

Student Identity and the Need to Make Classroom Mathematics Relevant to Engineering Practice

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Cobb and Hodge's (2005) identity theoretical framework suggests that learning is facilitated if normative identity (realised and co-constructed in the classroom by lecturer and student) is reconciled with core identity (the trajectory of who the student is and where he feels he is going). The cohort of students involved in the study discussed in this article largely embodies trajectories of social mobility, with a great willingness to study engineering for its role in providing a way out of poverty rather than for the sake of the discipline itself. The pedagogic implication is that teaching must proceed sensitive to the reality of the students which is that they potentially have little idea what engineering entails other than a route out of a disadvantaged background.

Introduction

The mathematics instruction for students enrolled for engineering studies at university needs to be relevant to engineering practice and correctly calibrated and scaffolded for the students' levels of mathematical competence in order for the desired learning to occur (Porter and Fuller, 1998). First-year mathematics courses are often in danger of being taught at too abstract a level and not maintaining a connection of relevance with engineering practice and more advanced engineering studies (Craig, 2010; Holmes and Spilker, 2007). Students enrolling for a university degree in engineering do not necessarily begin their studies with an existing idea of what engineering is, other than a professional degree with good employment prospects. This disconnect has implications for classroom activities designed to make connections between classroom mathematics and post-graduation practice as well as the use of mathematics in their engineering courses.

The Academic Development Group at the University of Cape Town has undertaken a longitudinal, cross-faculty investigation into the experiences of a cohort of students who registered at UCT in 2009. I am the representative, on the project team, of ASPECT, the academic support programme in the Faculty of Engineering and the Built Environment (EBE). The project has produced a large quantity of data in the form of questionnaires and interviews. For the purposes of the investigation discussed in this article, the data were interrogated for student expressions of "trajectory". Analysis of the data uncovers a recurring theme of the students expressing their sense of who they were in secondary school and where they hope to go, who they hope to become, through the attainment of an engineering degree. The theoretical identity framework designed by Cobb & Hodge (2005) and Cobb, Gresalfi and Hodge (2009a, 2009b) was found to be useful, both for framing what emerges from the data and for the inevitable implications for classroom instruction.

We ask the question "What core identities (the trajectory of who the student is and where he

feels he is going) are revealed by the students (this cohort, on this data set) in the context of their enrolment for engineering studies, and what are the pedagogic implications?”

Theoretical framework

Cobb & Hodge (2005) define three key constructs of identity from a situated perspective, namely normative identity, personal identity and core identity. These constructs are informed by prior theoretical perspectives on identity development, in particular Boaler & Greeno (2000) and Gee (2001, 2003) and developed through empirical data analysis of a classroom design experiment by Cobb and Hodge. **Normative identity** is defined as the obligations the student understands she needs to fulfil, in the form of social norms and mathematical norms, in order to become a mathematical person. **Personal identity** is involved with who a student actually becomes in the mathematics classroom, her affiliations or alienation with classroom activities (Cobb, Gresalfi and Hodge, 2009a) and her assessment and valuation of her own and other students' mathematical competence. **Core identity**, the construct which is of primary interest in this article, refers to a student's envisioned trajectory, who they see themselves to be and who they want to become. A student's core identity can also be associated with their "life story" which resonates (Cobb, Gresalfi & Hodge, 2009b) with the identity theoretical perspective of Sfard & Prusak (2005).

Cobb & Hodge (2005) argue that their (empirically grounded) identity constructs allow us to account for "students' persistence, interest in, and motivation to engage in mathematical activity as it is constituted in that classroom" (p. 31). Normative identity is co-constructed by teacher and students; the reconciliation of aspects of core identity with the classroom normative identity is correlated with affiliation with mathematical activities.

... building on Boaler and Greeno's work, normative identity as we define it comprises both the general and the specifically mathematical obligations that delineate the role of an effective student in a particular classroom. A student would have to identify with these obligations in order to develop an affiliation with classroom mathematical activity and thus with the role of an effective doer of mathematics, as they are constituted in the classroom. Normative identity is a collective or communal notion rather than an individualistic notion.

(Cobb, Gresalfi and Hodges, 2009a, p. 43)

The constructs of Cobb & Hodge (2005) have been found useful in this article for providing us with a vocabulary for addressing issues related to identity, alienation and classroom community. The construct of core identity in particular was found to be evoked by the student interviews and other data collected for this analysis. Students enter engineering studies with an existing envisioned trajectory related to their intended degree. The reconciliation (or lack of reconciliation) between core identity and classroom normative identity impacts directly on the student learning experience. An understanding of the students' envisioned engineering and mathematical identities can help the teacher design classroom activities to support learning.

Research Methodology

The analysis discussed in this article forms a part of a larger, cross-faculty, multidisciplinary, longitudinal project located within the Academic Development Programme at the University of Cape Town. The project was initiated in 2009 to investigate the experiences of the first cohort of university students who had completed the New Senior Certificate examinations at school and is focused on access and throughput of students from disadvantaged educational backgrounds. Data collection took the form of a questionnaire, two interviews (2009 and 2010), a mathematics and language history, and a technology questionnaire. Data collection is ongoing in the form of interviews. The data for the analysis discussed in this paper is taken

from the 2009 interviews and the mathematics and language histories, specifically from the students registered for a degree in the Faculty of Engineering and the Built Environment (EBE).

The students enrolled in the study, across all faculties, largely come from disadvantaged educational backgrounds. Prevalent among their backgrounds are broken homes, poorly educated parents, inadequate housing, communities rife with drug use and violence, classrooms without teachers or sufficient books, and lack of educational support from teachers and peers. The EBE students were all enrolled in the Academic Support Programme for Engineers in Cape Town (ASPECT) in 2009; I was their mathematics lecturer. ASPECT is a first-year programme and the students join the mainstream cohort from second-year onwards. Fifteen ASPECT students, seven women and eight men, took part in the project and continue to take part in the interview schedule (at time of writing, these students are in their third year at university). The students represented four engineering departments: mechanical, electrical, chemical and civil engineering.

Results

Directing the question “Where do these students want to go; who do they want to become?” at the data, certain answers emerge. The most prevalent answer is that the students want a degree from a university with an excellent academic reputation, a degree which can reliably be expected to get them a good job. The reason why these students have chosen engineering is not particularly for the discipline itself, but because they recognize in themselves, or had that recognition imposed upon them by a bursar, the skills necessary for success at engineering (such as proficiency at mathematics and physics). For instance,

Nwabisa wants an engineering degree because “it counts” and has chosen UCT as “the best university in Africa”.

Tsego sees herself as having a career involving chemistry (either medicine or chemical engineering) – working in a lab in a white coat. She imagines herself earning, having worked hard for a good and “meaningful” degree at a respected university: “UCT is the best, wherever you go, we used to go to Career Exhibitions and they would tell us, ‘If you aren’t at the University of Cape Town, you should be at the University of Witwatersrand or UP’, so UCT was the best and I, because I was the best I decided to choose the best, so I am here.”

Senzo actually chose accounting as his first choice on his application form and engineering as his second. Now, finding himself in electrical engineering, he admits to being puzzled at the relevance of what he is studying in physics, but that does not matter. He is passing and is slowly but steadily approaching graduating with a degree with which he can get a good job and that is all that apparently matters to him.

Siphilisiwe considers that UCT is “the best university, you know, in my opinion, you know I thought I wasn’t going to go to any university but UCT”.

John discusses quite passionately how Engineering is the only subject of tertiary study known in his community – if you study at university, what you study is Engineering. Almost coincidentally, he is happy in his chosen field, but he speaks about how he wants to alert his community to the wider options available. [Concern about students’ ignorance of wider options and determination to choose a professional degree programme straight out of secondary school was publicly expressed recently (2011) by Dr Max Price, Vice Chancellor of UCT.]

Philile refers to his “future look[ing] good” because of his choice of study, which he went

into on advice from others who suggested Engineering studies because of his skill at mathematics.

Escape or upliftment from poverty and disadvantaged circumstances was the next most prominent theme in the data, inevitably tightly entwined with the theme discussed above, that of the buying power of a degree. Asked to talk about herself, almost the first thing Nwabisa says is *“I come from a disadvantaged family, my mom was not working, my dad was the only one working but I think at Grade 10 he left and he decided OK, and then he left and then ja, so we were kind of struggling financial.”*(interview). John says *“I began to see the future especially when I was doing grade 12 I saw how are the living conditions at home then I asked myself how can I change them then there was only one answer for that question education and no one can take it away from me but I can use it to get a better life for me and my family and also do something to help in the community”* (mathematics and language history).

In the pool of 15 students taking part in this study, only two are studying engineering for the sake of the discipline itself. One of the students had a friend whose father was a civil engineer and her observations of his work had inspired her to follow a career as a civil engineer. Another student had seen programmes on television associated with engineering and had been similarly inspired to study mechanical engineering. Other than these two examples, none of the students gave any evidence that their chosen field of study was for the sake of the discipline rather than social mobility.

The theme of skill at mathematics is strongly present in the data. Naïve interpretation of the data might conclude that the students are studying engineering for the sake of the mathematical content of the subject. Such an interpretation would be insufficiently nuanced for two reasons. First, the interviews and mathematics and language histories explicitly address questions related to mathematics to the students; it is inevitable that there would be much discussion of mathematics in the data. Secondly, the student narratives suggest that the path of reasoning was “I am good at mathematics. Taking advantage of that skill, what degree can I get at university which will lift me and my family out of poverty?” It is inevitable that discussion of why they chose to study engineering would result in talking about their skill at mathematics.

Trajectory of one student: Senzo

Each interview lasted approximately an hour. As such, there is a great deal of text in the interview transcriptions from which excerpts can be drawn to develop an idea of a student’s envisioned trajectory. To illustrate one student’s situation, passages have been shown below from Senzo’s interview. The evidence is necessarily only a portion of that available in the full interview transcript. Notably absent from the selections below are many more references, present in the interview, to how hard this student works, how dedicated he was to study of both mathematics and physics in high school and how focused he is on passing.

Interviewer: OK, so do you think you were a successful student?

Senzo: At my school? ... I think.

...

Interviewer: So what made you a successful student?

Senzo: To study hard.

Interviewer: Ok

Senzo: It’s like when I was, because in Grade 10 we didn’t have a Maths teacher, right ne, so in Grade 11 our Maths teacher have to start us from scratch, so

he didn't complete the Grade 11 work, same applies in Grade 12. When I saw that in June exam in Grade 12, I got 40% and I was like 'Eish', then I started thinking, 'no I am not going to do this again', then I try hard, like I was like Grade 12, then at 5 o'clock I wake up and go to study every day after the June examination, we continued doing that and then in trial I got around 69% in Maths, then continued waking at 4, then in the final I get 83%.

Interviewer: OK, so besides the studying how important was your self image at school in your final year?

Senzo: Like I can say I learnt, I didn't mind whatever people were saying about me as long as I know who I am ... I just forget everything they are saying and focus on my life..

Interviewer: Why did you come to UCT?

Senzo: [My teacher] told me it's the best school in South Africa ... So I chose it because I want to be in the best school, ja

Senzo: Like here my first choice was B.Com Accounting ne, but they reject me, then they wait to put me in Electrical Engineering.

...

Interviewer: So now you are doing, what are you doing?

Senzo: Electrical.....

Interviewer: So you were admitted into Electrical even it wasn't your first choice?

Senzo: It was actually my second choice

...

Interviewer: But are you still happy doing that?

Senzo: Ja, I'm still happy.

Interviewer: Or you still want to do your Accounting?

Senzo: No, I don't want to change now.

Interviewer: What do you do when you [and your friend] are together besides studying?

Senzo: Besides studying, chilling.

Interviewer: Chilling?

Senzo: But I just chilling for a few minutes because most of the time I am studying ... Ja, just chilling like for watching TV, 30 minutes just to relieve the mind, then after 30 minutes for back to the book.

...

Interviewer: So have you found a girlfriend yet?

Senzo: No ... I don't want because it's like she is going to disturb me in my books. I don't want anything to disturb me.

Interviewer: OK, so you want to stay focussed.

Senzo: Ja, stay focussed.

Interviewer: What role do you think Maths is going to play in your programme?

Senzo: Ja, I don't know yet, because like in Physics I thought I am going to do like the part, the Electrical part, but I'm doing Projectile everything, I'm still researching exactly why I am doing Physics and Maths in Electrical Engineering, ja.

Senzo is at UCT because it is the "best school in Africa". He chose two academic

departments (Accounting and Electrical Engineering) both among those programs of study typically suggested to people who excel in mathematics. Although Electrical Engineering was his second choice of study and despite the fact that he does not understand why his current topics of study (such as projectile motion) are included in the degree, he is happy with where he is because he is passing. Each student completed a background questionnaire, from which data it can be seen that Senzo was brought up by elderly grandparents in the rural Eastern Cape, went to schools with insufficient and poorly prepared teachers, insufficient textbooks, exposure to violence, and lived in a community where drug use and violence were rife. An engineering degree (or one in accounting) would provide potential for economic and social upliftment for him and for his family.

Discussion

The students taking part in this study are hard working students who were successful at school, winning academic (and other) prizes. They continue to be hard working at university, tightly focused on passing and achieving academic success, often to complete exclusion of a social life. A repeated motif in the student interviews and in the mathematics and language histories is the information that the students made a decision in secondary school, or in some cases as early as primary school, to study engineering, either as a discipline for its own sake or, far more prevalent, for its promise of a better future for themselves and their families. This study suggests that, in a majority of cases, the fact that we are teaching them **engineering** is irrelevant. We could be teaching them aardvark farming and, as long as UCT aardvark farming degrees are respected and internationally recognized and jobs in aardvark farming are thick on the ground, the students would be thrilled.

I have discussed elsewhere (Craig, 2010), as have others (Porter and Fuller, 1998; Stevens et al, 2008) , that drawing explicit links between classroom activities and real-world engineering is necessary for development of engineering identity, and that such identity is advantageous for engagement with studies and ultimately graduation. Employing the language of Cobb and Hodge's key identity constructs, such an approach attempts to reconcile the co-constructed normative identity developed in the classroom with a core identity associated with an envisioned trajectory towards becoming an engineer. The findings of the study discussed in this paper have continued the argument and increased the necessity that connections need to be made between the classroom and real world practice. The students all necessarily have a core identity in some way connected to studying engineering, yet their envisioned futures are not so much as practising engineers but as people who have escaped poverty by acquiring through hard work a degree with strong potential for getting them a good job. The data available to me in this research project is almost entirely confined to students in the academic support programme. Students enrolled for mainstream studies might have a similar view of engineering to the students discussed above, or it might be the case that the more affluent students enrolled for mainstream studies exhibit a core identity more in line with an "engineering identity".

I tend to think of my students as having some sense of identity similar to "I am a novice engineer" and I consider it my responsibility to nurture that sense and develop it by showing how the mathematics we encounter in the classroom can be used in more advanced engineering studies or in real-world engineering. Within this context I have designed classroom activities based on real world engineering examples and projects aimed at allowing students to personally discover classroom mathematics in real world engineering (Craig, 2010). These activities have assumed a degree of interest in engineering mathematics, with me seeing my role as providing links between their understanding of mathematics in

engineering and real world practice. With the insight gained from the study discussed in this article I recognise that the students might have far less of an understanding, however partial or flawed, of the role of mathematics in engineering studies and practice. While the activities and projects I already have in place can still be seen to have value, I recognise that a more fundamental level of alerting the students to the role of mathematics in engineering is required. With a class of students who have a good idea of what engineering entails and with some interest in the real-world activities of an engineer, there is some (but not much) excuse for a mathematics educator to take for granted that the students can see the potential use of first-year mathematics in engineering. With a class of students who have little to no idea of what being an engineer means or what the work of an engineer might entail (despite some of the interviews in this project taking place in the second semester after exposure to their Introduction to Engineering courses), the educator needs to be constantly making clear what role classroom mathematics is playing in the overall degree structure.

If my aim is to teach the students engineering mathematics in such a way that they recognise its relevance, enjoy it and can continue to 2nd-year mathematics with a minimum of trouble then I want the normative identity which I co-construct with the students to reconcile with their existing core identities. Their envisioned trajectories, central to their core identities, are towards being an engineer. However, a key point worth noting is that, although they are determined to become engineers, it is not for the sake of the discipline itself, nor with much or any understanding of what real-world engineering entails, but rather because they understand engineering to be a career with good employment prospects and the potential to lift them out of poverty.

I consider enrolling for engineering studies for purposes of social mobility and economic upliftment as good a reason as any. Our role as engineering educators, under these circumstances, is to develop an understanding of what engineering is and how the specific subjects we are teaching fit into the structure of the degree programme. In the current educational climate in South Africa, we are fortunate to have the opportunity to contribute to the socio-economic ambitions of some of the top students in the country.

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