

# Bringing Computational Thinking to K-12: What is Involved and What is the Role of the Computer Science Education Community?

By Valerie Barr and Chris Stephenson



The process of increasing student exposure to computational thinking in K-12 is complex, requiring systemic change, teacher engagement, and development of significant resources. Collaboration with the computer science education community is vital to this effort.

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## 1.0 INTRODUCTION

Jeanette Wing [12] launched a discussion regarding the role of “computational thinking” across all disciplines, she ignited a profound engagement with the core questions of what computer science is and what it might contribute to solving problems across the spectrum of human inquiry. Wing argued that advances in computing allow researchers across all disciplines to envision new problem-solving strategies and to test new solutions in both the virtual and real world. Computing has made possible profound leaps of innovation and imagination as it facilitates our efforts to solve pressing problems (for example, the prevention or cure of diseases, the elimination of world hunger), and expands our understanding of ourselves as biological systems and of our relationship to the world around us. These advances, in turn, drive the need

educated individuals who can bring the power of computing and problem solving to an expanded field of endeavors.

no longer sufficient to wait until students are in college to introduce these concepts. All of today’s students will go on to live a life heavily influenced by computing, and many will work in fields that involve or are influenced by computing. They must begin to work with algorithmic problem solving and computational methods and tools in K-12. The successful embedding of computational thinking concepts into the K-12 curriculum requires efforts in two directions. Educational policy must be changed, overcoming significant infrastructure hurdles, and K-12 teachers resources, starting with a cogent definition and relevant appropriate examples. In this paper we report on the first part of a multiphase project aimed at developing an operational definition of computational thinking for K-12 along with suitable resources for policy and curricular change. In addition to explaining the issues involved in the K-12 arena, this paper, following Gal-Ezer and Stephenson [4], is intended to help bridge the gap between the K-12 and CS education communities. We note that this effort is distinct from CS education efforts, such as that of Zendler and Spannagel [13], in that our goal is to articulate a set of key concepts within computation that can be applied across disciplines, rather than proposing a set of central concepts of computer science solely for CS curricula.

The computer science education community can play an important role in highlighting algorithmic problem solving practices and applications of computing across disciplines, and help integrate the application of computational methods and tools across diverse areas of learning. At the same time, CS educators must understand the complexities of the K-12 educational setting, incorporating that knowledge into outreach activities and support for K-12 changes.

Developing a definition of, or approach to, computational thinking that is suitable for K-12 is especially challenging in light of the fact that there is, yet, no widely agreed upon definition of computational thinking. Clearly, K-12 students already learn how to think and to problem solve, but computer scientists can help teachers understand these processes as algorithmic, and identify where actual computation and manipulation of data with a computer may fit in. Many disciplines require, promote, and teach problem solv-

ing skills, logical thinking, or algorithmic thinking. Computer scientists can promote understanding of how to bring computational processes to bear on problems in other fields and on problems that lie at the intersection of disciplines. For example, bioinformatics and computational biology are different, but both benefit from the combination of biology and computer science. The former involves collecting and analyzing biological information. The latter involves simulating biological systems and processes. Presenting both bioinformatics and computational biology in algorithmic form helps scientists exchange information [5].

## 2.0 MULTIPLE DEFINITIONS OF COMPUTER SCIENCE AND COMPUTATIONAL THINKING

Questions of the nature and educational value of computer science are as old as the discipline itself. In 1985, Abelson and Sussman argued that computer science is “a discipline of constructing appropriate descriptive languages” [1]. Denning [2], however, posited that computer science consists of mechanics (computation, communication, coordination, automation, and recollection), design principles (simplicity, performance, reliability, evolvability, and security) and practices (programming, engineering systems, modeling and validation, innovating, and applying). The ACM Model Curriculum for K-12 Computer Science [11] provides a definition of computer science specifically for K-12 educators. Computer science, it argues, is neither programming nor computer literacy. Rather, it is “the study of computers and algorithmic processes including their principles, their hardware and software design, their applications, and their impact on society” (pg.1). Computer science therefore includes:

- programming,
- hardware design,
- networks,
- graphics,
- databases and information retrieval,
- computer security,
- software design,
- programming languages and paradigms,
- logic,
- translation between levels of abstraction,
- artificial intelligence,
- the limits of computations (what computers cannot do),
- applications in information technology and information systems, and
- social issues (Internet security, privacy, intellectual property, etc.).

More recently, Felleisen and Krishnamurthy [3] have argued that “imaginative programming” is the most crucial element of computing because it closely aligns mathematics with computing and in this way brings mathematics to life.

In framing the conceptual and educational importance of computational thinking, as distinct from computer science, Wing [12] suggested that computational thinking includes seeking algorithmic

## Bringing Computational Thinking to K-12

*continued*

approaches to problem domains; a readiness to move between differing levels of abstraction and representation; familiarity with decomposition; separation of concerns; and modularity. More recently, Isbell et al. [7] have argued for “computationalist thinking”, a focus on providing services, interfaces, and behaviors that involves a more central role for modeling as a means of formulating relationships and identifying relevant agencies that are sources of change.

Thinking the International Working Group on Computational Thinking [8] pointed out, however, computational thinking “shares elements with various other types of thinking such as algorithmic thinking, engineering thinking, and mathematical thinking”. Perkovic et al. [10] similarly focus on the intellectual skills necessary to “apply computational techniques or computer applications to ... problems and projects” in any discipline. Hemmendinger [6] notes that we must be aware of the risks of arrogance and overreaching when discussing the role of computational thinking, especially across disciplines. He argues that the elements of computational thinking that computer scientists tend to claim for their own (constructing models, finding and correcting errors, creating representations, and analyzing) are shared across many disciplines and that the appearance of grand territorial claims risks provoking

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- demonstrated leadership, particularly in STEM discipline areas.

The steering committee eventually selected 26 Thought Leaders and charged them with developing a shared vision and set of strategies for embedding computational thinking across the K-12 curriculum, most especially in the STEM subject areas. The purpose of the meeting, held over two days in April

2014, was not to craft a formal or definitive definition of computational thinking to be debated by academics. Rather, the goal of the meeting was to reach a consensus of what computational thinking means in K-12, as well as explain the particularities of K-12 education to the CS education representatives. Specifically, for any K-16 collaboration to be successful, college faculty must understand the complexities of teaching in and making changes in the K-12 setting. The computer scientists participating, in particular, noted that educational change was considerably more complex than they suspected and that working with educators from multiple diverse disciplines meant learning to “disconnect computational thinking from computer science”.

## The meeting participants also predicted that students whose learning abounded with opportunities for “computational doing” would evidence a more fluid kind of problem solving.

The classroom through active problem solving. They saw students: “engaged in using tools to solve problems”, “comfortable with trial and error”, and working in “an atmosphere of figuring things out together”. They also saw students using key concepts, so that “you will hear them talk about sequences, inputs, outputs, saved value, how complex the solution is”. The meeting participants also predicted that students whose learning abounded with opportunities for “computational doing” would evidence a more fluid kind of problem solving. These students would understand that “problems can be solved in multiple ways”, have “a tolerance for ambiguity and flexibility” and have “reasonable expectations about the prospect of producing a working solution”.

One structured model that emerged focused on identifying core computational thinking concepts and capabilities and providing examples of how they

might be embedded in activities across multiple disciplines. Table 1 shows the results of these efforts.

Participants also discussed the core concepts in the context of capabilities, dispositions and pre-dispositions, and classroom culture. In many ways the capabilities category is a reiteration of the core concepts, focused on what students would actually do. These capabilities include:

- Design solutions to problems (using abstraction, automation, creating algorithms, data collection and analysis);
- Implement designs (programming as appropriate);
- Test and debug;
- Model, run simulations, do systems analysis;
- Reflect on practice and communicating;
- Use the vocabulary;
- Recognize abstractions and move between levels of abstractions;
- Innovation, exploration, and creativity across disciplines;
- Group problem solving; and
- Employ diverse learning strategies.

The dispositions and pre-dispositions category arose from an attempt to capture the “areas of values, motivations, feelings, stereotypes and attitudes” applicable to computational thinking. These included:

- Persistence in dealing with complexity,
- Persistence in working with difficult problems,
- The ability to handle ambiguity,
- The ability to deal with open-ended problems,
- Setting aside differences to work with others to achieve a common goal or solution, and
- Knowing one's strengths and weaknesses when working with others.

### 4.0 WAYS OF ENVISIONING COMPUTATIONAL THINKING IN K-12 CLASSROOM

The participants identified many ideas about what computational thinking is and what it could be in K-12 classrooms. When challenged with the task of describing what makes computational thinking distinct from other kinds of thinking, participants tended to focus on the centrality of the computer and a set of concepts encompassed by computational thinking and doing:

CT is an approach to solving problems in a way that can be implemented with a computer. Students become not merely tool users but tool builders. They use a set of concepts, such as abstraction, recursion and iteration, to process and analyze data, and to create real and virtual artifacts. CT is a problem solving methodology that can be automated and transferred and applied across subjects.

They also considered the generation of computational thinking from its potential use in, a wide variety of disciplines:

The power of computational thinking is that it applies to every other type of reasoning. It enables all kinds of things to get done: quantum physics, advanced biology, human-computer systems, development of useful computational tools.

The participants envisioned computational thinking manifesting

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## TABLE 1: CORE COMPUTATIONAL THINKING CONCEPTS AND CAPABILITIES

CT Concept, Capability	CS	Math	Science	Social Studies	Language Arts
Data collection	Find a data source for a problem area	Find a data source for a problem area, for example, flipping coins or throwing dice	Collect data from an experiment	Study battle statistics or population data	Do linguistic analysis of sentences
Data analysis	Write a program to do basic statistical calculations on a set of data	Count occurrences of flips, dice throws and analyzing results	Analyze data from an experiment	Identify trends in data from statistics	Identify patterns for different sentence types
Data representation	Use data structures such as array, linked list, stack, queue, graph, hash table, etc.	Use histogram, pie chart, bar chart to represent data; use sets, lists, graphs, etc. To contain data	Summarize data from an experiment	Summarize and represent trends	Represent patterns of different sentence types
Problem Decomposition	Define objects and methods; define main and functions	Apply order of operations in an expression	Do a species classification		Write an outline
Abstraction	Use procedures to encapsulate a set of often repeated commands that perform a function; use conditionals, loops, recursion, etc.	Use variables in algebra; identify essential facts in a word problem; study functions in algebra compared to functions in programming; Use iteration to solve word problems	Build a model of a physical entity	Summarize facts; deduce conclusions from facts	Use of simile and metaphor; write a story with branches
Algorithms & procedures	Study classic algorithms; implement an algorithm for a problem area	Do long division, factoring; do carries in addition or subtraction	Do an experimental procedure		Write instructions
Automation		Use tools such as: geometer sketch pad; star logo; python code snippets	Use probeware	Use excel	Use a spell checker
Parallelization	Threading, pipelining, dividing up data or task in such a way to be processed in parallel	Solve linear systems; do matrix multiplication	Simultaneously run experiments with different parameters		
Simulation	Algorithm animation, parameter sweeping	Graph a function in a Cartesian plane and modify values of the variables	Simulate movement of the solar system	Play age of empires; Oregon trail	Do a re-enactment from a story

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Attempting to define a classroom culture that would be most conducive to computational thinking, the participants identified strategies or characteristics that could be considered broadly beneficial to any learning experience. These included:

- Increased use by both teachers and students of computational vocabulary where appropriate to describe problems and solutions;
- Acceptance by both teachers and students of failed solution attempts, recognizing that early failure can often put you on the path to a successful outcome;

- Team work by students, with explicit use of:

- *decomposition* - breaking problems down into smaller parts that may be more easily solved,
- *abstraction* - simplifying from the concrete to the general as solutions are developed,
- *negotiation* - groups within the team working together to merge parts of the solution into the whole, and
- *consensus building* - working to build group solidarity behind one idea or solution.

While further detail and synthesis work is clearly required (and planned for in the next phase of the project) these models provide a way to begin embedding computational thinking within K-12 formal education. This counters the potential claim that computational thinking can only be addressed in informal education experiences where discipline based-learning and classroom constraints are not major encumbrances. However, there are still considerable barriers that must be considered in any attempt at systemic and sustained change.



## 5.0 STRATEGIES FOR ACHIEVING SYSTEMATIC CHANGE

The kind of systemic and sustained educational change proposed necessitates two sets of resources. Resources are needed to help inform educational policy makers about the nature and importance of computational thinking, its connections to learning goals that may have already been set for students (for example national and state standards), and ways it can best be integrated within the larger framework for student learning and success. Teachers also need resources that demonstrate how to most appropriately and effectively integrate these new concepts, first into their own sphere of content and pedagogical knowledge, and then into their classroom content and practice.

In order to articulate and expand on these two set of resources, the Thought Leaders identified several strategic areas that would have to be addressed in order to successfully embed computational thinking within K-12. For each strategic area, they developed a set of requirements and suggestions that would support that element of systemic and sustained change.

### 5.1 Policies, Vision, and Language

Educational policies that include computational thinking as a part of every student's education include the following activities.

- Present a single message at federal, state, and local levels about the importance of computational thinking in K-12 education.
- Encourage computer science professional organizations to advocate at the federal and state levels and work with groups that are active on state K-12 standards.
- Incorporate computational thinking throughout the entire K-12 experience with outcomes that demonstrate incremental steps.
- Attach computational thinking, where possible, to existing policies. For example, it could be included as an explicit outcome of state level technology tests.
- Include in all teacher pre-service preparation programs a class on computational thinking across disciplines.

A shared vision and common language include the following activities.

- Improve the relationships and communication between K-12 educators (faculty and administrators), college CS faculty, computer science professionals, and others in industry.
- Develop a clear statement of computational thinking as a core competency in K-12.
- Demystify terminology about computational thinking, give clear examples of ways it applies to and can be integrated into a range of curricular areas.

### 5.2 Inspiration and Leadership

An activity for school and district level leadership inspiring change is to provide materials that will help school administrators understand computational thinking and see why associated knowledge and skills are important for today's students. The larger CS community can help by providing suitable materials and taking advantage of opportunities to work with K-12 administrators.

## The larger CS community can help by providing suitable materials and taking advantage of opportunities to work with K-12 administrators.

Inspiring and preparing teachers to change include the following activities.

- Foster professional development since it is critical to successful educational change. CS faculty can help by providing summer institutes, demonstrating the role of computational thinking in non-CS disciplines and providing relevant curricular materials.
- Encourage school administrators to provide incentives for K-12 teachers to change courses and curricula. The NSF RET grants awarded to CPATH grantees are one model that provides incentives for K-12 teachers to adopt curricular or pedagogic changes that have been piloted at the college level.
- Provide teachers with resources to support change, including curricular materials, models and simulations, model activities, and web sites for independent student activities.
- Provide teachers with professional development and support in the form of learning communities, summer institutes, peer learning offered by teachers with computational thinking experience, exposure to industry applications where CT skills are utilized, and help identifying where computational thinking is already included in teaching.
- Make available to school districts open-source tools (blogs, wikis, forums) and web-based social networks and content delivery systems for use by teachers and students (vetted so that districts are not likely to block them).
- Encourage current professional education associations to show how computational thinking fits into their current standards/work.

## Bringing Computational Thinking to K-12

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- Ask professional education associations to include a focus on computational thinking in their conferences, workshops, and professional development events.



These represent strategic areas that would support the long-term goal of embedding computational thinking in K-12. They clearly demonstrate the myriad issues and obstacles involved when trying to achieve educational change in K-12. They also illustrate the critical importance of engaging knowledgeable K-12 educators in projects that purport to improve student learning, and the extent to which a successful effort will require the expertise, resources, and dedication of educators and policy makers at all educational levels.



## 6.0 NEXT STEP

The next phase of this project will involve a Practitioners Workshop that will begin to develop the resources and strategies identified in the Thought Leaders meeting. The challenge will be to determine the best possible artifacts to promote the implementation of computational thinking concepts in K-12. We expect that the Practitioners Workshop will therefore include development of various resource sets. For example, a framework might be developed to guide high-level policy work (e.g. school, district, state). A second resource might consist of exemplars or activities for classroom teachers. While the precise set of resources and their content have not yet been determined, it is clear that the Practitioners Workshop will be focused on formulating new materials both for implementing CT concepts into the curriculum and for advocating for computational thinking as a key educational component for all students. Given efforts already under way at the college level, including the development of new curricula and resources, we expect the computer science education community will have much to contribute to this effort. **Ir**

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**General terms:** Human Factors

**Keywords:** Computational thinking, K-12 curriculum, K-12 CS Education, cross-disciplinary computing

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## APPENDIX A

CSTA is a membership organization of more than 7000 computing educators at the K-12 and post-secondary level. Its mission is to support and promote the teaching of computer science and other computing disciplines at the K-12 level by providing opportunities for teachers and students to understand better the computing disciplines and to prepare themselves more successfully to teach and to learn. Since its inception five years ago, CSTA has become the primary voice for K-12 computer science education, advocating for the importance of computer science as part of the educational canon and its centrality to all of the STEM (science, technology, engineering, mathematics) disciplines. Through its development and publication of the ACM Model Curriculum for K-12 Computer Science and supporting curriculum implementation documents, CSTA has provided the de facto national standards for computer science in K-12. CSTA also conducts groundbreaking research and has published several germinal white papers on key computer science education issues. It provides multiple levels of professional development (through workshops and annual conferences) that have helped educators improve their technical knowledge and pedagogical skills.

ISTE is recognized for its leadership to improve learning and teaching through effective integration of technology across the curriculum and throughout the education enterprise. ISTE's commitment to educational transformation is best represented by its work to develop the National Educational Technology Standards (NETS) for Students, Teachers, and Administrators. By convening K-12 educators, teacher educators, curriculum and education associations, government, business, and private foundations, ISTE built consensus for the framework and momentum for using the standards. ISTE is also a leader in convening educators and school leaders, best illustrated by its annual conference which showcases emerging technology and innovative and effective use of technology in the K-12 classroom.

# Bringing computational thinking to K-12

Barr, Valerie; Stephenson, Chris

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| A tarefa de aumentar a exposição de alunos ao pensamento computacional, é uma atividade complexa que exige mudança sistêmica, engajamento do professor e o desenvolvimento de uma infinidade de recursos. Colaboração com educadores da ciência da computação é fundamental. |                 |        |
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| Os cientistas da computação tem um papel preponderante para ajudar professores a integrar o pensamento computacional |                 |        |
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| Wing argumenta que os desenvolvimento da computação favoreceu novas forma de resolver problemas e testar soluções. |                 |        |
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- 09 Hellon Machado Page 2  
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Essas possibilidades dirigem a necessidade de treinar indivíduos para que elas possam trazer fazer uso dessas possibilidades.
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- 10 Hellon Machado Page 2  
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- 11 Unknown Unknown Page 2  
30/7/2018 22:21  
Dada a onipresença dos computadores, não é suficiente esperar que alunos cheguem na universidade para terem contato com o pensamento computacional.
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- 12 Unknown Unknown Page 2  
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- 13 Hellon Machado Page 2  
10/5/2018 2:15  
INTRODUCTION  
  
Para pensamento computacional será implementado com sucesso nas escolas, obstáculos criados pela infraestrutura escolar precisa ser vencida, ao mesmo tempo que professores necessitam definições lúcidas para o significado do pensamento computacional, bem como de exemplos. Afinal
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- 14 Hellon Machado Page 2  
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- 15 Unknown Unknown Page 2  
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INTRODUCTION  
  
Desenvolver uma abordagem de implementação do pensamento computacional na educação básica é especialmente desafiador em face do fato que ainda não há consenso entre os educadores sobre a definição de pensamento computacional.
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## INTRODUÇÃO

De certo modo, a solução de problemas é uma habilidade que já vem exercitada em sala de aula. Mas cientistas da computação podem ajudar professores a identificar etapas da resolução de problemas que um elemento da ciência da computação pode ser integrado.

30/7/2018 22:52

## MUITAS DEFINIÇÕES DE PENSAMENTO COMPUTACIONAL E CIENCIA DA COMPUTAÇÃO

Wing sugere que o pensamento computacional envolve a busca de abordagens algorítmicas para problemas de vários domínios; uma disposição pra diferir níveis de abstração e representação diferentes; familiaridadee com decomposição; separação de preocupações (ver dijkstra na wikipedia); familiaridade com decomposição e modularidade.

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## MUITAS DEFINIÇÕES DE PENSAMENTO COMPUTACIONAL E CIENCIA DA COMPUTAÇÃO

De todo modo, como percebe é boa parte dos aspectos propostos pelo pensamento computacional são compartilhados em vários domínios do pensamento humano.

Portanto para Hemmendinger, o fim último não seria ensinar todos a pensar como um cientista da computação mas em vez disso ensinar os estudantes usarem tais elementos para explorar novos problemas.

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30/7/2018 23:51

## MUITAS DEFINIÇÕES DE PENSAMENTO COMPUTACIONAL E CIENCIA DA COMPUTAÇÃO

O international ... demonstra como o pensamnto computacional pode ser usado com sucesso em projetos que usa a simulação, modelagem, robótica e criação de jogos para ensinar abstração, automação e análise. Como notam, essas atividades envolvem atividades iterativas de refinamento e reflexão sobre processos que argumenta resnk são centrais para o pensamento computacional.

30/7/2018 23:14

## MUITAS DEFINIÇÕES DE PENSAMENTO COMPUTACIONAL E CIENCIA DA COMPUTAÇÃO

Para ser útil uma definição deve ser integrada a exemplos que demonstrem como pensamento computacional pode ser incorporado em sala de aula.

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## CRIANDO UMA DEFINIÇÃO DE PENSAMENTO EDUCACIONAL PARA EDUCACAO BASICA

A educação básica é um domínio especialmente complexo. Ela está sujeita a uma diversidade expectativas políticas, a um sem-numero de imposições de prioridades. Qualquer mudança sistêmica exigirá um entendimento profundo das suas realidades.

Assim, a incorporação do pensamento computacional exigem a reflexão sobre algumas questões práticas:

- \* Como seria a aplicação do pensamento computacional em sala de aula?
- \* Quais são as habilidades que os alunos iriam demonstrar?
- \* O que um professor precisa para implementar o pensamento computacional na sua prática?
- \* O que os professores estão fazendo hoje que poderia ser modificado e estendido?

31 Hellon Machado Page 4

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32 Hellon Machado Page 4

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Benefícios percebidos:

Estudantes passam a se sentir confortáveis com "trial and error" e passam a trabalhar colaborativamente para resolver problemas.

Ao mesmo tempo que passam a se questionar e discutir em grupo a respeito da complexidade um problema.

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31/7/2018 0:00

Os esforços para criação de um consenso a respeito do significado pensamento computacional tem sido materializados em um número considerável de eventos promovidos ao redor do mundo. Parte considerável deles são organizados por instituições governamentais ou mesmos empresas de tecnologia, como a Microsoft.

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Benefício percebido:

Estudantes passam a compreender que um problema pode ser resolvidos de diversas formas ao mesmo tempo que desenvolvem tolerância para ambiguidade e flexibilidade de problemas abertos. E a expectativa de de que pode prospectar e produzir soluções que funcionam

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Habilidades desenvolvidas pelo pensamento computacional, de acordo com participantes do encontro em ANO (consultar)

\* Desenho de solução para problemas, usando abstração, automação, criação de algoritmos, e coleta e análise de dados.

\* Implementar designs (usando programação quando apropriado)

\* Teste e depuração

\* Modelagem, execução de simulações, e análise de sistemas.

\* Reflexão em prática e comunicação

\* Uso de vocabulário

\* Reconhecimento de abstração, e articulação varios de seus niveis.

\* Inovação, exploração e criatividade ao largo de varias disciplinas

\* Resolução de problemas em grupo

\* Emprego de diversas estratégias de aprendizado.

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De acordo com o grupo o distingue o pensamento computacional de outras formas de pensamento seria o fato de ele estimular a resolução de problemas de tal modo que podem ser implementados computacionalmente.

O pensamento computacional, de acordo como grupo, é uma forma de resolver problemas que podem ser implementados por um computador.

Ele incentiva que alunos invertam o papel de consumidores de ferramentas, para se tornarem construtores.

Para alcançar esse objectivo eles usam uma série de conceito e estratégias, como a abstração, a recursão, a iteração para processar e analisar data para construir artefatos virtuais.

O pensamento computacional é uma metodologia de resolução de problemas que pode ser automatizada, transferiada e aplicada a uma gama de diferentes areas.

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Na "area de valores, motivações, sentimentos, steriotipos e atitudes", os participantes perceberam:

- \* Confiança para lidar com complexidade
- \* Persistência para trabalhar com problemas difícies.
- \* Habilidade/disposição para lidar com problemas aberto.
- \* Por diferenças de lado com outros para atigir um objetivo geral ou uma solução.
- \* E conhecer seus proprios pontos fortes e fracos quando trabalhando com outros.

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O poder do pensamento computacional e que ele pode ser aplicado a toda e qualquer area do pensamento.

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Tabela que exemplifica como aspectos do pensamento computacional estão presentes em várias atividades.

Ela também pode ser usada como exemplo elementos do pensamento computacional que podem ser trabalhados em sala de aula.

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Os participantes também propoe um conjunto de habitos que criam uma cultura em sala de aula propicia ao desenvolvimento do pensamento computacional. São elas:

\* aumento do uso do vocabulário computacional por alunos e professores durante a resolução de problemas.

\* A aceitação tanto por alunos quanto por profesoress de tentativas de solução "não tão boas", reconhecendo que um erro cedo pode conduzir a um caminho bem-sucedido.

\* desenvolvimentos de trabalhos em grupo uso explicito de:

☐ - decomposição: quebrar problemas em unidades menores

☐ - abstração: simplificação do concreto ao geral a medida que as soluções são desenvolvidas.

☐

☐ - negociação e contrução de consenso dentro do grupo.

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