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Case-Based Learning Approach to Teach Students How to Read Academic Papers

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Abstract

The typical approach to learning how to read academic papers in engineering follows an apprentice/experiential model. In this model, the learning of how to read a paper is achieved over time using ad-hoc methods to develop one's skill in understanding the typical layout of papers, the expected structure of arguments, and evidence to inform others about discoveries including the needed background work, and the methodologies used to analyze and present new ideas in all of our varying fields. In graduate school, this skill is learned, as needed, via advisors and their suggestions, performing a background or literature survey in the field one expects to contribute to, and in some cases, by participating in active reading groups devoted to a particular topic area.

This approach to learning how to read papers is not necessarily problematic, but the outcome and skill to read papers are dependent on the student and the random interactions. Instead, we have tested a modified case-based approach to teach graduate students and senior undergraduate students how to read papers. In our case, we implemented this case-based approach in a 400/500 level course focused on teaching the general ideas of Computer-Aided Design (CAD). Over 3 years we have implemented the case approach for approximately 12 papers. To test if students are learning to critically view an academic paper, over each of the years we progressively made a higher quality "Fake Paper" as part of the curated list of papers that the students would have to read and experience through our case methodology. Our results show that students can identify the fake paper in their group discussions until our most recent version of the "Fake Paper". These results give us some confidence that the case-based approach to teaching and learning about reading academic papers has merit.

1 Introduction

Learning to read an academic paper is not a formally taught subject, but is an essential skill needed by senior undergraduates and graduate students as they arrive at the edges of curated textbooks and human knowledge, and begin to explore new ideas on the cutting-edge based on research and development. For those of us who continue in our respective fields and want to contribute with our own peer-reviewed academic papers, the skill of reading papers is necessary, but the approaches to teaching students how to read academic papers mainly use ad-hoc experiential learning. Improving and learning this skill comes from guidance from our senior advisors, our literature searches are typically done to begin a piece of work and for a dissertation or paper, and sometimes in larger schools we join reading groups that are run with some regularity at a respective university.

In this work, we present an extension to our work-in-progress in 2017 [1] for a "case-based" learning approach to teaching students how to read academic papers. Over 3 years, we have taught a 400/500 level Computer-Aided Design (CAD) course where we spend half of the class time using a modified case-based approach to teach the students how to read academic papers. In this paper, we will review existing research on this topic, describe our intervention for how to adopt our proposed method, provide a discussion on what we have learned, and provide results on our approach to testing if the approach is helping students critically read academic papers - noting that our study of this is a simple approach to validating this idea. Our results suggest that this approach has merit, and would be appropriate to adopt in graduate schools where educators believe that teaching these skills will help their graduate students.

The remainder of this paper is organized as follows: Section 2 describes what a case-based teaching approach is and related work in students learning to read academic papers. Section 3 describes our intervention applied to our class and provides details on the approach to guide students in a case-based paper discussion. Section 4 discusses our fake papers and tests if students could determine if a paper was fake. Section 5 discusses the weakness of our experimental approach, describes how we might test it better in the future, and briefly discusses the quality of the intervention. Finally, section 6 provides a conclusion to this work, and more importantly, our future work to more formally evaluate this work.

2 Research on Educating Graduate Students

Case-based learning is classified as an evidence-based instructional practice (EBIP); EBIPs in the broad STEM-based fields have been identified and proven to be an effective teaching approach as viewed using several studies. We reference the following meta-studies as guidance on EBIPs: Ruiz-Primo *et al.* [2] on discipline-based educational research (DBER) science-based teaching practices, NRC 2012 report [3], Borrego *et al.* [4] for Engineering, Freeman *et al.* [5] on DBER based active-learning across STEM, and Rahman and Lewis [6] for Chemistry.

The case-based learning method uses a case study as a complex problem to be discussed and investigated by students. This type of teaching is common (and has existed for a long time [7]) in law and business, and has several research studies that evaluate the efficacy of this EBIP. Case-based learning was first adopted and has become a synonymous method from Harvard Business School [7], [8]. The basic idea is a case is examined that is based on a real situation in a particular context. This presents a situation of some complexity, and case participants need to discuss and come to some solution(s) or plan(s) for the case. Shapiro's book [9] lists the basic process as:

1. Case learners prepare for the case by reading and analyzing it
2. Optionally - students can perform a deeper preparation by having a priori small group discussions
3. An in-class discussion is done for the case
4. An end-of-class summary is provided by the facilitator

As there are many books on the case method, our approach uses ideas from Rosenthal and Brown's book for examples of pedagogically strong cases [10], and Barnes, Christensen, and Hansen's book [11] on how to teach cases (readers should note that this book is not only good for learning about the case method, but is also an excellent resource for learning about teaching). Additionally, we attended a discussion with Rosenthal on "How to use case method" in 2014 at Miami University.

Case-based learning requires students to look at either historical or hypothetical situations providing decisions on an approach or problem solution as the outcome focus while a teacher guides the practice (but the teacher is not the focal point of the discussion). Fasko [12] showed that student retention was improved with case-based studies. The approach has been applied in engineering in cases such as Lundeberg and Yadav's meta-study of the approach [13], and Newson and Delatte's application to Civil Engineering [14]. Herreid's book [15] and Crosling and Webb's book [16] provide implementation details for this intervention.

2.1 Learning to Read Academic Papers

In terms of how to read scientific papers, there is a small set of research papers related to the topic broadly in the domain of graduate education, reading groups, literature searches, and focus papers on how to teach this skill. Reading comprehension is a broad topic in K-12 education and higher-education research but is beyond the scope of this work. As for information on how to read scientific papers, there are some online articles such as "How to (seriously) read a scientific paper" (Accessed January 10th, 2024 - `http://www.sciencemag.org/careers/2016/03/how-seriously-read-scientific-paper`).

From a graduate engineering education perspective, Jenkins *et al.* [17] in their assessment of the importance of aspects of graduate writing skills found that 98% of respondents believed that "Reading/understanding relevant research literature" is of high importance. This highlights the relevance of the topic, but there is not much additional focused research on this topic within engineering let alone graduate student education. Recently there are a few research papers related to this topic such as Nejadghanbar *et al.* [18] performed a self-study with linguistic graduate students looking at their reading strategies, English proficiency, and various literacies. They found that "information literacy" (self-evaluation on determining if the literature source is a valid source) was the most important, but weakest skill among their subjects.

Recently, there are three interventions (as we are aware of) that are suggested to either improve the reading of academic papers or test the reading comprehension of academic papers:

1. Shi *et al.* [19] propose a paraphrasing approach to improve graduate student writing. To test this approach they had students self-evaluate their own paraphrased attempts and found that most students have a difficult time paraphrasing academic ideas.

2. Salehudin [20] suggests a similar approach where graduate student "Pitch" a research idea (very similar to paraphrasing under a different communication channel) via Faff's [21] template for research pitches. This work provides a few examples of pitch templates filled for academic papers but does not include any evaluation of how useful this technique is.

3. Moldonado *et al.*[22] describe a technique of testing comprehension using Large Language Models (LLMs) such as ChatGPT and a tool they created to quiz a student's understanding

of a paper. This technique appears to be very promising for evaluating comprehension, but they have not completely verified their method and formalized a methodology.

Each of these approaches can be orthogonally applied to our case-based intervention, and the ReaderQuiz technique (once validated) would help us evaluate our approach as opposed to our proposed technique. Our approach focuses on how to teach the reading of papers, and we briefly look at both reading groups and systematic literature reviews as they relate to this goal.

As stated earlier, reading groups are a common entity that exists in Ph.D. granting schools and are a means for many incoming graduate students to learn about a specific research area as well as how to read the papers in the space. These are ad-hoc groups with their own cultures and approaches to running and training. Again, there is not a large literature base in this space. Schenk and Steppan [23] provide a small research paper investigating why graduate students do not attend their reading groups. Jabanesan and Ashok [24] provide a methodology for teaching undergraduate students how to read papers in groups, however, this approach is more related to collaborative/cooperative learning (as an EBIP).

Finally, in relation to reading academic papers, it is now common to see “systematic literature review” papers driven by a number of proposed methods including engineering education methods [25] and software engineering methods [26]. To do a systematic literature review, however, requires a coding phase that we argue is related to the topic of this work. You can not code unless you can already read and comprehend academic papers. In addition to systematic literature reviews, researchers have also provided tools for literature reviews such as Wang *et al.* [27] visualization tool. Researchers have spent some time discussing how researchers stay up with their respective fields such as Mysore *et al.* [28] discussing how data scientists review their literature.

Overall, there is not a significant focus on how to learn or teach the reading of academic papers.

3 Our Case-based Method as applied to in-class Paper Discussions

The goal of this work is to create a learning method to help learners understand how to read academic papers related to a research area. The framework we propose and have run for 3 iterations is a modification of the case-based method as reported earlier. In this section, we describe our framework as applied in a class on FPGA CAD taught in 2015, 2018, and 2021 to undergraduate students in their 4th year and graduate students.

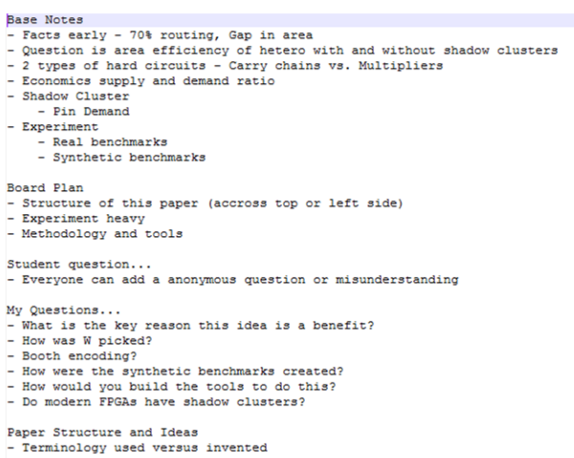
Within this course, the goal is to learn about general computer-aided design (CAD) where the focus CAD flow targets FPGAs. For the focus area, the topics include an understanding of both FPGA architecture (which is a specific type of integrated chip that has reprogrammable properties) and the algorithms that map a design to these architectures. Table 1 shows the papers covered in this course and the topics that they cover. This list was created by the facilitator based on his experience in this research and development field.

Before class discussions begin, the first lecture is used to make a contract as to behavior during each paper/case discussion. Each student is required to read the respective paper before class and make notes on the respective paper. One (or more) student is selected before the class as the

Table 1: Papers covered and the areas covered

Number	Paper	Area
1	[29]	Architecture Survey
2	[30]	CAD Survey
3	[31]	Architecture - Homogeneous FPGAs
4	[32]	Architecture - Heterogeneous FPGAs
5	[33]	Architecture - Routing Architecture
6	[34]	CAD - HDL Synthesis
7	[35]	CAD - Techmapping
8	[36]	CAD - Packing
9	[37]	CAD - Placement Optimality
10	[38]	CAD - Placement
11	[39]	CAD - Placement and Routing
12	[40]	Creating FPGAs
13	[41]	Power Measurement
14	[42]	FPGA quality to ASICs

discussion leader for the paper, and as the leader, the student is required to make additional notes and questions to guide the discussion for three-quarters of class time, where class time is 75 minutes. Each student makes a name tag that is displayed in front of them so that other students can identify each other and use their names in the discussion. Each student is expected to participate in the discussion as described in the contract, and this is recorded by the facilitator.



Base Notes
- Facts early - 70% routing, Gap in area
- Question is area efficiency of hetero with and without shadow clusters
- 2 types of hard circuits - Carry chains vs. Multipliers
- Economics supply and demand ratio
- Shadow Cluster
    - Pin Demand
- Experiment
    - Real benchmarks
    - Synthetic benchmarks

Board Plan
- Structure of this paper (accross top or left side)
- Experiment heavy
- Methodology and tools

Student question...
- Everyone can add a anonymous question or misunderstanding

My Questions...
- What is the key reason this idea is a benefit?
- How was W picked?
- Booth encoding?
- How were the synthetic benchmarks created?
- How would you build the tools to do this?
- Do modern FPGAs have shadow clusters?

Paper Structure and Ideas
- Terminology used versus invented

Figure 1: Facilitators notes in preparation for the class discussion

The facilitator is required to do several tasks within this intervention to prepare for the discussion:

1. Prepare for the discussion by reading the paper, making notes, preparing some questions to stimulate discussion (if needed), and planning out a general flow for the board - Figure 1 shows the prepared notes for paper 4

2. Record and observe if each student has sufficiently participated in the discussion
3. Write on the board notes from the discussion to frame what the students are doing
4. Refrain from talking in the discussion as much as possible unless the discussion goes off-topici
5. At the end of class the facilitator reviews the discussion using the board to identify poignant and missing points during the discussion

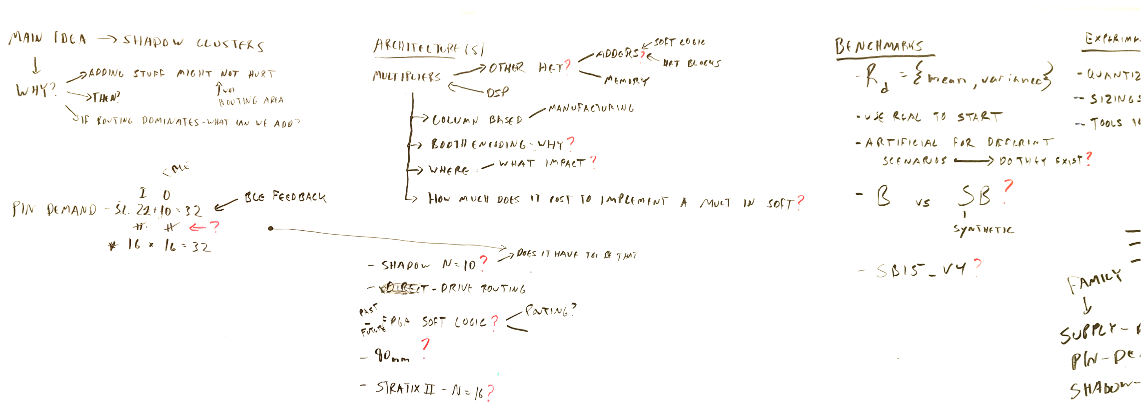


Figure 2: A sample board from the class created by the facilitator. Note the red question marks if viewed in black and white.

Figure 2 shows the discussion as captured on the board from paper 4 (in Table 1). Note that there are many red question marks included on the board; these notes are used by the facilitator to highlight additional questions as related to the discussion. These questions or notes are remarked on when the facilitator provides a final review at the end of the class, and the marks are used so the facilitator doesn't join the discussion until the end.

This framework is the same as the case method approach, The main difference between using this approach for papers instead of cases is that the discussion focus is less about a case discussion of "what to do" and is instead a discussion of "what was learned". The main challenge for an instructor is how to pick the set of papers that will be included in the class. The good thing, however, is an instructor is, usually, an expert in the topic area, and if survey papers exist for the topic area then they also provide a good starting point for students.

Since this process is done over a course, ideas on how to read academic papers can be included in the final discussions. Some of these ideas include:

- Is the new terminology in this paper invented by this work, existing within this research community, or academic vocabulary?
- Is there a common structure to papers?
- How do you compare similar papers to one another, and is one paper better than the other?
- Could you replicate the experiment and do you think your results would be similar?
- How does an industrial-produced academic paper differ from one generated strictly from academia?
- What can be learned from looking at the citations other than where the information came from?

- How does an abstract differ from the introduction and the conclusion?

4 Evaluating if the Students are Learning to Critically Read

In our work-in-progress paper, we proposed that including a fake paper in the list would provide a method to evaluate if students are at least learning to critically read a paper. In this experiment, we did not provide ideas on how to detect if something is fake or tools to investigate this as the experiment was to observe if the critical reading of the paper resulted in students suspecting this. In this section, we will describe the fake paper experience in both 2018 and 2021.

2018 - Fake Paper Class

In 2018, we used the work by SCIgen project (`https://pdos.csail.mit.edu/archive/scigen/`) to create a fake paper purely with the tool. The paper is titled ”Exploring Routing Using Optimal Architectures”, and the author was Moshe Krieger (a tribute to my undergraduate advisor). The citations in this paper are all made up using researchers' names in the FPGA research space. Additionally, there are no tables or figures in this generated publication. The fake publication can be viewed at `http://drpeterjamieson.com/html_papers/krieger_exploring_routing_using_optimal_architectures_2018.pdf`.

The paper review in 2018 was done in the 12th week of the course, and 13 students (2 graduate students and 11 4th-year undergraduate students) were all in attendance. The lead discusser of the paper was an undergraduate student and we had a meeting before the actual class discussion. In this pre-meeting, the discusser commented that something was strange with this paper, and asked if we had given them the correct paper to evaluate. Additionally, they could not find the original paper online to check. At this point, we told the discusser that the paper was fake, but not to tell the remainder of the class.

At the beginning of the actual paper discussion class, we provided a brief survey of the paper with questions such as ”What did you notice about this paper?”. All 12 of the remaining students noted that the paper was very strange compared to the other papers we discussed, and as the group discussion began the group, without prompting, went into a detective-like search on the details of this paper. In a matter of minutes, the group determined the fakeness.

Overall, the quality of this generated paper was very poor, and we're not surprised that 100% of the class identified the fake. The basic ideas of paper structure and expected pieces are demonstrated by even this simple identification process.

2021 - Fake Paper Class

In the 2021 version of this course, we repeated the above activity, but in this case, we made a better fake. To do this, we took aspects of the SCIgen-generated paper but mixed actual publication work with it to include real figures and tables (with fake numbers). Some of the numbers that we generated we made sure to betray Benford's Law [43]. Additionally, we made all the citations to valid articles in the field. Finally, in this paper we made an edit pass to blend the generated paper with the included real work to make the paper appear to have some merit as a real publication, though the ideas presented are meaningless. The fake publication can be viewed at http://drpeterjamieson.com/html_papers/krieger_exploring_routing_using_optimal_architectures_2021.pdf.

We, similarly, met with the undergraduate discussion leader before the class meeting, and in this case, the leader expressed some concerns about strange aspects of the paper but presented more of a case where after reading the paper multiple times the ideas presented didn't make sense to them. We suggested that they go into the discussion as best as they understood the work and that maybe as a group they could understand the paper.

In the actual class discussion, we provided a similar pre-survey and the class responded before the discussion began. In 2021 there were a total of 12 students (2 graduate students and 10 undergraduate students). The surveys showed that all students were confused about the results, but in all cases, they attributed this to them not understanding the ideas as opposed to the ideas being fake. As a discussion group, it took approximately 45 minutes of discussion until the consensus was made to us that the group could not understand how to comprehend the paper. Unfortunately, nobody made a simple check to see where this paper was published, which would have immediately raised flags about the contribution of the work.

At this moment we let the class know of the fake paper, and spent time debriefing why it took the class so long to question the validity of the paper. Of course, the experiment is done in a space of trust where the students expect that the facilitator is only giving them academic papers of value, and this experiment betrays that trust. Still, the students were able to critically question the results.

5 Discussion of what we learned

This work's intervention - case-based learning for academic papers - and evaluation - including a fake paper to see if students can identify them - is a reasonable approach and evaluation of our ideas. Our approach, however, provides little conclusive results if this is an EBIP for teaching students to read academic papers is conclusive. The results are still more anecdotal than qualitatively driven, and in reality, the result suggests that the intervention teaches students with a critical eye to question whether a paper is fake or not, but not necessarily how to read an academic paper. We will argue that the ability to identify fake papers suggests that a student has learned much concerning reading and comprehending academic papers.

With the advent of ReaderQuizzer [22], and some of the teaching approaches for reading academic papers described in the background, we believe that our approach could be more thoroughly verified and improved. We, however, will not be teaching this course in the foreseeable future, and will not have an opportunity to test out further ideas.

From an experimental design perspective, we would maintain our case-based paper reading intervention, and to assess student comprehension, we would add ReaderQuizzer capabilities and have students perform three to four assignments on answering ReaderQuizzer questions. These assignments would be evaluated to provide data to analyze each learner's progress and capabilities for comprehending academic papers. We note, however, that this skill does not seem of importance to most in graduate training, and it appears that most of us are fine with relying on our existing ad-hoc methods.

This intervention, however, is of value to graduate educators who are teaching graduate courses that cover several academic papers in a research space. The approach places the learning and effort on the learners as opposed to the facilitator but allows the facilitator to curate a set of seminal papers about a specific research theme.

We should also note that this course was highly sought out by graduate students to audit so they could experience the paper reading portion of the course. These students, for a number of reasons, could not take the course formally but felt that the experience would be useful for them.

6 Conclusion

In this work, we described our case-based approach to teaching students to read and discuss academic papers in a FPGA CAD research area. We used this approach three times and in the last two instances created a fake paper and a session discussing that fake paper. In both instances, the students collectively figured out the strangeness of such fake papers, noting that in the second instance, the higher quality of the fake paper made it much more difficult for learners to identify it. Overall, the case-based approach to teaching how to read academic papers has been successfully implemented and is a method that both teacher and students liked.

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