Different Types of Assessments for implementation of Computational Thinking

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Abstract: - Among the goals of Higher Education, it is to prepare students for the activity in a professional field in order to contribute to their personal development and respond to the needs of qualification of the productive sectors.

Nowadays, technology is a consumable that is everywhere and at all times. Therefore, the educational system has to be modified to include this technology in some way in the training process of the students. Computational thinking can help this incorporation in a remarkable way.

This paper shows what computational thinking is and also how to assess it, since any action taken should be able to measure and improve it, if necessary. In addition, it can be used to assess certain skills and competences that students must obtain during the course, such as digital competence. Digital competence is, besides a right promoted by European Union, a necessity of all citizens that should be taught and provided from early years and during all the life. Although technology is a common matter for young people, its use and its competences have differences among countries, cultures, status, residence places, etc., even within the members of the same family.

Key-Words: - Computational Thinking, assessment, digital competence, education, teaching, learning.

1 Introduction

In the context of the economic crisis that is taking place in these years, the countries of the European Union are carrying out numerous actions to, through the universities, promote measures to alleviate the important youth unemployment and promote the professional qualification and specialization of young people. Some of these actions are combining the teaching-learning process of the training center with learning and work in the company. In addition, these actions also extend to the years prior to university (High School and Vocational Training), where increasingly technology is part of the education system.

The secret of being able to integrate technology into preschool classrooms is to see it as any other tool or material to teach specific skills and concepts. The use of technology in schools is supposed to expand, enrich, implement, individualize, differentiate and extend the curriculum.

Many of the development and learning needs are coupled well with the appropriate use of technology in the classroom, especially exploring, with the manipulation of symbolic representation, using alternative learning styles and adjusting the modalities of each learning that the student can control and adjust to meet your individual needs.

There is also a danger that technology may be used inappropriately in the classroom, but proper and periodic training of teachers can be a way to minimize this danger. You have to have professionals who can select applications, programs and internet sites appropriate for the development of those ages. They should also be taught digital ethics, which is the power to distinguish the right from the wrong in this area, either with social networks, or sending texts and even not copy information from the Internet without citing where it came from.

In this sense, we can speak about digital competence and how we can introduce it in the educational system. But we do not say within the curricula, but within the day-to-day of our class and homework. In 2006, the European Parliament and the Council [1] published a recommendation identifying eight Key Competences for Lifelong Learning:

- Communication in the Mother Tongue;
- Communication in Foreign Languages;
- Mathematical Competence and Basic Competences in Science and Technology;
- Digital Competence;
- Learning to Learn;
- Social and Civic Competences;
- Entrepreneurship; and
- Cultural Awareness and Expression.

Four years afterwards, the value of this recommendation is recognized in the Europe 2020 Strategy [2]. But this is not one more competence, but this 2006 recommendation already points to Digital Competence as a fundamental basic skill. Digital Competence is there defined as follows:

"Digital Competence involves the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet." [1].

So, if we consider that Computer Science and ICT are generally recognized as very important issues at all levels of Education, and if we read that Digital Agenda for Europe [3] includes them as Pillar VII "ICT-enabled benefits for EU society", then we cannot turn our back on this fact and we should modify our systems.

2 Computational Thinking: some characteristics and definitions

Therefore, it would be desirable to find a methodology or a compendium of norms with some specific characteristics. It should cover different aspects of education and learning; in addition, it would be good if this new framework could be applied to any area of knowledge, that is, that could be used in STEM subjects, or in subjects related to Health, and in the subjects of Arts and Literature too. If in addition to all the above, we could be introducing new technologies and the way of thinking that would be needed to implement the concepts in computers or electronic devices, it would be a better option.

According to the publication DigComp 2.0: The Digital Competent Framework for Citizens [4], of the European Commission's science and knowledge service, there are 21 digital competences that all citizens must have at present. Digital competences encompassed in five areas: Information and Data Literacy, Communication and Collaboration, Creation of digital content, Security and, finally, Problem solving.

These 21 digital competences refer to the search for information on Internet, its evaluation and data management. It also refers to interaction with other people, sharing information, participating, collaborating and following rules of conduct. Of course, the creation of digital content, copyright and programming are included. It also emphasizes security and protection in devices, personal data, health and well-being and the environment. And finally, it makes reference to the identification of technological needs and the resolution of any kind of problems.

And this is where we can introduce Computational Thinking. Its main characteristics include:

- Analyzing and logically organizing data.
- Data modelling, data abstractions, and simulations.
- Formulating problems such that computers may assist.
- Identifying, testing, and implementing possible solutions.
- Automating solutions via algorithmic thinking.
- Generalizing and applying this process to other problems.

Computational Thinking is a type of analytical thinking that employs mathematical and engineering thinking to understand and solve complex problems within the constraints of the real world [5]. This term was first used by S. Papert [6] in 1996, who is widely known for the development of the Logo software. However, it was brought to the forefront of the computer society by Wing [7] to describe how to think like a computer scientist. She described CT as "solving problems, designing systems and understanding human behavior by drawing on the concepts fundamental to computer science".

Other recent authors, as Dagienė and Stupuriene, remark that the abilities that computational thinking can provide are really valuable not only for informatics professionals or for students of STEM subjects, but for all citizens [8]. Computational thinking is fundamental to deal with many types of problems, although obviously the first impression is more related to mathematics, science and engineering, where models, simulation and experiments are basic in their learning and are used continuously.

Liu and Wang defined computational thinking as a hybrid of other modes of thinking, like abstract

thinking, logical thinking, modeling thinking, and constructive thinking [9]. In this way, they include the main characteristics of CT. For example, abstract thinking is essential in computer science and technology.
Logical thinking is the process in which one uses reasoning consistency to come to a conclusion.
Modeling thinking, in the technical use of the term, refers to the translation of objects or phenomena from the real world into mathematical equations (mathematical models) or computer relations (simulation models).
Constructive thinking is any well-defined computational procedure that takes some value, or set of values as input and produces some value, or set of values as output.

3 The Problem of assessing the implementation of Computational Thinking

The Computing Progression Pathways is an example of a non-statutory assessment framework [10]. It was produced by a small team of authors and reviewers, all teachers, based on their classroom experiences. It is an interpretation of the breadth and depth of the content in the 2014 national curriculum for computing program of study.

The key to developing a framework lies in understanding that computational thinking concepts can be demonstrated in multiple ways and because it can be applied for multiple matters, subjects or areas.

Final aim is to assess the implementation of CT in school. Therefore, we follow three different but inter-connected groups of assessments: CT competences, attitudes and used definitions (vocabulary). In any body of a task we can link some part of the body with CT characteristics and measure them.

The competences of the CT that we apply are the following:

- Formulating problems in a way that enables us to use a computer and other tools to help solve them.
- Logically organizing and analyzing data.
- Representing data through abstractions such as models and simulations.
- Automating solutions through algorithmic thinking (a series of ordered steps).
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources.
- Generalizing and transferring this problem-solving process to a wide variety of problems.

These competences are supported and enhanced by a number of dispositions or attitudes that are essential dimensions of CT. These dispositions or attitudes include:

- Confidence in dealing with complexity.
- Persistence in working with difficult problems.
- Tolerance for ambiguity.
- The ability to deal with open-ended problems.
- The ability to communicate and work with others to achieve a common goal or solution.

Vocabulary (and definitions) of the CT that can be used in a task:

- Data Collection: the process of gathering appropriate information.
- Data Analysis: Making sense of data, finding patterns, and drawing conclusions.
- Data Representation: Depicting and organizing data in appropriate graphs, charts, words, or images.
- Problem Decomposition: Breaking down tasks into smaller, manageable parts.
- Abstraction: Reducing complexity to define main idea.
- Algorithms and Procedures: Series of ordered steps taken to solve a problem or achieve some end.
- Automation: Having computers or machines do repetitive or tedious tasks.
- Simulation: Representation or model of a process. Simulation also involves running experiments using models.
- Parallelization: Organize resources to simultaneously carry out tasks to reach a common goal.

As a simple but clear example, imagine that we ask our students to do the next task [5]:

We draw a rectangle in a squared sheet. Our rectangle contains inside several small squares (of the squared sheet). Deduce how the area of the rectangle is calculated based on the lengths of the base and height and express it through a single formula.

Solution is obvious: Base x Height. Relation of the body of the task and CT is shown in Table 1.

Table 1. Example of competences, attitudes and concepts.

CT competences	*CT attitudes*	*CT concepts*
"Based on the lengths of the base and height"		
- Logically organizing and analysing data	*- Confidence in dealing with complexity*	*- Data analysis* *- Data representation*
"Deduce how the area is calculated"		
- Representing data through abstractions such as models and simulations	*- The ability to deal with open-ended problems*	*- Abstraction*
"Express it through a single formula"		
- Formulating problems in a way that enables us to use a computer and other tools to help solve them	*- Tolerance for ambiguity*	*- Algorithms and procedures* *- Automation*

We use for evaluation of these three inter-connected groups (competences, attitudes and concepts) a model based on rubrics, where teacher must fill in a table, with marks, following a list of questions that lead teacher to assess the three groups of the CT.

Other authors, as Brennan and Resnick [11], articulate their framework for computational thinking in the next three areas: concepts, practices, and perspectives. They define three approaches to assessing the development of computational thinking in young people who are engaging in design activities with Scratch: project portfolio analysis, artifact-based interview approach, and design scenarios.

Project portfolio analysis, where each member of the Scratch online community has a profile page that displays their creations, as well as other dimensions of participation, such as projects they have favorited and Scratchers they follow. Teacher analyzes the portfolio of projects uploaded by a particular community member (student).

The second approach to assessing the development of computational thinking is an artifact-based interview approach, that is, interview Scratchers.

Design scenarios is the third approach to assessment. These design scenarios are used exclusively in classroom settings.

These three approaches are focused on the development of computational thinking through Scratch programming activities, so perhaps they cannot be generalized for any type of implementation of computational thinking.

4 Conclusion

Currently, the great change in the education system has to do with its adaptation to the digital age and its transformation to adapt the students who prepare for a life in which technology is everywhere. In addition, we must also take into account that the labor market is constantly evolving, and that in the near future there will be professions that we cannot even imagine at the moment.

From the institutions, a great effort is being made and the digital competence has been talked about for a few years now. But also from the educational sectors are promoting new ideas so that the adaptation to this new era is faster and better. In this sense, computational thinking has emerged with strength and is making its way around the world.

Therefore, we can define computational thinking as a type of analytical thinking that employs mathematical and engineering thinking to understand and solve complex problems within the constraints of the real world

We cannot forget that any system or methodology that we use should be possible to measure it. See how much is fulfilled what we expect to start or implement it. That is why the computational thinking assessment is an important part of its implementation. The assessment presented in this paper is not intended to be the only one valid for its purpose, but at least a starting point in the evaluation of the implementation of computational thinking.

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