This is an extract, with permission, from the proceedings of the 2011 SASEE Conference. The citation is:

Luckay, M., & Collier-Reed, B. I. (2011). Admitting Engineering Students with the Best Chance of Success: Technological Literacy and the Technological Profile Inventory (TPI). Paper presented at the 1st Biennial Conference of the South African Society for Engineering Education, Stellenbosch, 133-144.

Admitting Engineering Students with the Best Chance of Success: Technological Literacy and the Technological Profile Inventory (TPI)

Melanie Luckay[1] and Brandon I. Collier-Reed[2]

Centre for Research in Engineering Education & Department of Mechanical Engineering, University of Cape Town, South Africa

[1] mb.luckay@uct.ac.za, [2] brandon.collier-reed@uct.ac.za

Abstract

In this article we describe the development and validation of an instrument – the *Technological Profile Inventory* (TPI). The instrument can be used to determine whether an applicant's level of technological literacy is suitable for admission to an engineering programme. It might be argued that students entering an engineering programme should demonstrate a level of technological literacy, not sought during the admission process at most universities in South Africa, which rely primarily on the National Benchmark Testing instrument and the National Senior Certificate examination results. The items used in the TPI were drawn from a previous study (Collier-Reed, 2006) and were based on a rigorous qualitative analysis of interview data which was in turn informed by categories that emerged from a phenomenographic analysis. Data were collected from 198 Engineering and 237 Commerce students and the items subjected to exploratory factor analysis and Cronbach alpha testing. The result of the analysis was a modified version of the TPI where the data were found to be reliable and valid. The significant factors that defined the 'nature of technology' were found to be the view of technology as either an *artefact* or related to a *process*, while those constituting 'interaction with technological artefacts' were *direction* and *tinkering*. A cohort analysis suggests that the anecdotal view of the possible difference in technological literacy between Commerce and Engineering students is supported by the data – Commerce students are statistically more likely to view technology as an artefact and interact with technological artefacts only when directed to do so, a less technologically literate position. Further work involves determining how to meaningfully combine the scores achieved by an individual completing the TPI to ultimately determine a score indicative of their applicable level of technological literacy.

Introduction

The South African school curriculum has been in a state of flux for more than a decade. The move to Outcomes-Based Education (OBE), which was initiated by Curriculum 2005, reached a milestone in 2008 with the first students matriculating with the National Senior Certificate (NSC). Concerns were raised when the Mathematics pass rate rose by 225% between 2007 to 2008, with significantly greater numbers of students achieving 80% or more. A similar, yet less drastic trend was shown in the Physical Science results. A panel of experts investigated this trend, concluding that, though the standard of the examination was appropriate, "there was a lack of differentiation at the level of A and B" (Department of Education, 2009). Therefore, it might be argued that A and B symbols in Mathematics and Physical Science might not be useful indicators of students' success in engineering programmes, which might imply that in general the NSC as an admission differentiator might be less useful, as significantly more students were meeting minimum entrance requirements and being accepted into engineering programmes.

A number of universities in South Africa have adopted the National Benchmark Testing (NBT) instrument to provide complementary information to the NSC about admission choices. One of the objectives of the NBT is to "assess the relationship between higher education entry level requirements and school-level exit outcomes" (Higher Education South Africa, 2009, p. 1). One of the aspects included as part of this testing is Quantitative Literacy which aims to assess the "ability to manage situations or solve problems of a quantitative nature in real contexts relevant to higher education" (National Benchmark Tests, 2011). The University of Cape Town has for the 2012 admission cycle included scores achieved by applicants for the NBT in the composite score used for admission into engineering programmes (University of Cape Town, 2011, p. 33)

However, it might be argued that students entering an engineering programme should have more than just a demonstrated competence in Quantative Literacy. They should rather have a certain level of technological literacy (of which Quantitative Literacy can be considered an aspect) in order to have the best chance of success in their chosen engineering programme. There are a number of reasons why students elect to study engineering (Reed & Case, 2003), with psychometric testing, bursary availability, school marks in Mathematics and Physical Science being some factors that bare little relation to a learner's innate ability to engage in technological activities. In fact, it is quite possible that these potential engineering students are "technologically phobic" (Collier-Reed, 2006, p. 145) in that they experience interacting with technology as a "potentially intimidating experience" (Collier-Reed, Case, & Linder, 2009, p. 301). There is no claim being posited that should an engineering student on entry to university not have an advanced level of technological literacy that they will not be successful in an engineering programme. Rather, it has been argued in our earlier work (Collier-Reed, 2006) that learners with more simplistic levels of technological literacy may possibly be less suitable candidates for admission.

In order for applicants' levels of technological literacy to be included as part of the suite of characteristics available for admission decisions to be based upon, it is necessary to be able to accurately determine just what these are at an individual level. This article introduces an instrument that can be used to determine an applicant's level of technological literacy – the *Technological Profile Inventory* (TPI).

What it means to be technological literate

There have been many definitions of what it means to be technological literate. When the term was first used in this context in the 1970s, it was understood as something that incorporated the "knowledge and skills needed to function in a society dominated by technological innovation" (M. A. Rose, 2007, p. 35). In the years since, various researchers (cf. Barnett, 1995; de Vries, 2005; Devon & Ollis, 2007; Gagel, 1997; Hayden, 1989; Kahn & Kellner, 2005; Waetjen, 1993) and organisations such as the International Technology Education Association and the National Academy of Engineering (ITEA, 2000/2002/2007; Pearson *& Young*, 2002) have put forward their own definitions of what it means to be technologically literate. In previous work we have argued that for a person to be considered technologically literate, they must "understand the nature of technology, have a hands-on capability and capacity to interact with technological artefacts, and … be able to think critically about issues relating to technology" (Collier-Reed, 2006, p. 15). It should be noted that action (or *doing*) forms a central part of all aspects relating to this definition.

Ingerman *& Collier-Reed* (2011) suggest that "what it *is* that is required in order to be considered technologically literate remains difficult to articulate as there is no one universal set of requirements that satisfies technological 'literateness'" (p.138 - italics in original).

Furthermore, what people would need to *be* to be considered technologically literate "would vary depending on the socio-cultural context in which they found themselves" (ibid). Ingerman *et al* go on to suggest that typical definitions (such as that presented above) focus nominally on the *content* of technological literacy and don't recognise the importance of a complementary feature of technological literacy – *function*. They argue, drawing on the definition of function in the Oxford English Dictionary (Simpson, Weiner, & Oxford University Press., 1989) that the function of technological literacy is the "mode of action by which technological literacy fulfils its purpose" (p. 139).

Waetjen (1993) suggests that "people can, and do, live without the faintest notion of the nature of technology" (p. 5) – the intrinsic, or characteristic, qualities of technology (Collier-Reed, 2006, p. 15). Two Gallup surveys undertaken to assess what North Americans think about technology (L. C. Rose & Dugger Jr, 2002; L. C. Rose, Gallup, Dugger Jr, & Starkweather, 2004) support this view. In these surveys, more than two-thirds of respondents indicated that the first thing that came to mind when they heard the word technology was *computers*. This was followed by electronics at 5%. We would argue then that for many people, technology is seen as involving computers and technological literacy as involving "competence" (Barnett, 1995, p. 120) in the interaction with computers.

Given that engineering degrees by design lead to technologically focussed vocations, one could reasonably assume that seeing technology simply as computers is not useful. Although one could assume that a graduate attribute of an engineering programme should be technological literacy, we would argue that it would improve the chance of success of students in a programme if they entered with a more developed conception of the nature of technology and level of technological literacy.

The Technological Profile Inventory (TPI)

In our previous work, we interrogated the dimensions of technological literacy presented above and after a phenomenographic analysis of interview data described five qualitatively different ways of experiencing the nature of technology (Collier-Reed, 2006) and four qualitatively different ways of experiencing interacting with technological artefacts (Collier-Reed, *et al*., 2009). These categories of description are presented in Table 1. We argue that collectively, these dimensions of technological literacy satisfy the core content requirements for what it means to be technologically literate.

Table 1. Ways of experiencing the nature of technology and interaction with technological artefacts

The nature of technology is conceived of as:	**Interaction with technological artefacts is through:**
An artefact	Direction
The application of artefacts	Instruction
The process of artefact progression	Tinkering
Using knowledge and skill to develop artefacts	Engaging
The solution to a problem	

In order to be able to classify students relative to these categories, and hence ultimately to be able to describe their technological profile, we developed a series of statements that could be used to interrogate students' views on these dimensions of technological literacy. It was important when developing the statements to ensure that they were in fact representative of – or attributable to – the categories under consideration. In order to ensure this congruence, the interviews that were previously phenomenographically analysed were reanalysed with a focus now on the individual. Sections of an interview which related to a specific category were 'assigned' to it, resulting number of clearly defined statements pertaining to each category.

As an example of how the essence of a section from an interview was used in the development of a statement, consider the following extract that was classified as belonging to the category 'Technology is conceived of as an artefact':

> Well, it's a bit complicated, firstly. It's *very technological*. It's exactly what I was talking about, what I said *complicated wires* and *things that you don't understand*, it *looked* like technology. (Italics in original)

From this interview extract, the following representative statement was constructed: *Things with complicated wires and parts that you don't understand are technology*. The critical feature of the statements resulting from this process is that they originate from the interviewees own comments and are thus in the style to which they can relate. The draft TPI was defined by 41 statements constructed in this way. There were 25 statements relating to experiencing the nature of technology (see Table 2), and 16 statements relating to the experience of interacting with technological artefacts (see Table 3).

Table 2. Questions relating to the nature of technology

Technology as an artefact	
39.	Having wires coming out of things makes them technology.
06.	Because a door has a handle and hinges and can be locked, is it technology?
38.	A washing machine on a rubbish dump with no motor or wires is not technology. It is just a thing.
30.	Things with complicated wires and parts that you don't understand are technology.
19.	Technology is all about computers and other electronic and electrical things like that.

Technology as the application of artefacts	
40.	A door lock becomes technology when a key is turned in it and the levers move to lock it otherwise it is just a lock.
07.	A map is technology because satellites were used to give the information needed to make it.
04.	A CD is technology when you put the CD into a computer and then copy music onto it.
36.	An amplifier or CD player becomes technology when it is switched on.
34.	A television is technology when you can watch a movie on it using a signal from the air.

Technology as the process of artefact progression	
31.	Technology is when a product progresses and develops over time.
01.	Technology is something that has advanced over time and that makes life easier for you.
21.	The process that goes into making (for example) a running shoe makes the shoe technology.
23.	Technology is the process of progressing from something like the horse-and-cart to a motorcar.
16.	Technology is the changing or development of a product to help you in your life.

Technology as using knowledge and skill to develop artefacts	
37.	Technology is the planning and research of something and then the making of it.
27.	Technology is using knowledge and skill to develop some product.
32.	Something is technology because a person had a plan that was put into practice by making it.
14.	Technology is about using scientific knowledge to make something that makes life easier.
22.	Technology is using knowledge to evolve and develop to a product.

Technology as the solution to a problem	
35.	Technology is about solving a problem.
20.	Technology is making use of knowledge people have about something and using this to solve a problem.
13.	Technology is an idea that has been put into place by someone to help people.
09.	Technology is coming up with an idea to solve a problem.
02.	Technology is a person making something to solve a problem and improve quality of life.

Table 3. Questions relating to interacting with technological artefacts

Interaction with a technological artefact is through direction	
05.	I always ask permission before I use some new technological thing in case I break it.
28.	I would rather watch someone work with a complicated technological thing instead of trying to do it myself.
33.	I always seem to do something wrong when I try to use technological things.
15.	I would rather get someone else to work a technological thing. I might get it wrong or mess it up.

Interaction with a technological artefact is through instruction	
24.	If someone first shows me how to do something with a technological thing then I can use it.
17.	With instructions, I would be able to find out how to do what I want with this technological thing.
25.	When using technological things, instructions tell me exactly what to do – and then I can do it.
41.	I can usually use technological things when I follow instructions.

Interaction with a technological artefact is through tinkering	
11.	When I see a new technological thing, the first thing I want to do is play around with it to see what it can do.
03.	I would rather play around with a technological thing than waste time reading instructions about how to do it.
12.	I like opening up technological things to see what's inside.
08.	It is fun figuring out how technological things work without being given instructions to follow.

Interaction with a technological artefact is through engaging	
29.	I like to understand a technological thing by playing with it as well as by reading more about it.
10.	With a new technological thing, I read the manual a bit and play with it a bit – whichever helps me most.
26.	Finding out how a technological thing works is easiest by reading the manual and playing around at the same time.
18.	To find new features on the technological thing and understand it better, manuals often help.

A 41 item pilot instrument emerged from this analysis with the statements presented in Table 2 and Table 3 arranged in random order – the numbers alongside each statement indicate the order in which they were presented on the pilot instrument. The instrument was now subjected to wide-scale testing to confirm the validity and reliability of the items.

Exploratory analysis of the TPI

Data were collected from 435 students in May of their first year of study at the University of Cape Town. The groups were split between Engineering (198) and Commerce (237) students. These two groups were chosen because not only do both have similar admission criteria, but evidence suggests that the Faculty of Commerce is not typically in direct competition with the Faculty of Engineering and the Built Environment for students (Donald, 2011). We would argue that the requirement to be technologically literate is more desirable in the latter.

Participants were required to supply biographical information in the form of their age, gender, and degree programme. From this information, it was determined that the sample consisted of 63% males and 36% females – five people did not indicate their gender. The average age of the students was 18 years 11 months (*SD* = 2.89, range = 16-29 years).

The participants were informed that the purpose of the study was to explore their ideas about technology. We administered the questionnaires personally to ensure consistency in the instructions given to the students and to answer possible queries. During the instruction session (which lasted on average 6 minutes), the students were told that completion of the questionnaire was voluntary (no student objected to completing the questionnaire), and that all responses were confidential. Participants were required to mark on a seven-point Likert scale (Cohen, Manion, & Morrison, 2000) their level of agreement with each item on a scale ranging from *Strongly Disagree* to *Strongly Agree*. The questionnaire took between 13 and 20 minutes to complete.

The data collected from the students were used to examine the validity and reliability of the TPI. As a first step, a factor analysis was performed to group or cluster variables (Field, 2005). In order to perform a factor analysis, an appropriate sample size is required. The sample size for the present study was appropriate as Tabachnick and Fiddell (2007) suggest that "it is comforting to have at least 300 cases for factor analysis" (p. 613), where in the present study the sample consists of 435 students. In addition, other authors suggest that the ratio of the items to subjects is of importance (Nunnally, 1978). Indeed, Nunnally (1978) recommends a ten to one ratio, that is, 10 cases for each item to be factor analysed. Others suggest 5 cases for each item (Tabachnich and Fiddell, 2007). On the whole, the data in the present study fit the requirements for both sample size and case to item ratio.

The data was imported into SPSS, the statistical analysis software package, and a principal component factor analysis using the varimax method of factor rotation was performed to obtain a small number of more unique indices, Initially, this analysis derived a nine-factor solution which accounted for 52.3% of the variance. Items with a factor loading of less than 0.3, and items whose factor loadings were low, were removed from further analysis. These items were thus of low value in contributing to the overall view of those completing the TPI. The remaining scales were subsequently re-analysed, and a six-factor solution was obtained accounting for 54.5% of the variance.

The factors emerged in line with the categories presented in Table 1 – which was not unanticipated as the items themselves were developed based on a rigorous qualitative analysis of interview data which was in turn informed by categories that emerged from a phenomenographic analysis (Collier-Reed, 2006). These factors were subsequently collectively named in line with the original categories described in Table 1 and are shown in Table 4. The factors contain items from Table 2 and Table 3 as follows: *Artefact* (items 39, 40, 38, 36, 34, 30); *Process* (35, 16, 14, 09, 02, 01); *Direction* (15, 28, 33); *Instruction* (24, 19); *Tinkering* (03, 08, 11); and *Engaging* (10, 29, 26). The eigenvalues ranged between 1.1 and 3.6.

Table 4. Factor loadings for a modified version of the TPI

Factor Loading						
Item No.	**Artefact**	**Process**	**Direction**	**Instruction**	**Tinkering**	**Engaging**
39	0.74					
40	0.73					
38	0.73					
36	0.71					
34	0.43					
30	0.40					
35		0.73				
16		0.69				
14		0.69				
09		0.59				
02		0.57				
01		0.40				
15			0.79			
28			0.78			
33			0.63			
03					0.79	
08					0.73	
11					0.68	
10						0.72
29						0.71
26						0.71
24				0.81		
19				0.70		
% Variance	15.5	11.8	8.7	4.9	7.8	5.9
Eigenvalue	3.6	2.7	2.0	1.1	1.8	1.4

Factor loadings smaller than 0.30 have been omitted. *n* = 435

The analysis presented in Table 4 indicates that the items making up the factors relating to the nature of technology fall into two rather than the four categories presented in Table 1. The first is a category related to understanding technology in terms of *artefacts* (cf. the Gallup poll described earlier) and the other which recognises technology to be related to *process* and the solution to problems. The factors that emerge relating to interaction with technological artefacts align very well with the categories described in Table 1 in three of the four instances.

For the revised 23-item TPI, a further index of scale reliability and validity were generated. Table 5 shows that the internal reliability – the Cronbach alpha coefficient – for the TPI scales ranged between 0.60 and 0.73.

Table 5. Cronbach alpha coefficient for the modified version of the TPI

Category	Scale	No. of Items	Cronbach alpha coefficient
Nature of Technology	Artefact	6	0.73
	Process	6	0.68
Interacting with a Technological Artefact	Direction	3	0.71
	Instruction	2	0.62
	Tinkering	3	0.64
	Engaging	3	0.60

Kline (1999) notes that although the generally accepted value of 0.8 as a Cronbach alpha co-efficient is appropriate for cognitive tests such as intelligence tests, for ability tests a cut-off of 0.7 is more suitable. He goes on to say that when dealing with psychological constructs, values below 0.7 can, realistically, be expected because of the diversity of constructs being measured – as in the case of the present study. Overall, these results indicate that the internal consistency for the TPI is satisfactory for an exploratory study of this nature.

Taken together, the results from the factor analysis, as well as the index of scale reliability and validity (the Cronbach alpha reliability index) suggest that the Technological Profile Inventory is reliable and valid for use amongst the group that would be targeted as part of an admissions process and can therefore be used with confidence.

Cohort comparison based on TPI data

Notwithstanding the fact that the data collected were from a 41-item pilot instrument, it is possible to extract the responses received to the questions relevant to the updated 23-item instrument. In so doing, it is possible to perform a preliminary analysis of the differences between the Commerce and Engineering students as highlighted by the revised TPI.

A one-way between-groups multivariate analysis of variance (MANOVA) was performed to investigate group differences (see Table 6). Six dependent variables were used, namely, *Artefact, Process, Direction, Instruction, Tinkering,* and *Engaging*.

The results show that there was a statistically significant difference between the Commerce and Engineering students' responses to the TPI on the combined set of dependent variables F (6, 428) = 6.51, p = 0.000. When the results for the dependent variables were considered separately, there was a statistically significant difference on the scales *Artefact* F (1, 433) = 7.011, p = 0.008; *Direction* F (1, 433) = 19.57, p = 0.000; and *Instruction* F (1, 433) = 15.81, p = 0.000. Closer inspection of the mean scores indicated for each of the three scales, showed that Commerce students showed higher levels of agreement with the statements in the scales *Artefact* (M = 3.57, SD = 1.15) compared to the Engineering students (M = 3.28, SD = 1.05); *Direction* (M = 3.32, SD = 1.48) compared to the Engineering students (M = 2.73, SD =

1.19); and *Instruction* (*M* = 4.74, SD = 1.14) compared to the Engineering students (*M* = 4.28, *SD* = 1.28).

Table 6. Differences between the responses of Commerce and Engineering students (MANOVA)

Scale	**Commerce**			**Engineering**				
	M	**SD**	**n**	**M**	**SD**	**n**	**F**	**p**
Artefact	3.57	1.15	236	3.28	1.05	198	7.011	0.008*
Process	5.38	0.81	236	5.37	0.82	198	0.012	0.913
Direction	3.32	1.48	236	2.73	1.19	198	19.57	0.000*
Instruction	4.74	1.14	236	4.28	1.28	198	15.81	0.000*
Tinkering	5.23	1.23	236	5.36	1.18	198	1.38	0.241
Engaging	4.97	1.27	236	4.88	1.36	198	0.446	0.505

* $p<0.05$

Discussion

The statistical analysis undertaken on the 435 student responses collected suggests that the factors to emerge are valid and reliable. It has already been discussed how the association between items – and hence the factors – align with the phenomenographic categories determined in an earlier study (Collier-Reed, 2006).

A careful consideration of the factors as they emerged from the analysis (see Table 4 and Table 5) suggests that the factor associated with the interaction with technological artefacts through *instruction* was possibly less useful in measuring what was originally intended by this category. The focus of this category is on receiving “instruction via some means which enables the interaction with an artefact” (Collier-Reed, et al., 2009, p. 299). The two items to emerge that could potentially constitute this category are from Table 3: 19) *Technology is all about computers and other electronic and electrical things like that*; and 24) *If someone first shows me how to do something with a technological thing then I can use it*. While item 24 is clearly related to the category as described, item 19 is less so and yet the Cronbach alpha coefficient (see Table 5) was 0.62 which suggests that the internal consistency of these two items can be considered reasonable – albeit only just so.

It was argued previously that a Cronbach alpha coefficient greater than 0.70 in an analysis is preferred, but that a coefficient of more than 0.60 is also acceptable in Social Science studies of this nature. Table 5 shows the co-efficients achieved in this analysis with the co-efficients for *instruction* and *engaging* having the lowest values (0.62 and 0.60 respectively). The research objective described in the introduction relates to developing an instrument that can provide useful data on an applicant’s level of technological literacy to help in the admission process. Careful consideration of the factors as they emerged suggests that it would be possible to omit *instruction* and *engaging* from the instrument without a reduction in the value of the information obtained.

The two factors that would remain as part of the ‘interaction with technological artefacts’ categories – *direction* and *tinkering* – are the essence of the possible ways of interacting with technological artefacts. In our previous work (Collier-Reed, et al., 2009) we have described the experience of interacting with a technological artefact through *direction* as

> the result of a directive by someone. It is not something that happens spontaneously as there is a reluctance to making a first move towards approaching it. This category describes the experience as being on the outside looking in towards a technological artefact as a reified object; the artefact is placed on a 'pedestal' in an exalted, unapproachable position. (p. 298)

Tinkering on the other hand is described as being

> characterised by a self-initiating interaction with a technological artefact by beginning to tinker with it. … [T]here is no need for instruction to enable this interaction. There is no sense of being intimidated by anything to do with the artefact. … [They] recognise that an artefact has a variety of functions and set out to determine what they are and make the artefact operate. (ibid, p. 299-300)

Turning our attention to the factors that define the nature of technology, Table 5 indicates that viewing technology as either an *artefact* or as related to a *process* achieved Cronbach alpha coefficients of 0.73 and 0.68 respectively. The categories described in Table 1 for the nature of technology are fourfold, viz technology as an artefact, the application of artefacts, the process of artefact progression, using knowledge and skill to develop artefacts, and the solution to a problem. In the first two categories, the nature of technology is seen primarily in terms of the artefacts themselves. In the final three categories, artefacts are simply *part* of what makes up the meaning of technology and that here the nature of technology is seen as collectively involving the application of knowledge, design, and production in the development and use of objects, systems, and processes to satisfy human needs – an altogether more advanced conception of the nature of technology.

When one considers the cohort analysis between the Commerce and Engineering students' responses to the TPI, three factors showed a statistically significant difference, namely, *artefact*, *direction*, and *instruction* (see Table 6). It has been argued above that *instruction* is a factor that will not be taken forward as part of the TPI.

While considering the nature of technology, one could anecdotally expect that Commerce students may be more inclined to conceive of technology as being related to artefacts than Engineering students. It could be argued that students electing to follow a programme in engineering do so in part because they recognise that technology – the core of their intended profession – does not simply revolve around artefacts, but rather involves all the aspects described earlier, viz the application of knowledge, design, and production in the development and use of objects, systems, and processes to satisfy human needs. The results presented in Table 6 empirically support this anecdotal view. Although the students had a similar mean score for the *process* factor (3.57 vs 3.58 for Commerce and Engineering respectively), there was a statistically significant difference between the students with respect to the *artefact* factor. As expected, Commerce students were statistically more likely to agree that the nature of technology was related to artefacts.

Turning our attention to the factors related to the 'interaction with technological artefacts'. The argument could be made that due to the nature of the profession, Commerce students may be less inclined to tinker with technological artefacts and rather interact because they are required to do so based on a particular situation in which they find themselves. In Table 6, the mean scores for *tinkering* (5.36 vs 5.23 for the Engineering and Commerce respectively) suggest that engineers more strongly agree with this factor – although not statistically significantly so. However, there is a marked difference in the means of the *direction* factor. Here, *direction* is statistically significant between the two groups with means of 3.32 and 2.73 for the Commerce and Engineering students respectively. Commerce students more strongly agree that interaction with technological artefacts is through *direction*.

Although we argued above for the exclusion of the *engaging* factor from the TPI, it is useful to nevertheless consider this factor as the mean scores are contrary to what we would consider to have been the anticipated outcome for the two groups (see Table 6). One could have expected, given that experiencing interacting with technological artefacts through engagement is the most complex or advanced (Collier-Reed, et al., 2009, p. 298), engineering students would have had a stronger agreement with this factor than commerce students. This turned out not to be the case with Commerce students having a mean of 4.97 and Engineering students a mean of 4.88 for this factor. Although the one-way between-groups multivariate analysis of variance did not show the difference between groups at the level of $p<0.05$ to be significant, the fact remains that anecdotal evidence would suggest that this is an outcome that should be investigated through further research – or omitted as we argued earlier.

Concluding remarks

This article had the objective of describing the development and testing through exploratory factor analysis of an instrument – the *Technological Profile Inventory* (or TPI) – for use in collecting information on specific dimensions of a student's level of technological literacy. We argued that this information could meaningfully be used to complement existing admission data, including the applicant's NSC scores and their performance in the NBT, to help ensure that students admitted to an engineering programme had the greatest chance of success. The outcome of the analysis suggests that the instrument does collect useful data that can be used to differentiate between students who entered two different faculties.

The next stage in this project is to collect data from across the different faculties to confirm what the results we have presented suggest. Furthermore, we need to determine how to meaningfully combine the scores achieved by an individual completing the finalised instrument to ultimately determine a score indicative of their applicable level of technological literacy.

References

Barnett, M. (1995). Literacy, technology and 'technological literacy'. *International Journal of Technology and Design Education, 5,* 119-137.

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education* (5th ed.). London ; New York: RoutledgeFalmer.

Collier-Reed, B. I. (2006). Pupils' experiences of technology: Exploring dimensions of technological literacy. Unpublished PhD. University of Cape Town.

Collier-Reed, B. I., Case, J. M., & Linder, C. (2009). The experience of interacting with technological artefacts. *European Journal of Engineering Education, 34*(4), 295-302.

de Vries, M. J. (2005). Teaching about technology: An introduction to the philosophy of technology for non-philosophers. Dordrecht ; New York: Springer.

Department of Education. (2009). Maths papers up to standard. Retrieved 13/06/2011, from http://www.education.gov.za/ArchivedDocuments/ArchivedMediaStatements/tabid/458/ctl/Details/mid/946/ItemID/2838/Default.aspx

Devon, R., & Ollis, D. (2007). *AC2007-1430: Technology literacy for the technologically literate*. Paper presented at the 2007 ASEE Annual Conference.

Donald, D. (2011). Personal Communication.

Field, A. (2005). Discovering statistics using SPSS: Sex, drugs and rock 'n roll. London: Sage.

Gagel, C. W. (1997). Literacy and technology: Reflections and insights for technological literacy. *Journal of Industrial Teacher Education, 34*(3), 6-34.

Hayden, M. A. (1989). What is technological literacy? *Bulletin of Science, Technology and Society, 9*, 228-233.

Higher Education South Africa. (2009). The National Benchmark Tests Project. Report on the February 2009 Pilot Tests.

Ingerman, Å., & Collier-Reed, B. I. (2011). Technological literacy reconsidered: A model for enactment. *International Journal of Technology and Design Education, 21*, 137-148.

International Technology Education Association. (2000/2002/2007). *Standards for technological literacy. Content for the study of technology*: International Technology Education Association.

Kahn, R., & Kellner, D. (2005). Reconstructing Technoliteracy: a multiple literacies approach. *E-learning, 2*(3), 238-251.

Kline, P. (1999). The handbook of psychological testing. London: Routledge.

National Benchmark Tests. (2011). About Test Content. Retrieved 13/06/2011, from http://www.nbt.ac.za/index.php/test-content

Nunally, J. C. (1978). Psychometric theory. New York: McGraw-Hill.

Pearson, G., Young, A. T., National Academy of Engineering. Committee on Technological Literacy, & National Research Council (U.S.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, D.C.: National Academy Press.

Reed, B., & Case, J. (2003). Factors influencing learners' choice of Mechanical Engineering as a career. *African Journal of Research in Mathematics, Science and Technology Education, 7*, 73-83.

Rose, L. C., & Dugger Jr, W. E. (2002). ITEA/Gallup poll reveals what Americans think about technology. A report of the survey conducted by the Gallup Organization for the International Technology Education Association. *Technology Teacher, 61*(6 insert), 1-8.

Rose, L. C., Gallup, A. M., Dugger Jr, W. E., & Starkweather, K. N. (2004). The second installment of the ITEA/Gallup poll and what it reveals as to how Americans think about technology. *Technology Teacher, 64*(1), 1.

Rose, M. A. (2007). Perceptions of Technological Literacy among Science, Technology, Engineering, and Mathematics Leaders. *Journal of Technology Education, 19*(1), 35-52.

Simpson, J. A., Weiner, E. S. C., & Oxford University Press. (1989). *The Oxford English Dictionary* (2nd ed. Vol. VI). Oxford: Oxford University Press.

Tabachnick, B. G., & Fiddell, L. S. (2007). Using multivariate statistics. Needum Heights, MA, USA: Pearson/Allyn & Bacon.

University of Cape Town. (2011). 2012 Undergraduate Prospectus.

Waetjen, W. B. (1993). Technological literacy reconsidered. *Journal of Technology Education, 4*(2), 5-10.