brief text and numerals to the drawn lines and shapes of the schematic. Such schematics may not be presented to the client, but do provide a base for further patient room design, and are therefore important. Design work necessarily requires the use of a semiotic that is efficient, effective and useful; drawing being preferable to either spoken or written text (Medway, 1996).

Figure 3 is an isometric drawing subsequently produced by designers. The isometric represents a patient room and as a multimodal resource, combining visual imagery with text.

The isometric facilitates swift understanding of room dimensions and room contents for a client audience; both text and visual image elements (i.e. colors; internal room fixtures) are non-coded sign constructs, being immediately understandable to a viewer. This compositional choice assists viewers when engaging with the drawing. The text and visual image elements are connected by labelling lines: selected room elements being labelled with text to provide linguistic anchorage for the visual image that denotes specific items. However, only 8 elements are labelled on the image: the isometric authors directing viewer attention to these elements. Whilst two images are labelled, one remains label-free. It is valid to argue that too many text labels would clutter up the drawing, detracting from it being an effective mode of communication.

The isometric makes liberal use of iconic visual signs to represent room furnishings and fittings: iconic signs resembling their objects of reference. A construction connotation is achieved via an absence of color and absence of decorative detail on the furnishings in the isometric. The use of white space and white interior features gives the room an unfinished resonance; the 4 color combination (brown; green; beige; blue) being used minimally. The lack of detail on the isometric and the use of white indicates that the room is unfinished, in an early phase of design; such details encouraging viewers to see the isometric as the product of professional designers. The effect is enhanced by the overall composition; threeseparate views of the patient room are given: 1 floor plan view; 2 angled perspective views. Although the floor plan view may be a less familiar representation for hospital employees, the isometric remains a non-coded semiotic composition as no specialized knowledge is required to understand it. Communicating effectively with the client, and opening up the design process for their input is important at this stage of the design process:

“Part of that is about communication, so my design team understand a 2D drawing but the client may not understand it…To move them away from decisions they don`t need to make and get involved with so that they are streamlined onto what is important and how they can help us.” (Clinical Design Manager)

Whilst sign choice contributes to overall communicative effect, the design team focus on certain issues through the isometric drawing. For example, 8 room elements are highlighted for attention; it is reasonable to assume that designers want the client to look at these issues in the design meeting. The isometric room drawing is a good example of how a client-facing resource needs to strike the correct balance between embodying design knowledge and also being flexible to change. Although the isometric lacks numeric room measurements, dimensional requirements have been transferred to this isometric drawing; but designers do not represent the dimensions because viewer attention may be taken in another direction if they had. Therefore, through semiotic composition, some requirements (room dimensions) are closed down, whilst others (room features) are opened up for examination: the text, color and image combination focusing attention on room features and the en-suite bathroom detail.

The isometric is a narrative representation of a patient room as the room is not represented conceptually or in an abstract way. But the narrative representation is qualified: viewers are invited to imagine how a room may function but no specific persons or actions are depicted.

A narrative representation usually presents a story, but the absence of people or actions here leaves it to the viewer to imagine a scenario; the designers not influencing viewer engagement by depicting such signs. The compositional effect makes the isometric a neutral conveyor of information.

Viewer attention and interaction is obtained via compositional effect: the room is depicted from above to give a feeling of power over the subject matter. The size of room images and the interior features also creates an appropriate social distance between viewer and subject matter to facilitate engagement and examination. Salience (viewer attention) is obtained via compositional choice: the 4 colors, isometric perspective, text font size and 3 separate images. The multimodal combination of semiotic modes is an important characteristic of how the isometric works as a communicative device.

Compositionally, the isometric has information value for the client, conveying design team ideas about patient room design and fitting out. For designers, information value would be obtained from client reaction to the proposals. Thus, the isometric room drawing prompts client thinking and contributions in certain directions, some room requirement issues (e.g. clinical, regulatory and functional issues) being totally absent from the isometric.

The modality of the isometric (i.e. how real the patient room is) is debatable. The use of visual semiotic elements has moved the design towards physical realisation (i.e. away from briefing text formulations), but the representation is still open to change and amendment. An interviewee commented how competing design teams will interpret requirements differently, producing contrasting solutions:

“The brief will have been done to a certain level and is quite prescriptive and in line with building standards, but they will always interpret. Things like generic rooms are good examples. You would think they are quite simple. We have 50 odd generic rooms...we have already said what we want, we have already drawn them and shown them what we want but they will bring their own interpretation to it." (NHS Head of Planning)

As noted, designers are careful that representations should encourage further client input into the design process, and semiotic composition facilitates such an input.

Ward corridor schematic

"The way I encourage my team to work is to do the design but then kind of overlay it with the interpretation, so they can see you have good sight lines from that nurse base into those rooms. And you would actually do a little diagram that illustrates that." (Healthcare Sector Leader)

The ward corridor schematic (figure 4) is a further iteration of hospital design, the schematic being presented to the client in order to discuss ward design issues and visioning sight lines.

The schematic is a combination of textual and visual semiotics, constituting a multimodal design resource to give a close-up of 4 patient rooms in addition to a general ward plan. The schematic gives a 2D representation of a ward corridor, combining text with visual images. It is an informative device for multiple professional interests: information being conveyed to architects, building contractors and designers through communicative signs (i.e. furniture placement; door positioning, distances between elements). The schematic conveys a design vision to the client, meanings being conveyed by coded and non-coded signs that have denotative and connotative meanings.

Denotative signs convey physical and spatial realities of the ward through lines, spaces and shapes; the denotative signs being both coded (e.g. "Type 3" and "SHWR") and non-coded iconic signs (e.g. beds; toilets; sinks). The coded signs require explanation if not understood; the non-coded signs do not require explanation. Connotative meanings are also conveyed by the overall schematic aesthetic: this representation suggesting design work is moving towards formality as the schematic drawing composition has a distinct "construction" feel.

The schematic engages with client requirements regarding patient room design, but is limited in the information it conveys. Issues such as room light penetration, noise levels, staff working patterns and medical equipment are not represented by the schematic, the schematic instead focusing upon physical elements rather than organizational issues.

Visioning and "sight-lines" are represented with red shadings that emanate from nurse stations on the ward. These are coded visual signs and may require explanation. Designers could have represented visioning in a variety of ways, but the 2D schematic representation influences the choice of semiotic sign choice in this instance. With the red visioning sight lines, the design team are presenting their interpretation of the requirement in their own way, integrating it with the patient ward design and informing the client that it is being addressed (and potentially satisfied). As Kress (2010) states,

"What the sign maker takes as criterial determines what she or he will represent about that entity." (p.70)

The representation of requirements may lead the client to question their validity, as an interviewee noted regarding how visioning issues were questioned following their visual representation:

Semiotic representation can therefore be instrumental in how the client may interpret and understanding their own requirements; new meanings being facilitated through their representation in visual image forms.

As hospital construction design work proceeds, representations must necessarily begin to engage building service and M&E (mechanical and engineering) issues. As an interviewee noted,

“We had bedrooms down either side and then we had an internal spine with support accommodation. 50% of that was all M&E space and they looked at that and thought “we could have so many rooms in that space but it is all duct work”. But you can`t do anything about it as it is building regulations.” (Clinical Design Manager)

Ward schematics such as figure 4 immediately invoke issues of interpretation and understanding amongst stakeholders as the signs depicted may not be completely understood. There are elements of the ward corridor schematic that are not easily understood by a non-construction audience: for example, the coded terms (SHWR; Type 3; hatched areas). A hospital Manager commented upon stakeholder engagement with such drawings,

"We will look at their drawings, we will talk about it, and then whoever is really around the table will say what they do or don`t like. Or the matron might be there, and she will say that something will not work. There is understanding issue. We can look at a drawing 10 times and not see an issue, but a matron will see it on first look. We get clinicians who say that we want this and this. But medics have their own interests."

The quote indicates the significance of stakeholder interpretations of the signs depicted on a design drawing. The NHS Manager digressed on how important issues are often not recognized on drawings. One example concerned the plan for a ward where male and female patients were monitored by separate nurse teams, the architects not recognising that one nurse team could monitor both sets of patients adequately,

"It would have cost £250k plus £250k to run that as 2 separate teams per year but if you just join these teams together, you will have 1 team, but the architect didn`t come along and think of that which was a bit of a surprise."

A similar example concerned the design of an entrance to a radiology department at the request of a hospital Director. In this case, necessary fire regulations had not been considered carefully, resulting in doors that were impractical and dangerous in an emergency scenario:

“And she wanted a grand entrance on the hospital street that said “Radiology” and a set of double doors…But there were serious fire regulatory issues with the doors. But I saw it and it changed almost overnight. What they described would work but they (the architect) often do not take that extra step of “how will it really be like for a patient”? He hadn`t taken that extra step of visualizing something. The really good ones will do that automatically. (NHS Manager)

The insights reveal how designers may interpret design proposals differently to client stakeholders, lacking the same cognitive knowledge as their client partners.

As a social semiotic resource, the ward corridor schematic works on several levels. It functions through signs that convey direct information about the ward configuration and the central column of services. The inclusion of visioning lines shows how designers are representing other important client requirements; the use of red shapes linking together different design resources and briefing meetings with the client. More directly, the schematic informs the work of the hospital construction professionals, communicating the ideas of designers whilst conveying their professional credentials to a client audience. Finally, the schematic can be a facilitator of learning and understanding as signs potentially trigger cognitive interpretations amongst project stakeholders that may be different to hospital design teams. Such multiple interpretations can be a cohesive force in briefing and design work.

Patient room images

"They want to get our attention, seduce us." (NHS Manager)

Images can be produced by designers through the briefing phase, providing a more visual view of room spaces.

Figure 5 is an image of a patient room produced during design phase work. The image is composed of signs that are non-coded, denotative and iconic, the image showing a scene from a patient room, with interior furnishings and people being depicted through visual imagery. The images convey meanings that do not require explanation, attempting to give a realistic view of what patient rooms would look like and how people may use them. Visual imagery is here used for presentational effect; the power point slide not being used to initiate interactional work with the client, but rather to convey how a future patient room would look.

Space and visibility issues appear to be emphasized by the composition. The arrangement of room contents and views from the corner of the room convey an idea of space to the viewer. This is complemented by giving the people in the images lots of space and visibility. Some of these messages are questionable when the images are scrutinized. For example, the length of the bed appears distorted. Although 3D imagery can sometimes cause distortions of perspective, the benefits of using 3D over 2D representations was defended by an interviewee,

“It is not going to be exactly right because the parallax and the eye and the way that these 3D environments work is kind of screwy...but it does show that it either works or doesn`t work.” (BIM Manager)

However, the contrasting length of patient beds could lead to the supposition that the image authors wished to emphasize space and visibility issues to the client audience.

The image presents a narrative account of action, depicting people doing things. This connects with client desire to know how rooms function, but also leads the viewer to begin imagining narrative scenarios themselves. By depicting people, designers have started to formulate stories around the patient room designs, but have also provided the client with a potential starting point for their own functional and operational insights. Thus, the inclusion of narrative signs on the images can provide a story for how a design may work whist also prompting the viewer to formulate their own narratives.

The image also work subtly in other ways. Viewers are engaged with events in the room as a “detached equal”: the horizontal view (rather than an above or below rendering) and the degree of distance from the events (the observer being in the corner of the room) combining together to achieve this effect. Such visual effects have been noted by Kress and van Leeuwen (2006). With these visual techniques, designers have set up an interpersonal relationship between client viewer and the patient room design: the images invite client engagement, but from a pre-determined perspective decided by the design team. The use of visual semiotic resources enables this to happen.

For the client, information value resides in how the patient rooms would appear and their potential functionality. For designers, information value resides in client reaction to them. Whilst salience (viewer attention) is obtained via visual graphic elements, modality (realness) of the images is greater than on previously analysed resources, but remains questionable as 3D imagery can distort views of reality and perspective.

Despite their visual nature, an NHS Facilities Manager commented that room functionalities on such images can often missed, with floor, furnishings, wall colorings and light fixtures within rooms all having implications for functionality and cost of space:

"Architects are more concerned with appearance than practicalities…an architect always has an opinion of what the inside of this building should look like, what color scheme should be in there, what kind of lighting, type of furnishing but not thinking this is a hospital and not a hotel…the type of people using this area and how long the lightings and furnishings would have to last as cost is of paramount importance to us in the NHS."

That visual images can trigger stakeholder interpretations that are distinctly different to designers. Project stakeholders may interpret designs from their own professional perspectives; signs triggering cognitive understandings that other project participants may not possess, stakeholders relating to designs with different personal cognitive levels of knowledge (Barthes, 1967). The insights validate Eco`s Model Reader (1979) concept that designers actively try to interpret from a client perspective, although their interpretations may be limited. Figure 2 shows how design resources can trigger different levels of understanding amongst project stakeholders, with denotations leading to connotative understandings.

That design resources have interpretive flexibility does not detract from the probable purpose of the patient room images for the design team, as explained by the above social semiotic analysis and emphasized by an interviewee comment:

“They will always focus in upon a selection which they think tell the story the best way they can. It will be the design team who do the selecting process. They try and make things really clear for the client, expressing what we are trying to convey…in many cases they are storytellers…trying to tell a story and from a design perspective they are great at doing that.” (BIM Manager)

An NHS Project Manager commented upon the use of visual images in briefing work,

“One of the things you increasingly see from bidders is the use of computer generated images but I am always wary. You can often find visual rhetoric in the representations, so the representation is embellished to make it look better than the final physical product. And if you think about the PFI process as being a very competitive with 2 bidders, they are spending millions of pounds to win the bid, they have every incentive to try and make their design as appealing as they can.”

A Project Director also noted how different stakeholder groups bring their own sets of requirements to the table:

“Different staff groups, including doctors, nurses, clinicians, director of clinical care will all bring with themselves their requirements…so if you are looking at putting a glass screen in front of a new patient bedroom, they will be looking at the crash eventualities…can we open the door, can we get past that chair…you are looking at all of those aspects, it is not just a "here is a room with the furniture in"

That individuals can bring personal and professional sets of requirements with themselves to the table is another notable characteristic of briefing and design work. Different stakeholders will potentially interpret a hospital design proposal from their own understandings: a design image (such as the nurse station slide) may invoke multiple and diverse stakeholder interpretations.

The visual image was used by designers to present an aesthetically pleasing representation of patient room spaces. Semiotic analysis reveals how such images have been composed to have a social impact in the competitive briefing context; the strategic intention of the design team being made evident through choice of compositional effects. The images are more presentational than practical design tools.

The analysis noted that despite the narrative imagery and the emphasis upon space and visibility, stakeholders may still relate to the design with their own cognitive understandings based upon professional experience and knowledge. It is possible that hospital design team may not possess such knowledge. As a resource of design, the images are used in a later phase of briefing work, where designers are looking for affirmation of their room design from the client.

Discussion – Practicality issues

In noting that communication is an essential professional skill for civil engineers, the ASCE Body of Knowledge (2019) provides a review of cognitive domain and affective domain levels of achievement (p.42-43). The different levels of demonstrated ability/achievement detailed for these domains may be linked directly to semiotics theories of communication and the analytical techniques detailed in the paper. For example, the required ability to "Formulate effective and persuasive communication to technical and nontechnical audiences" (Cognitive Level) links to the Model Reader concept of Eco (figure 2) and the choice of semiotic to use in civil engineering work.

Mobilisation of the semiotic concepts and framework detailed in this paper would be possible at several stages of the civil engineering education journey to reinforce the criticality of communication in civil engineering work. For example, undergraduates and postgraduate classes on communications skills/processes could integrate the Eco theory and semiotic framework into learning outcomes. Additionally, the insights of the paper could be integrated into self-development of communication skills and semiotic peer-review of project communications prior to their use.

The examination of resources from the hospital project revealed how they function as communicative devices through their semiotic composition (i.e. being composed of coded/non-coded; denotative/connotative; visual social semiotic signs). From the empirical evidence, it is clear that semiotic choices were intrinsic to the civil engineering communications occurring; specific meanings being conveyed through sign constructs (e.g. room sizes; equipment/furniture placement). The sharing of resources with more stakeholders multiplies understandings and interpretations, with effective stakeholder engagement work requiring a sharing and open discussion of engineering ideas, often around a shared resource. Useful knowledge for engineers can emerge from such discussions, which contrasts to the neutral and anonymised requirement statements that commonly initiate civil engineering projects.

The significance of resources to open up, mask or highlight certain engineering issues (through semiotic composition) was evidenced: such choices being significant in a time constrained project lifecycle. The strategic motivation of sign authors (both client and civil engineers) was evident through the analysis: the composition of resources reflecting the desires of parties in the communication process. It may be noted that requirements remain a tangible link to the client through successive iterations of design, so the representational transformation of requirements through semiotic resources provide practitioners opportunities to create linkages between meetings spread across several weeks or months. Therefore, semiotic resources are key to developing the relationship between parties and maintaining a flow of continuity between engineers and other parties.

Theoretical and Pedagogical Issues

As noted earlier in the paper, the Model Reader concept of Eco (1979) clarifies how communication works from cognitive and social perspectives (figure 2). The data presented in the paper provides tangible evidence of the validity of the Model Reader for civil engineering communicative exchanges. However, the Model Reader of Eco (1979) should be qualified: whilst engineers actively produce communicative signs, attempting to interpret them from the perspective of an audience, they can fail to interpret them in the same way. Interpretive codes (Eco, 1979) and lexicons of knowledge (Barthes, 1967; 1977) (figure 2) inform our understanding of interpretative events: whilst interpretative codes may sometimes be shared (i.e. the key to a schematic drawing), lexicons of knowledge may not be. Which meanings and understandings derive depends upon the signs displayed as well as the different interpretive frameworks of persons interacting with them. Unforeseen interpretations may occur in spite of civil engineer efforts to educate project stakeholders (i.e. to provide them with an interpretive code). Civil engineers should be mindful of the possibility of such occurrences happening.

Civil engineering pedagogy should recognise the social semiotic nature of communicative resources used in civil engineering work, so that future professionals are aware of the theoretical and conceptual nature of their communicative choices. The author contends that it would be possible to integrate the social semiotic framework into technical communication skills classes for civil engineers and project managers. The empirical insights also reveal how project resources can trigger educational and learning activities between parties (e.g. a facilities manager will have a different interpretation to an NHS manager). The inherent usefulness of visualisations was evidenced: new meanings emerging from representations that use visual rather than textual semiotics. It can be argued that the visible manifestation of requirements engages individual stakeholder attention, triggering cognitive understandings and interpretations: meanings being either co-produced in interactive dynamics or being proposed by either client or designers through semiotic resource use.

The terms detailed in the semiotic framework (figure 1) provide the conceptual apparatus by which images and resources should be composed for audiences in civil engineering contexts. To assist in practical usage, a simple checklist of questions can help to prompt a review of resources before their active use in meetings/presentations:

- Is the image/resource easily understandable for the intended audience?

- Can it or should it be simplified?

- Does it address the civil engineering issues in order for work to move forwards?

- Is there a correct balance between information and visual aesthetic?

Conclusion

Scholars regularly emphasize the criticality of communication skills for everyday professional practice (e.g. Froehle et al. 2022; Pourmand et al. 2021; Pradhananga et al. 2022). Whilst previous work has rightly noted the importance of representational choices and cognition in engineering practice (Barner and Brown, 2021), with semiotics and engineering resource functionality (i.e. schematics; images; text documents) being identified as important (c.f. Simpson, 2014; Simpson and Archer, 2019), no previous work has systematically employed a social semiotic framework to deconstruct the functionality of engineering resources in a civil engineering context.

The empirical insights of the paper provide evidence of the importance of the functionality of project resources (e.g. schematics; images; drawings) when mobilised in the project discourse. The semiotic composition of resources can impact stakeholder management and the overall project management trajectory by the representational choices of resource authors. Civil engineering resources enable project teams to engage various stakeholders in cooperative, interactive processes of learning through the proactive use of modes of communication. In this process, sign communications contribute both procedurally (via delivery of data) and socially (as relationship building resources), either opening up or closing down design issues in strategic ways. It is through this semiotic exploration of civil engineering resources that the paper builds upon the work of scholars who have identified semiotic processes as intrinsic to project management and civil engineering communications. The theoretical and conceptual contributions add further to our understandings of communication in civil engineering. The insights may complement the teaching of civil engineering communication skills whilst supporting professionals in the field when reviewing and refining their communications.

Data Availability Statement

All data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

References

APM (2019) Body of Knowledge. 7th edition.

ASCE (2019) Civil Engineering Body of Knowledge. Preparing the future civil engineer. 3rd edition. American Society of Civil Engineers: Virginia.

ACCE (2021) American Council for Construction Education Document 104 Standards and Criteria for Accreditation with Commentary, Available from https://www.acce-hq.org/file-share/430b0bae-4bca-49b9-ac41-be9945a81d1e [Accessed 30 May 2022]

Barner, M.S. and Brown, S.A. (2021). Design Codes in Structural Engineering Practice and Education. Journal of Civil Engineering Education, 147 (2).

Barthes, R. 1967. Elements of Semiology. New York: Hill and Wang.

Barthes, R. 1977. "The Rhetoric of the Image." In Image, Music, Text, edited by R. Barthes, 192–205. London: Fontana.

Barthes, R. 1979. "The Eiffel Tower." In The Eiffel Tower and Other Mythologies, edited by R. Howard, 3–17. New York: Columbia University Press.

Bateman, J. A. 2014. Text and Image: A Critical Introduction to the Visual/Verbal Divide. Oxon: Routledge.

Bateman, J. A., and J. Wildfeur. 2014. “A Multimodal Discourse Theory of Visual Narrative.” Journal of Pragmatics 74: 180–208.

Bogers, T., J. J. van Meel, and T. J. M. van der Voordt. 2008. “Architects About Briefing.” Facilities 26 (3/ 4): 109–116.

Boxenbaum, E., C. Jones, R. E. Meyer, and S. Svejenova. 2018. “Towards an Articulation of the Material and Visual Turn in Organization Studies.” Organization Studies 39 (5–569)7: –616.

Chartered Institute of Building (2018) CIOB Education Framework for Undergraduate Studies, Available from https://www.ciob.org/learning-providers/education-framework [Accessed 30 May 2022]

Chiu, M. L. 2002. “An Organizational View of Design Communication in Design Collaboration.” Design Studies 23: 187–210.

CIOB (Chartered Institute of Building). 2022. Code of Practice for Project Management for the Built Environment. 6th Edition. Oxford: Wiley-Blackwell.

Cobley, P. (2010). The Routledge Companion to Semiotics. London: Routledge.

Collinge, W.H. (2019). Exploring construction project design as multimodal social semiotic practice. Social Semiotics, 29, 5, 603-621.

Collinge, W.H. (2017). Client requirement representations and transformations in construction project design. Journal of Engineering, Design & Technology, 15, 2, 222-241.

Collinge, W.H. (2015). Infection control in construction and design. Health Environments Research & Design Journal (HERD), 8, 3, 68-79.

Collinge, W.H. and Harty, C.F. (2014). Stakeholder interpretations of design: semiotic insights into the briefing process. Construction Management & Economics, 32, 7-8, 760-772.

Danesi, M. (2010), "Semiotics of media and culture", in Cobley, P. (Ed.), The Routledge Companion to Semiotics, Routledge, London, pp. 135-149.

Datta, A., Ninan, J., & Sankaran, S. (2020). 4D visualization to bridge the knowing-doing gap in megaprojects: an Australian case study. Construction Economics and Building, 20 (4).

Eco, U. 1979. A Theory of Semiotics. Bloomington: Indiana University Press.

Emmitt, S., and C. Gorse. 2007. Communication in Construction Teams. Oxon: Taylor and Francis.

Froehle, K., Dickman, L., Phillips, A.R. and Murzi, H. (2022). Understanding Lifelong Learning and Skills Development: Lessons Learned from Practicing Civil Engineers. Journal of Civil Engineering Education, 148 (4).

Gluch, P., and C. Raisanen. 2009. "Interactional Perspective on Environmental Communication in Construction Projects." Building Research & Information 37 (2): 164–175.

Halliday, M. 1978. Language as Social Semiotics. London: Arnold.

Harrison, C. 2003. "Understanding how Still Images Make Meaning." Technical Communication 50 (1): 46–60.

Hiippala, T. 2015. The Structure of Multimodal Documents: An Empirical Approach (Routledge Studies in Multimodality). Abingdon: Routledge.

Hiippala, T. 2017. "An Overview of Research Within the Genre and Multimodality Framework." Discourse, Context & Media 20: 276–284.

Hodge, R., and G. Kress. 1988. Social Semiotics. Oxford: Polity Press.

Institute of Civil Engineers (ICE). 2020. Civil Engineering Procedure (8th Edition). Institute of Civil Engineers.

Jewitt, C. 2014. The Routledge Handbook of Multimodal Analysis. 2nd ed. Abingdon: Routledge.

Jewitt, C., J. J. Bezemer, and K. L. O'Halloran. 2016. Introducing Multimodality. Abingdon: Routledge.

Jewitt, C., and G. R. Kress. 2003. "A Multimodal Approach to Research in Education." In Language, Literacy and Education: A Reader, edited by S. Goodman, T. Lillis. J. Maybin and N. Mercer, 277– 292. Stoke on Trent: Open University.

Jewitt, C., and R. Oyama. 2001. "Visual Meaning: A Social Semiotic Approach." In Handbook of Visual Analysis, edited by T. van Leeuwen and Carey Jewitt, 134–156. London: Sage.

Karlsson, A. M. 2004. "How to Build a House from Reading a Drawing: Professional and Popular Mediations of Construction." Visual Communication 3 (3): 251–279.

Kress, G. R. 2010. Multimodality: A Social Semiotic Approach to Contemporary Communication. London: Routledge.

Kress, G. R., and T. N. van Leeuwen. 2006. Reading Images: The Grammar of Visual Design. London: Routledge.

Lloyd, P., and J. Busby. 2001. "Softening up the Facts: Engineers in Design Meetings." Design Issues 17 (3): 67–82.

Markus, T. A., and D. Cameron. 2002. The Words Between the Spaces: Buildings and Language. London: Routledge.

Medway, P. 1996. “Writing, Speaking, Drawing: the Distribution of Meaning in Architect`s Communication.” In The New Writing Environment, edited by M. Sharples and T. van der Geest, 25–42. London: Springer Verlag.

Medway, P., and B. Clark. 2003. “Imagining the Building: Architectural Design as Semiotic Construction.” Design Studies 24 (3): 255–273.

Morton, J. 2006. “The Integration of Images into Architecture Presentations: A Semiotic Analysis.” Art, Design and Communication 5 (1): 21–37.

Ninan, J., Mahalingam, A., Clegg, S. and Sankaran, S. (2020). ICT for external stakeholder management: sociomateriality from a power perspective. Construction Management and Economics, 38, 9.

Penn, G. 2000. “Semiotic Analysis of Still Images.” In Qualitative Researching with Text, Image and Sound: A Practical Handbook, edited by M.W. Bauer and G. Gaskell, 227–245. London: Sage.

Pourmand, P., Pudasaini, B. and Shahandashti, M. (2021). Assessing the Benefits of Flipped Classroom in Enhancing Construction Students’ Technical Communication Skills. Journal of Civil Engineering Education, 147 (1).

Pradhananga, P., ElZomor, M. and Kasabdji, G.S. (2022). Advancing Minority STEM Students’ Communication and Presentation Skills through Cocurricular Training Activities. Journal of Civil Engineering Education, 148 (2).

Prior, L. 1997. “Following in Foucault’s Footsteps: Text and Context in Qualitative Research.” In Qualitative Research: Theory, Method and Practice, edited by D. Silverman, 63–79. London: Sage.

Rapoport, A. 1990. The Meaning of the Built Environment. Tucson: University of Arizona Press.

Ravelli, L. J., and R. J. McMurtrie. 2016. Multimodality in the Built Environment. London: Routledge.

Simpson, Z. (2014). Resources, Representation, and Regulation in Civil Engineering Drawing: An Autoethnographic Perspective, In: Multimodal Approaches to Research and Pedagogy. Routledge.

Simpson, Z. and Archer, A. (2018). Semiotic technologies: a case study of discipline-based practices and pedagogy. Social Semiotic, 29 (4), 524-542.

Turkulainen, V., Aaltonen, K. and Lohikoski, P. (2015). Managing Project Stakeholder Communication: The Qstock Festival Case. Project Management Journal, 46, 6, 74-91.

Van Leeuwen, T. N. 2005. Introducing Social Semiotics. London: Routledge.

Veltri, G. A. 2015. “Social Semiotics and Social Representations.” In the Cambridge Handbook of Social Representations, edited by G. Sammut, E. Andreouli, G. Gaskell and J. Valsiner, 234–249. Cambridge: University Press.

Winch, G.M. and Kelsey, J. (2005) What do construction planners do? International Journal of Project Management, 23, 2, 141-149.

Table 1: Interviewees by professional occupation

Category of Interviewee~~INSERT COLUMN HEADING~~	Professional Occupation of Interviewee~~INSERT COLUMN HEADING~~
NHS interviewees	NHS Project Manager 2
	NHS Head of Programme Development 1
	NHS Commissioning Manager 1
	NHS Design Development Manager 1
	NHS Building Services & Energy Engineer 1
	NHS Head of Clinical Planning & Development 1
	NHS Head of Facilities 1
	NHS Clinical Healthcare Planner 1
Project/Civil Eng. interviewees	Project Director 2
	Design Director 2
	Medical Planner 2
	Company Director 1
	Operations Manager 1
	Client Relations Manager 1
	Clinical Design Manager 1
	Healthcare Sector Leader 1
	Building Information Modelling (BIM Manager 1