Building Awareness About Computational Thinking as a Research Field through a Graduate Course for Computer Scientists: a Metacognitive and Self-regulated proposal

Paula Torales Leite, Graziela Ferreira Guarda, Ismar Frango Silveira

Faculdade de Computação e Informática – Universidade Presbiteriana Mackenzie
01302-907 – São Paulo –SP – Brazil

{paula.leite, graziela.guarda, ismar.silveira}@mackenzie.br

Abstract. *The area of Computational Thinking has been grown the last years and became an important research field that relies on the field of Computer Science at the same time that intersects with different areas like Mathematical Reasoning, Problem Solving and Engineering. Despite the impact and relevance of this area, many professionals on Computer Science and related areas are usually not aware of the Computational Thinking topics as part of a new research area. In this sense, this paper discusses a syllabus proposal for a graduate course on Computational Thinking for Computer Scientists that relies over Metacognition and Self-regulated learning.*

1. Introduction

Some barriers do exist when consolidating a new research field, like Computational Thinking (CT). Since the seminal and basilar studies of [Papert, 1980], passing by the short but foundational definition of the term given by Wing (2006), many studies have been bringing contributions to solidify Computational Thinking as a research field. However, as expected, some important challenges are posed to the researchers that have embraced this area.

As mentioned by Clancy (2022), the primary hurdle in persuading scientists to undertake research on a novel topic is the requirement of having a group of scientists who are already interested in the topic. According to [Akerlof and Michaillat's, 2018] model, new paradigms can only thrive if a critical number of adherent researchers is reached. In this sense, one can consider that the research in CT topics already existed before the definitive [Wing's, 2006] paper, since its key elements appeared in innumerous academic products on the areas of Education in Computing and Computers and Education, often relying on the fuzzy borders of the intersection of both areas. Since the researchers on these topics already belonged to one of these areas, many of them resisted – and maybe still resist – to the idea of conforming a brand new research field.

The second common obstacle pertains to the difficulty for outsiders - researchers from other fields - to make a substantial contribution to a topic, even when a critical mass of scientists is already working on it; this might deter potential new members from joining the field and consequently hinder its progress. In the field of CT, maybe this barrier could have turned on its main advantage, since the CT foundations claimed that the body of knowledge of this research field was aimed to everyone, not just Computer Scientists. Nonetheless, this amplitude of audience could have sound to some scientists as a sign that this was another application area of Computer Science, not deserving too many attentions.

Fact is that, as mentioned by [Tekdal, 2021], CT is then an emerging research field that has been experiencing an exponential growth in the last ten years, having the expected maturity level that every emerging discipline sought to have, and will continue to evolve in the future. However, this evolution does not necessarily represent a growth on research products, but maybe on the general interest on the topic, as initiatives on CT are spreading all over the globe. A quick and simple search on Google Scholar, compared with data obtained from Google Trends about research on CT is depicted at Fig. 1: first data source, about academic research, is represented with orange bars, superseded by a continuous blue line representing general interest on the topic, according to searches performed in Google worldwide.

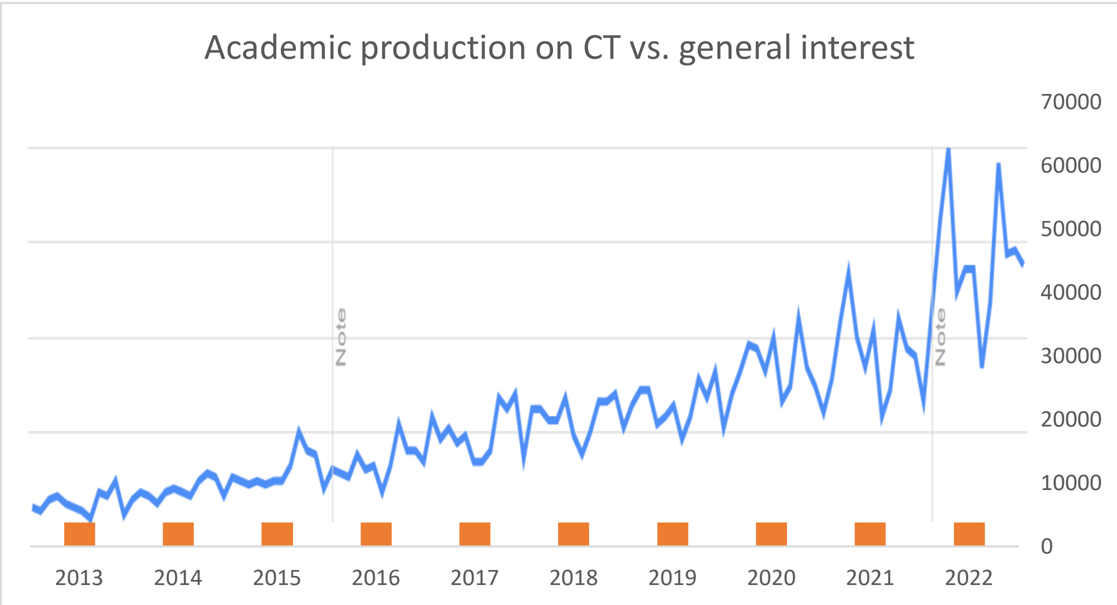

Figure 1. Academic production (orange bars, Google Scholar) versus general interest on CT (blue line, Google Search Engine).

Eve though no statistic validity is being claimed by Fig. 1, given the simplicity of search criteria and the subjects over which the comparison is done, some interesting insights about CT could arise: the peak of academic production is perceived among 2019-2020, whilst the general interest on the topic – which has been consistently growing – was obtained in 2022. Still about 2022, the reduced number of publications is due probably to the fact that most academic productions of that year have been not yet indexed at the moment that this paper was written (2023, March).

Given the attraction that this area is performing over the general audience, it became important to the Computer Science area to recognize, to valorize and to consider the body of knowledge of CT as an integral part of the area. This was done not neglecting the multifaceted influence from other research areas (like Math and Engineering) but claiming for some knowledge and skills that have been previously associated to these areas, specially those related to Problem Solving – a comprehensive discussion on this topic can be seen at [Barcelos et al., 2013], while the interdisciplinary aspects of CT are well discussed by [Henry et al., 2018].

2. Computational Thinking: Definitions and Trends

In 2006, Wing defines Computational Thinking (CT) as a set of skills used to solve problems efficiently, providing mental tools found in the field of Computer Science. In a practical way, the idea of the CT is not to program or make humans think like machines, but to create a way for humans to solve problems [Wing 2006]. This skill encompasses the capabilities of: decomposing the problem into smaller parts, solving each one at a time; abstraction of the problem at several levels, choosing what would be the best way to represent it; identification of patterns and necessary generalizations; and having a thought focused on evaluations of an adopted solution, verifying the different possible scenarios [Csizmadia et al. 2015].

However, despite the expression 'Computational Thinking' having become popular after the publication of [Wing, 2006], the lack of consensus regarding the skills that configure CT in the literature is still discussed. In this direction, [Hu 2011] makes criticisms stating that this type of thinking can be a hybrid of the capacity that people acquire from different means. More than defining computational thinking, the author highlights that what we need is to develop a computational culture in the educational/school context as digital technologies continue to advance.

In addition, there are many works that do not discuss the term CT in depth, presenting a view that it is only related to computer programming or handling of such equipment [Carvalho and Braga 2022].

Another critical point to be discussed is the lack of continued teacher training in Computational Thinking and, consequently, their lack of preparation to develop the topic in the classroom – what compromises the application of the CT in the classroom, since the training of these students is left to research groups, while the teacher is not considered in this didactic-pedagogical relationship. [Medeiros et al. 2021]. This creates difficulties and barriers to its implementation at all levels: from basic education to higher education [Guarda 2022].

3. Metacognition in Computer Science

Metacognition was first mentioned by [Flavell 1979, 1987]. He proposed that it's the knowledge and regulation of a person's cognitive activities during learning processes, dividing it into two different categories:

- Metacognition knowledge: used to control the cognitive process.
    - Knowledge of Person Variables: the way that an individual relates to their own learning process.
    - Task Variables: deep understanding of what a task requires and the individual demand that it entails.
    - Strategy Variables: comprehension of the differences between cognitive and metacognitive strategies, as well as when to apply them.
- Metacognitive Experiences and Regulation: the individual's understanding of the cognitive process, mainly in regard to its relation to the evaluation of goals.

Further on, it's also interpreted as the control of the cognitive process that is engaged during learning [Livingston, 2003]. This incites the discussion of the differences between cognitive and metacognitive strategies. What research has shown, is that the main distinction is in the use of the information [Livingston, 2003]. They point out that, the first is directly related to the acquisition of goals, while the last focuses on the ways that these goals can be achieved.

In the field of Computer Science, there has been increasing interest in the metacognitive process. In recent research, this process has been cited as one of the top theories in computing education venues [Stepherson et al., 2018]. One reason why this has been a sought out topic, is because of the impact that it could have in the way that the interpretation of observations in a computing classroom occur [Loksa et al., 2022]. Here in after, it has been discussed that the mastery of the development of fundamental programming skills can be built with the use of metacognitive skills, including self-regulation [Falkner; Vivian; Falkner, 2014].

This self-regulation process is another topic that relates to metacognition and is researched in the field of Computer Science. There are many theories of the connection between these topics, but they mostly amount to them being sub-components of one another [Prather et al., 2020].

4. Self-regulation

Self-regulation is an active process, with which learners find techniques that help them build goals and monitor, regulate and control their cognitive development, based on personal and environmental opportunities [Newman; Newman, 2020]. It’s a concept that has been around for many years, starting with its basis that comes from previous research on the self [James, 1984], until its relation to education was made in the mid-1980’s [Ganda; Boruchovitch, 2018].

The Social Cognitive Theory is known as one of the main psychological theories where self-regulation resides [Ganda; Boruchovitch, 2018]. It determines the existence of a reciprocal relationship between personal, behavioral and environmental factors in human functioning [Bembenutty; White, 2013]. Research has pointed out that self-regulation requires a conscious, self-reflective and proactive conduct from the student [Zimmerman, 2013]. This leads to the necessity of learning strategies from the learner. These could be negative or positive, but what matters the most is the level of motivation that they have [Wolters; Benzon, 2013].

The three most important stimulants of motivation are self-efficacy, where the individual evaluates their capacity of learning certain content; causal attributions that the learner creates when faced with an academic situation; and the individual’s beliefs about the origin of their intellectual ability [Ganda; Boruchovitch, 2018]. The same authors detail another underlying concept in self-assessment are sentiments, which are a fundamental part of emotional control. Not just that, but the environment in which the learner is inserted is also very influential [Grau; Whitebread, 2012].

Until this moment, there are seven different theoretical models for self-regulated learning. The first was developed by Bandura (1978). He divided the process into three sub-processes: self-observation, self-judgement and self-reaction. Later on, Zimmerman (1998), based on previous work, theorized three phases for self-regulation: activity planning, execution of the activity and self-evaluation. Also, working during this same period, Winne e Hadwin (1998) broke down the process of executing a task into four stages: formulation of a model, establishment of goals, execution and evaluation. A few

1 years later, Schunk (2001) expanded on top of Zimmerman's theory, where his biggest contribution was adding a social variable in the activity planning phase. Pintrich (2000) based his research in Bandura's and Zimmerman's projects, where he formulated four areas for regulation: cognition, motivation, behavior and context. Lastly, Perels, Gürtler and Schmitz (2005) proposed that the learning process is composed of daily activities, that are divided into pre-action, action and post-action. Schunk (1990) points out that self-regulation coincides with the execution of learning objectives. Once the relationship between goals and these objectives is created, certain cognitive and behavioral processes are activated. It involves self-observation or monitoring of behavior, self-evaluation or self-judgment of the learning process and self-reaction (Bandura, 1986).

A cognitive control technique that resides in self-regulation, is self-assessment. It helps learners prioritize their studies and brings notions of performance in projects [Veiga, 2017]. Not just that, but, based on research from Panadero, Andrade and Brookhart (2018), the student can evaluate and attribute merit or value to their learning products. Schunk (1990) has also found that this technique can lead to feelings of efficacy and that it contributes to the self-regulatory process. Not just that, but the author emphasizes the importance of discussions between the student and the teacher. This contributes to self-regulation, since it can help the learner determine the difficulty of the learning objective and find ways of controlling the results of their knowledge acquisition. Moreover, Ross John (2018) conducted research that evaluated the sentiments of distrust that these techniques have brought in regard to their reliability, validity and usefulness. The author concluded that the psychometric properties of self-assessment led to new-found trust in it. Another research that supports this is from Bandura (1999), where he found that when a student is successful in a task, they tend to believe that they'll be successful in another. This emotional reinforcement contributes to the demystification of the use of self-assessment. Other research have also shown that this can contribute in graduate courses, mainly because it can lead to professional and academic development [Bembenutty; White, 2013], [Wolters, 2011]. The amount of discussions and new theories that have been shown in the topic, point to the relevance of the subject.

5. Computational Thinking for Graduates: A Syllabus

This section presents a syllabus proposal for a Graduate course on CT aimed to Computer Scientists and similar (more likely Engineers or Mathematicians).

The syllabus is organized according to its three main goals: 1) to create awareness on Graduate students about CT as a research area; 2) to share initiatives on unplugged and plugged activities for developing CT-related skills on different contexts and learning levels, connecting them with Learning Theories and Computer Science foundations; and 3) to build abilities on problem-solving and problem proposal in order to allow new activities and artifacts to be produced by Graduate students on Computer Science or related areas. It has been built over the KSA model, centered on Knowledge, Skills, and Attitudes that students are meant to build along the course. Table 1 synthetizes the syllabus proposal.

Table 1. Syllabus for a Graduate Course on Computational Thinking.

1. CT as a research area	**Goal**: To create awareness about CT as a research area.
	Learning strategy: Presenting of basic concepts and literatute on the area, bringing a historic evolution, from Papert to Wing and beyond. With CT

	foundations settled, students are required to look for recent production on CT on conference and journals, first in a local (national or regional) context, moving to a more global overview of research being done.
	Knowledge: Students are supposed to build knowledge on the foundations of CT, its concepts and assumptions, as well as to take contact with basic references and have an oversight on the state-of-art of academic production on CT. An effort of metacognition is expected at this point, since students are to be required to reflect on their own past learning processes when in K-12, College, or Undergraduate courses. **Skills**: The abilities to be developed are related to the capacity of arguing on CT as a research area and to identify CT pillars and features, making connections with Computer Science foundations and Learning Theories. **Attitudes**: Students are expected to give a new meaning to their own formative process, understanding Computer Science basics as common elements with CT skills through Metacognition.
	Assessment: Students must be able to present their own ideas about CT as a research area and also bring some papers of interest to be discussed in classroom (face-to-face or online). Self-evaluation of this topic is done by analyzing the contributions of colleagues to the discussion compared to the own understanding of the subject and the comprehensiveness of each literature review that is presented.
2. Developing CT skills with unplugged activities	**Goal**: To show the possibilities of developing CT skills without computers or electronic devices.
	Learning strategy: Bringing of unplugged learning materials on CT to be shared with students. Students should experiment these materials in simulations at the classrooms with colleagues and even with Undergraduate classes that could be available and open to the experience.
	Knowledge: Knowing of examples and basic principles on developing CT skills through unplugged activities is generally a game-changing moment in this course, since often the Computer Science-related knowledge is deeply entangled with the need of computer-supported simulations and experiments. **Skills**: Student must be able to recognize CS-related concepts in CT activities and to evaluate the problem-solving strategies expected to be mobilized by people during the activities, associating them to the CT skills to be developed. **Attitudes**: It is expected that students should be able to: 1) to identify adequate activities for specific CT skills and their related learning goals; 2) to conduct an already validated unplugged CT activity with a group of people.
	Assessment: Students are required to perform evaluation of the strategies through adequate instruments and protocols. A self-evaluation of their performance when conducting unplugged activities with colleagues or Undergraduate students (or other groups) are to be also done, analyzing students' abilities on engaging people, organizing teams and balancing difficulties and expectancies.
3. Developing CT skills with plugged activities	**Goal**: To show the possibilities of developing CT skills using hardware and software.
	Learning strategy: Showing of possibilities of using hardware (robots, sensors and so) and/or software (games, gamified environments, Scratch-like programming environments, etc.) to develop CT skills.
	Knowledge: Students must build knowledge on how to develop simple and

	complex programs in CT-driven programming environments (like Scratch, mBlock, Construct, Alice and others) and also know the foundations of Educational Robotics, if devices are available at the University. The knowledge of children-oriented CT-driven environments (like specific games and/or adapted programming and robotics environments). **Skills**: Student must be able to conduct activities using software and/or hardware, like programming, with other groups, as well as to identify the CT skills to be developed in each activity. **Attitudes**: Students are meant to be able to select adequate plugged activities for specific CT skills, having a special attention to age requirements and limitations. In this sense, they must be able to conduct an already validated plugged CT activity with a group of people in laboratories or practical classrooms or in computer-supported remote environments.
	Assessment: Students can evaluate the activities using adequate instruments and protocols, as well as to perform self-evaluation of themselves while proposing and conduction plugged activities.
4. Proposing new CT activities	**Goal**: To give students subsides for the creation and proposal of new CT activities.
	Learning strategy: Strategies of problem-solving and problem proposal are to be shared with students, giving them support for the elaboration of new CT activities.
	Knowledge: Artifacts like Lesson Plans have to be known by students, as well as the foundations of problem-solving and problem proposal. **Skills**: Students should be capable to propose new CT activities, considering the target groups, expected learning goals and adequate approach (unplugged, plugged, or mixed) to be used, synthetizing the proposal in a Lesson Plan. **Attitudes**: Students must identify the profile of target groups and its previous skills, if any. Learning materials and classroom preparation (or remote environment adaptations) must be performed by the students, according to the activity being planned. The relationship among time, effort and results expected must also be calculated by students.
	Assessment: Using adequate instruments, the activity could be evaluated by students according to many dimensions (acceptance, perception of learning, knowledge impact, engagement and so on). The conduction of this activity is meant to be target of a self-evaluating process.

In some cases, it is suggested that Graduate students could experience CT activities with Undergraduate classes. This obviously requires some local arrangements inside the University, and it also demands professors to develop some didactic skills with students, considering that, for most of them (especially Master's students), this would be their first experience conducting a classroom activity. This new situation for many students reinforces the need for a Metacognitive-based approach, since it requires students to think about their own learning paths, giving new meanings to knowledge and procedures that were supposed to be already crystalized on their own cognitive structures. In this sense-, self-assessment brings the opportunity to the students to rephrase and rethink the preconceptions and their own approaches when assuming some roles typical for teachers – conducting classroom activities and proposing new ones, for instance, and the main change on a key attitude, which is starting to worry about the learning processes of other persons. When designing new CT activities, some important skills are to be developed by students, like the ability of weighting previous knowledge and skills of target groups, the required effort, time expected and all the strengths and challenges related to the potential social interactions among members of the target group.

This syllabus has been taught in a Graduate Program of Electrical Engineering and Computing since 2017 at Mackenzie Presbyterian University, once a year, with the duration of one semester or 48 hours spread along 12 weeks. During COVID-19 pandemics (years 2020 and 2021), it was offered in remote mode, requiring some of the original strategies (specially those involving unplugged activities) to be adapted, leading to the new syllabus being presented in this paper. Qualitative data has been collected from students along these years – however, since syllabus have substantially changed, the results are not comparable. The artifacts produced by students are being organized in a repository to be publicly available through Creative Commons licenses.

6. Conclusions

CT is then an emerging research field that has been an exponential growth in the last ten years. However, this evolution does not necessarily represent a growth on research products, but maybe on the general interest on the topic, as initiatives on CT are spreading on a rising curve.

This article presented a syllabus proposal for a Graduate course on CT aimed to Computer Scientists and similar (more likely Engineers or Mathematicians) using self-regulation and self-assessment as bases.

Self-regulation is an active process, with which learners find techniques that help them build goals and monitor, regulate and control their cognitive development, based on personal and environmental opportunities [Newman; Newman, 2020]. Already the self-assessment it helps learners prioritize their studies and brings notions of performance in projects [Veiga, 2017]. Thus, self-regulation brings the opportunity to the students to rephrase and rethink the preconceptions and their own approaches when assuming some roles typical for teachers.

The syllabus has been organized according to its three main goals: 1) to create awareness on Graduate students about CT as a research area; 2) to share initiatives on unplugged and plugged activities for developing CT related skills on different contexts and learning levels, connecting them with Learning Theories and Computer Science foundations; and 3) to build abilities on problem solving and problem proposal in order to allow new activities and artifacts to be produced by Graduate students on Computer Science or related areas. This proposal has been implemented in 2017 and it is suggested that the same thing can be used in other graduate programs focusing on Computational Thinking. As future works, it is intended to share the artifacts produced by students.

7. References

Akerlof, G. A., & Michaillat, P. (2018). Persistence of false paradigms in low-power sciences. Proceedings of the National Academy of Sciences, 115(52), 13228-13233.

Bandura, A. (1978) The self system in reciprocal determinism. American Psychologist, v. 33, p. 344–358, 1978.

Bandura, A. (1986) Social foundations of thought and action. In: . [S.l.: s.n.], 1986.

Bandura, A. (1999) Self-efficacy: The exercise of control. Journal of Cognitive Psychotherapy, v. 13, p. 158 – 166, 1999.

Barcelos, T. S., & Silveira, I. F. (2012). Pensamento computacional e educação matemática: Relações para o ensino de computação na educação básica. In XX Workshop sobre Educação em Computação, Curitiba. Anais do XXXII CSBC (Vol. 2, p. 23). sn.

Bembenutty, H.; White, M. C. Academic performance and satisfaction with homework completion among college students. Learning and Individual Differences, v. 24, p. 83–88, 2013. ISSN 1041-6080. Available on the Internet at https://www.sciencedirect.com/science/article/pii/S1041608012001641. Access March 20th, 2023.

Campbell, J., Horton, D., & Craig, M. (2016, July). Factors for success in online CS1. In Proceedings of the 2016 ACM conference on innovation and technology in computer science education (pp. 320-325).

Carvalho, F., & Braga, M. (2022). Pensamento Computacional na Educação Brasileira: um olhar segundo artigos do Congresso Brasileiro de Informática na Educação. Revista Brasileira de Informática na Educação, 30, 237-261. DOI: https://sol.sbc.org.br/journals/index.php/rbie/article/view/2649.

Clancy, M; (2022) Building a new research filed. Available on the Internet at https://www.newthingsunderthesun.com/pub/7dh7t8uu/release/6. Access Mar 18th, 2023.

Csizmadia, A., Curzon, P., Dorling, M., Humphreys, S., Ng, T., Selby, C. and Woollard, J. (2015). Computational thinking - a guide for teachers Swindon. Computing at School 18pp. doi: https://eprints.soton.ac.uk/424545/.

Falkner, K., Vivian, R., Falkner, N. J. Identifying computer science self-regulated learning strategies. In: Proceedings of the 2014 Conference on Innovation Technology in Computer Science Education. New York, NY, USA: Association for Computing Machinery, 2014. (ITiCSE '14), p. 291–296. ISBN 9781450328333. Available on the Internet at https://doi.org/10.1145/2591708.2591715. Access April 1st, 2023.

Flavell, J. H. Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychologist, v. 34, p. 906–911, 1979.

Flavell, J. H. Speculations about the nature and development of metacognition. Lawrence Erlbaum Associates, p. 21–29, 1987.

Ganda, D.; Boruchovitch, E. A autorregulação da aprendizagem: principais conceitos e modelos teóricos. Psicologia da Educação, v. 46, 2018. Available on the Internet at http://educa.fcc.org.br/scielo.php?pid=S2175-35202018000100008script=%20sciarttexttlng%20=%20pt%C2%BF. Access Mar 19th, 2023.

Grau, V.; Whitebread, D. Self and social regulation of learning during collaborative activities in the classroom: The interplay of individual and group cognition. Learning and Instruction, v. 22, n. 6, p. 401–412, 2012. ISSN 0959-4752. DOI: https://doi.org/10.1016/j.learninstruc.2012.03.003.

Guarda, G. F. Um Framework pedagógico desplugado para a prática das habilidades do Pensamento Computacional no Ensino Fundamental. 2022. 141 f. Tese (Doutorado em

Ciências, Tecnologias e Inclusão) - Instituto de Biologia, Universidade Federal Fluminense, Niterói, 2022.

Henry, J., Hernalesteen, A., Dumas, B., & Collard, A. S. (2018). Que signifie éduquer au numérique? Pour une approche interdisciplinaire. De 0 à, 1, 61-82.

Hu, C. (2011). Computational thinking: what it might mean and what we might do about it. ITiCSE '11: Proceedings of the 16th annual joint conference on Innovation and technology in computer science education. 2011. p. 223–227. doi: https://dl.acm.org/doi/10.1145/1999747.1999811.

Livingston, J. Metacognition: An overview. 2003.

Loksa, D. et al. Metacognition and self-regulation in programming education: Theories and exemplars of use. ACM Trans. Comput. Educ., Association for Computing Machinery, New York, NY, USA, v. 22, n. 4, Sep. 2022. Available on the Internet at: https://doi.org/10.1145/3487050. Access April 1st, 2023.

Medeiros, S. R. S.; Martins, C. A.; Medeiros, I. G. Materiais didáticos utilizados nas formações de professores em Pensamento Computacional. In: Simpósio brasileiro de informática na educação, 32, 2021, Online. Anais [...]. Porto Alegre: Sociedade Brasileira de Computação, 2021. p. 1096-1106. doi: https://sol.sbc.org.br/index.php/sbie/article/view/18133.

Newman, B. M.; Newman, P. R. Self-regulation theories. In: Newman, B. M.; Newman, P. R. (Ed.). Theories of Adolescent Development. Academic Press, 2020. p. 213–243.

Papert, S. A. (1980). Mindstorms: Children, computers, and powerful ideas. Basic books.

Panadero, E.; Andrade, H.; Brookhart, S. Fusing self-regulated learning and formative assessment: a roadmap of where we are, how we got here, and where we are going. Aust. Educ. Res., v. 45, p. 13–31, 2018. doi: https://doi.org/10.1007/s13384-018-0258-y.

Perels, F.; Gürtler, T.; Schmitz, B. Training of self-regulatory and problem-solving competence. Learning and Instruction, v. 15, n. 2, p. 123–139, 2005. DOI: https://doi.org/10.1016/j.learninstruc.2005.04.010.

Pintrich, P. R. The role of goal orientation in self-regulated learning. In: . [S.l.: s.n.], 2000.

Prather, J. et al. What do we think we think we are doing? metacognition and self-regulation in programming. In: Proceedings of the 2020 ACM Conference on International Computing Education Research. New York, NY, USA: Association for Computing Machinery, 2020. (ICER ’20), p. 2–13. ISBN 9781450370929. Available on the Internet at: https://doi.org/10.1145/3372782.3406263. Access April 1st, 2023.

Ross John, A. The reliability, validity, and utility of self-assessment. Practical Assessment, Research, and Evaluation, v. 11, paper10, 2018. Available on the Internet at https://scholarworks.umass.edu/pare/vol11/iss1/10. Access March 10th, 2023.

Schunk, D. H. (2008). Metacognition, self-regulation, and self-regulated learning: Research recommendations. Educational psychology review, 20, 463-467.

Stephenson, B. et al. Exam wrappers: Not a silver bullet. In: Proceedings of the 23rd Western Canadian Conference on Computing Education. New York, NY, USA: Association for Computing Machinery, 2018. (WCCCE ’18). ISBN 9781450358057.

Available on the Internet at: https://doi.org/10.1145/3209635.3209655. Access April 1st, 2023.

Tekdal, M. (2021). Trends and development in research on computational thinking. Education and Information Technologies, 26(5), 6499-6529.

Veiga, A. V. L. d. Conselho de Cooperação Educativa: A Participação dos Alunos na

Regulação dos Processos de Aprendizagem. 2017. Available on the Internet at http://hdl.handle.net/10400.21/8426. Access March 20th, 2023.

Winne, P. H.; Hadwin, A. E. Studying as self-regulated learning. Routledge, p. 291–318, 1998.

Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33-35.

Wolters, C. A. Regulation of motivation: Contextual and social aspects. Teachers College Record, v. 113, n. 2, p. 265–283, 2011.

Wolters, C. A.; Benzon, M. B. Assessing and predicting college students' use of strategies for the self-regulation of motivation. The Journal of Experimental Education, Routledge, v. 81, n. 2, p. 199–221, 2013. doi: https://doi.org/10.1080/00220973.2012.699901.

Zimmerman, B. J. Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models. Guilford Publications, p. 1–19, 1998.

Zimmerman, B. J. From cognitive modeling to self-regulation: A social cognitive career path. Educational Psychologist, Routledge, v. 48, n. 3, p. 135–147, 2013. DOI: https://doi.org/10.1080/00461520.2013.794676.