Civil Engineering work as social semiotic work: A theoretical view of teaching and learning

Zach Simpson
Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa.
zsimpson@uj.ac.za

This paper argues that pedagogy can be enhanced through the study of theory, and begins with the assumption that, for the benefit of the professionalization of the field, there is a need for engineering education researchers to engage in theorization of the specific events and practices that make up the myriad teaching and learning experiences within the context of the engineering sciences. The aim of this paper is to show how one particular theoretical approach, social semiotics, can shed light on various aspects of the teaching and learning of one particular engineering discipline, namely Civil Engineering. This is done in order to achieve the greater aim of demonstrating how and why engagement with theory such as social semiotics is of use in informing pedagogy. The paper draws specifically on the concept of *transduction*, the process of transforming meaning from one semiotic form to another. In so doing, four key implications from a social semiotic account of civil engineering work are drawn. First, differential access to meaning-making resources and technologies must be accommodated in the educational sphere. Second, students need to be encouraged to view the activities in which they are engaged in the engineering classroom as meaning-making practices and not routine procedures. Third, some transductions require greater abstraction of meaning than others and may therefore require mediation in the form of intermediate transductions. Fourth, it is only through pedagogic efforts aimed at enabling students to perceive meaning-making practices as functional within context, that students can potentially come to engage in the full articulation of their communicative and representational practices as meaningful work. Finally, the paper calls for further research into the social semiotics of engineering education as it appears this may offer useful pedagogical insight.

Introduction

The basic premise of this paper is that pedagogy can be enhanced through the study of theory (Biggs, 2003). Thus, it begins with the assumption that, for the benefit of the professionalization of the field, there is a need for engineering education researchers to engage in theorization of the specific events and practices that make up the myriad of teaching and learning experiences within the context of the engineering sciences. The aim of this paper is to show how one particular theoretical approach, social semiotics, can shed light on various aspects of the teaching and learning of one particular engineering discipline, namely Civil Engineering. This is done in order to achieve the greater aim of demonstrating how and why engagement with theory such as social semiotics is of use in informing pedagogy. The paper is structured such that it begins with an overview of social semiotics and some of the more important concepts which are employed in this paper. The subsequent discussion analyses some of the activities which Civil Engineering students engage in during the course of their study, in social semiotic terms. Thereafter, the implications of this theoretical viewpoint for engineering pedagogy are discussed.

However, at the outset, it is important to note three crucial provisos of this work. First, this paper posits social semiotics as one theoretical approach among many, and does not seek to promote social semiotics as the only, or even as the best such approach. Secondly, the 'engineering' aspects of this paper are simplifications of the practice of Civil Engineering. This is of necessity as the research design employed is an autoethnographic one in which the researcher is engaging in Civil Engineering diploma study as part of a larger doctoral research study in education. As such, this paper represents the attempts of a student of Civil Engineering to make sense of the formal learning experiences involved in becoming a Civil Engineering technician. Thirdly, this paper presents a theoretical argument and not an empirical one. Thus, although some 'data' is referred to in the form of student texts, these texts are used only to illustrate the theoretical observations made. Also, in line with the autoethnographic nature of this study, some observations drawn from the reflections of the author are included as further indication of the theoretical arguments presented.

Social Semiotics: An Overview

Social semiotics is, in fact, not a pure theory (van Leeuwen, 2005) and, as such, only becomes useful when applied to specific contexts, such as that of engineering education. Its forebear, traditional semiotics is a linguistic approach that concerns itself with the 'rules' or structures (the grammar) that constitute language (Vannini, 2007). However, semiotics has also included representational modes other than language, particularly visual design (Kress and van Leeuwen, 1996), film, art and even mathematics (O' Halloran, 2009). As such, the study of semiotics is multimodal. In addition, in line with the so-called 'social turn' that took place across much of the social sciences in the mid-to-late 20th century (Gee, 2000a), social semiotics arose as a response to the gaps and limitations in traditional semiotics. In particular, social semiotics is concerned with how the 'rules' of representation come to be and how they are enforced, and how this impacts upon individuals' use of these rules (Jewitt, 2009; Vannini, 2007; Van Leeuwen, 2005; Kress and Van Leeuwen, 1996).

For the purposes of this paper, three observations about multimodal social semiotics need to be mentioned here. First, multimodal social semiotics is fundamentally concerned with texts – the products of social practices (Van Leeuwen, 2005). Within engineering education, these texts could take the form of student assignments, text books, lecturers' notes written on black boards or in PowerPoint slides, or even the doodling of students in the margins during class. They can be spoken, written, mathematical, drawn or any of a multitude of other forms. In short, multimodal social semiotics is concerned with "meaning in all its appearances, in all social occasions and in all cultural sites" (Kress, 2010: 2).

Second, social semiotics is concerned with the social, institutional and historical contexts within which these texts are produced (Kress, 2010; Jewitt, 2009; Vannini, 2007; Van Leeuwen, 2005). This is because the kinds of texts that are produced and the ways in which they are received or evaluated can be traced back to these specific contexts. Student lab report assignments, for example, are assessed, at least in part, according to the degree to which they conform to the social, institutional and historical rules governing what is considered the appropriate form such lab reports should take.

Finally, social semiotics is concerned with power: it raises questions as to whose interests are served through the enforcement of certain rules and conventions regarding the representation of knowledge (Jewitt, 2009; Vannini, 2007; Van Leeuwen, 2005). In order to change the 'rules' of meaning-making, individuals need to hold power within the above-mentioned social and institutional contexts in which the meaning-making occurs. One of the challenges of the engineering education project is the fact that students are accorded very little power in this regard. Thus, instead of exercising power in the text they produce, engineering students are subject to the social power exerted through and/or by their lecturers, professional councils, corporations and even textbooks.

In addition to these three key concerns of multimodal social semiotics, it is important at the outset to discuss *transduction* as one core concept of social semiotics. Transduction is the process of transforming meaning from one semiotic form to another (Kress, 2000a). A simple example of this is the verbal expression *one plus one equals two* being replaced with, or transducted into, mathematical notational form (1 + 1 = 2). However, different representational modes offer different potential for meaning-making. That is to say, some semiotic forms are better for representing specific meanings than others. Thus, when transducting meaning from one mode to another, there is not always a perfect fit (Kress, 2000a). In addition, it is a myth that language is "fully adequate to the expression of anything we might want to express: that anything that we think, feel, sense, can be said (or written) in language" (Kress, 2000b: 193). Instead, a plethora of representational means have arisen because each is "embedded in distinct ways of conceptualising, thinking and communicating" and each positions us in terms of its own criteria of relevance (Kress, 2000b: 195).

The notion of transduction does not constitute the entirety of a social semiotic perspective on communication and representation; instead, for reasons of space, I frame the discussion that follows around this concept and use it as indicative of the potential benefit that social semiotics offers in terms of understanding specific teaching and learning activities within engineering study. While further social semiotic concepts are introduced in the discussion as and when needed, the notion of transduction is the framing principle around which the bulk of this paper is presented. In the sections that follow, I put this concept to use within the context of specific teaching and learning activities involved in learning to become a civil engineering technician.

This is done in order to demonstrate three key arguments: 1) that engineering students need to be encouraged to view the practices they engage in during their studies as meaning-making practices, and not as routine procedures; 2) that some transductions of meaning require a greater degree of abstraction than others and that they are therefore more complex and require greater mediation; and 3) that each semiotic transduction fulfils a specific function within the larger goals of engineering practice and education and it is thus important to draw students' attention to these functions, and the larger objectives they fulfil, so that students can perceive these semiotic moves as functional within this context.

Autoethnography: A Methodological Note

As has already been mentioned, the primary orientation of this paper is towards a *theoretical* account of aspects of teaching and learning within Civil Engineering Technology study. However, it does draw on a limited amount of data in order to illustrate the theoretical arguments presented. This data was collected within an autoethnographic research design, the primary characteristics of which are that the researcher is a fully-fledged participant within the research site and that the researcher also acts as an important source of data within the study. Within this design, therefore, the data drawn upon in this paper was collected through three means. First, texts which students produced were collected, with permission. Second, texts which I have produced have been drawn upon as illustrative of the arguments made. Finally, one of the primary data collection methods employed in autoethnography, which sets it apart from other qualitative research designs, is reflective introspection and observation (Vannini, 2007) on the part of the researcher. As such, some of the observations made in this paper are based on my own reflections during a year of near-full time engagement with fellow Civil Engineering diploma students.

Initial Transduction: 'Re-presenting' the Landscape

It could be argued that the 'first step' in much civil engineering work is land surveying. It is common practice in South Africa and internationally that Civil Engineering (and construction management and mining engineering) students undertake at least one module on surveying during their degree or diploma studies. Kavanagh (1997) defines surveying as the practice of measuring altitudes, angles and distances on the land surface so that they can be accurately plotted on a map. In social semiotic terms, land surveying thus involves the use of technologies (theodolites, dumpy levels, prisms and so on) to construct a materialised (on paper, or computer screen) numeric, tabular representation of the surface of a piece of land. It is thus a transduction of meaning.

As part of a practical exercise in land surveying, the first year civil engineering diploma students at the institution at which this research was conducted were required to engage in a process of obtaining the relative elevations above sea level of a stretch of ground. Figure 1 is a photograph of a stretch of land chosen by one particular group. Through the use of various items of surveying equipment, such as a dumpy level and staff, and some additional computation, Table 1 was developed. Table 1 is a 're-presentation' of the landscape pictured in Figure 1. Figure 1 itself constitutes a transducted representation of this particular stretch of land. The differences between the photograph and the table are that different technological tools were utilised in their production, that different social practices were involved in this production and that the table represents the land surface with a much higher degree of abstraction than the photograph does. Despite this, both Figure 1 and Table 1 present a snapshot of this specific piece of land.

Figure 1. Photograph of a stretch of land surveyed by student group.

Table 1. Survey results.

A	B	C	D	E	F	G	H
Surveying Practical Results							
	Point	**Bs**	**Is**	**Fs**	**Rise**	**Fall**	**Red. Level**
Run	BM1	1.802					100.000
	1		1.298		0.504		100.504
	TP1	0.797		1.287	0.011		100.515
	2		0.582		0.215		100.730
	TP2	1.290		0.403	0.179		100.909
	BM2			1.150	0.140		101.049
Check	BM2	1.149					101.049
	TP1	1.140		1.655		0.506	100.543
	TP2	1.151		1.282		0.142	100.401
	BM1			1.449		0.298	100.103

In Table 1, columns C, D and E present the readings that would have been obtained from the instrument used. Columns F and G then present the change in elevation from one survey point to another. Column H presents the elevation of each point, as calculated. In the exercise, the students were told to assume that their start point was at an elevation of 100m above sea level. What this table tells its viewers is that as you walk from point BM1 to point 1, the elevation of the ground rises by 0.504 metres, or 504 millimetres. Similarly, as you walk from point 1 to point TP1, the ground rises by a further 0.011 metres, or 11 millimetres.

Figure 1 and Table 1 are useful in illustrating the different affordances that different representational modes offer. For example, by looking at Table 1 alone, one would not be able to deduce the surface features of the stretch of land in question. That is, it does not tell us if the surface is grassed, or if it is concreted, or if it has lots of trees, or if it is a dusty, sand-covered surface, all of which is deducible from the photograph. The photograph, on the other hand, does not offer its viewers a precise sense of the undulation of the surface in the way that the table does. And neither the table nor the photograph tells us much about the surroundings, location or uses of the land. As such, neither the table nor the photograph is a direct representation of the surface of the land, in that neither presents everything that can be said about the land in question. Instead, each presents only those aspects of the land that are deemed criterial according to specific interests.

In the case of the Table, the interests of its producers were solely in the changes in elevation from point to point. The production of this table thus constitutes a discursive practice. The term discourse is used here to refer to "socially constructed knowledges [sic] of some aspect of reality" (Van Leeuwen, 2005: 94). By describing them as socially constructed, Van Leeuwen implies that these knowledges "have been developed in specific social contexts, and in ways which are appropriate to the interests of social actors in these contexts" (2005: 94). Because texts draw on discourses (as knowledges of some aspect of reality), they are inherently selective – and what they select depends on the interests and purposes of the institutions that have fostered the knowledge they represent (Van Leeuwen, 2005). In the case of Table 1, only knowledge about a specific aspect of the landscape, namely change in elevation, is represented. This representation is developed within the specific social context of engineering education and reflects the specific interests of civil engineers in the landscape. In so doing, Table 1 illustrates the prevailing attitudes and ideas about the landscape privileged within civil engineering practice.

However, Van Leeuwen (2005) reminds us that some discourses become so commonplace that we cease to be able to imagine alternatives. In this regard, a further point that can be made about Table 1 is that this is not the only possible form in which changes in the elevation of this piece of land can be represented. For example, as I have done for the first two points, the information could be represented in linguistic form, in words and sentences. This, of course, would be far more cumbersome and would make it far more difficult to read how the surface elevation changes between points at a glance. However, the information could also be represented graphically, as in Figure 2.

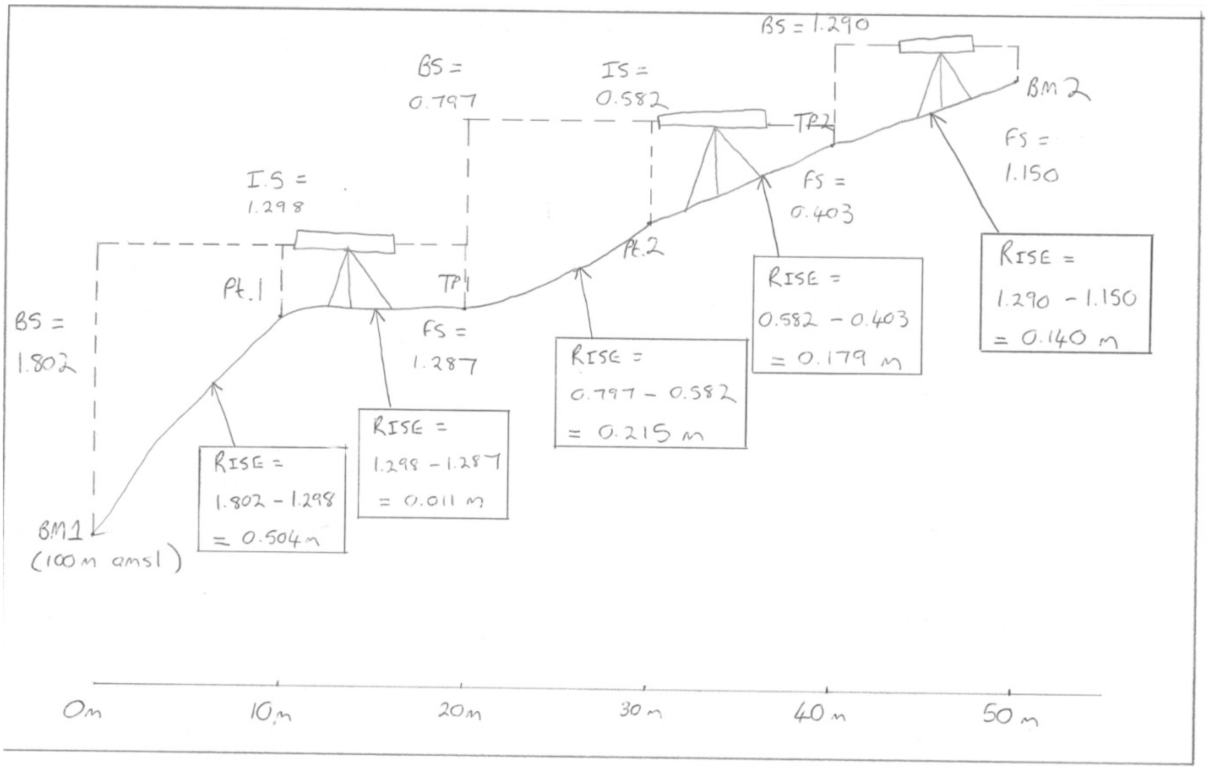

Figure 2. Alternate diagrammatic representation of the surveyed land.

It is worth considering why the socially agreed upon convention for representing undulations in the landscape is in the form a numerical table, rather than in diagrammatical / graphical form, particularly given the fact that representations such as those in Figure 2 were frequently used by the lecturer in class to explain how to produce the tabular results. This is particularly helpful in explaining some of the counter-intuitive aspects of Table 1, such as the fact that a decrease in the readings obtained – such as from 1.802 to 1.298 – translates into a rise in the ground levels. Indeed, if Figure 1 (the photograph) involves a lesser degree of abstraction than Table 1 does, Figure 2 probably exists somewhere between the two in terms of the degree of abstraction. That is, while it is more abstracted than Figure 1, it is not as abstract a representation as Table 1 is. For this reason, it serves as a useful tool to mediate the process of producing the more abstract representation.

Interim Transduction: From Numeric Data to Drawn Plan

In the previous section, the question was raised as to why a numeric-tabular representation of the landscape was preferred over a diagrammatic illustration. A further answer to this question relates to Van Leeuwen's (2005) observation that, in scientific discourses, 'things' should be able to be counted, measured and described in terms of static permanent qualities as this makes them more easily manipulated – in practice and in discourse. Table 2 presents an extension of the information presented in Table 1.

Table 2. Extended Survey Practical Results.

A	B	C	D	E	F	G	H	I
Surveying Practical Results								
	Point	**Red. Level**	**Corr.**	**Adj. Level**	**Distance**	**Grade Elev.**	**Cut**	**Fill**
Run	BM1	100.000	0.000	100.000	0	100.000	0	0
	1	100.504	0.017	100.487	10	100.200	0.287	
	TP1	100.515	0.017	100.498	20	100.400	0.098	
	2	100.730	0.034	100.696	30	100.600	0.096	
	TP2	100.909	0.034	100.875	40	100.800	0.075	
	BM2	101.049	0.051	100.998	50	101.000		0.002
Check	BM2	101.049						
	TP1	100.543	0.069	100.474				
	TP2	100.401	0.086	100.315				
	BM1	100.103	0.103	100.000				

In Table 2, columns A through C are a direct duplication of columns A, B and H in Table 1. Columns D and E present the results of a computed correction to accommodate for errors made during the fieldwork. Column F shows the distance between the points. Columns G through I assume that a road will be constructed on the stretch of land: column G presents the proposed elevation of the road at each point so as to ensure an even gradient, while columns H and I indicate the extent to which the existing landscape will have to be manipulated by removing (cutting) or adding (filling) soil.

It is clear to see, given the ultimate purpose of this information, that a diagrammatic illustration of the land (such as in Figure 2) would not afford the potential to manipulate the representation in the way Table 2 does. This manipulation is crucial in order to then produce a drawn plan of this fictitious proposed roadway. Such a drawn plan is presented in Figure 3. The key point to bear in mind here is that it is only through understanding that a second step will involve manipulating the discursive product of surveying practice, that the purpose and rationale for the initial step becomes clear. It also becomes clear, at this point, why a numeric table is preferred over a diagrammatic illustration or verbal representation. Furthermore, it is only through a third step of drawing a longitudinal plan of the proposed facility – in this example, a road – that the underlying purpose of the second step (calculating cut and fill, and road elevations) as a meaning-making practice becomes evident.

In this way, these various transductions of the physical landscape to another representational mode (numeric table) and then another (drawn longitudinal section) constitute what Van Leeuwen (2005) calls a staged and multimodal process in which each stage performs certain functions. Van Leeuwen (2005) uses the term genre to describe this process and argues that the way in which genres are sequenced reveals a strategy aimed at achieving an ultimate goal; this strategy, far from being value-free, reflects culturally, institutionally and historically specific representational forms that act as templates for engaging in communicative or representational work. In addition, each stage constitutes a discursive practice as illustrated using the example of surveying.

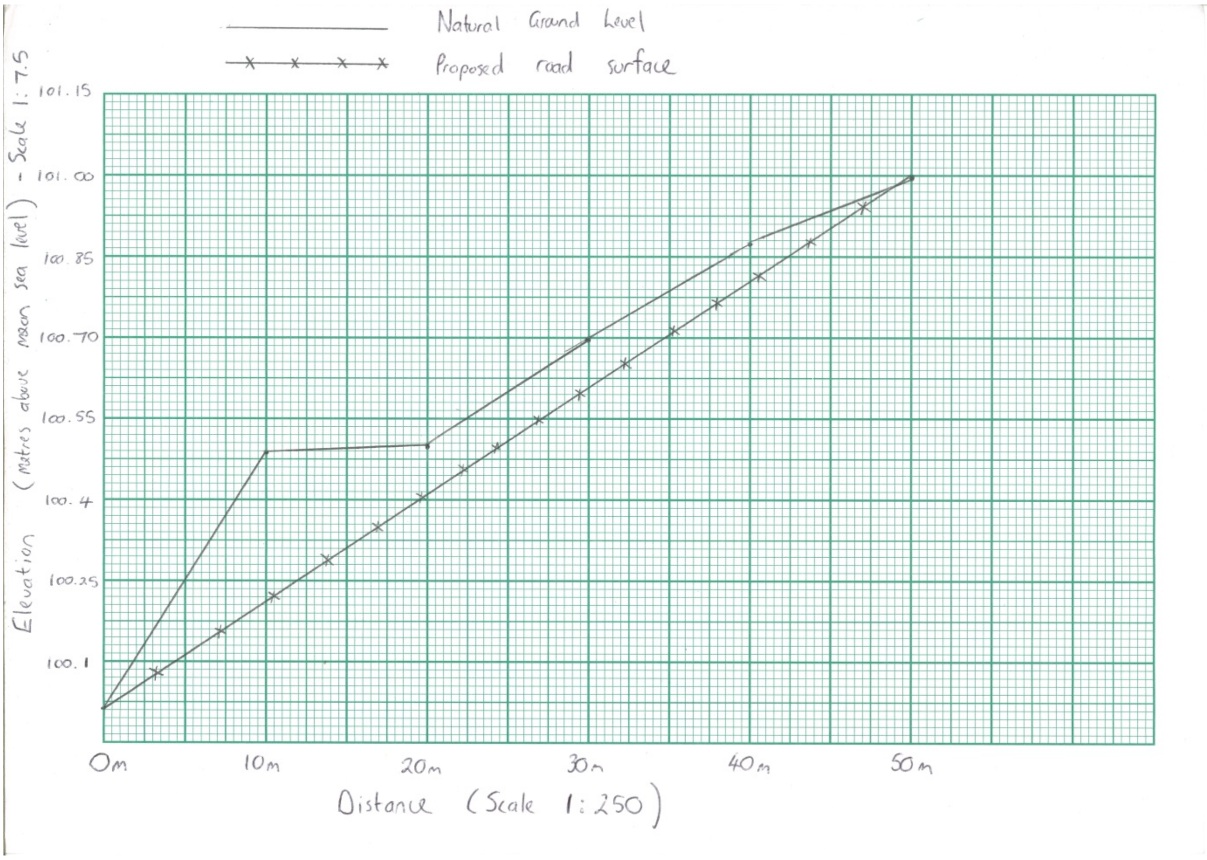

Figure 3. Longitudinal section of proposed road facility.

The Final Transduction: From Drawn Plan to Constructed Facility

The final transduction of meaning in civil engineering practice involves using drawn plans to construct built facilities. This happens in practice only – and not during formal education. As such, this 'final step' is beyond the scope of this paper. However, two points are worth mentioning here.

First, the phase of interim transduction described in the previous section is a simplification of the practice of civil engineering. Indeed, in practice this phase would involve numerous transductions of meaning, in which increasingly detailed plans are drawn using increasingly complex software applications. These drawings will undergo semiotic transduction into the form of models (either physical models or computer-simulated models) and will also undergo semiotic transduction into the form of oral presentations and written reports given to stakeholders, superiors and others.

Second, if each phase provides the purpose and rationale (the meaning-making importance) of its preceding phase, it is this final phase that imbues all of the preceding phases with meaning. This final phase constitutes the end-goal of the myriad representational and communicative practices of civil engineering work. This has significant implications for engineering pedagogy, which are discussed in the following section. However, as an aside, some implications – beyond the scope of this paper – provide strong rationale for aspects of the development of engineering professionals, such as the candidacy phase after graduation, the need for professional registration after this candidacy phase and the need for continuous professional development after professional registration.

Implications for Pedagogy

In this section, I would like to elaborate on four key implications this social semiotic account of civil engineering work elucidates. These implications have already been alluded to in the previous discussion and are discussed here in fuller terms. They relate to the notions of interest, articulation, abstraction and functional purpose.

First, it should not be assumed that the interests of the civil engineer in practice will coincide with the interests of the civil engineering student. To students, the semiotic rules governing communication and representation may seem far-removed and arbitrary. However, because students wield little to no power within the social context of their education, they are unable to challenge these rules. In fact, universities and university lecturers wield little power in this regard as well; instead, such power appears to largely reside in practice, in professional councils and in local and international regulatory bodies. As Barthes (1967: 14) states: these rules are “a collective contract which one must accept in its entirety if one wishes to communicate. Moreover, this social product is autonomous, like a game with its own rules, for it can be handled only after a period of learning”. However, to extend the game metaphor, it is problematic “to make people feel they are a failure when, late in the game, they don't 'make the team' in competition with others who have played the game all their lives” (Gee, 2000b: 66). In South Africa, where there are large discrepancies with regard to access to communicative and representational technologies and practices, and because, as has been shown, engineering education and practice are so intricately tied to these meaning-making technologies and practices, differential access to resources must be accommodated in the educational sphere.

Second, in the particular site of this research, surveying was one of the major stumbling blocks for the first year civil engineering cohort. This may have been for any number of reasons. However, in my dealings with these students, it emerged that one of the reasons may have been what Van Leeuwen (2005) calls articulation. This refers to many students’ reliance on learning the practices of surveying as a procedural list of ‘moves’ (as in first you do this and then you do that), rather than as a systematic, rule-governed method for representing the undulation of the landscape. In this particular context, it appeared that those students who struggled most with surveying practice did so because they could not engage in full articulation of those practices. That is to say, they attempted to rote learn them as a set of procedural steps which stemmed from their uncertainty regarding the ‘logic’ of the equipment utilised, the underlying system of meanings which constitutes engineering surveying, and the purpose of land surveying within the broader activities of civil engineering. This means that, at each stage, students need to be encouraged to engage in full articulation of representational forms as meaning-making resources and not as routinised procedures.

Third, the notion of degree of abstraction can be a useful concept in identifying practices that may pose particular challenges to students. As has been seen in this paper, the practice of engineering surveying involves a high degree of semiotic abstraction which may be aided by the use of interim abstractions that serve to reduce the semiotic ‘leap’ that students need to engage in. In this way, work such as this has the potential to inform practical, classroom-based interventions, not only in engineering surveying but potentially also in areas such as structural analysis and mechanics, which have also proven to be particularly problematic for students.

Finally, each semiotic transduction involved in the engineering education process appears to rely on the subsequent practices to become meaningful. This has implications for sequencing of concepts within curricula. In addition, each semiotic move fulfils a specific function within the larger goals of engineering practice and education. It is thus important to draw students’ attention to these functions, and the larger objectives, so that they can perceive particular meaning-making practices as functional within this context. This will, of course, be limited by the fact that the 'final transduction' only takes place in practice, and outside of the educational experience. Nevertheless, it is only through such pedagogical efforts that all students can potentially come to engage in the full articulation of their communicative and representational practices as meaningful work.

Conclusion

This paper has shown that meaning-making, in a very practical way, is "prospective: it is interest-laden and future-oriented" (Cope and Kalantzis, 2000: 203). It has done so using the particular theoretical framework of multimodal social semiotics. However, two provisos must be noted. First, social semiotics is not the only such framework that may offer explanatory potential within the context of engineering education. Second, nor is social semiotics incompatible with other theoretical frames that may be applied to the engineering educational experience. However, multimodal social semiotics is useful because "academic literacies in the twenty first century entails being able to navigate multiplicity, to critique representations in multiple modes, media and genres, and use a range of technologies in composing multimodal texts" (Archer, 2012: 420). Further research should be undertaken into the social semiotics of engineering education as it appears this may offer useful pedagogical insight. However, engineering education researchers may also choose to explore other frameworks in order to uncover new ways of understanding what happens in engineering students' classrooms and in the texts they produce.

References

Archer, A. (2012). Writing as design: Enabling access to academic discourse in a multimodal environment. *South African Journal of Higher Education*, 26(3), 411-421.

Barthes, R. (1967). *Elements of semiology*. London: Cape.

Biggs, J. (2003). *Teaching for quality learning at university, 2nd ed*. Buckingham: Open University Press.

Cope, B. & Kalantzis, M. (2000). Designs for social futures. In B. Cope & M. Kalantzis (Eds.), Multiliteracies: Literacy learning and the design of social futures (pp. 203-234). London: Routledge.

Gee, J. P. (2000a). The New Literacy Studies: From socially-situated to the work of the social. In D. Barton, M. Hamilton & R. Ivanič (Eds.), *Situated literacies: Reading and writing in context* (pp. 180-196). London: Routledge.

Gee, J. P. (2000b). New people in new worlds: Networks, the new capitalism and schools. In B. Cope & M. Kalantzis (Eds.), *Multiliteracies: Literacy learning and the design of social futures* (pp. 43-68). London: Routledge..

Jewitt, C. (2009). Different approaches to multimodality. In C. Jewitt (Ed.), *The Routledge handbook of multimodal analysis* (pp. 28-39). London: Routledge.

Kavanagh, B. F. (1997). *Surveying: With construction application, 3rd ed*. Upper Saddle River, NJ: Pearson Prentice.

Kress, G. (2000a). Design and transformation: New theories of meaning. In B. Cope & M. Kalantzis (Eds.), *Multiliteracies: Literacy learning and the design of social futures* (pp. 153-161). London: Routledge.

Kress, G. (2000b). Multimodality. In B. Cope & M. Kalantzis (Eds.), *Multiliteracies: Literacy learning and the design of social futures* (pp. 182-202). London: Routledge.

Kress, G. (2010). *Multimodality: A social semiotic approach to contemporary communication*. London: Routledge.

Kress, G. & van Leeuwen, T. (1996). *Reading images: The grammar of visual design*. London: Routledge.

O'Halloran, K. (2009). Historical changes in the semiotic landscape: From calculation to computation. In C. Jewitt (Ed.), *The Routledge handbook of multimodal analysis* (pp. 98-113). London: Routledge.

Van Leeuwen, T. (2005). *Introducing social semiotics*. Routledge: London.

Vannini, P. (2007). Social semiotics and fieldwork: Method and analytics. *Qualitative Enquiry*, 13(1), 113-140.

Acknowledgements

The author expresses his gratitude to the Faculty of Engineering and the Built Environment at the University of Johannesburg and, in particular, the Department of Civil Engineering Technology – its students and staff. This paper is based on on-going doctoral research and the author acknowledges the input provided by his supervisors, Dr Arlene Archer and A/Prof Brandon Collier-Reed, at the University of Cape Town.