Modeling Global Competencies for Computing Education

Stephen Frezza
Gannon University
USA
frezza001@gannon.edu

Arnold Pears
KTH Royal Institute of Technology
Sweden
pears@kth.se

Mats Daniels
Uppsala University
Sweden
mats.daniels@it.uu.se

Viggo Kann
KTH Royal Institute of Technology
Sweden
viggo@nada.kth.se

Amanpreet Kapoor
University of Florida
USA
kapooramanpreet@ufl.edu

Roger McDermott
Robert Gordon University
UK
roger.mcdermott@rgu.ac.uk

Anne-Kathrin Peters
Uppsala University
Sweden
anne.peters@it.uu.se

Charles Wallace
Michigan Tech
USA
wallace@mtu.edu

Mihaela Sabin
University of New Hampshire
USA
mihaela.sabin@unh.edu

Åsa Cajander
Uppsala University
Sweden
asa.cajander@it.uu.se

ABSTRACT

This working group contributes to formulating a framework for modeling competencies in the current and future disciplines that comprise computing education. We draw upon the innovative approach taken in the curricular document for information technology (IT2017), curricular competency frameworks, other related documents such as the software engineering competency model (SWECOM), the Skills Framework for the Information Age (SFIA), current research in competency models, and elicitation workshop results from other computing conferences.

The outcomes contribute to the Computing Curricula 2020 (CC2020) project, and include the formulation and review of sets of disciplinary-relevant competencies for use in computing education. This work directly informs the CC2020 project sponsored by the Association for Computing Machinery (ACM) and the IEEE Computer Society.

CCS CONCEPTS

• **General and reference** → **Reference works**; **Computing standards, RFCs and guidelines**; • **Social and professional topics** → **Model curricula**; **Computing profession**;

KEYWORDS

Computing competencies; computing overview strategies; curriculum guidelines; CC2020; CC2005

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).
ITiCSE'18, July 2–4, 2018, Larnaca, Cyprus
© 2018 Copyright held by the owner/author(s).
ACM ISBN 978-1-4503-5707-4/18/07.
https://doi.org/10.1145/3197091.3205844

ACM Reference Format:
Stephen Frezza, Arnold Pears, Mats Daniels, Viggo Kann, Amanpreet Kapoor, Roger McDermott, Anne-Kathrin Peters, Charles Wallace, Mihaela Sabin, and Åsa Cajander. 2018. Modeling Global Competencies for Computing Education. In *Proceedings of 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE'18).* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3197091.3205844

1 INTRODUCTION

This working group seeks to advance the state of the art in competency modeling for computing education. This will be accomplished by synthesizing multiple sources, including established scholarship in competencies, local, national, and international computing curricula and curricular guidelines, and elicitation among computing educators. The working group aims to establish a model for competencies, guidelines for utilizing the model, and examples of its use for the comparison of computing programs worldwide.

Our objective is to ensure that the new CC2020 report provides forward-looking summaries of educational outcomes formulated in terms of functional competencies in computing fields within the international context of computing education on a global scale. In particular, we aim to move from traditional outcomes-based nomenclature to a competency-based approach for computing education.

2 THE ROLE OF COMPETENCIES

While the term 'competency' may not be the best term, it is used in educational scholarship for consistency with the IT2017 Report and our initial approach.

Learning outcomes focus learner achievement rather than the intention of teachers. In contrast, there is an element of vagueness surrounding the terms 'competence' and 'competency'. The term competence generally refers to the performance standards associated with a profession or membership to a licensing organization.

Assessing some level of performance in the workplace is frequently used as a competence measure, which means measuring aspects of the job at which a person is competent. We adopt the definition found in the IT2017 report, which states

Competency = Knowledge + Skills + Dispositions

This triadic model of competency helps avoid perpetuating the practice of using knowledge as the focus of curricular guidelines within bodies of knowledge.

The concept of knowledge refers to a proficiency in core concepts and content of a discipline and application of learning to new situations. *Knowledge* usually receives most of the attention from teachers when they design their syllabi, from departments when they develop program curricula, and from accreditation agencies when they articulate accreditation criteria. *Skills* refer to capabilities and strategies that develop over time through practice and interactions with others. Skills also require engagement in higher-order cognitive activities, where "hands-on" practice of skills joins with a "minds-on" engagement. *Dispositions* refer to the socio-emotional skills, behaviors, and attitudes that characterize an inclination to carry out tasks and the sensitivity to know when and how to engage in those tasks [2]. They refer to areas of values, motivation, feelings, stereotypes, and attitudes such as confidence in dealing with complexity, tolerance to ambiguity, persistence in working with difficult problems, knowing one's strengths and weaknesses, and setting aside differences when working with others [1].

3 WORKING GROUP OUTCOMES

The goal is to develop a comprehensive competency framework, as well as guidelines and examples of their use for modeling competencies in computing education suitable for comparing programs across nationalities and disciplines by enabling comparisons of the competencies intended in each program.

The following Work package overviews outline our initial view of what work needs to be accomplished.

3.1 Case for Competencies

Theory: Theoretical framework for competencies

Issues: Documentation for the current and historical issues with, and arguments for the theoretical competencies approach proposed

Intellectual Merit: Clear argument for why a competency-based approach to defining computing education is better for describing/defining computing programs than current methods.

Broader Impact: Clear argument for how a competency-based approach can improve the quality of programs, benefit student learning, teaching, assessment, and other stakeholders in computing education.

3.2 Competency Framework

Model: A comprehensive competency framework. This is anticipated as a state-space network, involving meta-tags that can be used for describing both individual and sets of competencies desired for different levels of a profession, or expected of a program graduate. This includes exploring/describing the dimensionality of various meta-tags.

Methods: Guidelines for how to model competencies in computing education suitable for describing programs and discipline learner expectations, and for comparing programs across nationalities and disciplines by enabling comparisons of the competencies intended in each program. Refine the methods from experience in modeling example disciplinary and program models.

Assessment: Explore and explain how competencies, their various levels and ranges, and their mapping to an educational program can be assessed.

3.3 Application of the Framework

Discipline-level Descriptive Use: Develop examples of discipline-oriented competencies described using the model (e.g., current work in SE, CE, IS, IT, CS competencies through CC2020 activities).

Program-level Descriptive Use: Develop examples of mapping existing programs from US, Europe, Australasia, Middle-east, South America from the guidelines. Explore issues, methods and guidelines for using framework-based competency descriptions to describe educational programs.

Comparative Use: Explore issues, methods, guidelines for using framework-based competency descriptions to compare educational programs.

Inputs: There is an active set of workshops and group work developing disciplinary-level competencies. These results will be available to the WG in June. Interested participants can be directed to this on-going work. Other inputs to this work are participants computing programs and assessments from their institutions.

Achieving these goals will be facilitated by synthesizing multiple sources for global competencies, including published scholarship, international curricular documents, national and local curricular documents (to be requested from participants), and the results of at least two elicitation workshops being conducted by the CC2020 committee members prior to the working group sessions at the IEEE Global Engineering Education Conference (EDUCON) 2018 and the 2018 Conference of the American Society for Engineering Education (ASEE), as well as CC2020 Task Force work due in May 2018 [CS|IS|IT|CE|SE]. The framework anticipates developing generic, globally-acceptable descriptions of common competencies that map to the competencies described in curricular documents, workshop outputs, and other competency documents such as the Software Engineering Competency Model (SWECOM).

4 SUMMARY

This working group advances the state of the art in competency modeling for computing education. To accomplish this we synthesize multiple sources, including established scholarship in competencies, local, national, and international computing curricula and curricular guidelines, and qualitative data elicited from computing educators. The working group goal is to establish a model for competencies, guidelines for utilizing the model, and examples of its use for the comparison of computing programs worldwide.

REFERENCES

[1] Valerie Barr and Chris Stephenson. 2011. Bringing Computational Thinking to K-12: What is Involved and What is the Role of the Computer Science Education Community? *ACM Inroads* 2, 1 (Feb. 2011), 48–54.

[2] D.N. Perkins, E. Jay, and S. Tishman. 2007. Beyond abilities: A dispositional theory of thinking. *Merrill-Palmer Quarterly* 39, 1 (2007), 1–21.