Full Paper

Introduction

For postgraduate research students, critical thinking and communication skills are foundational to their research activity, as emphasized in the Australian Qualifications Framework (AQF) level 10 criteria. Critical thought is developed through interaction with the scientific literature, including reading journal papers and generating original contributions. Written communication skills are generally developed as students write research proposals, journal papers and their thesis, whereas oral communication skills are developed during review presentations and at conferences.

Despite the importance of these skills to the successful completion of a postgraduate degree, there are few formal programmes in Australia for developing a student's skills in these areas, with most of the learning coming incidentally as students work towards their degree. Graduate centres typically focus on milestone completion, writing and learning centres provide workshops, remedial support and targeted training sessions, but much more could be done to improve these central areas of skill development. Students, however, commonly look to their supervisors for how to critique existing literature as well as write and publish original research, with the latter increasingly being viewed as the principal metric by which the impact of research is measured (e.g. see Ziegler and Gillen, 2015).

Journal clubs are one option for developing both critical thinking and communication skills at a postgraduate level, and are widely used in postgraduate programs—particularly in the field of medicine (Alguire, 1998). This paper describes the implementation of a journal club in the discipline of hydrological engineering, which has been designed to:

- improve critical thinking skills, written skills and oral presentation skills;
- broaden discipline-specific knowledge by reviewing journal articles within the students' field;
- combat the sense of isolation that is commonly felt at the postgraduate experience (e.g. Zuber-Skerritt, 1987) —a known contributor to PhD non-completion— by providing an opportunity to interact socially with other students; and
- accommodate repetition of topics and differing skill-bases in the group by means of scaffolded and peer-oriented learning techniques.

This paper reviews the use of journal clubs in the development of postgraduate research attributes and the educational approaches which have given greatest success. The paper also documents the authors' experiences in running journal clubs over the past few years, covering trade-offs such as the balance between instructor led skills development and peer-oriented instruction, how to iterate between topics of reading comprehension, review, writing and other specialist elements (e.g. graphics, statistics), and how to motivate students. Section 2 reviews the literature on journal club objectives, followed by Section 3 in which the specific structure of the University of Adelaide hydrology journal club. Section 4 briefly summarises student feedback on the current implementation of the club, and conclusions are presented in Section 5.

1. Journal club objectives

Journal clubs have been used with diverse formats and to address multiple alternative objectives (Alguire, 1998), depending on the discipline, size and experience of the group, involvement of academics and so on. A list of alternative objectives that have been commonly adopted for journal clubs is provided below. Most of these objectives are based on detailed systematic reviews of journal clubs in the medical literature (e.g. Ebbert et al, 2001; Edwards et al, 2001; and Deenadayalan et al, 2008), where journal clubs are a much more common feature of the postgraduate curriculum.

Overall objective: The extent to which the purpose is to maintain currency of knowledge; improving a student's critical appraisal skills; facilitate peer interaction; or act as a mode of formal instruction to students.

Selection of papers: Whether to acquaint students with seminal papers in their broad area, the latest technical research in their field, papers from the supervisor, papers discovered by students, or manuscripts under preparation by the students.

Skills-development focus: Whether to explore criticality within the review process (see also Guilford, 2001), reading and writing, oral communication (see also Minerik, 2011) or technical skills such as statistics.

Aspect of paper: Whether to consider entire papers, specific features (e.g. abstract, introduction, challenge, discussion, recommendations, graphs), or specific styles (review, discussion, opinion).

Stage of learning: Whether to focus on newer students who are uninitiated to academic writing concepts; international students who may require additional language skill development; students facing specific challenges such as first submission of a manuscript or responding to reviewer comments; or advanced postgraduate students.

To assist with determining the optimal format of a journal club, it is important to clearly articulate the club's objectives (Alguire, 1998). Many journal clubs are informal and initiated with a basic motivation focussed on a specific element; for example to maintain currency, or to teach writing skills. To address the diversity of a group and realize the potential of multiple objectives requires a more formalised programme with planned activities (Deenadayalan et al, 2008).

2. Structure of journal club

A journal club was initiated within the School of Civil, Environmental and Mining Engineering at the University of Adelaide in 2012, following the first author's experience with similar journal clubs at the School of Civil and Environmental Engineering, University of NSW. The journal club is designed to support postgraduate research students in the specialist field of hydrology, and currently comprises six students (both local and international) across all levels of their PhD. The objectives have been formulated to align with the Australian Qualifications Framework (AQF) level 10 criteria for doctoral students, and focuses on the development of critical thinking skills and communication skills.

The journal club is structured around two major blocks. The first block focuses on building specialist knowledge and critically appraising published journal papers. The second block focuses on developing written and verbal communication skills, focusing on manuscripts that

are in preparation by the students themselves. The club meets for one hour, weekly, and attendance is compulsory for students.

Both blocks adopt the model of a 'blended' learning environment where the content of reviewing written material and developing a critique are conducted prior to a weekly meeting. The requirement of completing exercises prior to the journal club was based on initial experiences that students would commonly be unprepared prior to the club. This finding was also made by Deenadayalan et al (2008) and Alguire (1998), with the latter paper suggesting that inadequate preparation is a key reason for momentum of the journal club dissipating after one or two years of activity. As part of the preparation, students are expected to form their views prior the meeting to provide them with an opportunity to reflect without influence of others. During the meeting itself students will review their opinions with the benefit of group discussion.

The students are expected to spend about four hours per week (three hours of preparation plus an hour of in-class time), or ~10% of total workload assuming a 40 hour work week. The preparation is based on an assumption of two to three hours to read a ~12 page journal paper or text plus completion of a short survey, or a longer written exercise based on the readings from the previous week. Based on the authors' experience, the techniques learned by the students improve their efficiency in other areas such as completing their own literature review or writing their thesis, so that the increase in the structured workload means more efficiency in the less structured components of a PhD. Academic workload is minimised by rotating between multiple academics, so that each academic staff member attends one journal club meeting approximately one in three weeks.

The value of group interaction as part of the journal club format was highlighted by Zuber-Skerritt (1987), who suggest that "*students would learn the foundations of academic research in theory and practice through group discussions with fellow-students and several members of staff… students would be assisted in the crucial problem areas in the research process through mutual support and interaction*…". The journal club meeting therefore follows a peer-oriented approach where students are expected to both lead and contribute to discussion (see Topping et al, 2000). The academic supervisors provide scaffolded contribution to the classes through provision of the structured exercises, surveys and rubrics, input towards selection of papers and interaction during the meeting, while taking care not to dominate the discussion.

Table 1 summarises the three-week cyclic structure of the first block of the journal club, which relates to the critical appraisal of a journal paper. The block is structured using a 'principles', 'evaluate' and 'discuss' format, in which Week 1 focuses on building the students' knowledge of the topic, which involves pre-reading material that has been selected by the academic. Week 2 requires the students to complete a survey (Table 2) that assists them in their critique of a selected journal paper. The subsequent peer-oriented discussion allows input from the group and a chance to review

Table 1: Block 1 – journal paper review. One week of theory development, followed by a review of a single journal paper.

Week	Pre-class preparation	In class activity	Relation to AQF10 skills
1 "Principles"	Review pre-reading materials (e.g. chapter of discipline-	Academic-led discussion about selected topic	Build body of knowledge at frontier of field.

	specific text or a review paper).		
2 “Evaluate”	Review a journal paper selected by the academic, and complete Survey 1 (refer to Table 2).	Student-led evaluation, focusing particularly on areas of contention based on survey responses. The survey is repeated at the end of the class to assess whether student’s opinions have changed as a result of the discussion.	Build cognitive skills to think critically, evaluate existing knowledge and ideas.
3 “Discuss”	One-page critique of journal paper reviewed in week 2.	Student-led discussion on how to improve the paper or move it to the next level. This may include a formal presentation by one of the students.	Build communication skills to explain and critique theoretical propositions, methodologies and conclusions.

Table 2: Sample questions for Survey 1, with results to be presented on a Likert Scale from “strongly agree” to “strongly disagree”.

1	The study objectives are clearly articulated
2	The research has a high level of societal significance
3	The research has a high level of scientific significance
4	The literature review or ‘background’ section provides a good survey of the current state of the field
5	The literature review or ‘background’ section is used successfully to carve out a research niche
6	The data are clearly described and presented in adequate detail
7	The data are adequate for the study purpose
8	The methods are clearly described and easy to follow
9	The methods are appropriate
10	The approach used in the paper is reproducible
11	The results are correctly interpreted
12	The statistical tests used are appropriate (if relevant)
13	There are alternative interpretations of the results that have not been highlighted by the author
14	The figures and tables are clearly and professionally presented
15	The figures and tables support the claims made in the text
16	The study objectives have been addressed
17	The paper’s findings are clearly articulated
18	The extent to which the paper’s findings build on existing knowledge are clearly articulated
19	The conclusions are in agreement with the results (i.e. the conclusions are not overstated)
20	The authors provide a reasonable reflection of the limitations of their study

their thoughts. Week 3 requires students to generate a formal one page critique following a standard model used by journals. At the end of the three-week block, the student should have developed knowledge of the topic being discussed, critically evaluated a published

manuscript, and developed presentation skills to discuss how the paper could have been improved.

The domain knowledge and critical appraisal skills developed in block one were the primary basis of the journal club up until this year (2015), where it became clear that additional support was required for developing students' writing skills. The second block focuses on the development of skills needed for the preparation of original manuscripts, and is based on reviewing a draft manuscript that has recently been completed by one of the students in the club. Scientific writing texts such as Schimel (2012) are used, as well as more general writing texts such as Clark (2006) and Zinsser (2006) that cover topics such as branching sentences, strong and weak verbs, and use of active/passive voice.

Block 2 uses a similar structure to block 1, in that the academic introduces material in the first week ('principles') and sets exercises for skills development in week 2 which are reviewed using a paired evaluation followed by group discussion ('evaluate'). In week 3 the students complete a survey (Table 4) to aid the formation of their critique of the paper followed prior to a student presentation on the process of writing their manuscript and challenges they faced with its composition ('discuss'). Finally, the need to complete a formal peer review of the manuscript in week 4, which not only helps to develop their own skills in manuscript peer review, but will also provide potentially useful critical feedback to the student whose manuscript is being reviewed.

Table 3: Block 2 – one week of theory development, followed by a review of a single journal paper

Week	Homework	In class activity	Relation to AQF10 skills
1 "Principles"	Review pre-reading materials (e.g. chapter of book on journal paper writing)	Academic-led discussion about paper writing skills	Develop communication (writing) skills to explain theoretical propositions, methodologies and conclusions
2 "Evaluate"	Complete writing exercises based on the chapter reviewed in week 1 (typically approx. 1 page of writing)	Paired evaluation of each other's writing exercises	Develop communication (writing) skills to explain theoretical propositions, methodologies and conclusions
3 "Discuss"	Read a manuscript that is in preparation by a member of the journal club, and complete survey on writing style used in that paper	Student-led discussion, focusing particularly on areas of contention based on survey responses	Develop communication (writing) skills to explain theoretical propositions, methodologies and conclusions
4 "Discuss"	Peer review of a manuscript that is in preparation by a member of the journal group, based on method proposed in Nicholas and Gordon (2011)	Paired discussion of quality of peer review. Pairs report back to group through impromptu presentations	Develop communication (writing and presenting) skills to critique theoretical propositions, methodologies and conclusions

Table 4: Sample questions for Survey 2, with results to be presented on a Likert Scale from "strongly agree" to "strongly disagree". Chapter references in parenthesis relate to the writing text by Schimel (2012).

1	The paper has the elements: Simple, Unexpected, Concrete, Credible, Emotional, Story (§3)
2	The structure of the paper is clear (§4)
3	The paper structure make it easy to identify the: opening, challenge, action, resolution (§5-9)
4	The introduced story arcs (themes) are nested and appropriately resolved (§10)
5	There is only one idea per paragraph and there is flow within the paragraph (§11)
6	The sentences are succinct and to the point (§12, 14)
7	There is flow between the paragraphs (§13)
8	The terms (including acronyms) are appropriate, defined once, and used consistently (§16)
9	The referencing is appropriate and the reference list formatted consistently
10	All equations, figures and tables are defined in the text and sufficiently explained
11	Overall comments on writing style (free form response)

3. Student feedback

There is very little quantitative evaluation of journal clubs in the literature, with most feedback being qualitative or anecdotal. This is particularly the case within the engineering discipline, where relatively little formal research has been completed on the effectiveness of journal clubs for postgraduate education. Additional difficulties with measuring the effectiveness of journal clubs are related to their small sample size, the long timeframes involved in achieving objectives, and the informal nature of most journal clubs (e.g. Alguire, 1998; Deenadayalan et al, 2008).

Opportunities to formally evaluate the hydrology journal club have been limited for two reasons (i) the structure of the meeting has evolved since its conception in 2012 and was significantly revised in 2015; and (ii) the invitation to students was initially very broad (all water engineering PhD students at the University of Adelaide, comprising more than 20 students), but was restricted in 2015 to make student attendance compulsory and require supervisor commitment to the journal club meetings (currently only six postgraduate students).

To evaluate the effectiveness of the club, the six students were voluntarily and anonymously surveyed. All six students responded to the survey. The students were generally supportive of the peer-oriented nature of the club, with one stating that "*fleshing out and challenging ideas in a group discussion is my preferred way of learning anything*" and another highlighting that "*explaining concepts to each other… [enables them to be] better understood than reading from the book*". The students also highlighted the benefits on communication skills, stating that the club helps "*the students understand their own paper better and also improve their communication skills*" and that "*analysing journal papers is a good way to learn how to practically use various writing skills*".

Recommendations for improvements by the students include the potential to invite guest lecturers, the inclusion of gamification approaches to some of the in-class activities, a greater focus on practicing presentation skills. Finally, two students highlighted their desire for food to be provided during the club, with one students expressing a desire for "*some biscuits or*

sandwiches" and another suggesting that having "*lunch/afternoon tea together*" would "*motivate people to come*". Interestingly, the finding of the importance of provision of food was also highlighted in the reviews by Alguire (1998) and Deenadayalan et al. (2008).

4. Discussion and conclusions

At the University of Adelaide there is no coursework component to PhD completion. A significant challenge therefore has been to demonstrate to students the intrinsic benefits of skills development as a motivator for investing time into preparing for and engaging during the meeting. The issue of motivation was also highlighted by Minerick (2011) who recommended the creation of a formal study course for credit to encourage all students to read the articles prior to the meeting and enhance group discussions. Although this option is not available to the authors, it may be possible to integrate performance during the journal club with the PhD student 'confirmation' process and annual review process.

Considerable attention has been given to the scheduled activities so that student workload is limited to approximately four hours per week. The same paper is reviewed over multiple weeks, and weeks that have more reading exercises have less writing activities. The small size and high-level focus of subject matter (i.e. only targeting students studying hydrology, rather than attempting to cover the discipline of water engineering more broadly) allows the students to develop domain-specific skills relative to their discipline, and thus the four hours of 'investment' in the club is designed to make the students more efficient during the less structured parts of their PhD.

Some attempt has been made to celebrate milestone achievements (such as acknowledging paper submissions) but more effort is needed. Examples might include encouraging latter-stage PhD students to share their reflections and experiences, more public acknowledgement of achievements—perhaps through a "gamified" points/reward system—or by reviewing performance in journal clubs as part of the structured annual review. Developing a structured approach for summarising weekly journal club outcomes (e.g. by documenting outcomes in a shared DropBox account) could also help instil a sense of 'progression' of the student's knowledge and skills (see also discussion in Deenadayalan et al, 2008 on this topic).

The issue of student motivation was one of the major reasons for stipulating that supervisors must be committed to the club meetings, so that there was increased accountability for students to engage with this forum through pre-class exercises (e.g. see Minerick, 2011). While the requirement of supervisor commitment increases supervisor workload, this can be reduced by using a rotation system, and selecting review papers based on their areas of specialisation. Furthermore, the use of peer-based learning techniques also assists in reducing grading requirements, as does the use of excellent texts (e.g. Schimel, 2012; Clark, 2006 and Zinsser, 2006).

As highlighted in Section 2, there are a wide variety of possible formats for journal clubs, and the format of the University of Adelaide hydrology club will continue to evolve. In general, however, we must agree with Minerick (2011) who conclude that "*student involvement in literature discussions teaches critical thinking, increases technical vocabulary, bolsters confidence, and aids in development of experiments*" and that the club outcomes include "*increased student knowledge of the literature, decreased apprehension in younger students*

toward understanding technical publications, and a slight increase in productivity towards publication goals within the group."

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