Report

Computational Literacy Work Group

November 4, 2022

Background Information

In his 2022 State of Academic Affairs Address , Provost Fotis Sotiropoulos called for the university to consider teaching students new literacies, arguing that they would help the university prepare students for work in a changing world if we were to weave them "into the fabric of VCU curriculum across all disciplines and degree programs." As part of this work, the Computational Literacy Work Group was convened with the following charge: to provide recommendations for the definition of computational literacy (what is it? How is it meaningful for our students? What does that mean in practice for the university?); criteria by which courses may be developed to achieve computational literacy; and eventually, an assessment plan for the literacy, to be crafted in collaboration with the General Education Assessment Committee.

Our interdisciplinary group membership includes Peter Aiken from the School of Business; Jason Bennett in the Department of Communication Arts; William Korzun from the College of Health Professions; David Shepherd from the Department of Computer Science; Robert Wieman in the Department of Mathematics; Benjamin Young from the Wilder School's Homeland Security & Emergency Preparedness Program; Elizabeth Fagan in the Department of Focused Inquiry; with early contributions from Erin White, formerly of the Cabell Library.

Methodology and Context

The Computational Literacy Working Group approached this project first as a literature review, trying to establish a formal definition of computational literacy as founded in expert scholarship. After considerable reading into the topic from a variety of perspectives, the group came to realize that there is no one single, consensus-driven, definition of computational literacy. The group found that, in order to define computational literacy, it was necessary to examine its boundaries and in particular, from what it is distinct. This realization led to a number of terminological discussions among the group as a way to begin to chart a definition.

The group explored the difference between computational literacy and computational thinking, as both terms on occasion seemed to be interchangeable in the literature. The group traced literacy vs. thinking in the literature, coming to a conclusion that computational thinking had to do with a particular set of activities, while a literacy could be considered something of a competency in those activities. The group also explored what literacy means in the VCU ConnectED curriculum by examining the racial literacy requirement and the history of its origin.

The group realized that the literature frequently spoke of computational literacy in a way that appeared quite similar to discussions of problem solving. The group discussed the relationship between computational literacy and problem solving, with particular emphasis on VCU's general education definition and assessment criteria for problem solving (critical and creative). The group came to a consensus that, in fact, computational literacy can be considered as a particular type of problem solving, whose defining characteristic is the use of a technological tool.

Through these discussions and further refinement, the group honed a definition that explicitly addresses the ConnectED skill of problem solving. The criteria that the group developed reflect the need for students to utilize technological tools while engaging with a set of problem-solving capabilities that begin with the consideration of a problem (design) and culminate with the ability to explain the problem (communication). After crafting a first formal draft of definitions and criteria, the group met with the co-chairs of the General Education Curriculum and Assessment committees to examine their work.

Recommendation: Definition

> At VCU, we take computational literacy to mean proficiency in a particular type of problem solving, where our students examine real-world challenges in their fields and harness technological tools to achieve progress. Computational literacy is the ability to use programmatic logic and algorithmic concepts to automate rote analysis and make complex calculation possible, pushing forward work in the 21st century.

This definition draws upon a variety of discussions of computational thinking and computational literacy offered by scholars in the field; as mentioned above, there is no consensus on a precise definition of either term in the scholarly literature. However, most work looks at computational literacy as either a way of thinking, or a set of skills, or both (cf. Settle and Perkovic 2010; Shute et al. 2017). Authors tend to draw upon Wing 2006, "Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability" (Wing 2006, cited in Settle and Perkovic 2010, p. 2). As Jacob and Warschauer note (2018, pp. 1-2), we can consider computational thinking as a generalized problem-solving approach, involving skills such as algorithmic thinking, navigating abstractions, breaking down complex problems into apprehensible components, generalizing from first principles, representing data in models, etc. When we then conceptualize this way of thinking as a *literacy*, we see computational thinking as these skills, habits and approaches to problem solving that use a computer to carry out the process of communication of socially- and culturally-situated ideas (Jacob and Warschauer 2018, p. 7).

Recommendation: Course Criteria

A course in any program may be given the computational literacy tag if it meets the following requisite course criteria:

- The course requires students to use technology relevant to the discipline;
- One of the learning objectives of the course is the ability to apply programmatic logic and/or algorithmic thinking to use that technology to produce useful results.

Recommendation: Goals and outcomes for student learning

Because we envision CL as a set of technologically-based problem solving skills that transcend discipline, courses that fulfill the computational literacy requirement will ask students to fashion, determine, and communicate aspects of problems in appropriate contexts.These courses will introduce a set of problem solving capabilities that could include but are not limited to the following skills:

Design: the ability to select the analytical process appropriate to the problem, or to craft a process if needed;
Computation: the ability to implement the process to determine or calculate specific results;
Evaluation: the ability to assess results and alternative approaches
Communication: the ability to explain the process from design through evaluation

Computational literacy as defined in VCU's ConnectED program will look different in the various fields offered by VCU's degree-granting programs. For example, in literature, computational literacy may be the ability to write and execute a search program to assist with textual analysis. In business, computational literacy may include the ability to craft Excel spreadsheets to assist with complicated accounting tasks. In archaeology, data management (e.g. querying and manipulation in databases and geodatabases) is a common way to engage in computational thinking.

Alignment with ConnectED goals and outcomes

Although the use of multiple technologies dependent on discipline is specified in the definition of computational literacy, the learning outcomes above map closely with the learning outcomes associated with the ConnectED goal of problem solving (critical and creative). The outcomes listed for that goal include:

- Define complex problems, issues, or questions
- Identify and seek out approaches, information, skills and relevant resources
- Develop and propose multiple solutions (demonstrating intellectual risk-taking and tolerance for ambiguity)
- Evaluate potential solutions with awareness of contradictions, competing assumptions, and consideration of context
- Analyze the implications, consequences, and outcomes of solutions

Both the computational literacy and problem solving outcomes offer a progression, from an initial grappling with the shape of the question or problem, through the deployment of solutions, and an evaluation of what happened. For computational literacy, however, because the crux of its definition is the step of computation through the use of a technological tool, we articulated the steps slightly differently. The overlap between the computational literacy and problem solving outcomes may mean that it would make sense to assess computational literacy in a fashion similar to that used for problem solving.

Conclusion

The group agrees that computational literacy involves the use of a valuable and necessary set of skills that will greatly benefit VCU students. Because of their work on the definition and criteria, and as a result of their discussions with the co-chairs of the General Education Curriculum and Assessment Committees, this group recommends that VCU consider whether computational literacy fits into the ConnectED curriculum. In fact, because computational literacy may be activated through a very wide variety of computer-based, technological tools, it may be best suited to each major or degree program so that students become proficient in the discipline-specific tools that will set them up for success in their careers. While this question is best addressed by the Structure Working Group and the General Education Curriculum and Assessment Committees, the work group recommends that VCU consider computational literacy in the context of disciplines and degree-granting programs.

However, computational literacy is a key skill, and it may be the case that ConnectED, as the locus of centralized curriculum, is the only place where it could be offered to every student. This committee feels strongly that computational literacy and its associated skillset are important; if the General Education Curriculum Committee thinks that computational literacy can be addressed in VCU's general education program, then the committee recommends that all units be strongly encouraged to submit courses that adhere to the criteria above, so that students have a robust slate of possibilities from which to select a course using a computational tool that will be useful to them. That slate of possibilities could even include upper-division courses with the attributes listed above, used in conjunction with gen-ed level courses, perhaps for majors which do not currently explicitly teach computational literacy; although the committee notes that the exact nature of the structuring of this program is not in the scope of this project.

Besides the definition and criteria above, the appendix to this document provides numerous examples of extant courses at the upper division level that the group feels either clearly already address computational literacy or could easily do so, given the definition provided. The appendix is only a sample, reflecting the backgrounds and knowledge of the group membership in their departments or disciplinary specialties. It is by no means exhaustive, nor has it necessarily been vetted with the departments involved. It is meant to stand only as an example of how computational literacy can be found across a wide variety of disciplines and degree programs.

Works Cited

Jacob, S. and Warshauer, M. (2018). Computational thinking and literacy. *Journal of Computer Science Integration 1*(1),1. https://inspire.redlands.edu/jcsi/vol1/iss1/1 DOI: 10.26716/jcsi.2018.01.1.1

Shute, V., Sun, Ch. and Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review 22*, 142-158. https://doi.org/10.1016/j.edurev.2017.09.003

Settle, A. and Perkovic, L. (2010). Computational thinking across the curriculum: A conceptual framework. DePaul University Technical Reports. https://via.library.depaul.edu/tr/13

Wing, J. (2006). Computational thinking. *Communications of the ACM 49(*3), pp. 33-45. https://doi-org.proxy.library.vcu.edu/10.1145/1118178.1118215

Appendix - Selected Course Examples

Specific course offerings that could easily or currently engage with computational literacy include, but are not limited to, the following:

Anthropology

ANTH 110. REAL Experience in Anthropology. 1 Hour.
Semester course; 1 field experience hour. 0-1 credit. Prerequisite: ANTH/INTL 103 or ANTH 105. Enrollment requires the permission of the faculty supervisor. Introduces students to anthropological research. Students will participate in various stages of anthropological work, such as research design, data collection and analysis, and public outreach, working alongside an anthropology faculty member who will provide direct oversight of their contributions. The course enables students to participate in anthropological work from when they first encounter the major and promotes their continued involvement in that work throughout their academic career. Graded as pass/fail.

ANTH 230. Anthropological Linguistics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: ANTH/INTL 103. Explores the disciplinary subfield of anthropological linguistics. Emphasis is on the interactions between language and culture from a comparative perspective, as well as the relationship between language and social identities and relationships. Also an introduction to the field's methodology, research techniques, analytical tools and their applications.

ANTH 303. Archaeological Methods and Research Design. 4 Hours.
Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisites: ANTH 105/INTL 104 and UNIV 200 or HONR 200 with a minimum grade of C. Introduces the basic practices of archaeology, including planning, excavation, artifact analysis, documentary research, mapping, dating sites and artifacts, and interpretation and presentation of findings. Students will participate in an active field research program and will apply methods at an active site and lab.

ANTH 394/HIST 390. Historical Archaeology
Semester course; 3 lecture hours. 3 credits. Prerequisites: ANTH 103 or ANTH 105/INTL 104; and any history course. A review of historical archaeology, recognizing its contemporary emphasis on the spread of European cultures across the globe beginning in the 15th century. Methods and findings of historical archaeological research from the United States and around the world will be covered with special emphasis on the study of documents and artifacts related to the emergence and present state of the modern world.

Arts Courses

COAR 332. Digital Drawing. 3 Hours.

Semester course; 2 lecture and 3 studio hours. 3 credits. Prerequisites: COAR 201 and COAR 202. An intermediate course exploring the use of computer and peripheral devices in the creation of personal work. Students will be introduced to relevant conceptual themes and professional methods and practices.

COAR 203. Digital 3D Studio. 3 Hours.
Semester course; 2 lecture and 3 studio hours. 3 credits. Enrollment is restricted to majors and minors in the Department of Communication Arts. The course focuses on the use of 3D software as a powerful drawing tool and current methodologies. Modeling, surfacing, lighting, rendering and applicability to industry and personal expression will be addressed.

COAR 433. Game Design, Theory and Practice. 3 Hours.
Semester course; 2 lecture and 3 studio hours. 3 credits. Prerequisites: COAR 203 and COAR 321. Students will study the history, theory and design of games, gaming concepts and narrative from past to present.

KINE 348. 3D Computer Art. 4 Hours.
Semester course; 2 lecture and 4 studio hours. 4 credits. A comprehensive introduction to the use of the computer for modeling, rendering and animating three-dimensional objects and environments.

KINE 354: Creative Code and Electronics. 4 Hours.
Semester course; 2 lecture and 4 studio hours. 4 credits. An introduction to the concepts and techniques found within programming languages and electronics as applied to digital art making. Basic coding for creative practice from visuals to sound and interactivity will be examined as well as circuitry and hardware components for DIY projects.

GDES 308. Web Design. 4 Hours.
Semester course; 1 lecture and 6 studio hours. 4 credits. A course developing the design of websites. Emphasis is placed on the visual design, navigation, development, communication and authoring of websites.

Bioinformatics

BNFO 101. Introduction to Scientific Computing. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Enrollment is restricted to bioinformatics majors. This course will introduce students to basic principles and skills for using a computer to solve scientific problems. It is hands-on course and does not assume any special prior knowledge or skill with computers. Students completing the course will become familiar with and develop skills and practical knowledge of how to use common computer-based command-line tools and systems critical for effective scientific computing.

BNFO 201. Computing Skills and Concepts for Bioinformatics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 151 or 200 with a minimum grade of C, or satisfactory score on the VCU Mathematics Placement Test within the one-year

period immediately preceding the beginning of the course. An introduction to computation in bioinformatics, including basics of data representation, and computer organization, as well as programming in Python or other appropriate scripting language. Bioinformatics applications in the literature will be discussed. Guest speakers will share bioinformatics career experiences and opportunities.

BNFO 301. Introduction to Bioinformatics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BNFO 201 or permission of instructor. The course will present a practical and theoretical introduction to the tools and techniques needed to obtain and interpret a variety of genome-related data types. The course will include several bioinformatic methods underlying nucleotide and protein sequence alignment, statistical methods for data visualization in R, the types of experimental results commonly encountered in bioinformatics data analysis and the public databases where these data can be accessed.

Clinical Laboratory Sciences

CLLS 311. Clinical Chemistry and Instrumentation I. 3-5 Hours.
Semester course; 3 lecture and 4 laboratory hours. 3-5 credits. A study of human physiology and metabolism in health and various disease states. Topics include energy and nitrogen metabolism and proteins in body fluids. Emphasis is placed on the application of quantitative analytical methods and instrumentation for the chemical characterization of body fluids to provide clinically useful information for the diagnosis and treatment of diseases.

CLLS 312. Clinical Chemistry and Instrumentation II. 4-5 Hours.
Semester course; 4 lecture and 2 laboratory hours. 4-5 credits. Prerequisite: CLLS 311 or permission of the instructor. A study of human physiology and metabolism in health and various disease states. Topics include water and ion balance, clinical enzymology, therapeutic drug monitoring, and toxicology. Emphasis is placed on the application of quantitative analytical methods and instrumentation for the chemical characterization of body fluids to provide clinically useful information for the diagnosis and treatment of diseases.

CLLS 410. Advanced Clinical Chemistry and Instrumentation. 2 Hours.
Semester course; 2 lecture hours. 2 credits. Prerequisites: CLLS 311-312, or permission of instructor. Presents an advanced study of (1) the principles of clinical chemistry as related to intermediary metabolism and pathology and (2) laboratory and hospital information systems. Includes the application of laboratory data and technologies to solve problems in analytical methods and instruments.

CLLS 483. Biochemistry Practicum. 1-4.5 Hours.
Semester course; 40-180 clock hours. 1-4.5 credits. Prerequisites: CLLS 311-312. Individual participation in hospital chemistry laboratories. Students gain practical experience in the use of procedures and instruments by working with the staff. After gaining competence, students are

expected to perform and sign out routine laboratory work under supervision. Graded as pass/fail.

History

HIST 655. Digital History. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course explores the ways technology can change the way historians research, analyze, write, discuss and produce history. Beginning with the foundations of digital history, the course will consider a variety of media, platforms and projects, and will pay particular attention to the digital initiatives in the region. Students will experience hands-on training in web literacies and other skills, including sound editing, map editing and text mining, building toward presentations of final digital projects that employ at least one new skill. By the end of the course, students should gain a basic understanding of the field’s advantages and challenges along with enough technical expertise to begin participating in it, given their own interests and needs. Above all, the course should enhance students’ engagement with the past, not distract from it.

HIST 601. Historiography and Methodology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. A study of the development of history as a discipline from ancient times to the present. The course examines the evolution of historical theory and philosophy, great historians, schools of interpretation, and problems of historical methodology. This course is a prerequisite for research seminars.

Homeland Security & Emergency Preparedness

HSEP 314. Cybersecurity Policy. 3 hours.
Semester course; 3 lecture hours. 3 credits. This course addresses emerging strategic, legal and policy issues associated with computer attack, exploitation, detection and defense. Students will be introduced to research and developments across a range of issues and will engage with topics related to national security, homeland security and economic policy, and local governance.

Information Systems Courses

INFO 361. Systems Analysis and Design. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course is restricted to students who have completed at least 54 credit hours (junior standing). Examines the concepts, tools and techniques used to develop and support computer-based information systems. Systems planning, analysis, design and implementation are covered. Behavioral and model building aspects of systems development are emphasized throughout.

INFO 364. Database Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: INFO 202, INFO 250, CMSC 245 or CMSC 255; and MATH 211, both with a minimum grade of C. Enrollment is restricted to

students who have completed at least 54 credit hours (junior standing). Designed to prepare students for development of systems involving databases and database management.

INFO 463. Business Process Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: INFO 361. This course is restricted to students who have completed at least 54 credit hours (junior standing). A survey of legacy system re-engineering technologies in which the student becomes familiar with a variety of tools used in practice and has the opportunity to develop applications using these tools under supervision. Selection of technologies is determined each semester.

Mass Communication

MASC 300 Technical Prowess. 3 hours.
Semester course; 2 lecture and 2 laboratory hours (delivered online, face-to-face or hybrid). 3 credits. Prerequisite: MASC 203, MASC 204 or MASC 285 with a minimum grade of C. Examines the functions of visual and graphic communication in the print and electronic media. Focuses on mastery of graphics software and basic design principles. Students gain hands-on experience with state-of-the-art computer graphics and layout programs.

MASC 317. Visual Acuteness. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours (delivered online, face-to-face or hybrid). 3 credits. Prerequisite: MASC 300 with a minimum grade of C. Enrollment is restricted to advertising majors. Study and practice of visual problem-solving and graphic design. This course uses design thinking, conceptual thinking and process. Topics include building harmonious systems, using the typographic grid and understanding the relationship between type and image.

MASC 301. Graphics for Journalism. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisite: MASC 203 with a minimum grade of C. For journalism students only. Examines the functions of visual and graphic communication in the print and electronic media. Focuses on creative typographic and layout design principles and integrates practice in editing, graphic creation, digital-image manipulation and professional publishing. Students gain hands-on experience with state-of-the-art computer graphics and layout programs used in newspaper and magazine journalism. (May not be taken if student has taken MASC 300 or 334.).

MASC 334. Visual Communication and Design for Public Relations. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisites: MASC 203 and MASC 210, each with a minimum grade of C. Enrollment is restricted to public relations students or media studies minors. Provides hands-on experience with current graphic design software such as Adobe Illustrator, Photoshop and InDesign while building skills for concepting, developing and critiquing design projects for public relations. Explores theoretical and practical approaches to visual communication and message development. Exposes students to the language skills and empathy required to work with professional designers in the

industry. Establishes a diverse portfolio of graphic design materials. (May not be taken if student has completed MASC 300 or MASC 301.).

MASC 335. Multimedia Production for Public Relations. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours (delivered online, face-to-face or hybrid). 3 credits. Prerequisites: ENGL 304, MASC 300, MASC 333 and MASC 337, each with a minimum grade of C. Enrollment is restricted to public relations students. Multimedia technology course used to advance the digital and practical skills developed in MASC 300 and MASC 333. Explores current and innovative approaches to multimedia tools and technology used for public relations including, but not limited to, multimedia photography, audio and video storytelling, desktop publishing and website design. Explores industry trends in digital, online and mobile communication. Establishes a diverse portfolio of multimedia projects.

Math Courses

Math 255. Mathematical Computation. 3 hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201 with a minimum grade of C. (A core course for mathematics/applied mathematics majors.) An introduction to computer algebra systems (CAS) and their use in mathematical, scientific and engineering investigations/computations. Introductory mathematical computer programming using a CAS, including implementation of problem-specific algorithms.

Political Science

POLI 303. Public Opinion and Polling. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The study of the formation, expression and influence of individual and organized public opinion on political institutions in the U.S. Topics include how the public forms and expresses attitudes, how public opinion influences political outcomes and how public opinion is measured and analyzed.

POLI 305. Political Campaigns and Communication: Theory and Process. 3 Hours.
Semester course; 3 lecture hours. 3 credits. An examination of political campaigns focusing on presidential elections. Analysis includes the study of electoral contexts, political mobilization, campaign organizational structures and strategies, campaign rhetoric, and the evolution of campaign-related technology such as polling and social media.

POLI 307. Political Behavior. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Introduces students to the major theoretical approaches and empirical research in the field of mass political behavior, with a particular emphasis on how individuals develop their ideologies and party identifications, as well as how those and other factors shape political decisions.

POLI 374. Financial Management for Nonprofits. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Examines how nonprofit organizations are influenced by prices, distribution of goods and services and the distribution of income and

wealth. Topics include financial-statement analysis, time-value of money, budgeting concepts and techniques, securities valuation, long- and short-term financial planning issues and working capital management. Designed to develop skills in decision-making in financial management of the nonprofit organization.

POLI 320. Research Methods in Political Science. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Current methods of research in the discipline of political science. Includes a brief introduction to the tools and techniques for exploring and analyzing political science data.

Statistics

STAT 447. Introduction to Statistical Data Science. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: STAT 305 and STAT 321. Familiarity with a computer programming language is strongly recommended. Enrollment is restricted to mathematical sciences majors in the statistics or operations research concentrations. Introduces students to statistical concepts and tools of data science for processing, presenting and analyzing data. Topics include data visualization, data wrangling, simulation studies, statistical inference techniques and implementations, and other content that reflects the current needs of data scientists. The course takes an applied approach to provide a broad treatment of these topics from a statistical perspective. Students will be engaged in real data analysis using R and Python, progressing through data processing, exploratory techniques, statistical modeling, and interpreting and communicating analysis results.