# Research-led Active Learning Sessions in Cyber Security through Research Paper Reading

Joseph Maguire
School of Computing Science
University of Glasgow
Glasgow, Scotland, United Kingdom
joseph.maguire@glasgow.ac.uk

Rosanne English
Department of Computer and
Information Sciences
University of Strathclyde
Glasgow, Scotland, United Kingdom
rosanne.english@strath.ac.uk

Steve Draper
School of Psychology
University of Glasgow
Glasgow, Scotland, United Kingdom
steve.draper@glasgow.ac.uk

## ABSTRACT

Research-led teaching of cyber security can take many forms, but one approach in particular is acculturating students with cyber security research by engaging them with research artefacts. The present paper presents a computing science education practice where students are set weekly research articles to read in advance of sessions. The research articles are selected so as to best prepare students for the upcoming session topic. For example, for sessions on Risk and Risk Assessment, students are set a research article related risk. To motivate students to read the research article, a weekly quiz probes reading of it. The present paper outlines the background and motivation of the practice, learning design, feedback from students regarding the activity and closes with a discussion that explores thoughts from students as well as outlines future steps.

## KEYWORDS

cyber security, research-led teaching, active learning

## 1 INTRODUCTION

The majority of computing science departments in the United Kingdom (UK) are research-based institutions which expect academic staff to engage and disseminate in research. Consequently, it is unsurprising that many Higher Education Institutions (HEIs) adopt learning and teaching strategies that advocate for teaching to be guided and/or informed by research. This is sometimes referred to as research-led or research informed teaching.

For learners, such teaching practice has the potential to expose them to the latest debates and contributions as well as acculturate them in research culture. For academics, it has the potential to

weave research and teaching activities together rather than as separate concerns with differing priorities. Lastly, research-led teaching provides an opporunity for learners to engage with research instruments and artefacts.

Research articles are one such artefact. They come in many different forms and from many different venues. Many such articles can range from survey papers in journals that cover the wide breadth of a problem area to conference articles that may consider the early stages of a very specific and nuanced thought. Integrating the use of research paper reading into teaching has the potential to not only support learners in gaining fundamental knowledge, but also expose them to a valuable resource.

Consequently, the present practice paper makes the following contributions:

- Detailed design of a learning activity used in a taught postgraduate programme with approximately 400 students.
- Discussion around the experience and challenges encountered by students engaged with the activity.

## 2 BACKGROUND

There is an increasing expectation that teaching within UK HEIs is integrated to some extent with the research activities of those institutions [3]. It could be argued that such research culture and practice is a valuable way to distinguish HEIs from other types of education provision [7]. Consequently, there may be an increased expectation of HEIs to acculturate learners in research through teaching [8].

Healey and Jenkins argue that integrating teaching practice and research can take many different forms and suggest such practice may be research *led*, *oriented*, *based* or *tutored* [3]. Teaching could be considered *research-led* in that it considers emergent knowledge and thinking within the discipline, it could be *research-oriented* in developing research skills, *research-based* with activities that involve inquiry and/or *research-tutored* where learners engage in research discussions. There are also many academics that advocate for the integration of research and teaching practice.

Asghar and Luxton-Reilly suggest that integrating research knowledge as well as opportunities to be exposed to research culture and practice is crucial in delivering future cyber security professionals [1]. However, Barker argues that while there can be many benefits to such an approach, there are still many challenges and barriers to address to ensure positive experiences for learners [2].

Consequently, careful integration of research and teaching practices could deliver benefits without negative experiences. A potential teaching practice could require learners to consider research

articles in preparation for teaching sessions. The rationale is that research articles (1) are an important research output, (2) often represent a high-quality, concentrated artefact that are accessible to a trained audience and (3) are valuable resources that learners can consider beyond graduation in professional careers to stay informed.

Consequently, a learning design that incorporates the use of reading research articles as part of learning about a subject has the potential not only to further the understanding of learners but provide them with skills for their future careers. This paper reports on the context, design and experience of delivering such a learning design in a cyber security course.

## 3 CONTEXT

The present learning design was deployed in a postgraduate cyber security course delivered at a research-led UK HEI. The general learning and teaching strategy of the institution expects, in-part, for courses to be research informed and/or led.

The cyber security course itself is focused on enterprise cyber security and considers areas such as enterprise architecture, risk assessment, policy, adversarial behaviours as well as security metrics. The 10-week course is offered in the first semester of the academic year and typically has approximately 350 to 400 enrolled learners.

The demographic of the postgraduate course includes learners that have limited prior knowledge of computing science concepts, some prior knowledge of computing science concepts as well as some learners that will have completed an undergraduate degree in computing science. The element that unifies all learners is that they should have limited prior knowledge of cyber security as it relates to the concerns of enterprises and other large organisations.

## 4 LEARNING DESIGN

The learning design is that learners are set a single research paper or article to read each week in a 10-week semester long course with the exception of the first and final week. Consequently, learners are expected to read eight research papers or articles over the duration of the course.

The topic of the research paper is related to the topic covered in the course for a given week. The research paper or article is selected with the aim of preparing learners for the topic, rather than consolidation after learners have encountered the material.

Aside from the topic itself, other attributes of the paper that are considered are the intended audience of the paper, style, language and length of the paper. For earlier weeks, longer research articles may be favoured as they potentially provide more detail and background but learners also arguably have a bit more time as they have fewer competing deadlines and tasks from other courses. However, as the course progresses, research articles that are more concise and compressed are favoured as it takes less time for learners to consider and they are generally more confident and skilled at consuming such articles.

Another aspect is that of the intended audience, style and language of the paper. For earlier weeks in the course articles from professional magazines, such as ACM Communications, are often used as the language and style is for an envisioned audience of computing scientists and software engineers who may not know

much about the specific topic. The result is an article that may be slightly more accessible than other research paper articles. This eases learners into starting to acquire the skills of research reading. For example, an article from Nanavati et al. titled *Cloud Security: A Gathering Storm* is set as the topic is considered early in the course.

In order to motivate learners to complete the research reading in advance of sessions, reading of the research paper or article is assessed by a multiple-choice question (MCQ) quiz and learners are expected to answer seven questions. Each question comprises a stem with a single optimal answer and three distractors. Learners have 10 minutes to complete the quiz and are only permitted a single attempt. Learners can attempt the quiz in the 24 hours preceding the first lesson on the topic. Consequently, for the present course, learners could attempt the weekly quiz between 12 noon on Wednesday and 12 noon on Thursday, in advance of the first session on the Thursday.

Learners are provided a guide on how to consider the specific research paper or article. The guide provides a full reference, including an electronic link to the resource. The link is to the publisher of the article and provides the student with the opportunity to seek alternative formats other than PDF. Learners are also provided a range of questions to consider when reading the paper. These questions are designed to get them to focus on the salient aspects of the topic that are considered in class but also helps them prepare for the quiz.

Learners score one for each correct response, a negative mark for an incorrect response, and a zero for each question not attempted. The negative mark is -1/3 and the approach is aimed at discouraging guessing. If learners are not sure they should not attempt the question so as to avoid a deduction for a potentially incorrect response. The floor for the total mark for a quiz is 0, i.e. learners cannot earn an overall negative mark for a given quiz.

Each learner also has a single 'drop-day' where it is assumed that for whatever reason a learner may not perform a quiz or perform poorly on it; for example, a job interview or feeling slightly unwell. The drop-day takes the form of their lowest-scoring quiz being discounted before calculating the total grade for the quiz assessment. This is used to effectively minimise bureaucracy and administration of the assessment where learners may have personal circumstances impacting performance. The final grade is generated from tallying the seven highest scoring quizzes of the eight executed and a final overall grade is generated and released to learners.

## 5 RESULTS

Learners typically demonstrated an excellent performance with the majority answering questions correctly. This is not surprising as the MCQ quiz only probed reading of the research paper. Consequently, very low performance would only be expected in the case where learners had not made a sufficient attempt to read the research paper in advance of completing the quiz. The expectation was the quiz provided sufficient motivation for learners to engage with research material in advance of sessions.

The class was asked a series of questions to elicit feedback on the activity. Learners were asked what their approach was to reading the research paper, if the activity motivated them to read the research paper, did they find the support material provided useful,

what challenges they encountered with the activity and lastly how the activity could be improved. The feedback elicited for each of the questions is considered over the next few paragraphs. 113 learners responded to one or more of the questions.

Learners clearly had varied approaches to tackling the research paper, but there was similarity or patterns between approaches. Participant 70 or P70 stated their approach was "*going through the paper from top to bottom, understanding the main concept with reading one (10 min), then with reading two was more focused where to extract the key information out of it and consider writing things on a sheet of paper*". Similarly, P68 stated "*1. Read the paper briefly and highlight key passages. 2. Skim read the paper again matching up passages to the suggested thinking points. 3. Collate points that the paper said about each suggested thinking point*". P22 stated that they "*took notes on key points and definitions, and re-read parts I did not understand. Also googled definitions*". Lastly, P6 stated that their *"approach was to list the guidance questions you set out and add notes to the relevant questions. I read the whole paper front-to-back. Just kinda concatenating things as necessary. I like this approach to teaching, I learned things"*. Generally, learners appeared to use a combination of using the guidance questions, several readings with different aims and taking notes in considering the weekly research paper.

The majority of learners also felt the quiz was a key motivator for reading the research paper in advance of sessions with comments such as "*100%*" (P104), "*Yes 100%*" (P5), "*100% Felt like a nice challenge*" (P16) and "*Yes, Definitely*" (P10). P6 stated "*I almost certainly wouldn't read the research paper anyway. I'm motivated when it will directly affect my grade and it makes it much more difficult to find excuses to avoid it when it is, and I feel like a lot of people are like this too*". However, there were some learners remarked that the quiz felt "*more like a pressure*" (P18) and P8 stated that the quiz represented "*Unneeded stress*". Moreover, there were some learners felt the quiz was a not a significant motivator, P18 stated "*Actually no. It forces me, it does not motivate me. I like reading papers as an entertaining and informative activity*". Similarly, P105 stated "*Not quite. I prefer to use it as a motivation for my reading for the reason of interest rather than a grade.*" and P68 stated "*If there wasn't a quiz I would still read the research paper, although the suggested thinking points are really invaluable*". Consequently, while the majority of learners felt the quiz was a strong motivator to read research papers, some learners felt it unnecessary and even stressful.

There was almost unanimous feedback that felt the guidance questions provided to support learners in reading the research papers was valued. P7 stated "*Yes very helpful as a starting point for what we should think about while reading the research paper*", P17 stated "*Yes, they provide the direction for understanding the paper*", P46 stated "*Yes. The questions prompted me to focus on those critical points of the research paper*" and P90 stated "*Yes, it clarified the main ideas of the paper*". No feedback indicated guidance questions were not favourably received.

Learners were also asked to provide feedback on what challenges they encountered when trying to complete the activity. The majority of learners provided feedback that suggested that material was often complex, technical and required multiple reads. P22 represented the majority of feedback with "*Computer jargon - brevity should have been utilized more, especially for a group who collectively have less experience in Software/Cyber definitions*". Similarly, P8 stated "*Lots of concepts. Very dense*" and P38 stated "*very advanced vocabulary and concepts that are hard to understand*". The length of the material was also a concern raised in many of the comments provided by learners, with P2 stating "*length*" as did P5 "*the length of the paper*".

The last area of feedback sought was whether learners had any comments on how the activity could be improved in future. The majority of feedback focused largely on changes to the structure and delivery of the quiz. P44 stated "*The questions could be the same order mentioned in the paper*". An interesting aspect as the virtual learning environment randomly selects quiz questions from a bank of available questions. There were more comments on the articles being shorter with P55 stating "*some shorter articles should be provided*". Many learners felt the biggest improvement would be to "*remove negative marking*" (P8) while some learners felt the focus should not always be on research papers, P94 stated "*maybe change research papers to some kind of videos, like a TED Talk*". There were also many learners who felt it would be worthwhile for the material to be released earlier so they had more time to consider it. P6 stated "*by far I think it'd be an improvement to give us a little more time to do it*".

## 6 DISCUSSION

The feedback data on this repeated activity shows both that learners mainly see it as beneficial to do it, and to do it regularly so that it becomes a familiar practice. Additionally the feedback indicates this is similar to the response to this activity over decades and many other disciplines. As such it is a rather rare finding where an educational practice works well in a computing science course, as well as other disciplines.

The activity itself is relatively inexpensive if educators are able to access the necessary resources and provide them to learners for little to no cost. It would seem from the feedback that learners valued the support material in the form of the guidance questions and the loose support in terms of how to tackle the reading of the research paper. This would suggest that providing more detailed guidance on how to read research papers and specifically computing science and cyber security research papers would not only cement the positive reaction of learners but ensure they are able to extract more from the activity. McNeal provides guidance that is as relevant today as it was when published and providing this to learners may be a valuable starting point [4].

The area of concern for some learners was the use of negative marking within the quiz that was used to probe research reading. The motivation for using negative marking is to dissuade learners from guessing answers and to answer a question only when they have high-confidence in the judgement they are making. While the rationale may be sound, the blunt approach may have led to a negative experience in the mind of learners. Consequently, an alternative may be to ask learners to state their confidence in a given answer when they make it and award points on the basis of their confidence. Such an approach has been met with success in many medical education programmes as well as other domains [6].

The most interesting element of feedback was likely from Participant 72 when they suggested that we should "*maybe ask something*

*about our own understanding of the paper*". In many ways, this suggests that a possible next step for the activity is to be more ambitious and ask learners to make their own comment on the research article itself, rather than just probe reading of research articles.

## 7 LIMITATIONS AND CONCLUSIONS

The present paper reports the use of a teaching practice to engage learners with research articles in advance of teaching sessions. The feedback elicited for the activity suggested that learners favoured the experience and found it rewarding and valuable in terms of a learning and teaching experience within a research-led university. However, the activity could arguably go further in future in getting the learners to comment on and discuss the article itself. It should also be stated that as a research experience, it is somewhat limited and research-led institutions may aspire to something more. Nevertheless, it is a relatively light-weight practice that many educators could employ on their course with minimum effort but with probable rewards.

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