A Case Study and Call to Action: Incorporating the *ACRL Framework for Information Literacy* in Undergraduate CS Courses

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ABSTRACT

Information literacy (IL) is fundamentally important for CS students and graduates who are required to write research papers and stay abreast of new technologies and ideas. However, IL is absent in CS curriculum guidelines and the literature is scarce on research focused on IL skills among CS students. In this paper, we discuss aspects of IL and introduce the *ACRL Framework for Information Literacy in Higher Education* in the context of an undergraduate CS course covering social issues. We share how we used the *Framework* as the basis of our learning activities, which included lectures, a reading, and an assignment in which students reflected on core ideas pertaining to IL. We analyzed responses from the assignment to assess whether students achieved our learning outcomes. Nearly all students recognized markers of scholarly authority, but fewer students achieved learning outcomes based on more abstract concepts. We provide recommendations on incorporating IL activities in CS courses, and encourage explicit interventions to improve CS students' IL skills.

CCS CONCEPTS

• **Social and professional topics** → **Computing education**; **Information science education**.

KEYWORDS

computing science curriculum; information literacy; ACRL Framework; instructor-librarian collaboration

1 INTRODUCTION

We live in an 'Information Age' where all citizens have access to more information sources than we could ever consume in our lifetimes. The problem is not information accessibility, but information literacy: how to locate and distinguish quality sources from irrelevant and untruthful ones. In the rapidly evolving field of computing science (CS), we believe that information literacy (IL) is essential to CS students. While definitions of "information literacy" vary between academics and disciplines [1], there is general agreement that IL includes a complex set of technical skills, cognitive understandings, and attitudes. Students must learn about specific information resources relevant to their information needs and must also learn how to conduct effective searches within these resources. They need to understand both the rationale that underpins citing sources, and the conventions of citation themselves. IL also includes higher order abilities that include evaluating information sources, assessing authors' authority, and understanding the diverse and dialogic nature of the information ecosystem. University students who are information literate understand that the point of 'research' is not just to find an answer but to gain insight into debates within the discipline and to critically engage with sources [2]. Heidi Julien [3] argues that IL competencies are not innate and are not acquired through experience, even for the 'Net Generation' of students who were born after the Internet became widespread. We agree with Julien that explicit instruction in these skills and competencies is required.

Very little benchmarking of computing science students' IL skills has taken place. Hilberg and Meiselwitz [4] examined the results of an Information and Computer Technologies (ICT) exam which assessed students' perceived and actual skills in searching online for credible information, evaluating and citing sources for information, and using databases. Students reported high confidence levels in their ability to navigate the Internet, but low confidence levels in using databases. This study also revealed that students' high confidence levels do not match their actual skills. Other studies [5, 6] analyzed information seeking behaviour of CS undergraduates and reported on students' lack of awareness of library resources and services, including discipline specific databases and librarian expertise. Head and Eisenberg [2] note that STEM students' evaluation criteria involves the currency of the source and the information contained in charts and tables, and they consult peers to confirm whether sources are accurate. These studies correlate with earlier work by Leckie and Fullerton [7] who additionally found that STEM faculty infrequently included IL learning objects in the curriculum.

In this paper, we report on our efforts to incorporate IL curriculum modules in a third year CS course on the social implications of a computerized society. The authors of this paper, two academic librarians and the course instructor, based our IL lesson modules on the Association of College and Research Libraries' (ACRL) *Framework for Information Literacy for Higher Education* [8], hereafter referred to as the *Framework* or *ACRL Framework*. We provide information on the *ACRL Framework* and challenges in assessing IL; we also examine where IL is situated within the ACM curriculum standards guidelines. We then discuss details of the course, the workshops and the assignment, as well as the methodology we developed to assess student learning of the concepts.

We found that most students provided thoughtful and engaged responses to the assignment questions, but they had difficulty acquiring the learning outcomes related to more abstract IL concepts. Our findings align with scholarship on student research behaviour and IL competencies, which point to a need for more teaching and learning activities related to IL. Finally, we provide recommendations for CS faculty to consider when developing information literacy curriculum and incorporating concepts from the *Framework* in addition to teaching basic research skills.

2 LITERATURE REVIEW

Information literacy is not specifically mentioned in the *ACM/IEEE 2013 Computer Science Curriculum Guidelines*, but adequate IL skills underpin many of the knowledge areas [9]. In particular, the *Social Issues and Professional Practice (SP)* section of the guide states, "While technical issues are central to the computing curriculum, they do not constitute a complete educational program in the field. Students must also be exposed to the larger societal context of computing to develop an understanding of the relevant social, ethical, legal and professional issues." [9, p.190] In order for this exposure to occur, students must be able to effectively find and evaluate information sources that develop their understanding of our complex world. Sample course outlines in these Guidelines indicate that students are required to write research papers and give presentations that demonstrate their knowledge. The authors of the Guidelines thus assume that students have the technical skills and cognitive comprehension to conduct literature reviews; recommending explicit training in IL has been overlooked. Given the importance of IL in a student's intellectual journey and the need for such skills in a professional context, we believe that IL can and should be more fully integrated into CS undergraduate curriculum.

The Association of College and Research Libraries developed *The Framework for Information Literacy for Higher Education* as a pedagogical resource for academic librarians and faculty in their efforts to incorporate IL into any post-secondary course. The *Framework* defines IL as "a collection of interconnected abilities that place the self-reflective and critical learner within an information community, being able to recognize how information is created and evaluated, and how new knowledge is built through conversation, consensus, and participation within that community." [8] The *Framework* organizes IL abilities around six frames or concepts: *Authority Is Constructed and Contextual, Information Creation as a Process, Information Has Value, Research as Inquiry, Scholarship as Conversation,* and *Searching as Strategic Exploration* [8]. These frames consider different aspects of how we create, discover, and evaluate information, how authority is created within disciplinary communities, and how research and scholarship evolve through communication and conversation.

Assessing competencies in each frame is not a straightforward endeavour; much work is required to develop methodologies to ascertain knowledge in these domains. Head et al. advise against inquiries that measure increased usage of a resource or whether the student reacted in a positive manner to the library workshop [10]. Taking a similar view, our assignment required students to perform some practical tasks such as searching subject-specific databases to retrieve relevant articles. This requirement led them away from the well-used search widget on the Library home page and into an unfamiliar search platform. For the more higher-level learning objects, we adopted Megan Oakleaf's recommendation to develop learning outcomes based on reflective activities [11]. To achieve this, we asked students about their evaluation criteria of a writer's authority and looked for evidence that they were cognisant of the conversation among scholars on a particular topic in an assigned reading. Ultimately, we hoped that instruction and learning activities based on *The Framework* would assist students in learning both practical and higher order skills.

3 COURSE OVERVIEW

Our institution is a Canadian comprehensive university with a population of more than 35,000 students. The School of Computing Science offers undergraduate, master's, and doctoral degrees and has more than 1,400 registered undergraduate majors. The goal of the course is for students to critically reflect on issues in society that are influenced by the extensive and intensive use of technology, computers and networked communications. The class of 83 students met once a week, 3 hours each class, for 13 weeks. Most (63) were Computing Science majors; participants also included majors in Interactive Arts and Technology, Communications, and Applied Mathematics. This course's prerequisites include completion of 45 units of coursework, including a CS course.

4 UNIT DESCRIPTION

We developed the information literacy unit with several objectives in mind. We aimed to build technical skills in searching databases, but we also wanted to raise awareness of information literacy concepts among students and to engage in self reflection on IL topics. This assignment was also used to prepare students for a second course assignment where they were asked to write an essay connected to the topic. At the same time, we conceived the assignment as a research project because very little work has been done in measuring assessment of IL learning outcomes. We therefore sought and obtained institutional ethics approval. Students were given the option of allowing that their responses were included in our research; 82% of the class consented.

The unit included multiple components: two one-hour workshops with a librarian, a reading, and an assignment that covered the information literacy topics. This unit was followed by a workshop on writing skills and a research paper. The scope of this paper includes only the information literacy workshops and assignment;

however, the course instructor continued to incorporate these concepts in subsequent assignments, by requiring students to conduct literature searches and to examine and analyse multiple and conflicting viewpoints.

The *Framework* does not prescribe a list of learning outcomes or skills; its function is to describe core ideas pertaining to IL that university graduates should understand. Educators are expected to develop learning outcomes based on these core ideas according to the learning goals of the assignment and the course. We consulted Oakleaf [11] and Hosier [12] for suggestions on how to create learning outcomes, but ultimately developed our own outcomes and assessment methodology. A more complete description of our methodology appears in a recently published book chapter [13] written for an audience of academic librarians, and is summarized below.

We chose to focus our IL unit on three frames: *Authority is Constructed and Contextual*, *Scholarship as Conversation*, and *Searching as Strategic Exploration*. We began with the librarian delivering an in-class presentation that covered two of the frames, Authority is Constructed and Contextual, and Scholarship as Conversation. She discussed signposts of authority in journal articles, which included a discussion of the peer review process. She unpacked a journal article and pointed out markers of authority, such as details of the author's affiliation. She also described how publishing conventions of peer-reviewed articles bolster the writer's authority – for example, the literature review reveals prior research on the topic, and the methodology and results sections provide transparency on the author's methods. The librarian then demonstrated how authority could also be ascertained by citation counts using Google Scholar; this 'chaining' method of research segued into a discussion of the Scholarship as Conversation frame, and how research is dialogic and cumulative in nature. A published article represents the author's best efforts of sense-making at the time of publication, but should be considered a building block of knowledge rather than an absolute truth.

We based the unit around a reading 'Have smartphones destroyed a generation?', published in the popular magazine *The Atlantic*. The article was written by a Professor of Psychology at San Diego State University, Dr. Jean Twenge [14]. Twenge notes numerous significant behavioural changes in young adults since the iPhone was released in 2007. She correlates smartphone use with increased depression and loneliness among youth, and reduced face to face contact with peers. This reading aligned with the course content (social and ethical aspects of computing), and we felt it would also resonate with students as young people who are heavy smartphone users.

The assignment consisted of eighteen questions and was due one week after the first class presentation about the *Framework*. Students were required to conduct literature searches in the PsycINFO subject database to find other articles Twenge had written, as well as articles written by other scholars that both supported and disagreed with Twenge's conclusions. We also asked students questions about the writer that related to her authority as a subject expert on the topic. Notably, we did not ask students whether they agreed with Twenge or not. The final question on the assignment asked students to write a brief reflective passage on what they learned.

After the assignment was due, the librarian gave a second workshop that covered the concepts in the Searching as Strategic Exploration Frame. This presentation, which included group activities, was a more traditional library workshop that covered brainstorming search terms, locating different resource formats such as encyclopedias, books, and journal article databases, and the importance of using both natural language and controlled vocabulary in searches. Other advanced search techniques included a demonstration of the thesaurus in EBSCO's *Academic Search Premier* and how to use Boolean logic to combine sets of search results. She emphasized the fact that the research process is iterative; students should approach a literature search knowing that they will need to adjust their terms and resource choices depending on their search results. The intention of this workshop was to build on the previous workshop and assignment that covered more theoretical aspects of IL, so students were well prepared for their research paper assignment.

5 ANALYSING AND ASSESSING LEARNING OUTCOMES

After the assignments were turned in, we deemed the following questions to provide the richest source of qualitative data for assessment:

- What are Twenge's credentials as an expert on the impact of smartphones on young people? Briefly explain in 1-2 sentences.

- Do you think that Twenge is a credible expert on the impact of smartphones on young people? Why? Briefly explain in 1-2 sentences.

- In your view, what are the characteristics of a credible expert on the impact of smartphones on young people? Briefly explain in 1-2 sentences.

- Write a reflective paragraph on what you learned from this assignment about the frame *Authority is constructed and contextual.*

We conducted a content analysis of the responses and developed a coding method based on the responses. Our codes consisted of evidence of a student demonstrating knowledge practices and dispositions from the Authority is Constructed and Contextual, and Scholarship as Conversation Frames [8]. For example, the *Framework* describes a knowledge practice for the Authority is Constructed and Contextual frame as: "define different types of authority, such as subject expertise (e.g., scholarship), societal position (e.g., public office or title), or special experience (e.g., participating in a historic event)" [8]. An example of a disposition for this frame is: "develop and maintain an open mind when encountering varied and sometimes conflicting perspectives" [8]. We tagged each instance of a knowledge practice or disposition demonstrated in every assignment response, then grouped these codes into three learning outcomes (LOs).

LO1: Student recognizes markers and/or types of authority. To achieve LO1, a student must mention the attributes that indicate that the writer has authority on the topic. For example, one student wrote: "*She's a professor at San Diego State University, studying*

generational differences for 25 years, starting when she was a doctorial [sic] student. She has also published entire books discussing topics like narcissism and what is called, "Generation Z"". This student identifies Twenge's career as a professor and her publication record.

LO2: Student challenges author, or acknowledges debate on the topic, or mentions the importance of skepticism. To achieve LO2, a student must have mentioned that the authority of the writer is not absolute. For example, "*Twenge may not be a credible expert on the impact of smartphones on young people specifically, but she may be an expert in behaviours in young people since many of her academic papers are about adolescents and generational differences.*" This student acknowledges the writer's expertise in one field (generational differences) but not in the impact of technology on young people.

LO3: Student recognizes that a scholarly work is just one perspective on a topic. This learning outcome incorporates concepts from the Scholarship as Conversation frame. One student who attained LO3 wrote, "*Yes, while there are obviously people with other opinions that disagree with her, she has a huge number of peer-reviewed publications on the subject so I would say that she is an expert. I would add the caveat that while she is an expert, if you are really looking for the complete picture on a topic it is wise to look at additional sources as well.*" This student recognizes the importance of reading more than one article in order to understand the topic and its various perspectives.

To ensure consistent coding, two of the authors initially independently coded a random sample of twelve student responses, and then compared their assigned codes for this sample. The inter-coder agreement for each of the individual codes varied from 63% to 100%, with a median of about 92%. We flagged responses that did not fall easily into a coding category, and came to mutually agreed decisions on the appropriate code.

With this clearly delineated coding scheme, all 67 assignment responses were analyzed and coded. Based on these codes, each student's acquired learning outcomes were then assigned to them. The results for each student were recorded in a spreadsheet and analyzed.

6 RESULTS

A direct count of acquired learning outcomes for all 67 students found that almost all of them demonstrated basic capabilities in assessing the authority of the writer of the assigned reading. Specifically, about 94% of students acquired learning outcome LO1 (Table 1), and were able to identify markers or types of authority.

Admittedly, attaining LO1 was not a difficult undertaking: the author clearly states she is a university professor who has published over 100 articles in peer reviewed journals, and students easily articulated these credentials. Some students also noted that the author had additional personal experience on the topic of smartphones and young people, as the mother of two teenaged daughters. Still, we are pleased to have created a learning opportunity for students to assess a source based on the writer's authority. Furthermore, students had no issues recognizing the authority of a writer who chose to publish in a popular magazine rather than a peer-reviewed journal. The following student acquired LO1 only, and not LO2 or LO3:

Table 1: Learning outcomes acquired over all 67 students

Learning outcomes with definitions	Number of students	Percentage of students
LO1: Student recognizes markers and/or types of authority	63	94%
LO2: Student challenges author, or acknowledges debate on the topic, or mentions the importance of skepticism	47	70%
LO3: Student recognizes that a scholarly work is just one perspective on a topic	25	37%

> "*Twenge's credentials as an expert on the impact of smartphones on young people include being a professor in a related field (psychology) at an established well respected university (San Diego State University). She has also studied and published work on generational differences for over 20 years, which strongly relates to the topic of smartphones impacting young people. Her credentials as a professor of psychology lend credibility to her claims [...] Based on the large amount of related peer reviewed articles, and the number of citations of her articles, I believe Twenge is an expert on the topic.*"

This student identifies the markers of scholarly authority, but accepts these markers at face value.

Table 1 also shows that a smaller number of students acquired LO2 than LO1, down from 94% to 70%. Students who attained LO2 mentioned that the writer's authority was not absolute. This response is from a student who acquired LO1 and LO2, but not LO3:

> "*Twenge is a credible expert due to her position at the San Diego State University and her area of expertise. Many people in similar positions collaborate with her, which also provides a sense of credibility. Someone who has a history of writing academic articles that have been peer-reviewed and cited by many other people would appear to have more authority over a subject. However, if a person who has the aforementioned qualities signifying authority attempts to write about a topic outside their area of expertise, it is unlikely that they will be recognized as an authority on that topic.*"

This student acknowledged Twenge's academic expertise (LO1), but also recognizes that authority does not transfer from one subject area to another (LO2).

We were surprised that only 70% of students acquired LO2 and challenged the authority of the writer. One of the assignment questions required students to find scholarly works that disputed Twenge's findings or methodology; we expected this search to manifest in their answers as doubt or skepticism regarding the writer's absolute authority. Furthermore, we also wondered how many students would pick up on the fact that the writer's field of expertise

was on generational differences rather than the impact of technology on young people. Our results showed that many students did not notice this distinction, and a significant portion accepted the writer's academic credentials and publication record as indicators of absolute expertise.

Students who attained LO3 demonstrated awareness of the diversity of opinions and approaches within a discipline. From Table 1 we see that an even smaller proportion, only 37% of the students, were able to place the assigned reading as one view in a context with multiple perspectives. Here is an example of a student who acquired all of LO1, LO2, and LO3:

> "... although a source you are referring to can be peer-reviewed and written by an authoritative person, it can still be scrutinized. This is because there are many different opposing views to any topic of interest and these opposing views which are articulated in forms of published research can also be written by authoritative people."

Responses from students who acquired all three learning outcomes described Twenge's markers of scholarly authority such as her record of peer reviewed publications and tenured faculty position, but also recognized that being an expert in one domain does not automatically transfer to a different subject area. Finally, they mentioned that there could be multiple expert views on a given question.

As mentioned earlier, we never asked whether students agreed with the writer of the article; we asked whether she was an authority on the topic of the impact of smartphones on young people. However, we acknowledge that some students might have conflated agreeing with the writer's premise with accepting her as an authoritative voice on the topic. Conversely, students who disagreed with the writer would have fewer reservations about challenging her authority and therefore acquiring LO2. In a similar vein, 11 students (roughly 16% of responses) questioned the writer's expertise because they determined her to be biased. One student said, "*There seems to be a bias agenda in her article and the statistics provided could be made up or been selected to paint a negative light on smartphones.*" Clearly, some students in this class could benefit from a discussion on the distinction between authority, neutrality, and bias.

7 DISCUSSION AND RECOMMENDATIONS

We designed a learning unit based on the *The Framework for Information Literacy* in a CS course and looked for demonstrated understanding of knowledge practices and dispositions of two of the Frames: Authority is Constructed and Contextual, and Scholarship as Conversation. We are encouraged by the students' thoughtful and reflective responses to the unit; however, our results indicate that students had difficulty with the concept of Scholarship as Conversation. This finding aligns with existing research on students' challenges with IL. Dawes [15] and Bury [1] interviewed faculty and reported on areas where students had difficulties making the cognitive leap from novice to expert learners. Faculty noted that many students are unable to contextualize how specific works fit into the broader discourse within their discipline, and synthesize divergent voices and opinions.

We also found a decreased number of students who questioned the authority of the author. This result aligns with Head et al. whose student surveys show that their research objective is to locate resources that provide 'an answer' to their question [2]. Such students do not conceptualize research as an opportunity to discover and synthesize new ideas, or critically appraise the material they encounter.

Our IL unit provided students with many opportunities to engage with IL concepts and develop their skills. Where students' typical research strategies involve consulting course readings and Google [2], we required them to conduct literature searches in a subject database. We also asked students to reflect on a writer's authority, which differs from the criteria they most often apply – the currency of a document, and the quality of data charts and tables it contains [2]. We elicited students' recognition of the divergent voices on a topic. Indeed, we feel strongly that we asked good questions [10] that provoked critical thinking. We are encouraged by many of the thoughtful and reflective responses we received.

However, we also acknowledge the limitations of our research and some challenges in delivering the IL module to a large, multilingual class. We did not extend our assessment to the students' research papers for the class, nor did we evaluate the quality and relevance of the sources in their bibliographies. By analyzing only the IL assignment responses, we were unable to discover whether students applied the concepts we covered in the IL assignment in the research essay assignment later in the semester. We also realize that the language used to express concepts in the *ACRL Framework* requires a high degree of English language proficiency. We could recognize in some responses that students had difficulty understanding the contextual nuance of terms such as "authority" and "constructed." Finally, we would have preferred to provide timely formative feedback to students; however, qualitative data analysis is time consuming and we experienced a learning curve in developing our assessment methodology. We hope to provide feedback to students in future iterations of the assignment.

Based on this study and the students' responses, we propose the following:

1. CS educators should incorporate IL units into their courses. IL can most easily be taught within courses that cover technical writing, social and ethical aspects of CS, or professionalism. Indeed, any course that requires students to investigate new topics would benefit from some instruction in IL skills. Instructors should use readings or examples relevant to the course content and relatable to the students. We found our reading on smartphones resonated with students.
2. Course assignment questions as well as assessments should be designed with the *ACRL Framework* in mind. That is, questions should gauge students' abilities on the individual dispositions and knowledge practices outlined in the *Framework*. Learning objects should include technical skills, such as awareness of databases, effective search strategies, and correct citation of references, as well as higher order skills that involve understanding of more abstract concepts as described in the *Framework*. Students' acquisition of these lower and higher order skills can be used to evaluate their IL learning.

3. When possible, course instructors should collaborate with an academic librarian. Librarians are up to date on resources relevant to CS students, and have expert knowledge of library services and systems. They are trained in delivering information literacy curricula and are aware of the core ideas in the *Framework*. After the collaboration, the course instructor should reinforce information literacy concepts throughout the semester of the course, and not in a single one-shot session. Students need repeated exposure to IL concepts for better chances of retaining these ideas.

8   CONCLUSION

This paper provides evidence that CS students stand to benefit from explicit instruction in IL, and gives suggestions on how CS educators can incorporate IL concepts into a course curriculum. Our findings confirm that students struggle with higher order IL concepts that resist a world view of easy answers or absolute truths. Instruction in IL can lead to cognitive transformations that lead to students understanding that the world is full of complexity, diversity, and nuance. This transformation, coupled with practical skills in locating and retrieving information sources, will assist them as students who are required to write research papers, and in their professional lives as lifelong learners.

We encourage instructors to reframe research as a means of intellectual discovery rather than a process to find an answer, and to engage with the *Framework* when introducing these concepts to students. The *ACRL Framework* is very familiar to academic librarians, but the document has not been widely publicized to educators in other disciplines. CS educators can adopt the concepts outlined in the *Framework* in collaboration with librarians, or by themselves.

Further research on teaching, learning, and assessing *Framework* concepts is required. We have a rich dataset which would benefit from further qualitative analysis, and in 2019 we collected a second dataset of student responses for comparison. We also wonder how the results from students in this course would compare to a class of third-year Humanities or Social Sciences students. Finally, we would like to explore theories of cognitive development, such as Perry's *Scheme of Intellectual and Ethical Development* [16] or Bloom's *Taxonomy of Educational Objectives* [17], in relation to student acquisition of information literacy concepts.

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