Variation in the mastering-practices of first-year, South African engineering students: A phenomenographic study

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A phenomenographic study into the learning practices of first year chemical and metallurgical engineering students at Wits, found that two qualitatively different kinds of study practice were exercised when the students studied alone: 'test-oriented study practice' – where the focus of attention is to prepare for tests so as to earn as many marks as possible; and 'mastering-practice' – where the focus is the mastering of the course material being studied and the mastering of the related skills. Mastering-practice was recognized to be a meta study practice involving a combination of two kinds of sub-practices which were labelled 'theory-focused study practice' – where the focus is the 'theory' relevant to the subject – and 'problem-focused study practice' – where the focus is developing the ability to solve 'problems' associated with that theory. Six categories of mastering-practice were identified. The significance of these categories is that even when students focus on developing understanding and the associated problem-solving skills and are not distracted by alternative test-focused, marks-earning learning strategies such as strategic study or rote learning, there is considerable variation in what they are oriented to do. The consequence of this is that the quality of student's learning is inherently constrained by the degree of sophistication of their mastering-practice and some empirical evidence is presented in support of this conclusion. The study suggests that many South African students enter engineering degree programmes with relatively unsophisticated mastering-practices and need to develop more sophisticated practices if they are to achieve their academic potential. The categories of variation in mastering-practice outlined in the study provide insights about what students need to learn in order to develop in this way and therefore what needs to be targeted by pedagogical measures that are implemented to facilitate such development.

Introduction

Three inter-related premises have motivated the study presented in this paper. The first is that the learning practices of students – the way they typically go about studying and learning – has a significant bearing on the quality of their learning and consequently on their academic prospects at university. The second is that learning practices are *orientations* to learning that learners have developed as a result of their past experience. More specifically we define a learning practice to be *an orientation or predisposition to study, learn or act in learning situations in certain ways and with certain intentions that a person has developed as a result of past experience*. The third premise is that in South Africa, as elsewhere, many engineering students enter tertiary education with relatively unsophisticated learning practices and that this is one of the reasons for the high rates of academic failure and drop out that currently prevail in engineering education in the country.

Accordingly, the objective of the study presented in this paper was to develop an evidence-based understanding of the learning practices of South African engineering entrants. Little work of this kind is to be found in the literature where the research most related to learning practices relates either to approaches to learning and the contextual sensitivity of those approaches (Biggs, 2003; Case & Marshall, 2009; Marton, Hounsell, & Entwistle, 1997;

Prosser & Trigwell, 1999; Ramsden, 2003) or to self-regulated learning (Schunk & Zimmerman, 1994, 2009; Zimmerman, 2001). The paper begins by describing the study and presenting its findings after which the implications of those findings are discussed.

The Study

Details of the study presented here may be found in Woollacott (2013). The specific aim of the study was to investigate the qualitative variation in the learning practices of the students who entered the chemical and metallurgical engineering programmes at Wits University in 2008. The research methodology employed was phenomenography. Thirty-one students were selected from the cohort of 156 students using maximum variation sampling (Cohen, Manion, & Morrison, 2007; Green, 2005). The dimensions of variation taken into account in the sample design were gender, ethnicity, and three scores from the MSLQ inventory instrument (Pintrich, Smith, Garcia, & McKeachie, 1991) administered to the students at the beginning of 2008; the inventory scores that were used purport to give an indication of a student's orientation to learning, and to their metacognitive self-regulation and time/study management practice.

Semi-structured interviews were conducted with the students at the beginning and towards the end of their first academic year using interview protocols that had been designed and trialled in conjunction with an experienced phenomenographer. The interviews were recorded and transcribed, and the transcripts were analysed using conventional phenomenographic methods to establish categories that described the qualitative variation in the ways the students related to studying and learning.

The Study Findings

Qualitatively different types of learning practices were found in 6 different contexts of studying and learning as indicated in Figure 1. The variation in the learning practices in four of these contexts was investigated in detail in the study but only two of these practices are discussed in this paper. These are labelled 'test-focused study practice' and 'mastering-practice' respectively. In the first of these, the focus of attention is to prepare for tests so as to earn as many marks as possible in them. In the second, the focus of attention is the mastering of the course material being studied and the mastering of the related skills; any concern about assessments is absent or is only in the back of students' minds when they are studying in this way.

The learning practice that was found to exert the most direct influence on the quality of a student's learning was their 'mastering-practice'. Accordingly, the variation found in this type of practice is presented in some detail. The variation in test-focused study practice that was found was quite conventional, in that it was in line with the literature, and so is only presented in outline.

Test-Focused Study Practice

It was found that the variation in the way students in the sample related to preparing for tests or examinations could be described in terms of four categories. These were labeled 'reproduction-oriented', 'pattern-recognition-oriented', 'strategic', and 'learning normally' study practices.

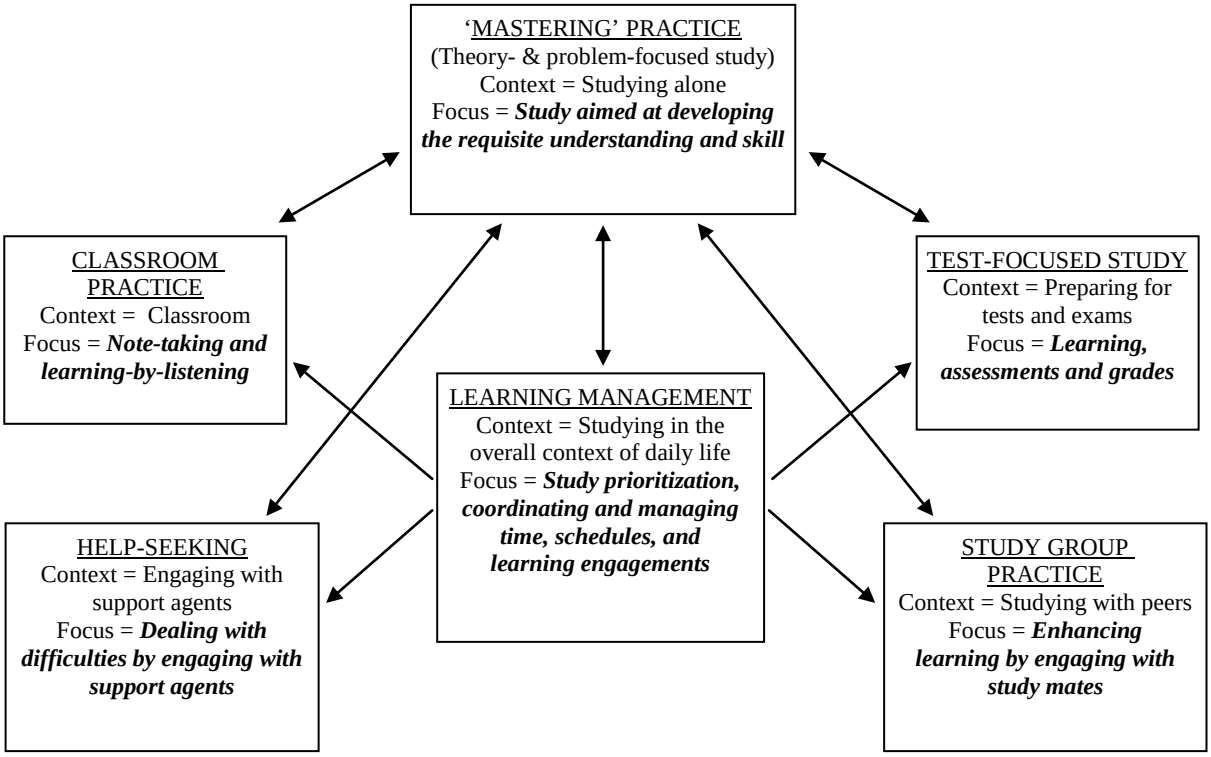

Figure 1. Contexts of Studying and Learning and the Learning Practices in Each Context

Reproduction-oriented study practice

This category of test-focused study practice is characterized by a focus on learning information for reproduction in tests/exams and involves repeated reading of the information for memorization with little or no regard for understanding the material being 'learned'. Common terms for this kind of practice are rote learning, memorizing, and cramming.

Pattern recognition study practice

This type of study practice is based on the conception that past test/exam papers and the questions in them follow a pattern, and that to be aware of the nature of such patterns can guide one's preparation for tests/exams in ways that can improve the grades obtained. Study practices that arise from this conception include reviewing past papers, working through past papers or questions from them, or even studying past papers, often alongside model solutions, in order to 'learning how to answer test/exam questions'.

Strategic study practice

This category of test-focused study practices is an example of what Entwistle calls a 'strategic approach to studying' (Entwistle & Ramsden, 1983). The practice involves using a strategic mix of study strategies that are guided by the student's conceptions of what will earn the most marks in tests/exams. Various forms of this practice were evident among the students: 'spotting' – i.e. identifying topics that have a particularly high or low probability of coming up in the test/exam and giving these greater or lesser attention when studying; identifying topics that are generally assessed by calling only for information – 'facts' or 'formulas' – and so can be 'learned' by cramming and memorization; and identifying those topics which will require 'understanding' and so need to be studied in more depth.

Learning normally

In this category of test-focused study practice, a student does not resort to any of the other types of study practice mentioned but 'learns normally' in the sense that the focus of study is on mastering the requisite understanding and skill. As such, the practice is identical to mastering-practice which is described next.

Mastering-Practice

Mastering-practice was recognized to be a meta study practice in which three qualitatively different aspects are evident. The first is a theory-focused aspect in which the focus was 'bookwork' and the theory or the conceptual framework relevant to the subject. The second is a problem-focused aspect in which the focus is 'working problems' and the development of problem solving ability related to that theory. (Here problems are taken to be *set tasks in which the presented situations or difficulties have to be resolved using some kind of numerical or mathematical manipulation and the application of the relevant theory*.)

These two aspects of mastering-practice are qualitatively very different in that one focuses on the development of some level of conceptual understanding while the other focuses on the development of a skill. The distinction emanates from the structure of maths, science and engineering subjects which the students take and in which they typically are required to develop both the appropriate conceptual frameworks – i.e. the 'theory' relevant to the subject – and the ability to solve problems using that theory.

The third aspect of mastering-practice is how the theory- and problem-focused aspects are associated when studying; they may be *sequentially associated* or associated in an *integrated* manner. In the first case, theory and problem solving ability are conceived as relatively independent requirements of the course and so are to be mastered in a relatively independent manner – typically learning theory first followed by working problems. In the second case, theory and problem-solving are recognized to be mutually and synergistically inter-related so that the learning of theory is enhanced by working problems and the solving of problems can be facilitated by insights derived from intentional reference to the relevant theory.

It was found that the variation in the way students related to the development of their understanding and skill could be described in terms of six categories labelled 'superficial', 'comprehension', 'consolidation', 'integration', 'refinement', and 'know-how' levels of mastering-practice. Figure 2 summarizes these categories in terms of the three aspects that characterize them. Each category is described in more detail thereafter.

	← CATEGORIES OF VARIATION IN MASTERING-PRACTICE →					
ASPECTS OF VARIATION↓	**Superficial**	**Comprehension**	**Consolidation**	**Integration**	**Refinement**	**Know-how**
Theory Focused Practice	Information-oriented practice	Comprehension-oriented practice	Consolidation-oriented practice	Integration-oriented practice	Refinement-oriented practice	Know-How-oriented practice
Problem Focused Practice	Formula-application practice	Theory-application practice	Theory-application practice	Theory-application practice	Heuristic problem-solving practice	World-application practice
Nature of Association	Sequentially associated	Sequentially associated	Sequentially associated	Integrated	Integrated	Integrated

Figure 2. Summary of the Variation in Mastering-Practice

Superficial mastering-practice

In this category of mastering-practice, the orientation to learning theory is simply to read through the prescribed texts, course hand-outs or lecture notes and to focus on learning the information contained with little or no explicit attention being given to understanding or making sense of it. The nature of this *information-oriented study practice* is illustrated by the following interview extract.

"[At school] I would read something through and through and then know to say it without looking on that page. Just, I don't understand that thing, but I can say it."

In the problem-focused aspect of this category, problems are experienced as the kind that requires merely the substitution of numerical values into formulae to calculate an answer. As such, the problem-focused aspect has been labelled *formula-application study practice*. Theory and problem-solving are addressed sequentially, first one and then the other.

Comprehension mastering-practice

In the second category of mastering-practice, the orientation to learning theory is again to read through the relevant textual material, but now with a focus not just on the information it contains but also on making sense of and comprehending the material. The nature of this *comprehension-oriented study practice* is illustrated by the following extract.

"What I try and do is read it once through and sort of get a broader idea. Read it a second time through, pick up anything I've missed and then read it a third time, sort of pick up the main points and the overall topic."

In addition to the application of formulae, as in the previous category, the primary focus when solving problems is now on analysing the problem situation in the light of the theory and applying that theory appropriately with the relevant formulae and mathematical manipulations in order to work out a solution. This problem-focused aspect of the practice has been labelled *theory-application study practice* and is sequentially associated with the learning of theory as in the previous category.

Consolidation mastering-practice

In the third category of mastering-practice, the orientation to learning theory is to consolidate what has been comprehended by using some kind of consolidation or reinforcement technique such as vocalizing what is being learned, highlighting or memorizing key points, or making a list or summary of key points. The following extract illustrates the nature of this *consolidation-oriented study practice*.

"You have to summarise some of the important material… because if you summarise that little bit of the material you are conscious about what you have summarised so you are able to know."

In this category, the orientation to problem solving is the same as in the previous category, and again learning theory and solving problems are sequentially associated.

Integration mastering-practice

The fourth category of mastering-practice includes all aspects of the third category (consolidation) but is more sophisticated with respect to the learning of theory and its association with problem-solving. Problems, and attempting to solve them, are now used as a resource for enhancing the understanding of theory and the development of problem-solving skill is enhanced by explicitly referring to theory when attempting problems. As such, the learning of theory and the solving of problems are now conducted in an integrated manner

rather than in the sequentially associated manner characteristic of the previous categories of practice. The following extract illustrates the nature of this *integration-oriented study practice* showing the shifts from theory to problem and back again.

"I read through a paragraph … and tried to understand it with the diagram that was next to it, and then the study guide always had like two or three practice [problems] and I tried those. Well I tried the first one with the answer. If I got the wrong answer then I went back into it [the theory], read through it again to figure out exactly what's happened and then tried [the problem] again."

Refinement mastering-practice

In addition to the practices just described, the orientation to learning theory in the fifth category of mastering-practice is intentionally to seek to make new conceptual connections and to restructure what has being learned. Such refinement of one's understanding is attempted by means such as generating concept maps; writing summary notes; expanding study notes; looking for the inverse of the concepts that have been learned; self-questioning; and 'what-if' analyses (thinking about *what* might happen *if* a different perspective on a situation were to be taken). The nature of this *refinement-oriented study practice* is illustrated by the following extract.

"The way I understand some things is that I look at it and then [say to myself]… this is what this is, and then I sort of ask myself a few questions about it, like, … this is what this is in this situation, but what if … this were to happen here and then what happens? Then if I look at it from the other way around what happens then? I usually just play around with the concept and that, put [in] a few [numbers], if it's a formula … know what those units are and where they derive from so that you can have a better understanding."

The problem-focused aspect of this category pays particular attention to the heuristics of problem-solving and problem-solving processes. This derives from an explicit awareness of 'problem-solving' ability as a relatively independent skill that transcends the particularities of how specific aspects of theory can be applied to solve problems. Accordingly, this aspect of the practice has been labelled *heuristic-problem-solving study practice.*

Know-how mastering-practice

The sixth and most sophisticated category of mastering-practice includes, but goes beyond, the previous categories by an intentional focus on trying to relate to real world situations the theory being learned and the problems being solved. The awareness behind this practice is that theoretical knowledge, theory-application skill and problem-solving-skill work together as a kind of world-related know-how that is relevant because it can be applied meaningfully to real-world situations. The theory-focused aspect of this practice was therefore labelled *know-how-oriented study practice* and the problem-focused aspect was labelled *world-application practice.* The following extract illustrates the nature of this type of mastering-practice.

"I'm not a big fan of just purely theory. I need to see how it works. If there is a practical sort of use for it I think it's a whole lot better because I can see it in action and actually see how the concept goes from being sort of abstract thought into… a physical thing."

Summary of the distinguishing features of the six categories of mastering-practice

Figure 3, which is an elaboration of Figure 2, gives a graphical representation of how theory- and problem-focused aspects of mastering-practice are associated and also summarizes the features which distinguish one category of practice from another. In brief, the theory-focused aspects of the six categories are distinguished by three features: the type of knowledge which the practice aims to develop (respectively information; comprehended, consolidated, integrated

and refined theory; and know-how); and the resources and strategies used to develop that knowledge (progressively and inclusively, texts and the techniques for comprehending, consolidating, integrating and refining theory and relating theory to real world situations). The problem-focused aspects of mastering-practice are distinguished by

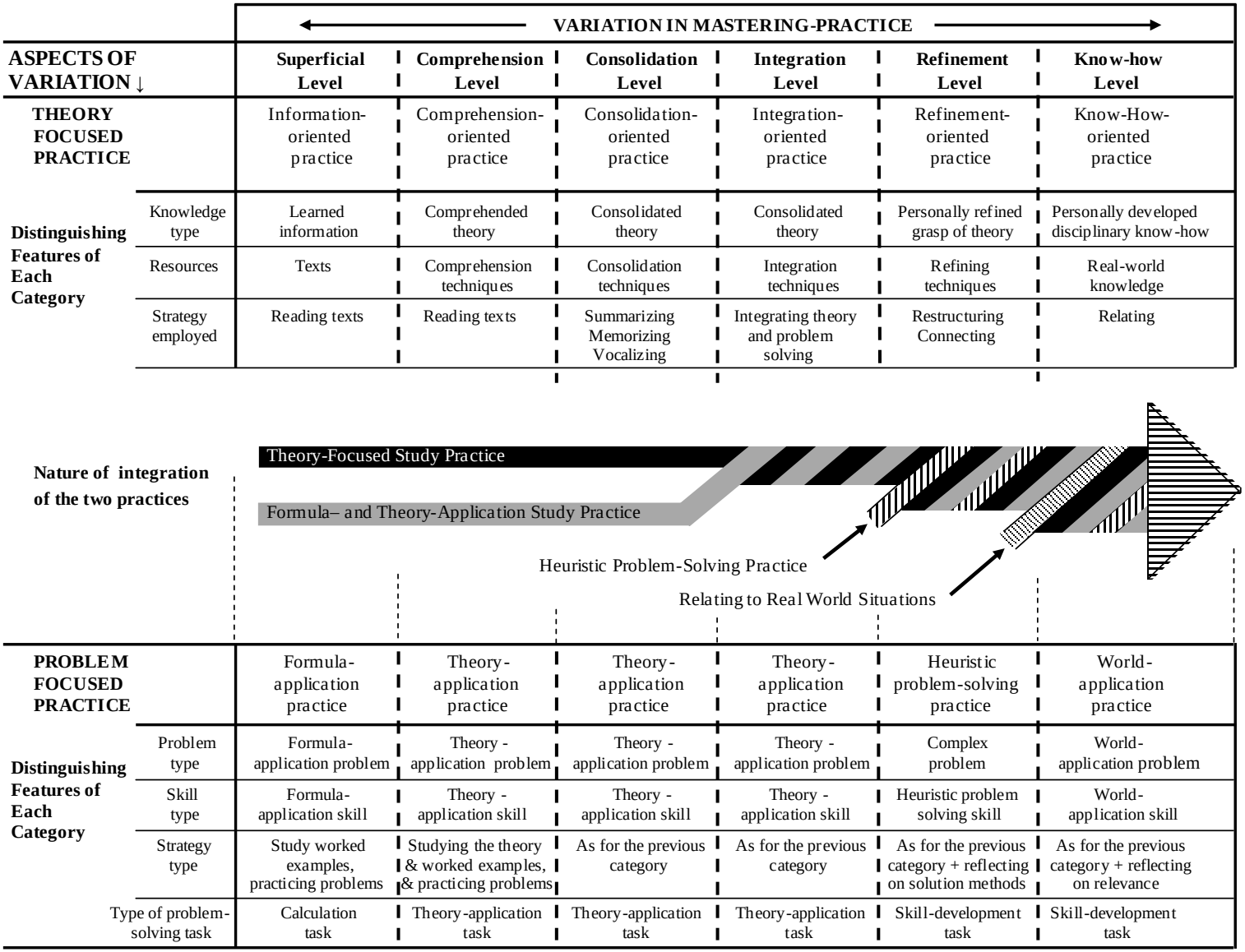

Figure 3. Graphical Representation of the Variation in Mastering-Practice Showing the Distinguishing Features of Each Category

the conception of the type of problem being solved (formula- or theory-application problem, complex problem or world-related problem); the conception of the skill type being developed (formula- or theory-application skill, heuristic problem-solving skill or world-application skill); the type of learning strategy used; and the conception of the type of problem solving task being tackled. The significance of these features is that any attempt to develop a student's mastering-practice should pay attention to developing the distinguishing features associated with the type of practice being developed.

Discussion

There are a number of implications of the findings of this study. The first, and perhaps most obvious, is that the distinction between test-focused study practice and mastering-practice has similarities to the distinction between surface and deep approaches to learning. A deep approach is characterized by the intention to understand what is being learned which is not the explicit aim of a surface approach where learning is frequently motivated by the intention to reproduce information when asked questions on the material being 'learned' (Case & Marshall, 2009). The parallel between the two distinctions is clear. However, the variation in both test-focused practice and mastering-practice provide far more fine-grained characterizations of learning than do the constructs of deep and surface approaches to learning. The study shows that even if the students are *oriented* to adopting a deep approach to learning, that is they are oriented to developing understanding and the associated problem-solving skills and are not distracted by alternative test-focused, marks-earning learning strategies such as strategic study or rote learning, there is considerable variation in what the students are oriented to do. In the case of the students in the study, that variation can be explained in terms of the six qualitatively different categories that have been described.

A second implication of the study findings is that the variation in mastering-practice forms a progression of increasing sophistication that is associated with a progression in the quality of student learning. This can be seen when it is recognized that each category of mastering-practice includes but builds on the previous category; for example, the consolidation level of mastering-practice includes but goes beyond the comprehension level of mastering-practice which in turn includes but goes beyond the superficial level of practice. That this increase in the sophistication of the categories of mastering-practice corresponds with an increase in the quality of learning afforded by each category of mastering-practice can be seen from Figure 3. It is evident from the figure that as the categories of mastering-practice become more sophisticated the type of knowledge which the practice is oriented to develop increases in depth and quality. The progression is from information, to comprehended-, consolidated-, integrated-, and refined-theory and to know-how, with each category inherently including the knowledge types associated with less sophisticated categories. The figure also shows a similar progression with regard to the type of problem solving skill each category is oriented to develop. The progression is from formula- to theory-application skill, to heuristic problem solving skill and finally to world-application skill (the orientation to relate situations to real world contexts when solving problems). Again, each category is inclusive of the skills associated with the sophisticated categories.

An immediate implication of the association between the degree of sophistication of a mastering-practice and the quality of learning that the practice develops is that such an association can be tested. One way to do this is to categorize students according to their learning practices and then to compare this with their academic performance. Such an exercise was undertaken with 26 of the 31 students in the study. (Five of the students could not be included in the exercise because two withdrew from the study at midyear, two were not serious about their studies, and the interview data from another was considered unreliable.) The level of practice of each of the 26 students was gauged from what each had said about their practices

in the study interviews. The indicator of academic performance that was used in the exercise was the students' final mark in their first year engineering subject. This was selected because it was considered to be the most discriminating with respect to the quality of the student's learning practice: it was the subject students generally found to be the most difficult in their first year programme; there were relatively few 'easy questions' in the course assessments; and the subject matter was new for all the students so that their performance was least affected by the students' prior knowledge and development. The results of the exercise are presented in Table 1.

Table 1. Level of Academic Performance vs Sophistication of Study Practice

		Percentage (or number) of the students in each Study Practice Category who performing at the indicated level		
Study Practice Category	**Number of students in the category**	**Fail**	**Pass**	**Distinction Level**
Comprehension level of practice	4	50% (2)	50% (2)	0
Consolidation or integration level of practice	11	36% (4)	64% (7)	0
Refinement level of practice	8	0	100% (8)	25% (2)
Refinement level and some degree of the know-how level of practice	3	0	100% (3)	100% (3)

The indications of the exercise can only be tentative because the sample size is small, and because grades earned may be influenced by a range of factors of which a student's mastering-practice and the quality of their learning are only two. However, the comparisons in Table 1 do give some support for the argument that there is a correlation between the degree of sophistication of a student's mastering-practice and the quality of their learning: both the pass rate and the probability of obtaining a distinction in the course are seen to increase with the degree of sophistication of a student's mastering-practice. The table also suggests that any measures implemented to improve the quality of students' learning practices should aim to develop students' practices at least to a refinement level of mastering-practice which appears to be associated with very satisfactory academic performance. Additionally, the table suggests that the learning practices of the majority of the students in the 2008 cohort were not at this level and that possibly a significant proportion of that cohort were functioning at the relatively unsophisticated comprehension and consolidation levels of mastering-practice. The table also hints at another implication of the study findings, namely that there are inherent in a student's study practices constraints on the effectiveness of their learning. This subject is discussed next.

Constraints on students' learning

Table 1 suggests that a student's learning is constrained by the degree of sophistication of their mastering-practice. We argue that such a constraint is a logical consequence of how learning practices influence a student's learning. In that a learning practice is an *orientation* or *predisposition* to act in learning situations in certain ways, students cannot be *oriented* to studying in ways that are more sophisticated than those with which they have had prior experience. As such, each level of mastering-practice affords the development of a particular

level of understanding and skill, but it also constrains learning in that it does not explicitly afford the development of higher quality understandings/skills that are afforded by more sophisticated categories of practice. It is of course true that a student is not necessarily *limited* to learn in the way in which their past experience orientates them because the nature of the learning context may prompt them to act in a way that is different from the orientations prompted by their typical practice.

The study found that there is another kind of constraint on learning that is is associated with the exercise of test-focused study practices. This arises because, to a greater or lesser degree, test-focused study practices divert a student from the exercise of their mastering-practices towards practices that are less concerned with developing the requisite understandings and skills.

Pedagogical Implications and Recommendations

To conclude this paper, the study findings are discussed from the perspective of their pedagogical implications and some recommendations are made. First, the findings endorse the premise outlined at the beginning of the paper that one of the reasons for the high rates of academic failure and drop out that currently prevail in South African engineering education is that some students enter tertiary education with relatively unsophisticated learning practices. Although the sample of students in the study was qualitatively rather than quantitatively representative of the 2008 entering cohort, the indication is that the mastering-practices of a large proportion of them were only at a comprehension or consolidation/integration level by the end of their first year and that this constrained their academic prospects considerably. It seems that one of the provisions that are needed to reduce the current high rates of attrition is measures that are effective in helping students to improve their learning practices. The study findings give some guidance about the kind of measures that are needed.

In the first place, the measures need to facilitate development that is appropriate for improving a student's mastering-practice and removing constraints to learning that are inherent in those practices. The six categories of mastering-practice identified in the study give an indication about the nature of these developmental pathways; i.e. a progression from the less sophisticated categories towards a refinement level of practice and even to a know-how level. The distinguishing features of each of the categories, summarized in Figure 3, provide details about what this progression involves. In summary, to progress from a comprehension level to a refinement level of mastering-practice and beyond requires the following changes.

1) A shift from a conception of knowledge as comprehended theory to a conception of knowledge as consolidated, integrated and personally refined theory;
2) The development of consolidation techniques– in particular *summarizing*;
3) The development of refinement techniques – in particular various techniques of conceptual *restructuring* and *connecting*;
4) A shift from a conception of problems as theory application problems to one that conceives them also as complex problems requiring heuristic problem solving skills;
5) The development of heuristic problem solving skills;
6) A shift from a conception that theory and problems are relatively independent aspects of a course requirement to a conception that they are mutually inter-related aspects of engineering understanding and skill.
7) Development of the highest level of mastering-practice (the know-how level) requires attention to (a) developing the conception that it is real world situations that give theory and problem-solving their relevance, and (b) developing the disposition to relate theory and problems to real world situations.

With regard to removing constraints to learning that are associated with a student's test-focused study practices, conceptual shifts need to be facilitated with regard to the objective of studying, what earns marks in tests, and the merits/demerits associated with reproduction-oriented, pattern-recognition, and strategic study practices. Developing a student's awareness about the qualitative complexity of the knowledge, understanding and skill associated with the discipline of engineering, as opposed to its quantitative extent, should also help to promote the conceptual shifts mentioned so that students are not drawn to give undue attention to test-focused study strategies that divert attention away from trying to master the requisite understanding and skill. Obviously assessment strategies need to be aligned to a focus on understanding/skill rather than on recall and reproduction of information and students need to be made aware of this focus and its implications for effective study when preparing for assessments.

To guide and support students along the developmental pathways just described, an appropriate teaching and learning environment is required. While some input is obviously required to raise students' awareness about the relevant conceptual issues, the most critical aspect of that environment is that it should be immersive in nature because the modification of learning practices requires the changing of orientations and predispositions, i.e. the environment must facilitate *habit change* which is notoriously difficult to accomplish. Students need to be immersed in an environment in which the attention given to the development of learning practices is consistent and coherent and is sufficiently sustained and pervasive that the required processes of habit change can occur. The environment should be as devoid as possible of factors that foster or reinforce problematic aspects of learning practices or that might cause students to revert to any of their old practices that are problematic. Where such problematic practices are particularly deeply ingrained – such as rote learning, for example – the teaching and learning environment should include 'counter-measures' whereby learning tasks 'force' students to adopt new and appropriate practices because it is patently clear to them that their old problematic practices will not be effective for those tasks.

In order to provide the kind of consistent and pervasive environment that has been described, all courses in the first year programme should be aligned with the developmental strategy and all teachers of these courses should be involved to some degree in that strategy otherwise it is likely to be undermined by conflicting messages or requirements. A traditional stand-alone 'skills course' is not recommended because, in the context of a single course, it is inherently difficult to achieve the kind of broad and consistent immersion described. However, it may be appropriate, in an across-the-curriculum strategy, for any instruction given on learning practices to be provided in one module as long as that module and the other courses in the first year programme are integrated with regard to the overall strategy for developing students' learning practices.

In order to contextualize the development of learning practices appropriately, the structure of the various components of the teaching and learning environment – lectures, tutorials and laboratories – should be redesigned with an eye to how these components influence the development and reinforcement of the desired learning practices. This recommendation amounts to having a dual focus when implementing each component of the teaching and learning environment – i.e. the intended learning of disciplinary knowledge/skill and the development of desired learning practices.

Conclusions

The study described in this paper set out to gain insight into the learning practices of entrants to an engineering degree programme in South Africa; insight that could inform interventions and/or curriculum re-design which aim to improve the quality of the students' learning by facilitating an improvement in the quality of their learning practices and, thereby, to reduce attrition. It was found that the quality of a student's mastering-practice was critically important

as well as the extent to which that practice was not undermined by the student's test-focused study practice. It was found that the qualitative variation in the mastering-practices of the students studied could be described in terms of six categories that formed a progression in the degree of sophistication of the practice. This progression corresponded to a progression in the quality of learning which the exercise of those practices afforded. Some empirical support for this correspondence was demonstrated. The categories of variation were shown to be useful not only for explaining the influence of mastering-practice on the quality of learning but also as a conceptual framework for informing the design of measures intended to facilitate the development or modification of the students' learning practices.

References

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

Case, J., & Marshall, D. (2009). Approaches to learning. In M. Tight, K. H. Mok, J. Huisman & C. Morphew (Eds.), *The Routledge International Handbook of Higher Education* (pp. 9-21). London and New York: Routledge Falmer.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education* (6 ed.). London: RoutledgeFalmer.

Entwistle, N. J., & Ramsden, P. (1983). *Understanding student learning*. London: Croom Helm.

Green, P. (2005). A rigorous journey into phenomenography: from a naturalistic enquirer standpoint. In J. Bowden & G. Green (Eds.), *Doing Developmental Phenomenography* (pp. 32-46). Melbourne: RMIT University Press.

Marton, F., Hounsell, D., & Entwistle, N. J. (1997). The experience of learning: Implications for teaching and studying in higher education. (www.tla.ed.ac.uk/resources/EoL.html)

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ). Ann Arbor, Michigan: National Center for Research to Improve Postsecondary Teaching & Learning.

Prosser, M., & Trigwell, K. (1999). *Understanding learning and teaching: the experience in higher education*: Open University press.

Ramsden, P. (2003). *Learning to teach in higher education* (2 ed.). London: Routledge.

Schunk, H., & Zimmerman, J. (Eds.). (1994). Self-regulation of learning and performance: Issues and educational applications. Hillsdale, New York: Erlbaum.

Schunk, H., & Zimmerman, J. (Eds.). (2009). Motivation and self regulated learning: theory, research, and applications. New York: Routledge.

Woollacott, L. C. (2013). *On the learning practices of first year chemical and metallurgical engineering students at Wits: A phenomenographic study*. PhD thesis, University of the Witwatersrand, Johannesburg.

Zimmerman, B. J. (2001). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman & H. Schunk (Eds.), Self-regulated learning and academic achievment: Theoretical perspectives (2 ed., pp. 1-37). Mahwah, New Jersey: Erlbaum.