Improving Engineering student reflective practice

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BACKGROUND
Reflective practice is an important skill for improving learning, analysing personal or work place situations and identifying areas for improvement. Engineering students at the University of Waikato carry out reflective practice as part of their work placements and this typically involves setting learning objectives and reflecting on how they performed. Reflective practice is not popular amongst engineering students because they perceive it as 'fluffy' and they will avoid it where possible. Over the past seven years the Cooperative Education Unit has trialled different strategies for reflective practice, the most recent being having the students submit a set of learning objectives, providing the students with feedback, and students submitting an updated set of objectives, and then reflecting on how they did. All three submissions are assessed and contribute towards the student's final work placement grade.

PURPOSE
To interview Waikato engineering students about their perceptions of the current approach to reflective practice, their opinion on reflective practice and how it might be improved.

DESIGN/METHOD
One-on-one interviews were conducted with a cohort of seven engineering students who had completed at least one 400 hour work placement. Questions were pre-set with the aim of ascertaining student opinion towards planning, learning objectives and reflective practice and the current method of assessment.

RESULTS
Engineering students use some form of planning in the form of lists, Excel spreadsheets, calendars, and other tools, and found that it was necessary to keep abreast of jobs. Mostly the planning is provided for them by University courses or on the work placements. They found learning objectives to be useful, it gave them greater appreciation of what they were doing on placement, and allowed greater efficiency by figuring out what they needed to learn and learning it before they had to carry out the task. But they found setting the objectives early in the placement difficult when they were still unsure of their duties or what the projects entailed. The pre and post placement paper contributed slightly to them being able to set objectives, but it was more so from the point of knowing what the academics wanted. Students suggested moving the learning objectives assessment dates to later in the placement, involving the employer in setting objectives, and including simulated exercises in the pre and post placement papers in setting learning objectives. Opinion was generally favourable of reflective practice, it was useful for big projects and assessing health and safety incidents, although students did not like the time it took away from other activities they could be doing.

KEYWORDS
Work placements, engineering, reflective practice

Introduction

Engineering students go on work placements each year during the summer vacation to gain work experience in the engineering profession prior to graduating, imparting many soft and technical skills that Universities cannot provide, and providing students with contacts for obtaining full time work after graduation. The aims of the placements are for the student to learn about the industry and their profession, apply and develop some of the technical and theoretical skills and knowledge they learnt at university, as well as learn how to be a professional engineer.

The Cooperative Education Unit at the University of Waikato has facilitated work placements for 30 years through the Bachelor of Science and Technology (BSc(Tech)) degree, which began in 1984, and the engineering (BE) degree, which was first offered in 2001. The majority of work placement students are now engineering students who need two three-month work placements. Examples of engineering placements include power generation companies and related industries, pulp and paper, milk processing and milk products, automation and fabrication, plastic extrusion, injection moulding and rotational moulding, food processing, and engineering consultancies. Work can range from routine testing, machining work in workshops, and maintenance, through to process design and economic analysis, 3D computer aided drafting, and commissioning plants.

Traditionally students submitted one report after their placement which included a reflection and review section worth 10% of the placement grade. Reflective practice (hopefully) provides students with greater self-awareness, useful for when they are promoting themselves to prospective employers. Various models of reflective practice exist such as those proposed by Schön (1978, 1983), Kolb (1984), Gibbs (1988), Johns (1995) and Rolfe (Rolfe, Freshwater, & Jasper, 2001). Rolfe's model is the simplest of the models and comprises three questions: What? So what? and What next?; i.e. what happened, why it happened, implications, etc, and what would be done next? While reflective practice is widely recognised by academics as a valuable teaching and learning tool (Hancock, 1998; Richardson, & Maltby, 1995), previous studies and anecdotal evidence has shown that in general students have difficulty 'reflecting' on their work placement experiences and in general do not like it. This is shown by a lack of detail, and failure to elaborate on skills obtained and personal development. Students will avoid it if possible and for the most part only do it for assessment purposes. However, being able to reflect on personal experiences allows students to recognise areas where they do and do not have competency, why they might have succeeded or failed, and determine strategies by which they can overcome their limitations. It also gives them a better understanding of why they are doing it (Millonzi & Reitano, 1977).

Strategies such as learning portfolios has been implemented to try and improve student's reflective practice, but it has been argued that students can find these burdensome and unengaging (Buckley et al, 2009). Another strategy is to use social media such as Facebook, Twitter, and microblogging (Brown, 2010), which students use already and can support each other, increase interaction between the educators and students while on placement (Brown, 2010) and improve learning (Junco, Heibergert & Loken, 2010).

A previous study at the University of Waikato of trainee teachers on practicum and engineering students on work placement showed that microblogging was a helpful tool for encouraging reflective practice. However engineering students were reluctant to use it routinely, and if they did, it was only to post about what they were doing or something that happened, but with no analysis as to why it happened or what to do next (Paku & Lay, 2011).

In an initiative which started in 2009 to try and improve reflective practice engineering students were asked to submit some learning objectives early in the work placement. This was later formalised and two pre and post-placement papers were added in 2010 that included sections on learning objectives and reflective practice. In 2012 the work placement report was broken up into eight assignments distributed over the duration of the placement which included two sets of learning objectives, usually one to two pages, near the start and in the middle of their placement, an occupational safety and health assignment, three sets of reflective assignments focusing on learning objectives and personal and professional development, a company overview, and at the end of the placement a technical report. Together this is worth 75% of their placement grade, with the final 25% coming from an employer evaluation which is supported by work placement visit interviews. This was implemented to try and spread out the student assessment workload over the placement, but also to try and improve student reflective practice, and give them feedback as they progress through their placement.

The aim of this study was to determine what students thought of reflective practice and setting learning objectives in general, and to look at ways the current assignments and teaching could be improved to better cater for the students.

Methodology

A cohort of seven volunteers were obtained from third and fourth year mechanical, materials process and chemical and biological engineering students who had completed one or two work placements and the pre and post placement papers. All students were briefed on the project, given a consent form which they signed to give their approval to participate in the project and their permission to use any data resulting from their participation. Each volunteer was interviewed according to a set of pre-prepared questions, and the interviews were recorded and transcribed. Interviewing was selected over surveys because the data obtained is rich, the students could ask clarifying questions, and the interviewer could explore areas of interest that arose during the interview.

Results and Discussion

Students 1, 4, 5, and 7 were chemical and biological engineering students. Students 2, 3, and 6 were mechanical engineers and were in the Waikato Formula SAE team (Wesmo), which participates in the SAE competition in Melbourne in December. Student 1 had completed a placement at AgResearch and was involved in a complex protein peptide recovery project. Student 2 had completed a project with a titanium materials research group. Both were looking to continue on to do their PhDs. Student 3 had completed a placement at Genesis Energy in Singers Maintenance, Student 4 had worked at Carter Holt Harvey pulp and paper mill as a process engineer, Student 5 had worked for a process engineering consultancy and had been involved in commissioning work with Fonterra, and Student 6 had completed two work placements with a contract beer brewer designing and building mobile breweries. Student 7 had finished one placement at Orica.

Setting learning objectives involves some kind of goal setting and planning behaviour, so we wanted to explore what planning type behaviour the students exhibited. When asked, the students said they used planning and goal setting to a certain extent, but usually used what objectives the university or employer had provided, e.g. for assignments and projects.

> ***Student 1:*** *It was one of those things at [high school] that's drilled into you… "If you fail to plan, plan to fail." Whenever I set out to do a bit of work I always look at the tasks allocated and figure out how can I setup the tasks I need to do.*

> ***Student 2:*** *Not immediately, but after a while in the placements I've been involved in there's always been an end goal and within that I guess I set little goals to try and meet the end goal. Sometimes they don't go as planned.*

Student 3: *You have to set objectives so you can clarify a timeline and what you want to achieve with the Wesmo car and everything.* ***Is it subconscious thought activity or something you do systematically on paper?*** *It depends if like I know I've got a few thing to do or if there's a few big things, that's fine, I can keep it in my head and know I've got to do this. Working in the workshop for example I know I've got for the week ahead bearing housings, these big specific things, and I knew my other main things I had to do and the workshop boys are at smoko or lunch and I'd go do that and come back and you just got a few things on your mind, but if you've got a lot of things sh*t hits the fan if you don't start writing it down, you got to write a big list and things like that. It basically comes down to what kind of situation it is, like if the pressure is really on, and there is a lot of things going on, it is easy to forget things, but if there is just a few things, a few really big things, that's easy, you just got to remember three things and keep them ticking along, but if there is lots of little things and the pressure is ramping up, you got to keep a list, otherwise you get people breathing down your neck if you are doing it wrong.*

Student 5: *For university, yup, definitely, I have a big wall planner, and I put all the important dates in there and I go okay, I have this, this and this to do in that week and try and schedule everything so that works out better. Not really so much in the workplace, because all the work I've had so far has been, it's not been set as in this is your project and then you have to go do it, it's all little things, so you kind of get it, you see what you have to do and then you just plan on what you have to get done but there's not necessarily goals set for that.*

Student 5: *You need goals otherwise you are going to be floating round not doing very much, you need to work for something, I suppose every person going into the job, every person's goal is going to be different depending on what you are doing and what you are trying to get out of the work, you need something to work for otherwise you are going to work not really learning anything, not really doing very much, so yeah you definitely need them.*

Student 6: *Yeah, I do, I probably do it more now from those courses, but yeah I do plan ahead and set tasks and goals, and put deadlines on them.* ***Any situations where you use them more?*** *Probably more in my work, and like at home, more projects than uni work, I don't have goals for uni work I just get them done on time. For the likes of projects I set goals.* ***What kinds of projects?*** *Like Wesmo, 4th year projects, and trying to get other people to set goals and targets, and my second year design group, get them to set goals as well.*

Student 3: *Yup, it's sort of with Wesmo this year you got to know what you are doing and if something has gone wrong, like at the moment we've been delayed by a couple of weeks, we got held up by stuff, like Stainless Design for the chassis and the dry sump has been held up by very finicky small specialised motorsport companies that like to take their time with things and go on vacation and don't tell you. So yeah it sort of shown you got to reflect, you got to plan it like a month before you actually want it, and arrange it to get there a month before you want it so it might actually be on time.*

Planning tools were restricted to wall planners, Excel spreadsheets, paper lists, and phone calendars:

Student 2: *For my previous placement I did make an excel spreadsheet of goals I wanted to meet to achieve the end goal, but that's as far as I've gone in terms of using tools.*

Student 4: *Primarily Gantt charts, and lists of things I want done by certain dates.*

Student 5: *Piece of paper, I make a lot of lists, so that's my main thing, I write everything, as soon as I have it on paper and I can see everything then I know about it and I'm happy,*

but as long as it's in my head I forget about it, diary as well, like I said the big wall planner helps, so I can see milestones coming up.

Student 6: *Sometimes a bit of a timeline, if it gets complicated, but otherwise just a list of tasks. I suppose using phone calendar is another planning tool, I use that quite a lot, so calendar and notifications on the phone.*

When asked about setting learning objectives, students 2 and 4 found them useful for planning ahead in work.

Student 2: *Yeah, I think they're useful, obviously some people are going to put more effort into them than others, me personally, I thought they were useful but I didn't like doing them, but I did feel I gained something out of them.*

Student 2: *I guess it helped me realise what I was getting out of placements, so without doing learning objectives you'd go through the placement and I would have felt I would have accomplished something, but setting the learning objectives kind of gave me a better picture of what I had actually accomplished and made me think a bit more about what I was doing there and yeah what – how I could get the most out of the experience, so I guess I did find them useful.*

Student 4: *I do on placement and I do write things in my dairy to have things done by such and such a date. I found it useful because I was ready to do things by the time I was required to do them, as opposed to getting given a task and going oh sh*t I need to learn how to do this and getting chucked in the deep end.*

Student 2: *Again it just makes you think more about what you want to achieve and I guess once you know what you want to achieve, I started to go about thinking how to go about achieving it. Some of my learning objectives were to improve my time management, multitasking with jobs, staggering different jobs I was doing and by actually thinking about that before I had to do these jobs I was thinking about what I had to do to prepare myself so I could when the time came I could actually get on with the work, I could be trained up on the equipment, if there was no other work to be done, and I started thinking more about how I could be asking the lab technicians and the boss how to some things, if I could be shown how to use the equipment and then I would learn how to use it and maybe write a little note to myself saying the processes in how to use the polishing and the microscope or whatever, and then when I came to testing samples and things I was already trained to just get on with the work and the learning objectives made me realise that I needed to do that sort of stuff and help me plan accordingly. Reflecting on it I was able to see that I had put some thought in ahead of time and that enabled me to do my job more efficiently. So reflecting back it is good to see that things had worked.*

There was some commentary about difficulty in setting learning objectives, and this stemmed from the objectives being set early when the student had just started work and was still feeling their way around, figuring out what they were supposed to be doing. Another difficulty was in the project changing after they had set learning objectives which meant they had to revise the objectives. In addition, setting personal learning objectives was difficult as opposed to setting technical learning objectives which they found much easier. One student involved their employers in the process.

Student 1: *It is quite challenging, especially when you do them quite early in the piece. You're sitting there and it's kind of like, so how much do I know about what I'm going to be doing? And I found that with the objectives I set, there are some that seemed really clear cut, really obvious and there were others I was sitting there going, I'd like to learn that, and I 'd like to learn that, but I can't guarantee that I would. And there were others I'm like yeah I'll learn that, and I learn that and three weeks later realise that no I won't be doing it now. So you constantly have to keep redeveloping.*

Student 2: ***Did you find them hard to set at all?*** *Not really, they weren't hard, it was just the time thing for an hour or so and put together a few things. I talked to my employers about some of the objectives I should set and I guess that helped a bit with the timeline. So I guess they were useful.*

Student 2: *One thing I didn't like was having to spend time after work and in the weekends writing them, it was a little bit annoying because I was working reasonably big hours and I'd want to go home and relax and there were these learning objectives.*

Student 3: *It was quite vague because we had to set them quite early on, it was hard to set an objective that was anything worthwhile, setting something that was worth working towards, but then it was hard to know what you were actually going to be doing and how you can work towards what you are trying to set so it was – I remember mine to be quite vague because we didn't really know what I would be doing or how my placement would work out. Setting them early made it difficult to make them specific, like high quality almost.*

Student 5: *Some of them were alright, some of them were easy enough because I think they were broken down into those three of four categories that you had to set two of each, something like that, I remember thinking some of them were not quite applicable to the type of work that I'm doing and I didn't know what to write for them, it must be the personal ones because I go I'm here to work and you're asking me to set some personal goals, it doesn't quite mix for me, but the technical one is always nice and easy, because like in my previous work, AutoCAD is a definite thing that you have to learn and it's a measurable goal that you have to achieve, and you go I can do this and I can do that, whereas with the personal stuff it's all a bit fluffy, so you can't really measure it, makes it a bit more difficult.*

Student 5: *What I found with the goals was that a lot of the times you have these assignments where you have to set these goals for work and in that period we haven't got much work yet, or started with a lot of things so you don't really know what you are going to be doing.*

Student 6: *I thought that was pretty hard, especially when you set them you don't know what you are doing, and I suppose you have to set them off on a whim, you don't know what is achievable, because you do your learning objectives quite early, just after you start your placement so obviously it is quite hard to plan when you don't really know what you are going to be doing, and you aren't really in control of what you are going to be doing. But I didn't think they were too bad, work out what you want to do and write it down.*

The feedback was interesting because a lot of the personal/professional learning objectives students had submitted had been borrowed from the assignment sheet and course material, e.g. verbal communication, time management and interpersonal skills, and had been addressed in a vague, non-specific way, rather than placing them in the context of the work they were doing. In contrast, the technical objectives were as wide and varied as the work placements, and addressed in a specific way. We also had wondered why students had found setting learning objectives hard, and it appears to be that the students have difficulty setting objectives because early on in the placement; they are new to the job, they are unsure of what they are supposed to be doing at work, so they do not know what they need to learn and therefore had difficulty setting objectives. Student 1 suggested the difficulty was in articulating the objectives:

Student 1: *It's just something that is not immediately natural to students… I mean lots of us do it completely without realising, like all the time, so I need to learn how to better communicate with this person you can try, or I want to learn this in my paper so go do*

extra study, you do do it naturally but when you ask us to sit down and be like write about them, suddenly everything goes out the window!

Student 1 also commented about achieving a balance between being specific and being broad:

Student 1: *I always find the personal and professional ones much more easy one to meet in terms of the work placement because academic ones can just change so much. For example, when I started with my work at AgResearch I wanted to do there are certain techniques I wanted to learn but the project took a different track and I didn't end up learning those techniques. But it's obviously not a bad thing because I can still do the project but, just the academic ones it's hard to keep them broad enough that you're not confining yourself but not too confined that you completely miss one out when you come to doing your work.*

Student 3 suggested moving the learning objectives assignment back to later in the work placement when everything had settled down:

Student 3: *There was a midway point where you re-evaluated wasn't there? That was definitely good because mine changed like 180 degrees, like they started off like I want to know how to do this or be better at doing this and by midway through you knew what you could do. You knew what was happening, what with the shut there in the first week it was like carnage, and you were running around giving a hand where you can, but then later on you are working more specifically, everything had quietened down and you knew what you would be doing and what you would be doing next week and how that would work and what the timeline was for things coming back that you had already done, so that was probably a lot better having that evaluation midway through and that was when you could set worthwhile objectives rather than just filling out the form.*

When asked about if the pre- and post-placement papers helped them with the learning objectives, opinion was mixed:

Student 2: *Reasonably prepared, it was cool to have a paper that was dedicated to basically getting us up to scratch for industry and the CV writing workshops were good. Just sort of stuff you could do on your own but it's always nice to get people who have had the experience to teach you some tricks, so yeah I thought they were pretty good.*

Student 3: *I would say it did help but not a great deal, it would have helped knowing what you were actually looking for in those assignments and objectives, so that was probably the best outcome of it, I've done this, that and you're like, that's not right at all, do it like this and it sweet, that worked a lot better. But the lectures, not so much at all.*

Student 4: *Not really a question I could give a good answer to because I've setting goals since I was a kid, so by early high school I was already pretty good at it. But the courses would have given people who didn't know what to do pointers in the right direction, but they wouldn't have been super helpful either.*

Student 6: *Suppose I felt pretty prepared for writing them, but I wouldn't have thought that the teachers would have taught papers that would change that.* ***So did they contribute at all or what fraction would you say contributed?*** *I honestly can't remember, cause did we do practice learning objectives?* ***Well, if you can't remember it obviously didn't make an impact on you.***

Anecdotally, we have had students complain about doing the pre and post placement papers; usually it was directed at the academics teaching it and some of the workshops. Some students found the papers worthwhile, but the more mature students with some life experience found them not to be valuable at all, as the course covered what they knew already, and sometimes in a contradictory way. For example student 5 said:

Student 5: *Well the thing for me was the whole preparing the CV thing, that was useful, but then the whole mock interviews, that was not as useful, because I've already been for so many interviews for scholarships and that sort of thing, so you've already had some experience and then you were sitting there and they were trying to teach you things that you were successful with and they say no you don't necessarily do that, it was a bit contradictory to what I personally experience. I would say on the paper side you were prepared and confident and that sort of thing, but nothing can really prepare you until you go to work on the first day and start doing the work.*

When asked what the students would change in the courses and learning objectives one suggested including simulated learning objective exercises in the papers and another suggested that the focus of learning objectives be placed more on technical skills:

Student 4: *I would go through some simulated exercises, I would sit people down and give them a brief for a project and they're in a situation where they have been hired and they have to come up with a list of things they would do, you could use briefs from previous work placements, so students could actually see what they had to do by the time they get on work placement. It seems that from what I remember of 279 and 379 that these are goals and these are roughly the areas they cover, so you don't really get any more guidance than that. So putting people in a situation where they actually have to do it, this is that kind of goal and this is the other kind of goal. That would be helpful.*

Student 5: *Well probably focus a bit more on the technical ones than the personal stuff, the other things are the professional ones, just ended up being wanting to give a presentation, or wanting to be able to talk to people, where I feel that was more just writing something down on paper so you can get the grade than rather actually thinking about what you want to learn from the work, definitely focus more on the technical ones rather than the other ones.*

As part of the work placement, students needed to evaluate how they were progressing with their learning objectives as part of their reflective analysis assignments. Anecdotally, students typically disliked reflective practice. We have tried to get them to appreciate that reflective practice is just like discussing experimental results and analysing why they occurred, but students in general seem to prefer discussing inanimate objects rather than looking at themselves. So we were naturally curious to see what the interviewees thought of reflective practice:

Student 1: *I'm not so sure if it's natural for the boys in engineering.... boys are far more getting the job done, whereas girls tend to hold on for it that little bit longer like guys oh yeah hand in that assignment it's done sweet, and I can still be worrying about it three days after it… Reflective practice is something you kind of need to do otherwise you can end up on a very wrong track.*

Student 2: *Does take up time where I'd rather be doing other things, again I did find that I did get something out of it, a better understanding of what I was actually achieving at the placements, both technical and non-technical, personal skills and things like that, and just an appreciation for what they are sort of showing other thing you wouldn't normally think about, making you actually think a little bit about what you are doing.*

Student 3: *Wasn't overly enjoyable, there were some things that were good about it, like the general overview of reflecting on everything but it was quite in-depth what we had to go through on it, and there was also the fact that it was worth zero points as well, so I didn't like working for that.*

Student 4: *It is very useful and I've found it to be very useful, but I've found that most people don't take it very seriously to start with, but after you have a few health and safety incidents, you find it to be a very important thing.*

Student 5: *I'm not a big fan of it, especially having to write things down for writing things down, maybe that's because of the type of person that I am, in my mind I go, yup that was good, do it again, or that was bad, don't do it again, that's as much reflecting as I do. I don't really tend to think about why things worked because when I apply myself to something, I put everything into it anyway, so I can't really pinpoint specific things that I've done right or wrong, so that was a bit tricky for me.*

Student 6: *I think it's massive, its wicked awesome tool in terms of developing and getting better at what you are trying to do, and more efficient and learning from mistakes, I'd say I'd be using it a lot.* ***Do you use it at the moment?*** *Yup, sit down and try and think about what has been going on, make notes, so I can summarise them at the end of the year, especially for the likes of Wesmo, try to get everything down on paper, so hopefully at the end of the year there is a big list of things to try to not do, it's getting pretty big. Yeah definitely getting pretty big. But yeah, that's all reflection and yeah, I think it is massively important… I thought that the reflection was something that you sort of don't get taught up until now, which seems ludicrous because it is so important, so I think it is definitely good, heaps of people bag on it, but I think it is a good idea, just the whole concept of reviewing your work is massive, a massive tool.*

Student opinion was generally positive of reflective practice; it was useful, it gave them greater appreciation for the work they were doing, for dealing with situations where something had gone wrong, but they did find that it took up time, and in the case of Student 5, they thought that they did not like to reflect that deeply because they put everything into their work anyway. Ironically, Student 5's reflective assignments and learning objectives were actually some of the best we had reviewed; the student had obviously put a lot of thought into it and was quite clearly a deep thinker. Student 6 is a manager on the Formula SAE Wesmo team, and the team try to participate in the formula SAE competition in Melbourne each year. This is one of the toughest fourth year projects any student can undertake because it involves designing and building a car, managing a cohort of students, dealing with sponsors, technicians and academics, trying to coordinate shipping, import permits, money, etc. Student 6 has been learning a lot about himself and found as a consequence that reflective practice is very important.

Conclusions

Engineering students use some form of planning in the form of lists, Excel spreadsheets, and other tools, and found that it was necessary to keep abreast of jobs. Mostly the planning is provided for them by University courses or on the work placements. They found learning objectives to be useful, it gave them greater appreciation of what they were doing on placement, and allowed greater efficiency by figuring out what they needed to learn and learning it before they had to carry out the task. But they found setting the objectives early in the placement difficult when they were still unsure of their duties or what the projects entailed. Another challenge was the projects changing after the objectives had been set, which forced the learning objectives to be revised. The pre and post placement paper contributed slightly to them being able to set objectives, but it was more so from the point of knowing what the academics wanted. Students suggested moving the learning objectives assessment dates to later in the placement, involving the employer in setting objectives, and including simulated exercises in the pre and post placement papers in setting learning objectives. Opinion was generally favourable of reflective practice, it was useful for big projects and assessing health and safety incidents, although students did not like the time it took away from other activities they could be doing.

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