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COMPUTER APPLICATION RESEARCH METHODOLOGIES

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ABSTRACT

The essence of Computing Research Methods (CRM) has yet to be agreed upon, although more and more schools are examining models and material for CRM courses. Reports like this one are part of an ongoing effort to construct an overall CRM framework that can be used to teach students about the subject.We provide a new structure for teaching CRM that helps students make sense of the material. There are three components to this structure: a guide to the CRM literature, a framework based on questions rather than answers, and two CRM skill sets: fundamental skills and more particular abilities. In order to help those who want to educate computer science students how to do research, we integrate our framework with a model for the process a learner goes through on their route to becoming an experienced researcher.With this approach, we hope to provide a foundation for the topic about CRM education and to serve as a road map for academic institutions and research groups to handle the transition from student to fully enfranchised researcher. There are several ways in which our model might be put to use.

Keywords: Education—Computer science education, Information systems education, Literacy

I. Introduction

Despite the fact that there is no consensus on the nature of CRM, an increasing number of schools are experimenting with models and materials for Computing Research Methods (CRM) courses, with varying degrees of success. The SIGCSE Committee on Teaching Computer Science Research Techniques (SIGCSE-CSRM) was founded in 2005 to foster collaborative examination of the content, pedagogy, and curricular challenges associated with teaching computer science research methods (CRM) (Dhillon, & Verma, 2020). In addition to maintaining a listserv and supporting meetings at technical conferences, SIGCSE-CSRM also maintains a Wiki for the benefit of its members. People on the SIGCSE 2006 Birds-of-A-Feather (BOF) session and on the listserv expressed concern that the most difficult challenges to setting up a successful course were: (1) not knowing what topic to teach, and (2) a lack of resources from which to construct a course from scratch

Because of this, the SIGCSE-CSRM funded an ITiCSE 2006 working group (WG) on teaching CSRM, which had the following responsibilities:

The first task involved identifying and classifying common characteristics of research methods used in various domains of computer science that could be used in formalising a core set of CSRM that was independent of

specific domains; the second task involved developing a basic set of standards for CSRM literacy (based on the outcomes of the first task); and the third task involved proposing a general framework for CSRM literacy.

Figure 1: A richer set of options for teaching CRM benefits all the stakeholders.

In response to the WG's discovery process, which occurred before to ITiCSE 2006, the WG's emphasis changed from information transmission to the building of a sense-making framework for customer relationship management (CRM). The fact that academic computing programmes outside the United States do not distinguish between sorts of computing degrees and do not utilise the same language has led us to expand our aim beyond only computer science to encompass research methodologies across all disciplines in computing (Spencer *et al.* 2019). Our concept of computing spans the same broad disciplinary ground as that covered in Computing Curricula 2005 – The Overview Report, which may be found here. As a result, throughout this work, we will be covering research strategies in computing rather than computer science as a whole.

Following that, we'll go into further depth on why we picked CRM as the beginning point for our research, as well as how it relates to previous attempts to describe computer research methodology. Report introduces a new conceptual framework for making sense of computer science research findings. There are three main components to this framework: a road map to the CRM literature, an overarching framework based on questions rather than answers, and two lists of essential abilities for doing high-quality research (Johnson, Adkins, & Chauvin, 2020). Report discusses the steps a student must take to progress from a novice to an accomplished computer researcher (Sakhavi, Guan, & Yan, 2018). For those who want to educate students how to do research in computers, we provide examples of learning exercises. Students, professors, and research communities of practise offer their perspectives on the transfer of research skills, which includes a variety of possible situations (CoP) (Brunetti, *et al.* 2018). After a brief discussion of our current situation, report outlines our future steps. There must be a common language (syntax) and a shared understanding of what that language means in order for people to communicate (semantics). Appendixes to the study contain a list of acronyms used in the essay, and a comprehensive vocabulary of research terms derived from the literature on computing research methodologies. It is our hope that by providing these definitions, we will encourage a greater level of agreement on the meaning of CRM terms.

In order to build a generic framework for thinking about and teaching computing research methodologies, this study serves as the first stage in a collaborative design process.

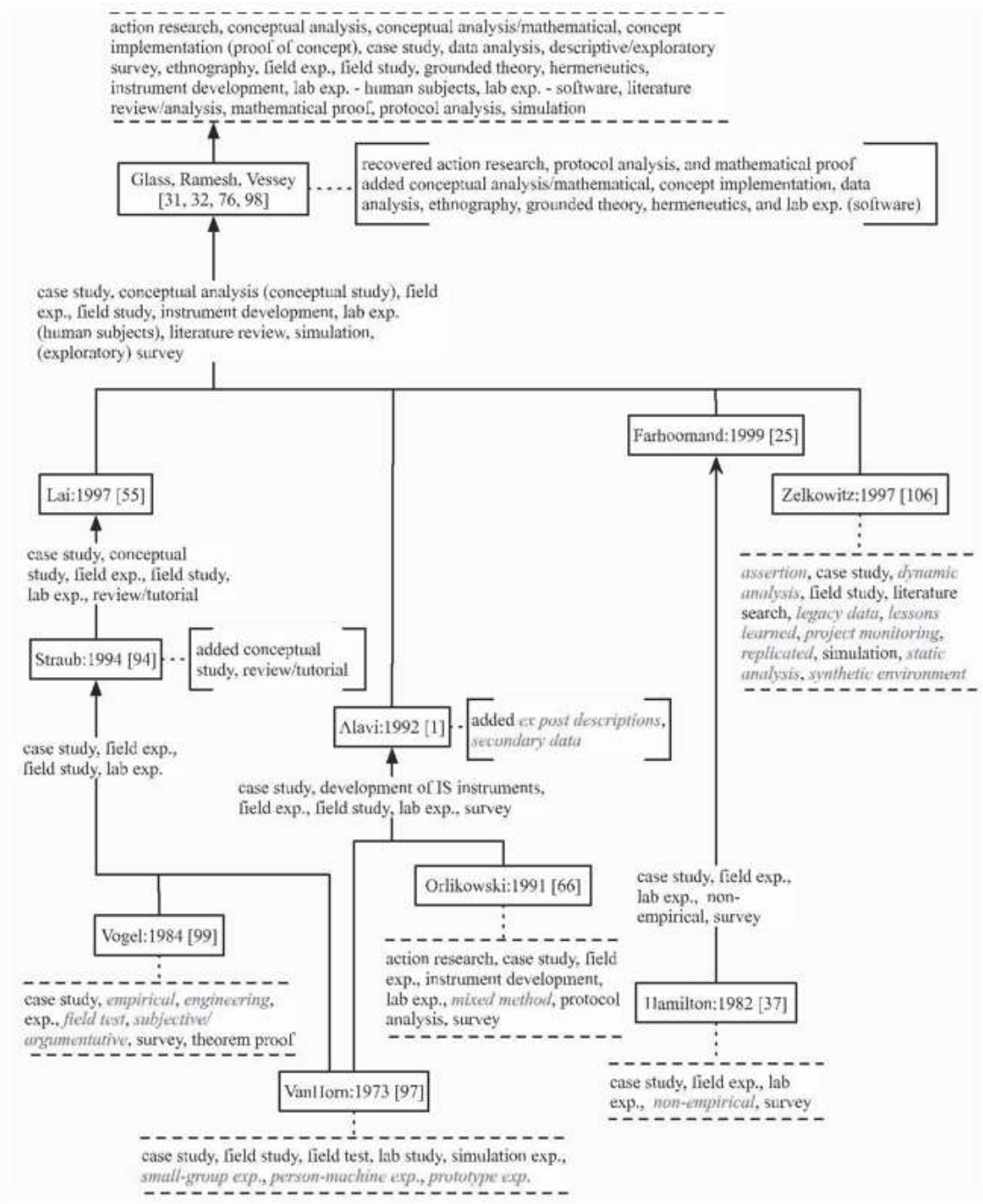
II. Approach

It is imperative that CSE [Computer Science Education] specialists take the time to examine what occurs in genuine CoPs and then design learning activities that as closely mimic those experiences as feasible within the confines of a school setting In order to avoid naive LPP [Legitimate Peripheral Participation] that insists on "actual" circumstances and surroundings, I employ the phrase "simulate (Valverde-Berrocoso, *et al.* 2020)." An apprenticeship-based approach to learning CRM has typically been used. A CoP member obtains the necessary information to join a CoP, and as a CoP member, one acquires that knowledge as a CoP member. This is the case with situational learning. In reality, gaining knowledge necessitates joining the CoP. Peripheral engagement is essential to successful contextual learning (LPP). In the context of a community of practise, LPP is peripheral involvement that is:

(1) genuine to the learner and the community, and
(2) Acceptable to the community as a whole.

An opportunity for LPP exists in the usual doctoral student/research adviser interaction. When it comes to studying CRM, LPP is an ideal methodology, as CRM is generally taught via apprenticeship.

Our method is design research, in keeping with our use of the constructivist literature model and the contextual learning model. "Iterative, process-focused, interventionist, collaborative, utility-oriented, and theory-driven" design research is an emerging educational research approach. SIGCSE's committee and working group processes are designed to be iterative. SIGCSE committees don't last indefinitely; instead, they're designed to accomplish a specific aim. The committee can be recreated with new objectives at the end of its term if necessary. When it comes to becoming a computer researcher, we are interested in learning more about how CRM-related educational artefacts play a role (Senyo, Addae, & Boateng, 2018). A key emphasis of our interventional work is the development of an activity-based code system that will enable both the adoption of novel learning activities and the reporting of their outcomes. The SIGCSE committee is available to anybody who wishes to join; the committee's membership is comprised of both committee members and working group members. We have a very utilitarian mind-set. Initially, a small number of faculty members began working together to improve the way their universities teach CRM. The design of our instructional objects has been theory-driven from the outset, and we will continue to do so.



III. Making sense of CRM

We want to build a CRM pedagogy that:

1. In addition, it: encourages collaborative sense-making by providing a distributed locus of control over CRM definitions;
2. seamlessly integrates and adapts to future changes in the CRM literature tradition;
3. is capable of incorporating a continuous stream of novel CRMs;
4. Provides a diverse range of options for acquiring knowledge about CRM.

For our structure's grammar, we began by compiling a list of nouns (particular CRMs). To serve as the overarching organising concept, we created a framework for creating sense (Lassonde, & Galman, 2019). Our next step was to identify a core and particular set of abilities that are essential for relevant computer research: We asked ourselves two questions at each step:

(1) In contrast to product development or general problem-solving, why is this component unique to computing research?
(2) What distinguishes computing research from other types of research, such as scientific research or even research in general?

IV. Specific CRM

In conjunction with ITiCSE, the WG organised a brainstorming session during which we listed as many CRMs as we could think of. After that, we trimmed down the list, eliminating things that were duplicated, as well as entries that were categories of research procedures (such as laboratory experiments) or data analysis approaches (such as sensitivity analysis) (e.g., simulation.) We had a difficult time distinguishing between a kind of CRM, a specific CRM, and a data analysis strategy when we were trying to narrow down the list. The conclusions of the brainstorming session are contrasted to the results of GRV's project and the corpus of relevant computer literature. The name of the customer relationship management system will appear in the first column of this table (Sakhavi, Guan, & Yan, 2018). Column 2 indicates whether or not the term CRM was mentioned during our brainstorming session. If CRM was mentioned in the GRV literary genealogy, a citation is included in the third column of the table. Aside from that, the last column offers a link to an article in the computer literature that is related to the topic. It may be used in combination with the Glossary to provide a jumping off point for discussions of certain CRM in the computer literature.

What distinguishes this CRM from others used in computer science? Many of the CRM on this list aren't just for computer science research; they're utilised in a wide range of fields across the IT industry. When used to research rather than development, several of these approaches take on a different quality. Data collecting methods and data types used in project monitoring, for example, vary based on the monitoring's purpose (Sakhavi, Guan, & Yan, 2018). This consistency in approach may be used to teach research across the curriculum, frequently beginning in the freshman year of college.

What is it about the CRM that is unique to computer science? CRM in It is not only widely utilised in other fields but also originates from other fields. Often, when a computing research CoP gets more familiar with a borrowed approach, it will develop its own version that is more suited to the needs of computing (Senyo, Addae, & Boateng, 2018). Contextual inquiry, which has its origins in ethnography but is grounded in everyday life, is one such example. CRM's breadth, if not unique, at least exceedingly rare, is one of the most striking aspects of the technology. Creating a CRM curriculum is problematic for many professors because of the overlap between computing practise and research in non-computer-related fields.

V. Discussion

As part of the SIGCSE Committee on Teaching Computer Science Research Methods, the Working Group was formed as a means to better formalise and promote discussion on the teaching of Computing Research Methods in the computing curriculum (Brunetti, *et al.* 2018). Identifying CRM and discussing how they might be taught

involves a number of important aspects. For computer scientists, a common ground is created by formalising CRM. It is equally important to formalise CRM in order to instruct future generations of computer scientists.

Researching literature references and defining CRM words in the context of the literature It took about 20 hours to complete (of author time, not graduate student time). Quite a few of the words were difficult to locate definitions for. CRM is rarely defined or even referred to in research articles (Putra, 2019). Research techniques are not defined or referenced in papers in the biological sciences. However, in the biological sciences, the reader might legitimately assume to have learnt the meaning in a research techniques class (Ullah, *et al.* 2020). While it is logical that computer science research articles typically lack conclusive information on CRM, the implications of this omission cannot be overstated. A first-year research student must feel completely confused if the Working Group couldn't even discover basic terms for CRM!

It is an indication that computer education is growing as a field when students are encouraged to engage in active research throughout the curriculum (Putra, 2019). However, while it may not be ground-breaking for computing in general, a practical investigation of some of the relevant facts presented in undergraduate courses (e.g., the relative efficiency of different sorting algorithms on different sized arrays) would provide a better understanding of the process of research and writing up a professional report (Senyo, Addae, & Boateng, 2018). They would, in fact, be re-creating genuine study and drawing the same findings as the professor. Here, it's the process that matters more than the ultimate product; in fact, it's more important than what is in it.

VI. Conclusion

Students in a wide range of scientific fields, including computer science, benefit greatly from research experience gained during their undergraduate and secondary school years (Lassonde, & Galman, 2019). Even among those who are considering a future in computer research, only a tiny percentage are selected for places in undergraduate computing REU programmes or are associated with an institution that actively recruits high school students for computing research projects. One of the most effective ways to attract and retain top-notch computer science students is through an exceptional CRM course or embedded activity.

As a result of the work detailed in this paper, SIGCSE-CSRM members are presently conducting three concurrent efforts:

(1) Compiling an annotated bibliography of our literature search findings for online release as a resource for academics and students researching CRM.
(2) Examining the link between CRM in general and CRM in specific CoPs like SIGGRAPH.
(3) The participatory technique of CRM codification ensures that all voices are heard and all points of view are taken into account.

As a result, our field will mature and earn a spot among the most prestigious branches of knowledge.

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