**Subject Matter Knowledge Matrix**

**Digital Literacy and Computer Science Curriculum Framework**

Students in Massachusetts must meet rigorous academic standards, which are outlined in the [Massachusetts Curriculum Frameworks](https://www.doe.mass.edu/frameworks/). To do so, they must have access to educators with strong content knowledge and pedagogical skills, the building blocks of effective instructional practice.

In support of this, the [Subject Matter Knowledge Guidelines](https://www.doe.mass.edu/edprep/domains/instruction/smk-guidelines.docx) set forth the content knowledge expectations for educator licensure in Massachusetts. Through these expectations, the Massachusetts Department of Elementary and Secondary Education (DESE) seeks to ensure that educators entering the workforce have sufficient content knowledge in their licensure area to support students in mastering the Massachusetts Curriculum Frameworks.

While the Curriculum Frameworks serve as an anchor, the intent is not that educators should simply know the content included in the Frameworks for two grades above and below the license grade span. Rather, educators must move beyond basic or functional knowledge to a level of fluency or expertise with the academic standards such that they can teach and support students in mastering the content.

The figure below shows a steady progression, not in the amount of information one knows, but in the depth and ability to use that information for a specific purpose. The boxes below the continuum outline assessments that may be used to determine varying levels of content knowledge. The depth at which the knowledge and application of content knowledge must be demonstrated is dependent on the stage of development for an individual educator (i.e. Basic, Functional, Fluent, or Expert) and/or license type (Provisional, Initial, or Professional).



This worksheet should be completed for licensure programs with Subject Matter Knowledge expectations in the [Digital Literacy and Computer Science Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html), including:

Digital Literacy and Computer Science, PK-6

Digital Literacy and Computer Science, 5-12

**Progression of Core Digital Literacy and Computer Science Concepts**

The Digital Literacy and Computer Science Curriculum Framework groups content standards into four strands: Computing and Society, Digital Tools and Collaboration, Computing Systems, and Computational Thinking. Each strand is further subdivided into core concepts comprised of related standards.

Educators should have the content knowledge to support PK-12 students in mastering these core concepts across grade levels. Teachers need to be able to access knowledge from prior grades, and teachers who are aware of later content can make better choices about what to emphasize, what language to use, and what larger contexts to provide for their students. This expectation allows teachers to meet students where they are and prepare them for where they are going.

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| **Instructions*:***The content knowledge below must either be covered directly through program coursework or screened during the admissions process. For each row, list the numbers/abbreviations/titles of the **sponsoring organization’s required courses where the core concepts are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus each core concept is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and content knowledge for each grade level should not be spread across too many courses.  The full [Digital Literacy and Computer Science Curriculum Framework](https://www.doe.mass.edu/frameworks/current.html), including the Guiding Principles which are also available in [Appendix A](#_Appendix_A:_Digital) of this document, should be consulted when designing programs to ensure appropriate content coverage and rigor for each licensure field’s grade span. Sponsoring Organizations should prioritize content fluency in the grade span for the license, while ensuring functional content knowledge in the two grade levels below and above the grade span. |

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| **1. Computing and Society (CAS):** Computing impacts all people and has global consequences on such things as communications, assistive technology, social networking, and the economy. (e.g., the level of impact, both positive and negative, may be dependent upon a person’s gender identity, race, ethnicity, income level, and other identities.) Society values many different computing innovations. Computing is a key component of many professions, and the content of digital media influences all citizens and society. Global disparities in access to the Internet, media, and devices may lead to an imbalance in equity and power. Principles of privacy, ethics, security, and copyright law influence digital safety and security, as well as interpersonal and societal relations. [3-5 CAS, 6-8.CAS, and 9-12.CAS] | **Course(s) or Screening** |
| *Example Row* | *EDU 101- Weeks 5-7* |
| **CAS.a. Safety and Security.** Responsible citizens in the modern world apply principles of personal privacy and network security to the use of computing systems, software, the Internet, media, and data. (e.g., this includes personal safety such as preventing and combating cyberbullying as well as mental health and peer pressure concerns of social computing [9-12.CAS.a]) |  |
| **CAS.b. Ethics and Laws.** Ethics include standards of conduct, fairness, and responsible use of the Internet, data, media, and computing devices. An understanding of principles and laws of software licenses, copyrights, and acceptable use policies are necessary to be responsible citizens in the modern world. |  |
| **CAS.c. Interpersonal and Societal Impact.** The use of computing devices, assistive technologies and applying a computational perspective to solving problems changes the way people think, work, live, and play. Computational approaches lead to new understanding, discoveries, challenges, and questions. Most professions rely on technology and advances in computing foster innovations in many fields. Differential access to principles of computing, computing devices, digital tools, and media in the global society, has potentially significant effects. |  |
| **2. Digital Tools and Collaboration (DTC):** Digital tools are applications that produce, manipulate, or store data in a digital format (e.g., word processors, drawing programs, image/video/music editors, simulators, Computer-Aided Design (CAD) applications, publishing programs). Digital tools are critical for conducting research, communicating, collaborating and creating in social, work, and personal environments. The use of digital tools is integral to success in school and career. [3-5.DTC, 6-8.DTC, and 9-12.DTC] | **Course(s) or Screening** |
| **DTC.a. Digital Tools.** Digital tools are used to create, manipulate, analyze, edit, publish, or develop artifacts. Individuals identify, evaluate, select, and adapt new tools as they emerge |  |
| **DTC.b. Collaboration and Communication.** A variety of digital tools are used to work collaboratively anytime and anywhere, inside and outside the classroom, both synchronously and asynchronously, to develop artifacts or solve problems, contribute to the learning of others, and communicate. |  |
| **DTC.c. Research.** A variety of digital tools are used to conduct research, answer questions, and develop artifacts to facilitate learning and convey understanding. Access to the Internet and digital tools allows people to gather, evaluate (for validity, bias, relevance, accuracy, etc.), organize, analyze, and synthesize information, data and other media from a variety of sources. Effective use of information, data, and media requires consideration of validity, ethics, and attribution of sources. |  |
| **3. Computing Systems (CS):** Computing systems are comprised of components, such as devices, software, interfaces, and networks that connect communities, devices, people, and services. They empower people to create, collaborate, and learn via human-computer partnerships. The design of many computing systems empowers people to debug, extend, and create new systems. Computing systems require troubleshooting and maintenance to consistently function. [3-5.CS, 6-8.CS, and 9-12.CS] | **Course(s) or Screening** |
| **CS.a. Computing Devices.** Computing devices take many forms (e.g., car, insulin pump, or robot), not just personal computers, phones and tablets. They use many types of input data (e.g, collected via sensors such as for sound, movement, location, temperature, and other data) and run instructions in the form of programs to produce certain outputs (e.g., images, sounds, and actions). (e,g., Candidates must have experience designing and coding devices using various inputs - including sensors - and outputs). |  |
| **CS.b. Human and Computer Partnerships.** Some tasks, such as repetitive tasks, or those involving complex computations, are best done by computers, while other tasks that do not have defined rules or are dynamic in nature, are best done by humans. Many tasks, however, are done through human-computer partnerships. Human-computer partnerships are characterized by the interaction of humans with devices and systems that work together to achieve a purpose or solution that would not be independently possible. These skills and knowledge inform the decision to use technology in creating, innovating, or solving a problem or sub-problem. |  |
| **CS.c. Networks.** Network components, including hardware and software, carry out specific functions to connect computing devices, people, and services. The Internet facilitates global communication and relies on considerations of network functionality and security. (e.g., candidates know the components of a network including local networks and the Internet and have knowledge of various network topologies. |  |
| **CS.d. Services.** Data storage and computing occurs in many interconnected devices creating computational “services” that are the building blocks of computing systems. These services make use of data, algorithms, hardware, and connectivity that may occur on remote systems. |  |
| **4. Computational Thinking (CT):** Computational thinking is a problem-solving process that requires people to think in new ways to enable effective use of computing to solve problems and create solutions. The capacity of Massachusetts Curriculum Framework for Digital Literacy and Computer Science 16 computers to rapidly and precisely execute programs makes new ways of designing, creating, and problem solving possible. Computational thinking is characterized by: analyzing, modeling, and abstracting ideas and problems so people and computers can work with them; designing solutions and algorithms to manipulate these abstract representations (including data structures); and identifying and executing solutions (e.g., via programming). [3-5.CT, 6-8.CT, and 9-12.CT] | **Course(s) or Screening** |
| **CT.a. Abstraction.** Abstraction is a process of reducing complexity by focusing on the main idea. By hiding details irrelevant to the question at hand and bringing together related and useful details, abstraction reduces complexity and allows one to focus on the problem. This process creates a new representation, which successfully reframes the problem. At the most basic level of abstraction, data structures are used to represent information so that algorithms can operate on the data to create a result. |  |
| **CT.b. Algorithms.** An algorithm is a sequence of precisely defined steps to solve a particular problem. Carefully designed algorithms are essential to solving complex problems using computers. Effective algorithms are efficient, clear, reusable, and accurate |  |
| **CT.c. Data.** Collecting, managing, and interpreting a vast amount of raw data is part of the foundation of our information society and economy. The storage of data impacts how data is used and accessed. (e.g., candidates should be familiar with various ways to store data including databases and should be able to “create, modify, and use a database” [6-8.CT.c.3] and perform “operations such as sorting, filtering, and searching in a database” [6-8.CT.c.4]). Computational tools enable insights and decisions through new techniques for data collection and analysis (e.g., including analyzing for bias). |  |
| **CT.d. Programming and Development.** Programming articulates and communicates instructions in such a way that a computer can execute a task. Programming makes use of abstractions, algorithms, and data to implement ideas and solutions as executable code through an iterative process of design and debugging. The process of creating software includes understanding the development life cycle, such as testing, usability, documentation, and release. Software development is the application of engineering principles (usually by a team) to produce useful, reliable software at scale and to integrate software into other engineered artifacts. (e.g., in grade 5 the MA DLCS standards recommend block-based coding, in 6-8 either block-based or text-based coding may be used. High school DLCS teachers will need to be fluent in text-based coding including the use of methods or functions, data structures, and some object-oriented concepts.) |  |
| **CT.e. Modeling and Simulation.** Computational modeling and simulation help people to represent and understand complex processes and phenomena. Computational models and simulations are used, modified, and created to analyze, identify patterns, and answer questions of real phenomena and hypothetical scenarios. |  |

**Digital Literacy and Computer Science Practices**

The Digital Literacy and Computer Science Practices describe the methods that digital literacy and computer science educators at all levels should seek to develop in their PK-12 students. The practices articulate the methods by which PK-12 students will learn and exercise the skills detailed in the content standards. These practices become internalized dispositions as students master digital literacy and computer science content.

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| **Instructions*:***Initial licensure program candidates must reach a level of fluent content knowledge in order to be endorsed. They must be able to apply content in a range of contexts and vertically connect content to build students’ knowledge. As such, sponsoring organizations must have at least one course covering the practices at the fluent level.  Please list the numbers/abbreviations/titles of the **required courses where practices are explicitly targeted and coherently addressed**. Then, **briefly describe where in the syllabus each practice is covered** (i.e., unit name, week number, objective number). Course identifiers should match those of submitted syllabi and practices should not be spread across too many courses |

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| **Digital Literacy and Computer Science Practices** | **Fluent**  *Initial*  *Licensure* |
| *Example Row* | *EDU 101- Weeks 5-7* |
| **1. Creating.** Digital literacy and computer science are disciplines in which students demonstrate creative thinking, construct knowledge, and develop innovative artifacts and processes using technology. Students engage in the creative aspects of computing by designing and developing interesting computational artifacts and by applying techniques to creatively solve problems. Skills include:   * Creating artifacts or computational projects with practical, personal, and/or social intent; * Selecting appropriate methods, paths, or techniques to develop artifacts; * Using appropriate algorithmic and information-management principles and/or digital tools; * Applying critical thinking, digital tools, and technology to solve problems; * Making ethical and responsible choices in selecting tools, information, and media to create and share artifacts; and * Reviewing, revising, and iterating work to create high-quality artifacts. |  |
| **2. Connecting:** Developments in computing have far-reaching effects on society and have led to significant innovations. The developments have implications for individuals, society, commercial markets, and innovation. Students study their effects and draw connections between different computing concepts. Skills include:   * Describing the impact of computing on society (humanity), economies, laws, and histories; and * Distinguishing between ethical and unethical practices with respect to safe and responsible use of information, data, media, and computing devices. |  |
| **3. Abstracting:** Computational thinking requires understanding and applying abstraction at multiple levels. Students use abstraction to develop models and to classify and manage information. Skills include:   * Identifying abstractions; * Describing modeling in a computational context; * Using abstraction and decomposition when addressing complex tasks or designing complex systems; * Classifying data into groups and hierarchies; and * Identifying attributes (properties) of the data groups. |  |
| **4. Analyzing:** Students use critical thinking and analytical skills to locate, evaluate, and analyze information, information sources, their own computational artifacts, and the computational artifacts others have produced. Skills include:   * Asking questions to define a problem or information need; * Describing and articulating a problem or information need; * Evaluating information sources, research, data, proposed solutions, models, or prototypes; * Identifying ways to improve solutions or information quality; and * Selecting and justifying appropriateness, precision, or quality of “best” solutions and information sources. |  |
| **5. Communicating.** Communication is the expression and exchange of information between two or more people. Communication includes written and oral mediums, as well as tangible representations supported by graphs, visualizations, demonstrations, stories, and analysis. Effective communication is accurate, clear, concise, persuasive, and responsible. Skills include:   * Evaluating various digital tools for best expression of a particular idea or set of information; * Selecting and using digital media and tools to communicate effectively; * Communicating to or with different audiences; * Describing computation with accurate and precise language, notations, or visualizations where relevant; * Summarizing the purpose of a proposed solution, model, prototype, or computational artifact; * Justifying the design, appropriateness of choices, and selection of a solution; and * Communicating responsibly, such as respecting intellectual property |  |
| **6. Collaborating.** People working collaboratively in teams, locally or globally, can often achieve more than individuals working alone. Effective collaboration draws on diverse perspectives, skills, knowledge, and dispositions to address complex and open-ended problems or goals. Skills include:   * Collaborating with others to conduct research, solve a computational problem, or developing digital artifacts; * Collaborating with others to create computational artifacts, computational projects, or digital by-products; and * Exchanging knowledge and feedback with a partner or team member. |  |
| **7. Researching**. Students apply digital tools to gather, evaluate, and use information in a legal, safe, and ethical manner. Skills include:   * Defining a problem, research question, or goal; * Identifying information needs, whether primary (e.g., raw data, experimentation, collection), or secondary (e.g., existing information); * Employing research strategies to locate all possible sources; * Evaluating and selecting the best sources of information for credibility, accuracy, and relevance, which may include original data, creating a prototype, or conducting other tangible work; * Using information ethically: attributing sources of information (text, written, images, other media) using the appropriate citation format for the discipline; * Organizing and analyzing information; * Synthesizing and inferring information and data; and * Creating a thesis that addresses the research question. |  |

# **Appendix A: Digital Literacy and Computer Science Guiding Principles**

The following principles are philosophical statements that underlie the pre-kindergarten through grade 12 Digital Literacy and Computer Science Framework standards and resources. These principles should guide the design and evaluation of programs in both PK-12 and higher education settings.

**Guiding Principle 1: Learning. Digital literacy and computer science ideas should be explored in ways that stimulate curiosity, create enjoyment, and develop depth of understanding.** Students need to understand digital literacy and computer science concepts and use them effectively. The standards for digital literacy and computer science practice describe ways in which students increasingly engage with the subject matter as they grow in digital literacy and computer science maturity and expertise through the elementary, middle, and high school years.

Students should be actively engaged in designing, creating and inventing, discussing ideas, and applying their skills in interesting, thought-provoking situations. As students develop technology skills, it is important they apply these skills in their classroom, school, and life so that they will understand why these skills are important. For example, a student who needs to gather data in a science experiment and organize and manipulate the data in order to analyze the results will see a reason for learning about the features and function of a data collection tool and database. This is context-sensitive learning in which technology skills instruction is centered on the students’ needs. Student understanding is further developed through ongoing reflection about cognitively demanding and worthwhile tasks.

Tasks should be designed to challenge students in multiple ways. Activities should build upon curiosity and prior knowledge and enable students to solve progressively deeper, broader, and more sophisticated problems. Digital literacy and computer science tasks reflecting sound and significant concepts should generate active classroom talk, promote the development of conjectures, and lead to an understanding of the necessity for digital literacy and computer science reasoning.

**Guiding Principle 2: Teaching. An effective program is based on a carefully designed set of content standards that are clear and specific, focused, and articulated over time as a coherent sequence.** The sequence of topics and performances should be based on what is known about how students’ knowledge, skill, and understanding develop over time. What and how students are taught should reflect not only the topics, but also the key ideas that determine how knowledge is organized and generated. Students should be asked to apply their learning and to show their thinking and understanding.

Creating and problem solving are the hallmark of computational thinking and an effective program. Skills in computational thinking require practice with a variety of problems, as well as a firm grasp of devices, tools, services, and techniques, and their underlying principles. Armed with this deeper knowledge, the student can then use digital literacy and computer science skills in a flexible way to create new products, attack various problems, and devise different ways of solving any particular problem. Problem solving calls for reflective thinking, persistence, learning from the ideas of others, and going back over one's own work with a critical eye. Students should be able to communicate their ideas and work collaboratively. They should analyze situations and justify their solutions.

As digital tools, computing devices, and services become an integral part of the learning environment, and as students gain the knowledge and skills to use, modify and create with them appropriately, new opportunities for learning open up. Dynamic geometric applets, for example, can help students visualize and understand complex mathematics concepts. Simulation software enables students to investigate models of real-world problems, such as climate change and population growth.

Success in creating and solving problems helps to create an abiding interest. Students learn to solve problems arising in everyday life, society, and the workplace.

For a program to be effective, it must also be taught by knowledgeable teachers.

**Guiding Principle 2: Equity. All students should have a high-quality digital literacy and computer science program that prepares them for college and a career.** All Massachusetts students should have a high-quality digital literacy and computer science program that meets the goals and expectations of these standards and addresses students’ individual interests and talents. The standards provide clear signposts along the way to the goal of college and career readiness for all students. The standards provide for a broad range of students, from those requiring tutorial support to those with talent in digital literacy and computer science. To promote achievement of these standards, teachers should encourage classroom talk, reflection, use of multiple problem-solving strategies, and a positive disposition toward digital literacy and computer science. They should have high expectations for all students. At every level of the education system, teachers should act on the belief that every child should learn challenging digital literacy and computer science concepts. Teachers and guidance personnel should advise students and parents about why it is important to take advanced courses in digital literacy and computer science and how this will prepare students for success in college and the workplace.

All students should have the benefit of quality instructional materials, good libraries, and adequate technology. All students must have the opportunity to learn and meet the same high standards. In order to meet the needs of the greatest range of students, digital literacy and computer science programs should provide the necessary intervention and support for those students who are below or above grade-level expectations. Practice and enrichment should extend beyond the classroom. Tutorial sessions, digital literacy and/or computer science clubs, competitions, and apprenticeships are examples of digital literacy and computer science activities that promote learning.

Because digital literacy and computer science is the cornerstone of our digital world, a comprehensive curriculum should include modeling activities that demonstrate the connections among disciplines.