Values and Objectives in Computing Education Research

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What is Computing Education Research (CER), why are we doing this type of research, and what should the community achieve? As associate editors to this special edition we provide our perspectives and discuss how they have influenced the evolution of the Koli Calling International Conference in Computing Education Research over the last nine years. The two papers in the special issue have been selected from among the twenty eight conference contributions for their originality and contribution to CER in the areas the Koli Calling Conference aims to emphasise. We hope that you find them inspiring reading.

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This papers which appear in this volume are extended versions of papers presented at the 8th Koli Calling, International Conference on Computing Education Research. Collecting and editing papers, both for the conference and the TOCE special edition involves determining selection criteria for relevant papers, as well as providing reviewing instructions to reviewers and deliberating over what revisions and final changes should be made before accepting the papers for final publication.

Central to this process is an understanding of "why" we are doing this, "what" we achieve by doing it, and also "how" we should go about doing it. Reflecting on the mission of Computing Education Research (CER) raises some interesting questions and merits some discussion as we introduce the two papers selected for this special issue.

We (the guest editors) believe that the development of CER should inform tertiary teaching practice and develop the discipline as a whole. Fundamental to this is an assumption that research builds on prior work, and extends the total sum of human knowledge in our discipline. To achieve this we argue that CER needs to engage in a broader discourse; one within which elements of the learning process unique to computing education can be presented and discussed in a scholarly manner. To achieve this we argue that CER should encourage and give credit to some types of "non-traditional scholarship". By non-traditional we mean rigorous research which contributes to CER, but is not necessarily the outcome of experimental research in the positivistic tradition. It is clear that we are not alone in this belief; Tenenber and McCartney [2008] have also made similar observations.

In this editorial we take the opportunity to explore two areas where the Koli Calling conference has been influential in changing the prevailing CER culture over the past ten years; namely tools development and qualitative studies of teaching and learning.

Several studies of the CER literature report a worryingly high percentage of published papers that center on a description of a classroom intervention; or aim to study learners and learning outcomes, but only advance anecdotal evidence in support of the author's claims. A systematic analysis by Randolph [2007] covered a proportional stratified sample of 352 articles from a population of 1306 computer science education articles published between 2000 and 2005. Each paper was classified on the basis of a set of report elements; research methodology; research design; independent, dependent, and mediating/moderating variables examined; and statistical practices. A second rater coded a reliability subsample of 53 articles to get estimates of inter-rater agreement. Among his conclusions one can find the following observations.

- About one-third of articles did not report research on human participants. Most of them were descriptions of interventions.
- Nearly 40% of articles that dealt with human participants only provided anecdotal evidence for their claims.
- Of the articles that used an experimental research design, the majority used a questionnaire and one-group post-test-only design exclusively.
- There was no difference in major methodological characteristics between articles published in computer science education journals and those published in peer reviewed conference proceedings.

The main outcome of Randolph's study is the observation that much published work in CER lacks methodological rigour. Many conclusions are not based on solid evidence and analysis. He writes "Based on the results of this review, I can say that what computer science educators have so far been great at is generating a large number of informed research hypotheses, based on anecdotal experience or on poorly designed investigations. However, they have not systematically tested these hypotheses." [Randolph 2007], p. 176. We agree that the CER discipline should take this message seriously.

Randolph's critique raises an interesting question about the *technical research* that has always been an important part of CER. With technical research we refer to papers that publish various kinds of tools and learning environments to support learning computing. These have been popular especially in papers concerning programming education. Another survey Valentine [2004] reviewed 444 papers dealing with education in CS1 and CS2 in years 1984-2003 in SIGCSE Symposium and identified 99 of them as "tools" papers describing various systems, in addition to identifying a large number of "marco polo" papers (papers describing classroom experiences).

When we compare CER with other fields of subject education, we can observe that the role of tools and visualizations is a somewhat special one in CER, since the tool and the learning objective overlap to a greater extent than in other disciplines. In most other areas of education computer based learning tools are completely

separate from what is being taught. In computing the tool and the subject matter are often closely related. Because of this, and also because CS teachers themselves have the competence needed to build new tools to support their teaching, a plethora of highly specialised tools have been developed and the number continues to grow.

From a research perspective, however, tools papers, have several problems. First, many papers present only a description of the tool itself, often augmented with some anecdotal data associated with its use (often for the first time). Second, tools research has somewhat overlooked the importance of hypothesis generation. For instance, many papers include references to previous technical research and tools in the subject domain, and the presented new tools usually add features and functionalities not available in previous related tools. There is less discussion about the pedagogical problem that the tool is addressing and what kind of theoretical framework lies behind the tool design. We believe that this is partly because tools often address an issue that is highly specific to the teaching context of the author.

Papers with rigorous evaluation of the impact the tool has had on student learning, attitudes, studying process, teacher's work are scarce. One obvious reason for this is that tool development is very laborious as such, and if experimental evaluation would be needed to validate the effects, the required effort to be able to publish even the first paper of a tool would be very high.

In some cases the construction itself can be considered the main contribution, for example, if the tool integrates several features presented earlier in the context of other tools into one tool. Or, similar functionalities are implemented in a tool supporting a new programming language (suppose that we could not publish a tool / method that manipulates Java programs because similar things had already been published in 1980's using Pascal). This issue obviously has a connection to Computer science research tradition where technical novelties often emerge, and where the prototype itself can be considered a research contribution, as it demonstrates a proof-of-concept that some novel design or technical method actually works. We conclude that one problem with technical research in CER context seems to be that the contributions can be evaluated from two very different points of view, CS research point of view emphasizing development of technologies as contributions, and Educational research point of view emphasizing hypothesis generation and evaluation as contributions. The evaluation criteria of these traditions are somewhat different. The question emerges: Which should we emphasize?

At Koli Calling conferences we have recognized this problem for several years, and we have looked for possible solutions to it. Since 2005 the conference has used different categories of these types of submissions in the call for papers. Research papers emphasize the tradition of educational sciences, where theory background and validation of results are emphasized. System papers, on the other hand, emphasize presenting technical work with solid support argumentation. In 2008 the categories were:

- Research Paper [8-10 pages]. Unpublished, original, theoretically anchored research related to the conference theme. Papers will be of high quality and present novel arguments, syntheses, results, methods or tools. Research papers are mainly evaluated by the relevance and quality of the research.
- System Paper [8-10 pages]. Unpublished, original work describing methods or

tools for learning or instruction in computing education, motivated by the didactic needs of teaching computing and supported by clear argumentation or a theoretical framework. Submissions are evaluated on their impact on and contribution to the research questions defined, and on their contributions to existing knowledge and practice. Submissions should preferably be accompanied by a Demo proposal.

Also the evaluation criteria given for the reviewers reflected the different emphasis on the papers of different categories. This process allows authors to decide on where they aim at.

In 2008 the conference introduced a new element, the *Tools workshop* and *Tools award*. Here, the motivation was to help provide recognition for the considerable effort that is involved in producing a tool that can really be used in a wide variety of institutions and educational settings. One major problem with tools research and development is that prototypes are considered scientific contributions, and publications about them can be included, for example, in PhD thesis works (but the tools themselves not). However, if the prototypes are further developed into production software that is user friendly, well tested, has wide selection of learning tasks and other support material and that can be easily adopted elsewhere, this work is not considered scientific contribution any more. It can be argued that this is how it should be. Product development is not scientific work, and should be carried out elsewhere. Unfortunately, there is serious lack of funding for such development work, and few commercial companies have emerged that have found enough markets to fund such software development in computing education domain. Therefore the fact is that few tools have enjoyed widespread use at their home institution, and very few have been adopted by more than one university in computing education. This, despite a shared vision that the results of CER should have a real effect on computing education practice!

The call for tools initiative hopes to build a venue to enhance the scholarly value associated with tool development activity. The basic idea is that the submitted tools and related documents will be subject to peer review, and selected for publication based on a range of criteria. The call for tools in 2008 stated that the submission should include:

- (1) A short paper (2-4 pages in ACM double column format) that summarizes the rationale of the tool
 - What is the problem in CS education the tool addresses and how does it address it?
 - What are the arguments / evidence that the tool works effectively to meet this aim?
 - In which way does the tool differ from other tools solving the same or similar problem? What are the key contributions of the tool?
 - Summary of possible publications about the tool and its evaluation results.
- (2) Instructions to access a web site that includes
 - A tutorial or guided tour of using the tool
 - Relevant documentation of the tool
 - Tool itself

- Source code of the tool (if appropriate) and instructions to install the tool on a new platform
- Any other relevant resources

The submissions were evaluated based on the following criteria:

- Originality compared to previously published tools
- Argumentation and evidence to support the claimed contribution
- Generality to address the task the tool handles
- Usability
- Documentation quality
- Software quality
- Maintenance support
- Possible additional resources

The international program committee reviewed the submissions (documents and software) in a very similar way to that used for conference papers. We hope to see in the future that accepted contributions could be considered as valuable as ordinary papers in academic evaluations. Obviously we cannot guarantee that this would happen, but generating new traditions always takes time.

Development of categories and criteria to encourage submission of high quality scholarship in a range of distinct areas has also been a focus for the Koli Calling Programme Committee and Conference Chairs. The aim is to provide guidance to authors, as well as to reviewers, about the criteria used to assess the worth of a scholarly contribution. Not only are the general criteria public, but also the qualitative rubrics used by reviewers to classify a submission. This open approach to the criteria for paper selection helps to increase the quality of submitted papers, and contributes to increased awareness of what attributes the Koli Calling CER community associate with high quality research. Non-restrictive criteria have also helped to build a climate of acceptance for a wide range of research approaches. Rigorously conducted research, be it qualitative, quantitative, empirical or speculative in nature is equally welcome. Another feature of Koli Calling is its discussion paper category. These contributions do not have the same expectations of rigour associated with them and help to build community, discuss emerging issues for the field, and lend much to the character of the conference and its discussions.

The papers included in this special issue, however, are examples of the Koli focus on promoting a wide range of high quality computing education research. Development of technologies based on theory, is a foundation stone of the Koli vision, and PatternCoder addresses a well identified problem in learning to program building on a range of relevant theories. The best tool among the 7 submitted tools, PatternCoder was granted the "Koli educational tool award" for 2008. For the ToCE version the authors have extended their original submission considerably and included material that could not be included in the original submission.

Supporting learning of programming is the topic of the second paper in this special issue. Drawing on studies of Bavarian school students Kiesmüller discusses problem solving approaches and how to provide appropriate individualised feedback to learners. He also discusses possible factors and relationships between

factors that might influence learner's choice of strategy. This paper provides food for thought for those of us who teach introductory programming courses.

This volume is the culmination of more than a year of planning and effort on the part of both the local organising committee and the conference chairs. However, we were not working alone. Without an active community of researchers doing quality research and writing papers, a conference like Koli has no function or purpose. Consequently, a large part of the success of Koli Calling lies in its vibrant research community. It is their submissions that have made it possible for us to select these interesting and thought provoking contributions. So now, without further ado, we leave you to the further perusal of the contents of the volume, in the hope that you will find its content both elucidatory and inspirational.

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