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The importance of project management documentation in computing students' capstone projects

KATHLEEN KEOGH*
Graduate School of Information Technology & Mathematical Sciences, University of Ballarat, PO Box 663, Mt Helen, Victoria, Australia.

ANNE VENABLES
Victoria University, School of Communications & Informatics, Victoria University of Technology, PO Box 14228, Melbourne Australia.

In attempting to integrate classroom studies with professional work practice, many universities include a capstone team project in the final year of their undergraduate computing degrees; the experience is designed to improve upon students' essential technical skills and to help prepare students to become work ready by developing communication and team building skills. The quality of such a learning experience is influenced by the subtle interplays of three key elements: the curriculum, practice and industry standards. At the University of Ballarat the curriculum endorses the practice whereby students adapt industry standard documentation, in particular, the Software Project Management Plan (SPMP), as a mechanism to manage teamwork and organizational processes. Over recent years at the University final year computing students have been surveyed about their project experiences - feedback indicates that the task of preparing and using these management documents has had a positive impact on students' readiness for the workplace. (Asia-Pacific Journal of Cooperative Education, 2009, 10(3), 151-162).

KEYWORDS: Experiential learning, industry standard documentation, project management practice, student teams.

Work integrated learning (WIL) takes on many different forms. In essence, it is an attempt to integrate classroom studies with professional work experience (World Association for Cooperative Education [WACE], 2008), and as education institutions and communities awaken to its benefits, much of its practice has been documented (Langworthy & Turner, 2003). In fact, Calway (2006) identified approximately 900 reports and articles on work integrated and cooperative learning, from which he distilled eight generic models of practice, including that of 'project based' experience. Project based learning is common in engineering, IT and computing studies where students apply what has been learned in the classroom to a 'real life' project, often for a business or community client (Gorka, Miller & Howe, 2007; Keogh & Venables, 2007; Martin & Devenish, 2007; McKenzie, Trevisan, Davis & Beyerlein, 2004).

In implementing any work integrated learning program, there are concerns in maintaining the quality of the learning experience resulting from the subtle interplays of three key elements: curriculum, practice and industry standards (Shakespeare & Hutchinson, 2007). Whilst the setting of the work related learning influences practice, the institution decides upon the curriculum and external accreditation bodies usually mandate the standards and competencies required from the WIL experience. For instance, it is common practice for higher education institutions to dissect the content and delivery of their WIL schemes in order to check that the programs systematically develop in their exiting students the specific knowledge for their discipline, together with the acquisition of professional and personal skills needed for their field (Cranmer, 2006; De La Harpe, Radloff & Wyber, 2000; Scoufis, 2000). In particular, information and communication technology (ICT) course content are

* Correspondence to: Kathleen Keogh, email: k.keogh@ballarat.edu.au

under continual review and change due to the evolution of the discipline, the introduction of new technologies, the demands of industry accreditation boards and from financial constraints resulting from see-sawing student numbers (Tan & Venables, 2008).

Employers demand that new ICT graduates be equipped with a strong set of technical skills coupled with a flexible and creative approach to problem solving, and it is highly desirable that they have collaborative teamwork experience (Hagan, 2004; Snoke & Underwood, 2001). Responding to this demand, many tertiary institutions incorporate a capstone project into the final year of their IT and computing curricula to encourage students through practice to develop a set of technical and personal skills needed for their future professional lives (Clear, Young, Goldweber, Leidig & Scott, 2001; McKenzie et al., 2004). Such projects encompass diverse technical areas including software development on specialized platforms, hardware design, networking problems and multimedia development where a concerted team effort is essential in tackling all development steps from specification, through software design to product delivery.

The importance of such WIL software team project experience in final year computing degrees is without argument (Fleming, 2005; Gehrke et al., 2002; Lynch, Goold & Blain, 2004; Newman, Daniels & Faulkner, 2003). There is, however, academic debate about how to best achieve 'industrial-strength' authenticity for students. To achieve this, we argue the necessity of introducing industry based project management documentation to students undertaking final year computing projects as a mechanism to add realism to the project experience. This practice, particularly when mandated by the curriculum, supports students through the challenges of project development whilst satisfying industry accreditation expectations. This has been shown in the context of engineering (Moor & Drake, 2001).

This paper presents a more detailed discussion and presentation of data summarized in (Keogh & Venables, 2008). The next section describes the context of final year computing projects at the University of Ballarat where project management processes and formal documentation are mandated by the curriculum. Driven by an interest in understanding student perceptions prior and post the project experience, several student cohorts were extensively surveyed about management of their projects. The results of these surveys are presented first, followed by a discussion of the feedback. The final section concludes by highlighting the importance to the student experience and the outcomes of using industry standard documentation to manage team projects.

PROFESSIONAL COMPETENCIES AND CAPSTONE COMPUTING PROJECTS AT THE UNIVERSITY OF BALLARAT

Computing students at the University of Ballarat in the Graduate School of Information Technology and Mathematical Sciences study a capstone project in their final year of study. For undergraduate students, the project is undertaken over two semesters and for Masters coursework students, the project experience is one semester long. In both cases, teams of five to seven students tender for projects that are sourced from real clients in the local community. The projects range from educational tools, games, multimedia systems, database developments and ecommerce websites. From writing an initial tender bid to the delivery of a working prototype system, student teams experience all aspects of managing a professional software project development. In reality, the project experience offers a level of complexity that goes beyond the students' previous course experiences, and accordingly through practice, students are expected to develop a set of product, project and social skills

needed for their subsequent professional careers. A list of such of competencies compiled by industry practitioners and educators is shown in Table 1.

Underlining the importance of the development of these sets of skills for computing students is the Australian Computer Society, the industry professional organization in Australia. In their accreditation specifications, it can be seen that project management and interpersonal communication are key attributes amongst the core generic skills needed by graduates seeking professional membership (Australian Computer Society [ACS], 2003). These professional competencies are essential skills required by new IT graduates, though their development in a curriculum may be difficult to pinpoint. It is possible to teach students that standards exist and to indicate the tools and methodologies that assist in project management, however the learning outcome can be vastly improved if students can *experience* these standards and processes for their own project. Through experiential learning the value and meaning of the relevant people-, project- and project-related skills become more than apparent.

Throughout their degree, students at the University of Ballarat gain exposure gradually to project management and larger problems so that when they enroll in their capstone project unit, they have developed technical and analytical skills, and they have an understanding of project management theory. In the project unit, students are supported by a variety of 'sign posts' and by scaffolding designed into the curriculum to guide practice (Keog, Sterling & Venables, 2007) where they are expected to produce significant industry level documentation in support and management of their project including: *Software Project Management Plan* (SPMP), *Software Requirements Specification* (SRS), *Software Architectural Design Document* (SADD), *Software Detailed Design* (SDD), *Test Plan* (TP), and *User Documentation*. Thus the creation of suitable management, planning and technical documentation in itself becomes a joint focus for students together with the delivery of a working final prototype. The project curriculum design and assessment as a whole is not the focus of this paper, however, it is worth highlighting that the assessment is based on both process (observed behavior and evidence based on records such as minutes, agendas and status reports) and product (documents and deliverables). Interested readers are referred to detail published previously justifying the chosen assessment tools (Keogh & Venables, 2007).

Software Project Management Competencies

Product Related	*Project Related*	*People Related*
Assessing processes	Building a work breakdown structure	Holding effective meetings
Awareness of process standards	Documenting plans	Interaction and communication
Defining the product	Estimating effort	Leadership
Evaluating alternative processes	Managing risks	Managing change
Managing requirements	Monitoring development	Negotiating successfully
Performing the initial assessment	Scheduling	Presenting effectively
Selecting methods and tools	Selecting project management tools	Selecting a team
Tailoring processes	Tracking project progress	Team building

TABLE 1
A list of professional competencies needed for software project development and management as compiled by industry practitioners and educators (after Futrell, Shafer & Shafer, 2002)

THE SOFTWARE PROJECT MANAGEMENT PLAN DOCUMENT: STUDENT EXPERIENCE DRIVEN BY INDUSTRY STANDARDS

As in industry, the Software Project Management Plan (SPMP[1]) is a valuable resource in that it documents the roles and responsibilities of a project's team members, as well as articulating team planning and management controls. To provide a realistic industrial experience and to mitigate the risk of project failure, students are required to spend a significant amount of time at the commencement of their project negotiating team roles and responsibilities, rules, standards, a team contract and a detailed communication plan. Of course, the tasks assigned to team members depend on the type of project, where typical roles include, such as: *Project Manager*, *Client Liaison*, *Secretary*, *Business Analyst*, *Design Lead*, *Tester*, *Programmer*, *Quality Assurance Manager*, *Risk Manager*, *Librarian*, *Website Manager*, and *Graphic Artist*.

Also the SPMP records team decisions about processes and it details a project schedule through the production of a detailed work breakdown structure (WBS) and a corresponding Gantt chart. Initially, the Gantt chart is based on a set of milestones for due dates suggested by the coordinating staff, however, students are instructed to negotiate with supervisors for any deadline changes particular to the needs of their project. Thus, teams are encouraged to take ownership of their project's management ensuring that the SPMP with its project plan (Gantt chart and WBS) become regularly revised, working documents. As teams develop their own normative rules, processes and methodologies are continually revised to suit their project and students are encouraged to revise and review all their artifacts. Likewise, students initially have limited skills in conducting formal meetings and so the assessment is keyed to the creation of records such as minutes and agendas for meetings to encourage students in the development of valuable communication, planning and leadership skills. In particular, communication skills – meetings, presentations and client management – tend to be underrated by students who nonetheless have difficulty preparing agendas, keeping minutes and developing negotiation skills. Client liaison and management is a crucial, 'learnt on the job' skill that is especially difficult for students where projects are initially loosely scoped and multiple meetings are needed to elicit requirements.

For industry and in the classroom, the importance of the SPMP or equivalent project management planning documentation in formally documenting project management processes cannot be underestimated. Using good project management principles can address problems experienced in student projects (Moor & Drake, 2001). So it is not unique to impose a requirement that students create or tailor a Project Management Plan to explicitly describe their processes as part of their capstone project (see, e.g., (Reichlmay, 2006)). Therefore it is important that the basic structure and content of a project team's SPMP is based upon similar documents used in industry, such as the Institute of Electrical and Electronic Engineer's SPMP template (Institute of Electrical and Electronic Engineers [IEEE], 2008) and the de facto standard process for planning and development of a project plan for Project Management professionals, PMBOK® (Project Management Institute, 2000), or the many other company specific processes and document templates available on the Internet.

[1] For the purpose of this document, we refer to the project management plan as SPMP following the IEEE standard, however our discussion broadly includes any Project Management Plan that documents management and controlling processes.

As part of the experiential learning process, student teams need to research and review the variety of SPMP types and the contents of industrial examples before custom building their own SPMP documents. Team members are guided by documentation samples from previous projects and the following marking scheme against which their SPMP document will be assessed. As detailed in Table 2, the SPMP components used for marking include many found in industry's IEEE SPMP template. The importance of structured assessment to drive learning is well established in the education literature, but for computing projects it is equally important to value process as well as product (Goold, 2003; Keogh et al., 2007). This is particularly important point since a study of assessment in capstone courses in the USA, found that assessments were lacking, in that, they were generally product focused rather than process focused (McKenzie et al., 2004).

Tying student assessment to documenting management and planning processes in an SPMP and then following these stated processes, ensures that students will 'go through the motions', but do they get anything from the exercise? The motivation for this research was a desire to investigate students' perspectives of the importance, or otherwise, of using SPMP documents to their overall project experience. Were the SPMPs used as intended? Did the documents direct practice? And did they influence student confidence in their project management abilities in preparation for the workplace?

METHODOLOGY

In 2006 and 2007, several student cohorts were surveyed regarding their project experiences and, in particular, the role of the SPMP document played in managing the team and its processes. Survey questions were a mixture of 'circle the appropriate response' type, short answer questions and open-ended questions inviting considered responses. Initial questions related to whether students had any previous collaborative teamwork experiences prior to the project. The focus of the survey questions analyzed for the current research was the SPMP document; whether it had been used, whether it had been helpful or not, and whether it had directed, as hoped, the project experience. Students were surveyed about their successful implementation or otherwise of processes described in their SPMP and they were asked to comment on their current beliefs and practices. Students were also asked to reflect retrospectively on their beliefs and behavior upon starting their project where responses were invited for both 'now' and 'at the start of your project'. Details of the survey questions are given in the Appendix. Surveys were distributed and administered close to the end of semester, by an independent person who had no influence on the assessment of the project students and the survey responses were not made available for analysis until the teaching semester was complete and results finalized.

Overall, the response rate was approximately 60%. There were 17 postgraduate and 38 undergraduate returns. All these students had worked with their team to meet a client and elicit requirements; perform some analysis and develop a detailed software requirements specification; and document a design to address their client needs; with some groups also having a prototype developed addressing some of the clients' needs. All teams had completed a series of management related documents, including status reports, their software project management plan and Gantt chart with major project milestones. After one semester of work, students had opportunities to learn through the experience of using their management documentation, reflect on, and update their processes and improving detail in their Gantt charts.

Component	*Description*	%
Project Scope	Broad project scope, limitations, constraints and boundaries defining responsibilities of project team.	10
Description	A high level description of the problem to be addressed by this project. May include project proposal or business case or a high concept statement in the case of game development	10
Team Contract	A clear statement of the time commitment expected of each team member; Define responsibilities and roles needed; and allocations of members to each role	10
Project Plan	Work Breakdown Structure including Gantt chart, scheduling major milestones, allocating resources (people) to tasks, including regular meetings. This is expected to remain a 'live' document throughout the project	20
Team Communication Plan	Timetable and details of where, when and how meetings are held, contact details for all members, processes for communication, processes for updates to electronic repository and other project tracking processes	10
Quality Assurance statement	Team auditing, review, change control processes that will be adopted.	5
Risk Management Plan	Definitions of the processes for identifying, monitoring and reporting project risks	5
Configuration Management Plan	Methodologies and Tools to be used. (e.g. configuration management, backups, email archives, web page/blog (electronic team repository) management and project management tools)	5
Team Standards	Standards for documentation and coding	5
Overall Document Quality	Completeness, presentation, organization and content, version control, table of contents, referencing, relevance to this particular project	20
		100

TABLE 2
Marking criteria for *Software Project Management Plan* (based on industry equivalent documents)

SURVEY RESULTS

In total, 55 individual returned surveys were collated over both undergraduate and postgraduate groups and the combined feedback is reported here. In the majority of cases, students' prior team collaborative experiences were limited to smaller team assignments previously encountered in their studies. In a small number of cases, students had been involved with smaller collaborative projects during work experience or their TAFE studies previously, although when investigated further, these did not share the same level of management documentation.

In 54 of a total 55 separate responses, students stated that their team members had been assigned well-defined roles with 50 students responding that they had been adhering to and updating their project plan regularly. As the SPMP document specifically defines team-member tasks and roles, it is interesting that 12 respondents report that there had been significant team conflict throughout the project. Informal feedback from staff supervisors suggests that the presence of the SPMP document with clearly defined expectations and processes for managing conflict is actually helpful in resolving such conflicts. This fact, together with the above responses, highlights the relevance and importance of the SPMP document in helping managing team difficulties. The SPMP is also a useful document to guide practice. Regarding meetings, students were asked whether they regularly prepared agendas and whether they kept minutes as they had directed in their respective SPMPs. Of 55 individual responses, 49 reported that agendas were done and most encouragingly 54 students attested that minutes were regularly kept. These results are graphed as the current practices in Figure 1. In an attempt to capture changing student practices, the survey tool retrospectively asked whether the processes described in the SPMP been done at the commencement of projects when they were establishing the team norms. Reported practice at the commencement of the project experience is also illustrated in Figure 1. It shows that over time students reported that they increasingly identified with their defined roles, they found the document useful, they were more likely to prepare agendas and that minutes were more regularly kept. Regarding use of the project plan, a total of 54 respondents answered that they had found it valuable; more specifically of these 49 students reported that they actively used their project plan for organization and planning within their team.

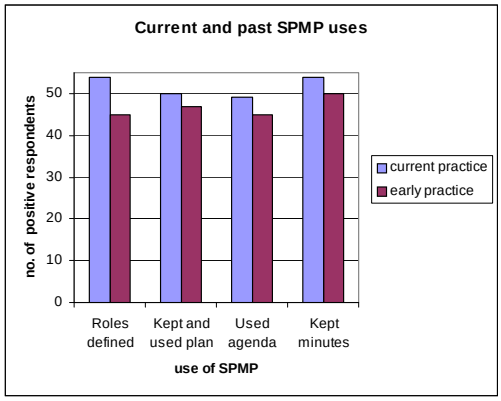

FIGURE 1
Positive survey responses (n=55) of current and early uses of SPMP components during team project experience.

Overall the survey feedback detailed above suggests that students found the SPMP progressively more valuable for managing their teams and processes as time went on. Others have reported that capstone courses can improve students' confidence for future work readiness (Dunlap, 2005). To try and gauge whether this is the case for University of Ballarat students, they were asked to measure their confidence regarding their ability to work well in a team or managing a project in the workplace. All students replied that that they would be able to work well in a team in the workplace, with 75% responding that they were very confident of this ability. When asked to reflect upon their abilities prior to the project experience to manage a development project in the workplace, 16 of 55 students replied that in the beginning they had not been confident at all, 47% had some confidence and a quarter of students stated that they were very confident prior to project. After their project course, 96% of students reported being confident enough of their skills to manage a new project, with 38 % of these students reporting to be very confident.

DISCUSSION

For the majority of students the WIL software team project experience is unlike any other encountered in previous studies, in that, the size of the problem ensures that true collaboration and teamwork is essential for overall project success. As in industry, management of project processes is aided by SPMP documentation. A SPMP is a blueprint for a software development project; it documents the project goals, team management and organization and the allocation of team responsibilities. At the University of Ballarat, the practice of using a SPMP document is mandated by curriculum where students undergo the valuable exercise of finding industry examples and having to judge what is relevant to their own project. Specifically, one survey respondent wrote: "I am really finding that the process of deciding what/not to use is very valuable." As reported by (Haberman & Yehezkel, 2008), this pedagogy encourages students to learn from practice. For instance, students learn of inadequacies in their Gantt charts and work breakdown structures when having to rely on them for team project management tasks. Overall, feedback from students on completion of their project suggests that their experience of using project management artifacts was appreciated even more on reflection in the open-ended responses where: "I didn't realize how important the SPMP document would be" was stated one student on completion of their project.

As mentioned earlier, it is important that students do not view project documentation as the end product in itself; the focus needs to be squarely upon the process (Umphress, Hendrix & Cross, 2002). In an effort to direct students at the University of Ballarat, assessments are clearly weighted to value processes as well as products; and this fact was not missed by students. Although other authors warn that students may find the demand for formal project documentation unnecessarily bureaucratic (Hood & Hood, 2006), the survey results show that most students do grow to value the formal documentation of team management processes. Initially, coordinating staff do make a point that the emphasis of the project course is on the experiential learning and exposure to relevant industry documentation; if this message is not heard, then students can complain that there is a lot of (arguably disproportionate) work required for the documentation in a (relatively) small project. However in most cases, they reported using their project plan actively and found them helpful for their planning and in team management. One student wrote "the SPMP document was the most important document that we wrote." Informally, we observe that students who did not follow formal project plans and schedules were less likely to achieve

the full scope of their project successfully. The value of students' engaging with scheduling their own project work is consistent with the experience found in capstone units in the engineering context (Moor & Drake, 2001).

For the cohorts surveyed, student's confidence in their ability to successfully manage a project in future workplace either remained positive or increased during the project experience. As one graduate commented: "If I was more aware that I needed to learn as much as possible as was delivered in the units, so that I can be discerning in a real world project, I would have embraced the units even more," whilst another stated "I think the SPMP was a good document, although the time [taken] to create the document was [a] large amount, it was evident in learning that documentation is a huge and important part of delivering a successful project … I am definitely more confident in my ability as a Project Manager and it has confirmed that this is my chosen career."

Further personal student feedback after completion of these capstone project units suggests that the broad project management experience becomes more relevant and valuable to them in their first jobs where they are required to make professional decisions. The following comment was offered by a graduate a few months after completing his project: "What I really hadn't grasped from the project units until now is how valuable the actual experience was as a whole." This graduate went on to explain how he now realized how his project experience had prepared him for a real world project and was enabling him to be discerning regarding his documentation and planning needs in the workplace.

One of the open-ended requests for comment on the surveys distributed to students asked what three pieces of advice students would give to future project students. The majority of responses offered advice relating to process, teamwork and communication. There were also some comments relating to effort and overall workload. Some 85% of students gave a total of 136 pieces of advice. Of these, 33 pieces (24%) directly related to documentation and planning, 23 (17%) particularly mentioned defining team processes and following them. Subsequent to the original survey, a separate cohort of 18 finishing students was asked for advice at the end of their project. There were 47 comments returned, of which 18 (38%) directly mentioned documentation and or planning. Typical comments include: "Allocate roles and tasks," "Plan well to get the work done," "Keep track of documentation," "Document all processes in SPMP," "Follow the plan," "Have set rules for members missing work or meetings," "Define roles," and "Start SPMP early." Such advice suggests that students value, albeit retrospectively, their management processes and the need to document these. It further supports that the educational objectives are being met.

New ICT graduates do need a set of project, product and people related skills (as listed in Table 1) to manage software development projects and find their feet out in industry. Whilst observing new computing graduates working in their first jobs, Begal and Simon (2008) noted the most significant skills needed were social problem solving skills. Likewise, in student software development projects, we note, as do others (Gnatz et al., 2003), that in most cases when conflicts and difficulties arise, it is not due to technical problems, but due to issues of communication and collaboration. The difficulties can be generalized as either communication problems with the client or intra-team problems. The former can lead to poor specification of the client's problem or implementation of a system that does not meet the client's needs. In this instance, students are supported by staff, involved with scoping the problem, to help manage the client relationship. It is outside the scope of this paper to discuss student inadequacies regarding client communication, but suffice to note that it is

often a significant revelation to students that the client relationship is ongoing and requirements are not simply gathered in one good meeting.

CONCLUSION

"I felt these units were the most important units of the whole degree. ICT graduates need to be equipped with a strong set of technical skills coupled with a flexible and creative approach to problem solving, together with relevant team building skills." A 'project-based' WIL experience in the final year of IT and computing courses helps develop important product, project and people related competencies for students particularly when the projects are 'real life' and sourced from business and the community. Importantly, through the pedagogy of introducing industry standards documentation to students, this work related learning experience helps transform students into industry ready graduates. In particular, the adoption of industry based SPMP standards has proved valuable for adding realism to the experience and for satisfying industry accreditation expectations. For students, the SPMP acts as a mechanism for guiding and managing their software development projects by defining tasks, communication protocols, processes and responsibilities. The exercise of tailoring an SPMP to suit the student project is valuable towards the development of students' work ready skills of discernment and understanding. It is a working document that proves to be helpful for students experiencing team difficulties. Through the interplay of curriculum mandating industry based practice, the empirical evidence from our survey responses has shown that students are transformed into graduates who value process and who are confident of their ability to work collaboratively in the workplace.

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APPENDIX

Selection of Survey Questions Used in the Study of the Software project management Plan at the University of Ballarat

Previously have you done much collaborative team work?
Please comment:

Does your team adhere to each of these processes as defined in your SPMP document:

	Now	At Start of project
Preparing an agenda for meetings	Yes/No	Yes/No
Keeping minutes of meetings	Yes/No	Yes/No
Each person has well defined role/s	Yes/No	Yes/No
Keeping and Using a project plan Yes/No	Yes/No	

Have you had any significant team conflict so far? Yes/No

How confident are you in producing a successful product now?
Not at all confident
Some confidence
Very confident

How confident are you that you could now successfully manage a project in the workplace?
Not at all confident
Some confidence
Very confident

How confident are you that you could now successfully work well in a team environment in the workplace?
Not at all confident
Some confidence
Very confident

Before starting your project unit, how confident were you that you could successfully manage a project in the workplace?
Not at all confident
Some confidence
Very confident

ABOUT THE JOURNAL

The Asia-Pacific Journal of Cooperative education (APJCE) arose from a desire to produce an international forum for discussion of cooperative education issues for practitioners in the Asia-Pacific region and is intended to provide a mechanism for the dissemination of research, best practice and innovation in work-integrated learning. The journal maintains close links to the biennial Asia-Pacific regional conferences conducted by the World Association for Cooperative Education. In recognition of international trends in information technology, APJCE is produced solely in electronic form. Published papers are available as PDF files from the website, and manuscript submission, reviewing and publication is electronically based.

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