Improving Student Learning by Growing a Teaching and Learning Culture in an Engineering School

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Abstract
The problem addressed in this paper is that lecturers in schools of professional education such as engineering schools are typically disciplinary experts first, researchers second, and teachers third; they typically have limited knowledge about good educational practice unless the school provides measures to develop such knowledge and practice. To address this problem in a School of Chemical and Metallurgical Engineering at a South African university, a 3-part strategy has been devised and implemented to grow a culture of teaching and learning among lecturers in the school.
The first part of the strategy is to involve lecturers in educational research 'mini-projects' in collaboration with an experienced educational researcher. The lecturers are invited to identify and research an issue or concept which the students they teach typically struggle with. The second part involves formal input on educational theory and practice to the lecturers involved in the mini-projects and to any other staff in the school who wish to attend. The third part is to provide regular in-house colloquia as a forum for feedback from the mini projects and for discussion of any teaching and learning issues that may arise.
The rationale behind this strategy is, firstly, that it provides a means for drawing lecturers into the scholarship of teaching and learning by researching a teaching and learning issue that is highly relevant to them in their own teaching. It facilitates access to educational theory, research and practice through collaborations with educational researchers and involvement in teaching colloquia tailored to the school's needs.

Keywords: Engineering education, teacher development, educational research

Introduction

At least since 1995 there has been a growing, global shift from a teacher-centred approach to teaching in higher education to a more 'student-centred' approach (see, for example, Barr and Tagg, 1995; Entwistle, 2009). The former approach is a traditional one characterized by a model of teaching that emphasizes the transmission of knowledge from teacher to students, whereas the latter pays more attention to student learning and how teaching can facilitate that learning. One of the factors that constrains this shift in schools of professional education, such as in engineering education, is the fact that lecturers in these schools are usually hired on the basis of their disciplinary expertise first, their potential as disciplinary researchers second, and, a distant third, their teaching ability. Such lecturers typically teach as they have been taught which usually involved a traditional, teacher-centred approach. The typical outcome of this background, combined with heavy workloads and an emphasis on disciplinary research, is that lecturers in schools of professional education usually know little about education theory and pedagogical good practices and have a limited inclination to learn and develop the knowledge and practices needed for effective student-centred approaches to teaching. This creates difficulties for those in higher education who wish to enhance the quality of learning of their students by improving the quality of teaching in their institutions.

Various strategies for overcoming these difficulties have been adopted by institutions around the world. These include insisting that prospective academic staff have an appropriate educational qualification in order to be hired; that current academic staff take steps to obtain such qualifications; and that lecturers solicit student evaluations of their teaching on a regular basis. Other strategies include direct academic development measures such as hiring and empowering academic developers; implementing and empowering teaching and learning committees in schools; establishing some form of pedagogical academy (see, for example, Ryegard et al., 2010); including quality of teaching as a criteria in performance evaluations and promotion procedures; and, in one way or another, promoting SoTL – the Scholarship of Teaching and Learning. Authors of books on teaching in higher education typically devote much attention to the difficulties associated with enhancing the quality and effectiveness of teachers' teaching (see, for example, Ramsden, 2003, chapters 11 and 12, and Biggs, 2003 chapter 13).

The work presented in this paper presents a strategy that has some elements of the measures just described and is compatible with all such measures. Its focus is to grow a teaching and learning culture within a school of higher education taking into account, and adapting to, the constraints that make such a strategy difficult to implement. The strategy was initiated in 2014 as a teaching development project within a school of chemical and metallurgical engineering in a South African university and was funded by a grant from the South African Department of Higher Education. The project is a work in progress. This paper describes the evolution of the strategy and what the project has achieved to date.

Growing a Teaching and Learning Culture in the School

The concept of a teaching and learning 'culture' in a school implies that the work and social environment in that school is permeated by values and commitments that seek excellence in teaching (as measured by the quality of student learning it facilitates); knowledge and practices that promote and advance such excellence; and effective structures that support these. The design of the strategy to grow such a culture in the school was based on assumptions about what was needed to facilitate such growth and what would constrain it. The affordances of such growth that were considered to be particularly important were (1) regular exposure to key pedagogical principles through formal input; (2) personal engagement with relevant teaching and learning issues through appropriate educational research; and (3) communal engagement with relevant teaching and learning issues through such vehicles as seminars, group discussions and brain storming sessions. An additional affordance that was recognized was the genuine concern for students' well-being and progress that was evident among the staff and the consequential positive attitude of virtually all of them with regard to the need to address teaching and learning issues in the school.

The chief constraints on the growth of a teaching and learning culture in the school were considered to be (1) the heavy workloads of the academic staff; (2) the high priority given to disciplinary research by staff in the school; and (3) the awareness on the part of most academic staff of considerable gaps in their knowledge and experience of pedagogical theory and practice and of the effort it would take to rectify this. It was assumed that these factors would constrain the motivation of staff in general to give much attention to the enhancement of teaching and learning in the school and the amount of time they would be prepared to devote to this. Accordingly, it was accepted that whatever measures were introduced needed to be relatively undemanding on lecturer's time and workload.

The strategy that emerged from these considerations was to put in place a simple structure that would both grow and sustain the desired teaching and learning culture in the school. The structure had two components which became known as 'mini-projects' and 'teaching colloquia'. Mini-projects consisted of small-scale projects designed to involve individual members of the teaching staff in educational research. To enhance the staffs' motivation to be involved in a mini-project, it was designed with three features in mind: a focus on a difficulty or issue the staff member was facing in their own teaching; a collaboration with an experienced educational researcher who would provide the knowledge and expertise needed for conducting a scholarly educational investigation; and the intention that a scholarly publication would emerge from the project.

The second component of the structure – 'teaching colloquia' – was a system of regular colloquia each of which provided a forum for formal input on relevant teaching and learning issues; presentations and feedback from the mini projects; and group discussions and brain-storming on issues emerging from the formal input and the mini-projects. To enhance the staffs' motivation to attend these colloquia they were designed with the following features in mind.

- *Duration*: each colloquium would be only a morning long. This was considered to be a reasonable balance between providing a worthwhile engagement with the theme of the colloquium and the requirement to minimize the time demand placed on staff.
- *Timing and frequency*: colloquia would be provided during teaching breaks so that no staff would be unable to attend because of teaching commitments. With a two semester system with mid-semester breaks, this implied four colloquia each year.
- *Quality venue and lunch*: to enhance the sense that the colloquia were important and significant events, they would be conducted in a quality conference venue and each would be followed by a quality lunch.

Execution of the Strategy

Mini projects

Over the period 2014 to 2016, 9 mini projects have been implemented, and interest in 3 others has been expressed. In addition, 2 follow up projects have been initiated. The majority of the projects were initiated by the 'in-house' educational researcher approaching a colleague with the question, "Is there a particular difficulty or issue you or your students are experiencing in one of the courses you teach?" In every case, the identification of such a difficulty was immediate and clear; in most cases it was instantaneous. What followed was a discussion of the nature of the difficulty and what the lecturer needed to find out in order to overcome that difficulty. The researcher then, in consultation with the colleague, worked up, through several iterations, a project design document.

Once agreement had been reached on the research design, the project was implemented. This process, and the discussions associated with it, not only developed a project design appropriate to the situation but also exposed the colleague to educational research practice and provided opportunities for informal mentoring on teaching, learning and educational research issues.

Two of the 11 mini-projects had a different genesis being initiated by lecturers approaching the 'in-house' educational researcher with an educational issue. In one case, the lecturer asked the researcher for advice regarding some conflictual difficulties with students that had arisen with regard to an innovation he had introduced in his course. In another, the lecturer had implemented an innovation and asked the researcher how he might investigate its effectiveness.

The intention of a mini-project was to generate evidence-based information that would provide pedagogically useful insights for the subsequent design, implementation and evaluation of an appropriate pedagogical modification or intervention. However, this proved to be too ambitious within the workload and time frame constraints of the educational researcher and of the staff researchers and, at the time of writing, few mini-projects had progressed beyond the research phase.

Teaching Colloquia

To develop and grow a teaching and learning culture within the school various types of communal engagement were seen to be necessary: formal input on teaching and learning issues; feedback from mini projects so that the findings could be appropriately disseminated and discussed among the staff; brain-storming of new or relevant ideas; and discussions on pertinent teaching and learning issues arising from the above. A 'teaching colloquium' was conceived as an appropriate forum to allow any combination of these types of activity. Four colloquia were offered each year, each with a specific theme, each presented and coordinated by one or more experts in the field. A total of 7 colloquia have been held to date.

Impact of the Strategy

The implementation of the teaching development strategy just described is still ongoing so only an interim assessment is possible at this time. To assess the impact of the strategy, academic staff were interviewed, the evaluation forms completed after each colloquium were analysed, and the ATI-R inventory, described shortly, was administered before and after the implementation of the strategy. The findings from these analyses are now presented.

Impact of the Mini-Projects

Lecturers involved in mini-projects were interviewed by an independent educational researcher in order to investigate their experience of their projects and what these had meant to them. The findings were as follows.

In the first place, it was clear that the research projects had helped the participating lecturers to gain deeper insights into their students' learning and the nature of the difficulties they were facing. In some cases, the lecturers were somewhat surprised by what they had found out, as the following interview extracts indicate.

> I realised that what I thought they knew, they actually didn't know.
> [The project helped me] to see what they [the students] were struggling with and understanding that. Normally they just say, "We don't understand, we don't know what's going on". But now I had an idea.

One participating lecturer went as far as saying that the research had made them aware that they, as lecturers, might be focusing on the wrong learning issue altogether: "I might be fixated on the fact that they can't see in 3D. In the meantime it might be something totally different. How do we know exactly what the problem is?"

Most participating lecturers reported gaining insights into the students' thinking. "Just to get an idea of what the students perceived and where they were, I learnt a lot from understanding the perspective from the students and how they actually think". One lecturer put it this way: "To listen to all those interviews and those questions that we set up for the students and to hear their response was helpful in the sense of seeing what they actually knew and also how they were dealing with the subject". Another pointed out how such understandings were useful pedagogically in that the research

had shown that "there were these different steps in understanding [the topic … and that appreciating this had been] very helpful in terms of developing the course so that one could aim it in the direction that people will not only understand, but also apply the knowledge."

All the participating lecturers involved in the mini-projects reported appreciating the value of educational research of the kind they had been conducting because "otherwise", as one lecturer commented, "one just speaks about things that you don't really know [about]". Another put it this way: "I think if you have a course where there is a specific issue, a specific part of the course that's not handled as well as the others, then this [i.e. educational research] is definitely very valuable".

With regard to the structure of the mini-project and how they were organized, several participating lecturers commented on the role of the education researcher colleague in their project. Most mentioned that just having an outside person as a sounding board was very helpful. One put it this way: "I think we all battle with time, so I think it's quite nice to have somebody else looking at all the results." Another went further to confess their own lack of knowledge in educational theory and best practice and how the colleague's "involvement as the education expert was extremely helpful. […] Beforehand I knew I didn't know much about education, but I realised more that I really don't know so much and you need somebody to guide you with that background". The following extract summarizes the sentiments of all the participating lecturers interviewed.

> I think it was a good exercise to focus on one specific area that I knew was a problem for quite a few of the students. It meant there was somebody that I could bounce some ideas off, not that [X] necessarily had the specific answers for me, but just in talking to him I was then able to think through what could help them, what are the different options I could try, and getting an "OK that sounds like a good idea" kind of response, worked quite well.

Impact of the Teaching Colloquia

Three perspectives on the impact of the teaching colloquia were available: attendance at the colloquia; the evaluation forms completed by the attendees of each colloquium; and interviews of lecturers conducted by an independent educational researcher sometime after the seventh colloquium.

Figure 1 shows how many colloquia each of the staff in the school attended. As can be seen, of the 30 members of staff, 37% attended 3 or more colloquia while 23% did not attend any. The most common reason for not attending a colloquium was the business of the staff and prior engagements. Some lecturers only attended colloquia where the topic was of particular interest to them. Two or three of the staff showed little interest in attending any of them.

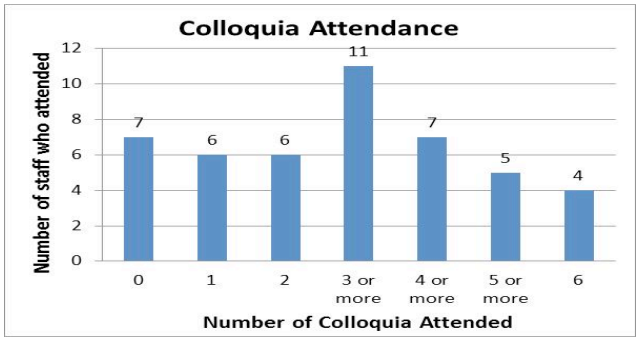

Figure 1: Staff Attendance of the Teaching Colloquia

The evaluation forms completed by each of the colloquium attendees showed that they had found them to be interesting and valuable, the discussions and interactions emerging from the formal input being particularly well appreciated. The interviews of staff were more specific in their endorsement of the colloquia, as the following extracts indicate.

> It was such a privilege to get input from these experts, people who are at the forefront of what they were doing in terms of the education stuff. It was very good.
> Just in general I found them also very useful and some of them very exciting in terms of the new ways you can apply [the ideas to your teaching. …] I think it's also important for us, as engineers, to be exposed to it at a more frequent level.
> And they [the teaching colloquia] were all valid and applicable. So that's the one [i.e. the colloquium on problem-solving] that really stands out for me and I think they're very worth it. I would hope that they continue.

The following comment, comparing the teaching colloquia to the 2-year, part-time diploma in teaching in higher education offered by the university, was particularly interesting.

> My other colleagues are doing the whole course – the post graduate diploma – and I really don't have time for that. This [the teaching development strategy] is a wonderful alternative and something that I can cope with. *(Interviewer: And it doesn't over-burden you in terms of your teaching load?* Not at all.

To conclude this section, it is interesting to note that lecturers from the school constituted the majority of engineering registrations for the university's post graduate diploma in higher education which was first offered in 2015. In 2015, 4 out of the 6 registrations from the Faculty of Engineering came from the school. In 2016, 3 out of 4 were from the school. The extent to which the registrations from the school were influenced by the teaching development strategy described in this paper is currently being investigated.

Overall Impact

The impact of the teaching development strategy as a whole was evaluated using the ATI-R instrument – the Approaches to Teaching Inventory (Revised) (Prosser and Trigwell, 2006, Trigwell et al., 2005). The instrument consists of 22 questions on a 5 point Likert scale. It generates two scores: the CCSF score which gives an indication of the extent to which a lecturer tends to adopt a Concept-Centred, Student-Focused approach to teaching in a given context; and the ITTF score which gives an indication of the extent to which a lecturer tends to adopt an Information-Transfer, Teacher-Focused approach to teaching in that context. Each score is the numeric mean of the Likert responses to the questions on each scale with 1 indicating a very negative response to the question and 5 indicating a very positive response.

Trigwell and Prosser (Prosser and Trigwell, 1999, 2006, Trigwell et al., 2005) have reported on work which has shown a correlation between the approaches to learning which students adopt and the approaches to teaching which lecturers use. According to this correlation, if a lecturer tends to adopt a concept-centred, student-focused approach to teaching, the students are more likely to adopt a deep approach to learning and to focus on understanding and mastering the topic. However, if lecturers tend to adopt an information-transfer, teacher-centred approach to teaching, then students are more likely to adopt a surface approach to learning, giving more attention to memorization than to the understanding and the mastery of the topic being 'taught'. Accordingly, an increase in a lecturer's CCSF scores suggests a shift in teaching approach that should correlate to some degree with improvements in student learning – i.e. students adopting deeper approaches to learning in the topics taught by that lecturer. Similarly, a decrease in a lecturer's ITTF scores should correlate the same way in that the students are less likely to adopt a surface approach to learning.

The ATI-R inventory was administered to the staff in the school in 2014 before the teaching colloquia began. It was administered again late in 2016 after the 7th colloquium and before the staff were interviewed. Because a lecturer's approach to teaching is context dependent and the teaching contexts of each staff member in the study were not the same, the ATI scores that are most meaningful are the pre-post data for each lecturer – i.e. the change in their ATI scores from the first to the second administration of the inventory; this makes each lecturer their own control.

A full statistical analysis will be conducted on the ATI-R data once all the questionnaires have been returned. The following findings are therefore only tentative. The results from pre-post administration of the ATI-R instrument are summarized in Figures 2 and 3. In each plot, the shift in a lecturer's score from the first (2014) to the second (2016) administration of the instrument is indicated on the Y axis. These shifts are plotted against the number of teaching colloquia attended (Figure 2) and, in Figure 3, the number of times staff participated in one of the teaching development offerings – i.e. the number of times they attended a teaching colloquium and whether or not they conducted a mini-project. (Note that the inclusion of mini-project with colloquia attendance in Figure 3 is a somewhat artificial device in that involvement in a mini-project is likely to have a bigger impact on a lecturer's pedagogy than attendance of one colloquium.) Although the significance of the results has still to be evaluated, some clear trends are evident. In each figre, the trend lines (linear) suggest that participation in the colloquia and mini-

projects has had the effect of shifting the teaching approach of lecturers away from information-transfer, teacher-centred approach and towards a concept-centred, student-focused approach.

Figure 4 shows the impact more clearly by plotting the shift in CCSF scores (2016 score minus the 2014 score) against the 2014 (Pre) CCSF score. The data is plotted this way to control for lecturers' initial CCSF scores because the potential for a lecturer's score to increase inherently decreases the greater their 2014 Pre score was. The left-hand plot shows that engagement with either a mini-project or the higher education diploma correlates with a significant increase in a lecturer's CCSF scores. The right hand plot shows that attending 3 or more teaching colloquia had a similar impact.

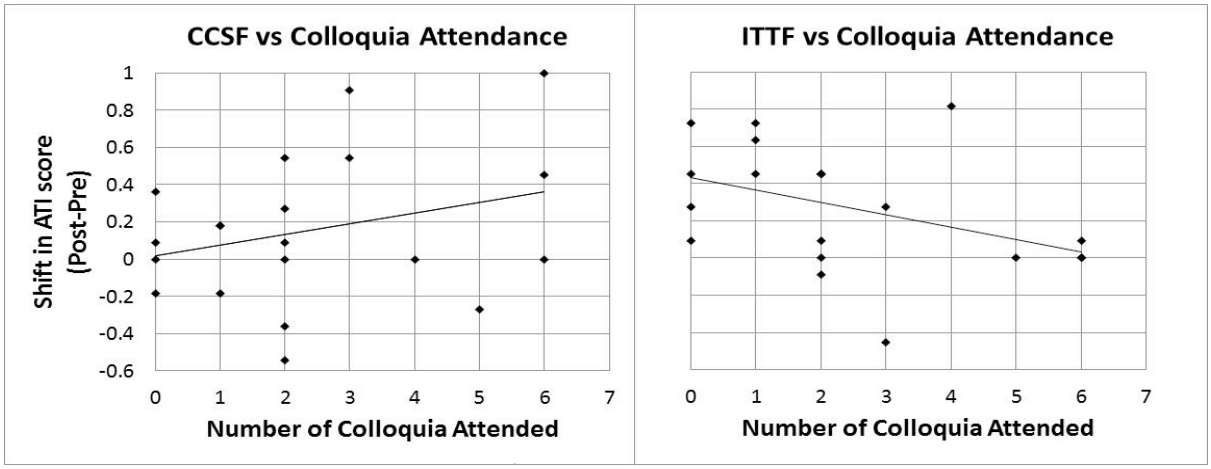

Figure 2: Shifts in Lecturers' ATI Scores (Score 2016-Score 2014) vs Colloquium Attendance

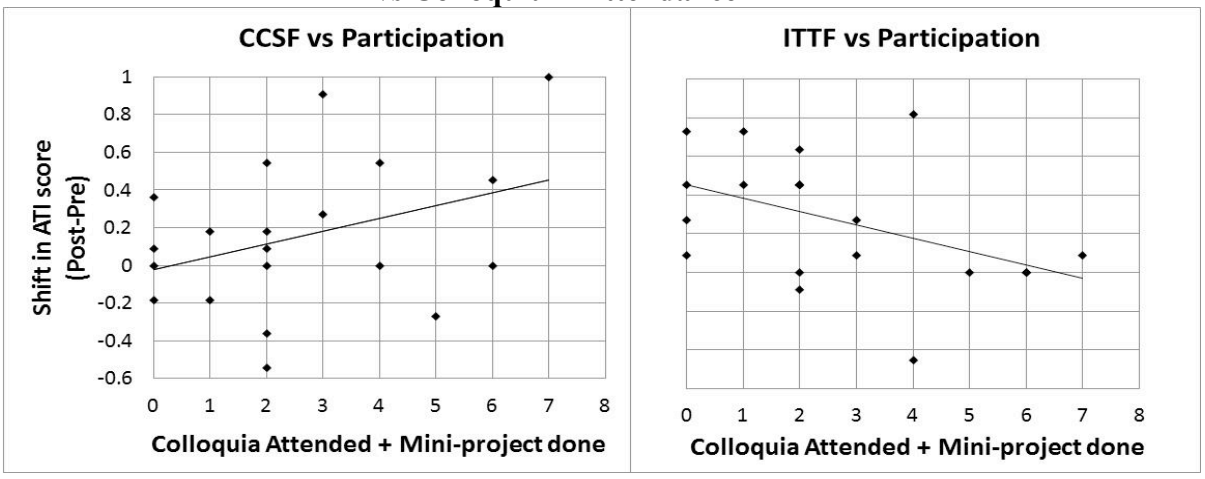

Figure 3: Shifts in Lecturers' ATI Scores (Score 2016-Score 2014) vs Participation in Colloquia and Mini-Projects

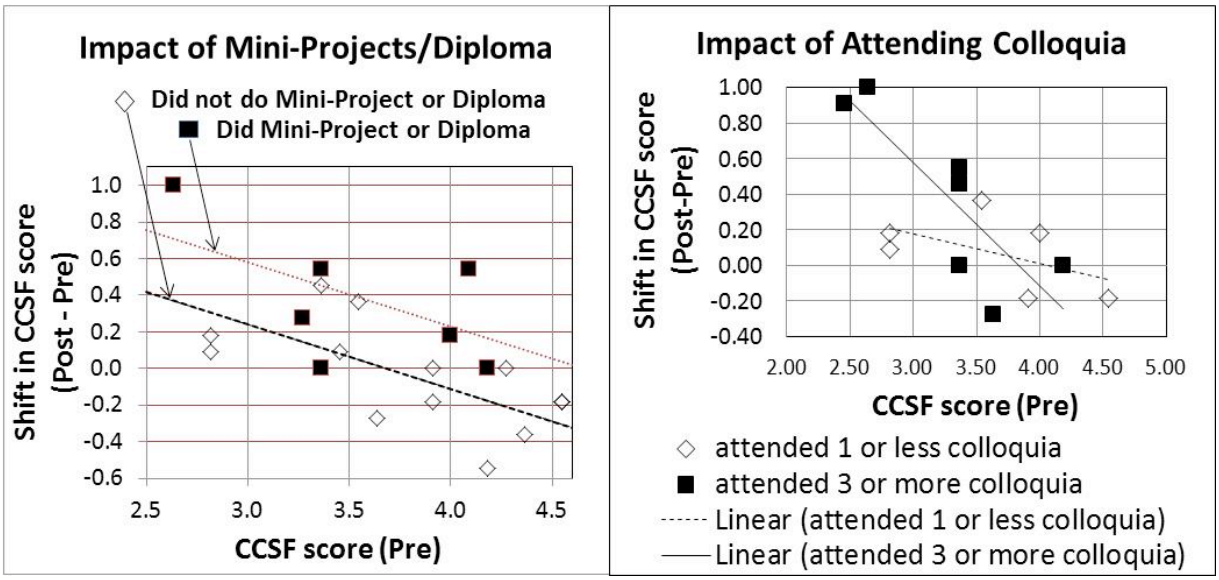

Figure 4: Impact on CCSF Scores (Score 2016-Score 2014) of Attending Colloquia or Engaging with Mini-Projects or the Higher Education Diploma

Discussion

The evaluation of the impact of the teaching development strategy has been and is being conducted by addressing four questions. Preliminary answers to these questions are as follows.

1) *How was the strategy received by the lecturers and how might it be improved to enhance its impact?* It is quite clear from the lecturer interviews and from the colloquium evaluations that both the teaching colloquia and mini-projects were very well received by those who participated in them. Even lecturers who did not participate in any of the offerings were positive in their opinion of the general value of the strategy.

   With regard to the general structure and implementation of the strategy and how these might be improved, the following points were noted. Attendance of the teaching colloquia was disappointing. At best, only about a third of the staff attended 3 or more of the colloquia and attendance at individual colloquia was almost always well less than half the staff complement. Attendance was greater when the topic was of more immediate interest to the staff – i.e. the colloquia on the flipped classroom, teaching problem solving, and teaching large classes. It therefore seems that in order to increase attendance, the colloquia should be framed and promoted within the school around topics that have immediate general appeal and that the more mundane but critically important issues such as educational research, pedagogy, assessment and curricula need to be woven into the fabric of those colloquia rather than as stand-alone topics.

   With regard to improving the mini-project component of the strategy, the primary issues have to do with execution rather than structure. The combination of the heavy workloads of the participating lecturers, the heavy involvement of the education researcher colleague in each project, and the number of projects being run concurrently resulted in a fragmentation of the time devoted to each project

and in the giving of feedback to the lecturers. In addition, a longer view of these projects seems appropriate so that the research investigation, the implementation of a pedagogical intervention, and the evaluation of the impact of that intervention should be seen as successive phases of a 'macro-project' each with its own time frame and resource budget.

2) *Did lecturers become more aware of how students were responding to their teaching?* It is quite clear from the lecturer interviews that the answer to this question is in the affirmative. Lecturers reported gaining insights into how students "were dealing with the subject" and how they were 'thinking' in that subject. One lecturer reported discovering that what they thought the students knew they actually didn't. In a phenomenographic project, the findings revealed that among the students there was a progression of increasingly more sophisticated conceptions about the topic. The lecturer reported finding this to be particularly helpful in guiding a redesign of the pedagogy he used.

3) *Did lecturers become more aware of the nature of their own teaching and how it could be modified to improve student learning?* Again the answer to this question is in the affirmative. This is evidenced by the previous lecturer's comment emanating from the phenomenographic project and, in addition, by the statements in the lecturer interviews sited earlier which reported that the inputs in the colloquia were "very useful" and some were "very exciting" in terms of learning new ways in which lecturers could 'teach'. Other evidence is found in lecturer statements that expressed appreciation about how aspects of the strategy had helped them to become better informed about education theory and practice.

4) *Did teaching change in any way and, if so, how*? The ATI-R instrument administered before and after participation in the teaching colloquia and mini-projects has shown trends that all suggest that this participation had the effect of shifting the teaching approaches of participating lecturers away from information-transfer, teacher-focused approaches towards more concept-centred, student-focused approaches. The significance of the observed trends must still be investigated because there is some variability in the data and the sample size was small. However, the trends do align with the indications from the evidence given in the two previous points. According to findings in the literature (see for example Prosser and Trigwell, 2006, Trigwell et al., 2005, Prosser and Trigwell, 1999) these trends generally correlate with improvements in student learning.

Conclusion

The work presented in this paper addressed the common problem that lecturers in engineering and professional education programmes are usually not conversant with education theory and best practice. The approach to remedying this situation in the school was to grow a teaching and learning culture within the school by involving lecturers in educational research, and, through regular teaching colloquia, providing formal input on relevant teaching and learning issues and also a forum for mutual interaction and discussion on teaching and learning. This strategy has been well received by the academic staff. Evaluations of the impact of this strategy all point to its effectiveness in increasing lecturers' awareness of relevant educational theory and best practice and in shifting their approaches to teaching in directions that align with

fostering improved student learning. However, the growth of a culture of teaching and learning in the school, as evidenced by participation in the teaching colloquia and mini-projects, has been slow. This is not surprising given the workloads of lecturers and their commitment to disciplinary research. Nevertheless, continued and perhaps accelerated growth is anticipated as the strategy is refined and the positive impacts of participation become more evident to the staff as a whole.

Acknowledgements

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