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Learning to programme in adult age *

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Abstract
In the aim of deepening knowledge regarding the theme of lifelong learning, this work presents a research project that leads us to understand how adults learn to program and to develop skills with the effective and critical use of digital technological resources. This work will study the learning of programming by Portuguese unemployed adults between the ages of 35 and the age of retirement. In its implementation, it will carry out a training intervention by designing, developing and organizing educational strategies and resources that will enable participants to learn to programme. In addition to collect the data needed to characterize the training process, it is also hoped to gather evidence to help to understand how this type of learning develops problem-solving skills and critical thinking skills. This research is in line with the priorities identified in the 2020 European Commission's Strategy Paper.
Keywords: lifelong learning, empowerment, programming, computational thinking, problem solving

1. Introduction

Going through a period of transformation, as the economic and financial crisis exposed the structural weaknesses of its economy, Europe must find a determined and collective response to the new challenges it faces. In March 2010, the European Union (EU) launched the European 2020 Strategy (EU2020) which aims to promote smart, sustainable and inclusive growth in order to find the means of creating new jobs and of proposing a clear course for our societies (European Commission - Europe 2020, 2010).

Building on the priorities identified in the EU2020 strategy framework document, "smart growth" is understood as an action "strengthening knowledge and innovation as drivers of our future growth" (European Commission - Europe 2020, 2010, p. 9). But for this to happen, it is necessary: to improve the quality of teaching; enhance the performance of our research; promoting innovation and knowledge transfer across the Union; to make the most of information and communication technologies and to ensure the transformation of innovative ideas into new products and services that promote quality growth and employment and that help to tackle the challenges and social problems that arise at European and global level. It is recognized that emphasis should be placed on some priority areas such as Education. A more generalized education of high quality and importance, in complementarity with all levels of education and learning, is therefore sought, given its essential role in promoting economic growth, in the development of individuals, in promoting social cohesion and in the development of the exercise of citizenship rights.

In recent studies, such as Livingstone and Hope (2011, p. 5) and Tapscott (2012, p. 5), it is found that some schools only promote basic skills, such as text processing, rather than the more specialized, critical and most needed knowledge about, for example, the range of different technological tools available, and about computer science and programming. In particular, the Livingstone and Hope report (2011, p. 5) states that "industries suffer from an education system that doesn't understand their needs. This is reinforced by a school curriculum that focuses in ICT on office skills rather than the more rigorous computer science and programming skills which high-tech industries like video games and visual effects need."

In this sense, this research aims to understand how adults, between the ages of 35 and the age of retirement, learn to program and, consequently, to develop skills in the effective and critical use of technological/digital resources. It is intended, therefore, through a training device, to provide knowledge about the process of learning code (programming) by adults, so that everyone can achieve the personal and professional success that society desires and needs.

This will contribute to smart growth (developing a knowledge-based economy and innovation), sustainable (promoting a more resource efficient, greener and more economically competitive) and inclusive (fostering an economy with high levels of employment ensuring social and territorial cohesion), which is part of the European Strategy 2020 (European Commission - Europe 2020, 2010, p.5).

Tapscott (2012) for its part, considers it essential that education promotes and encourages the development of more highly valued digital skills in this global competition so that Europe can move to the front line and build a workforce that includes also entrepreneurs and managers with a deep knowledge of the technology and culture of the digital revolution. In his words: in order to foster entrepreneurship and employment growth, governments must invest in education to create a workforce with advanced digital skills (Tapscott, 2012, p. 7). Tapscott also mentions that in Europe today, more than 300 million people are marginalized in the digital economy, and "the acquisition of e-skills could increase the supply of skilled workers, boost employment opportunities and give a much needed productivity injection" (2012, pp. 7-8). Tapscott suggests that workers should continue to develop their skills to ensure that they remain competitive in the complex and demanding 21st century job market, and present several critical levels where know-how becomes necessary (2012, p. 8):

- All workers have to have a certain level of proficiency, competence and knowledge about the tools of our time, as these are becoming essential for the efficient execution of all professional functions;
- Managers and executives must themselves have digital skills. This is a prerequisite for understanding how new media can transform an organization for success;
- We need to develop a much deeper pool of specialized knowledge at the level of technology professionals (programmers, analysts, engineers and systems architects) that are needed by businesses and governments to build and manage their ICT environments;
- The ICT sector itself requires a new level of talent: professionals who can compete in the global marketplace; Europe needs a world-class workforce of high-end, sophisticated technicians, inventors and technologists;
- The talent deficit problem in the ICT domain is the tip of the iceberg in the area designated by CTEM (Science, Technology, Engineering and Mathematics); That is to say that Europe must develop its capacities generally in science, technology, engineering and mathematics.

Tapscott (2012, p. 9) also points out, as a fundamental condition for all individuals, the lifelong learning ability, to think, to research, to find information, to analyse, to synthesize, to contextualize and to evaluate critically, to apply research to problem solving; to collaborate and communicate. As in the e-Skills Manifesto (i.e. a document based on a set of guiding and structuring perspectives for those who are interested in the acquisition, development and retention of digitally qualified talent in and for the 21st century), in this work, when using the term "digital competences", it is not only intended to describe the circumscribed abilities to use certain digital tools, but also the deep knowledge and aptitude of individuals to learn throughout life on all relevant areas of the digital revolution, including technologies, applications, programming (code), uses and opportunities for transformation.

Diagnosis of digital technological competency needs

According to the e-Skills Manifesto (Tapscott, 2012, p. 3), "despite average unemployment levels of 22% for young people across Europe, employers regularly state that they are unable to fill open positions that require scientific and technical skills".

Indeed, a recent research done by the Pan-European London School of Economics (LSE) indicates that there is a serious shortage of skills among Europe's young people, despite the popular view that they are 'digital natives'. In addition, the LSE states that progress in the acquisition of digital skills among the population has stagnated in recent years (Tapscott, 2012, p. 5). According to this observation, the following question arises: if these 'digital natives' have a shortage knowledge of digital skills and are in a process of learning, how are the other unemployed set of people, in what digital skills knowledge concerns namely the ones over 34 and under the age of retirement? Naturally, this set of people, who have long terminated their teaching-learning process, and, in many cases (https://www.iefp.pt/estatisticas), with low levels of qualifications, reveal less technological knowledge when compared to what society demands today. The problem becomes more serious because most of these adults will still be part of the active population for many years. It is also verified that the age group between 35 and 54 shows up to be the group of the active population, as well with a higher percentage of unemployment rate. One can also observe that the unemployment rate is more pronounced in women and in individuals with less literacy.

According to Tapscott (2012, p.5) "the digital capability gap is an epic problem" because literacy, knowledge and technological skills are essential for all industries. He even adds, that we are seeing through the entire Europe, a growing gap in digital capacities between the demands of digital transformation in one hand and the skills, knowledge and workforce on the other hand.

Participants in the project

Attendants in this survey will be Portuguese unemployed adults, aged over 34 years and below the age of retirement, with little or no knowledge regarding IT skills, due to the fact, that there is little or even no offer of training/integration initiatives (Instituto de Emprego e Formação Profissional (IEFP)
- Portugal), specifically targeted at this age group. Thus, the target group will be the unemployed individuals enrolled in the Portuguese Institute of Employment and Professional Training (IEFP) for more than a year, and with low levels of qualification. A group of sixteen participants, "key informants", will be formed.

Adult education

Lifelong learning is not defined in a time frame and in a single place; it occurs in different moments and during the life course, encompassing all the processes - formal and non-formal - that are provided to each individual, such as basic education, initial training, and adult education (Barros, 2013, p. 17).

With regard to adult education - the specific theme of the project - it is understood as "the entire body of ongoing learning processes, formal or otherwise, whereby people regarded as adults by the society to which they belong develop their abilities, enrich their knowledge, and improve their technical or professional qualifications or turn them in a new direction to meet their own needs and those of their society" (UNESCO, 2014, p. 13).

How adults learn

Defining andragogy as "the art and science of helping adults learn" (Knowles, Holton & Swanson, 2005, p. 61), Malcolm Knowles "the Father of Andragogy" (Knowles et al., 2005, p. VI) -proposes a set of six principles in which Learning among adults (Knowles et al., 2005, pp. 65-68). Fig. 1 presents this set of principles and their relationship with other factors that influence the learning processes of adults. Then the six principles of andragogy proposed by Knowles are explained, as well as some considerations of the author around each one of them:

1 - *The need to know* - even before they become involved in a learning process, adults need to know why they have to learn; the counterparts associated with this process and the negative consequences of not doing so. Thus, the awareness of this need to know and the value added by these learnings (e.g. in terms of their usefulness/application) is an essential condition for the adult to be involved in this process.

2 - *Learner's self-concept* - the adult´s self-concept is characterized by self-determination, that is; the ability for him to make his own choices (and the need to be perceived by others as competent at this level); to make decisions independently; to take a course and take responsibility for their own lives. Despite this, several of those who enter into adult education processes, (based on their previous school experiences) retain their self-concept of dependent learner, assuming a passive role and relegating the protagonism of the process to the trainer. Reversing this picture - helping each adult to switch-over from the role of dependent to self-determined learner - is, according to Knowles and his collaborators, a determining aspect of successful adult learning.

3 - *The role learner's experiences* - one of the aspects that differentiate the achievement of knowledge throughout adult learning processes from those that take place during the previous stages – lies on the experiences that these individuals have accumulated along their life course, which are distinguished - in quantity and quality - from those of the younger learners. In this context, one of the richest resources of the learning process is the learners themselves, since their experience can be made profitable. The very fact that in a group of adult learners we are faced with a greater heterogeneity of paths and experiences, and a greater diversity of interests, needs, motivations, learning styles and goals, can also be taken as a very valuable resource. By taking advantage of the different experiences and resources of these trainees, with respect for each one's identity, the most dynamic and interactive methodologies - such as group discussions, simulation exercises, problem solving or case studies - seem to be much more effective than the expository methodologies.

4 - *Readiness to learn* - the adult is willing to learn when, on the one hand, when he feels he is prepared to and, on the other hand, when he realizes that in order to be able to deal effectively with real life situations he needs to do this learning. According to Knowles et al. (2005), such readiness seems to be largely dependent on the resolution of some previous developmental tasks, and desirably the timings of the proposed challenges must coincide with their overcoming. As an alternative to waiting for such a resolution, in the context of adult education, the authors suggest

exposure to higher functioning models, vocational advisement, simulation exercises or other strategies capable of promoting this sense of "readiness".

5 - *Orientation to learning* - adults are motivated to learn as much as they realize how useful these learnings can be to help them accomplish a set of tasks or solve problems of their daily lives. As such, they are task-oriented or problem-solving and learn more effectively (in terms of knowledge, skills, values and attitudes) when learning material is presented in real-life situations. For the adult person, learning has to have meaning for their day to day life.

6 - *Motivation* - the major causes that generate motivation for adult learners, are intrinsic, they reside in their own will for growth and development (in terms of self-esteem, job satisfaction, quality of life). As such, they are more predisposed to this type of motivation than to those of an extrinsic character (e.g. promotions, better salary, better job).

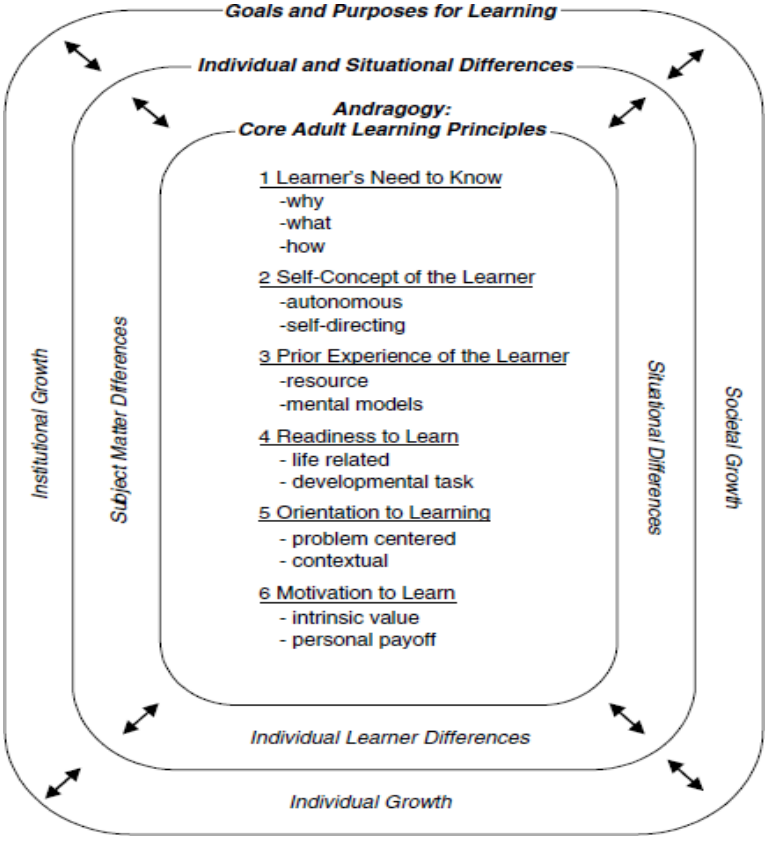

Fig. 1 – *Andragogy in practice* - from Knowles, Holton & Swanson (1998) published in Knowles, Holton & Swanson (2005, p. 4)

In addition to the principles presented above, and as shown in Fig. 1, there are other factors that influence the way adults learn such as: aims and purposes of learning, and situational and individual differences. It can be said that andragogy works best when adapted to each apprentice individually and to each learning situation/process and when all the above mentioned principles are assured (Knowles et al., 2005, p. 3).

Learn to program

Programing teaching is highlighted, especially because "programming" teaches experiences and develops the critical spirit, it allows to act/preform, describe and reflect on learning and/or knowledge. The people who program incorporate a dimension of critical judgment, increasingly autonomous and free, an indispensable condition for life. Shein (2014, p. 16) points out that not all individuals need to know how to program, but learning to think as a programmer can be useful in many areas. The important thing to learn to program is the thinking process and the development of problem-solving skills: "the emphasis should be on learning problem-solving skills in computer science, much like problem-solving skills" (Wing, as cited in Shein, 2014, p. 17). In fact, the new generations will learn to program at the same pace that today one still learns to read and write. Because the future will be written in lines of code (Oliveira, 2015, p. 6).

So, as we learn to read and then read to learn, so does this occur with programming. According to

Resnick (2013a), we use writing in all situations of our life; to send birthday messages, write shopping lists, record personal sensations in journals, etc. The act of writing also poses new ways of thinking; when we write, we learn to organize, refine, and reflect on our learning. The coding (computer programming) appears here as an extension of writing. The ability to program allows you to "write" new kinds of things, such as interactive stories, games, animations, and simulations. Therefore, as with traditional writing, it is also important to codify.

Problem solving

Programming emerges as an important new way of putting ideas into action. While many people view programming as a technical skill, only useful to some, Resnick (2013) believes that ability to program, such as the ability to read and write, is critical to a full participation in today's society: "when people learn to code, they learn important strategies for solving problems, designing projects, and communicating ideas" (Resnick, 2013b, sp).

Other authors also point out that programming requires problem solving skills and that developing problem solving skills is a matter of practice. Vivian, Falkner and Szabo (2014, p. 48) point out that "programming really is about problem solving". These authors point out that "problem solving" is a way to organize the ideas and manipulate their skills and techniques so that, during a process of solving their problems, they are able to transfer the skills and techniques to their effective resolution. This idea is what one intends to develop with the individuals with whom one seeks to promote programming skills, be able to solve their problems more effectively, using the best available resources (internal and external). "The educational benefits of being able to think computationally transfer to any domain by enhancing and reinforcing intellectual skills" (Wing, 2011, p. 5).

In the work conducted by Vivian et al. (2014, p. 41) with their students and IT professionals in Australia, it was found out that most respondents felt that any individual could learn to program, if they were motivated and involved. However, they also noted that more complex levels of programming require more specific (logical) knowledge of mathematics, which is therefore needed to develop problem solving skills. According to Vivian et al. (2014, p. 49), the development of programming skills also depends on the motivations of individuals, the ability to develop thinking skills and problem solving. It also depends on practice and persistence. Dweck (1995; 2000 as cited in Vivian et al., 2014, p. 42) corroborates this same idea, highlighting how learners view learning as dependent upon their motivations and persistence.

In another study, Rogerson and Scott (2010, as cited in Vivian et al., 2014, p. 43) points out that students in programming disciplines (code learning) said that in order to solve the problems proposed, they had to think differently. This type of thinking is described as logical and sequential, similar to the thinking advocated by Mayer (1986, as cited in Vivian et al., 2014, p. 43) – "a logical step-by-step process that enables programmers to translate goals into code". This author points out as factors susceptible to influence the success in the learnings of the students the development of abilities of comprehension and representation of problems. For Mark Surman, executive director of Mozilla Foundation (as cited in Shein, 2014, p. 16), "Code has become the 4th literacy" and is therefore an area in which individuals must invest to develop knowledge and skills.

Computational thinking

For Wing (Shein, 2014, p. 17), "computational thinking helps people learn how to think abstractly and pull apart a problem into smaller pieces. One concrete way to learn aspects of those skills is programming". Computational thinking is the set of mental processes involved in formulating problems and their solutions, so that solutions are represented in a way that can be effectively carried out (Cuny, Snyder & Wing, 2010, as cited in Wing, 2011, p.1). Wing informally characterizes computational thinking, as a mental formulation activity of a problem, foreseeing a computational solution. The solution can be carried out by a machine or by an individual, and is usually by combinations of both, humans and machines (Wing, 2011). Computational thinking contains a range of mental tools that reflect the spread of the field of computer science: "It is planning, learning, and scheduling in the presence of uncertainty" (Wing, 2006, p. 34). Computational thinking is the new literacy that is required for this century. This literacy gives individuals the application of programming to their needs (Cuny, Snyder & Wing, 2010, as cited in Wing, 2011, p. 3).

To Cuny, Snyder and Wing (2010, as cited in Wing, 2011, p. 3) learning to develop computational thinking skills is considered useful for all individuals because it means being able to.

- Find out which aspects of a problem are capable of computing;
- Evaluate the relationship between a problem and the available tools and computational techniques;

- Understand the limitations and the capability of the tools and computer techniques;
- Apply or adapt an existing tool or computational technique to a new use / situation;
- Recognize the opportunity to use computing in a new way;
- Apply computational strategies, such as identifying, understanding, controlling and solving problems in any domain.

Computational Computational thinking is moving towards a reality in which it will be fully integrated into society, which will no longer be an implicit philosophy. Computational thinking is a great vision and/or field of action that should be pursued by computer science educators, researchers and practitioners if they wish to change and modify society's "opinion" on this subject. To this end, and according to Wing (2006, p. 35), it is necessary and urgent to sensitize and act with the whole public, sending them two main messages:

- *Intellectually challenging and engaging scientific problems remain to be understood and solved.* The domain of a problem and solution is limited only by our own curiosity and creativity; and anyone can develop skills in the field of computer science;
- *One major in english or mathematics and one on the multitude of different careers.* Developing skills in the area of computer science is to equip individuals with "tools" that will not be reductive, rather they will be facilitators for any area of study and / or profession. It can be said that it covers all areas, for example: medicine, law, economics, politics, any kind of science or engineering, and even the arts. Developing computational thinking skills is a cooperative procedure that operates collaboratively for any activity/profession.

According to Wing (2006, p. 34) ubiquitous computing stands for today just as computational thinking is for tomorrow. Yesterday, ubiquitous computing was a dream that has now become reality; computational thinking is the dream of tomorrow.

Methodology

In order to understand how this type of learning develops problem solving skills and critical thinking skills, a training action will be carried out, through which they will design, develop and organize educational strategies and resources that allow participants to learn to program. Although it is considered necessary to use quantitative analysis methods, this research will be of a qualitative nature, of a critical, transformative and emancipatory nature and will have a research strategy for action- research.

To Esteves (2008, p. 17), the action-research advocates the need for a simultaneous link between theory and practice, i.e., between the process of knowing and the object known. However, although it is considered that the research is qualitative in nature, it will be necessary to use methods of quantitative analysis.

The choice for qualitative research relies on how data needs to be collected and analyzed. That means, that in a first phase a documentary analysis will be done within studies in the scope of the subject and object of study, such as books and journals of the specialty, in order to answer the following questions: What concepts? What studies? What methodologies? What results?.

Regarding the quantitative analysis, this refers to the treatment of the questionnaire data that will be used to identify for example, interested participants, needs, improvements, evaluation of training device, etc. According to Ghiglione and Martalon (1997, p. 106) it may be useful, after a quantitative inquiry, to carry out a complementary qualitative phase, for example, to help interpret certain unexpected results. We can thus conceive, instead of classical succession, a swing between the qualitative and quantitative phases, using these last ones to stress out the relations which they will allow to interpret.

Instruments for the research data collection

The Table 1. presents the data collection tools that are deemed necessary for the research with a briefly description of their purpose.

Table 1. Data collection instruments

Documentary Analysis	• Collect, according to the theme, information and analyze the contents (studies) • Obtain information of the stakeholders: define the training profile; recognize expectations, interests and attitudes; identify supervisory processes and practices of the actors with whom they want to work.
Participative Observation	• Interacting with individuals in a natural, non-intrusive and non-threatening way. • The researcher is at the same time an instrument in data collection and interpretation

Survey Questionnaires	• Survey of training needs; • Intervention process - diagnose progress and difficulties.
Focus Group	• Define areas of intervention (eg: what tools?).
Logbook	• Meditation on the way learning happens (eg reflect on barriers and how to overcome them, ….).
Training device	• Educational environment to learn how to program - design, develop and organize educational strategies and resources that allow trainees to learn to program; • Find answers to the research topic.

4. Conclusions

There The idea of providing to the participants in the study, through a training device, an environment to learn code (programming) and the possibility of understanding how they learn to program, aims to investigate how this type of learning develops problem solving skills and critical thinking skills that, in turn, promote the inclusion of the most disadvantaged individuals in terms of digital knowledge and skills.

The aim is to prepare individuals not only to be consumers and users of digital technologies, but also to provide them with the opportunity to develop the skills to create digital technologies, so that, they are better prepared for the challenges of the 21st century. "Computational thinking will be a fundamental skill used by everyone in the world by the middle of the 21st Century" (Wing, 2007, p. 2).

It is also considered that this is an intervention strategy from inside out. The participants, the less qualified, and therefore the less knowledgeable of digital literacy, and consequently with more difficulties in adapting to current requirements, such as the need to be proactive in solving professional problems, represent the greatest labour force, about 70% of the total active Portuguese population (Informação Mensal do Mercado de Emprego do Instituto do Emprego e Formação Profissional – Portugal; Instituto de Emprego e Formação Profissional (IEFP) – Portugal). On the other hand, by diminishing the lack of knowledge and skills, conditions of equity are developed and "communication" with the younger ones is facilitated.

With this work, in addition to the relevance of the development of scientific knowledge about how adults learn programming, it is hoped to push forward the valorisation of effective lifelong learning, creating opportunities for participants with the proposed intervention to acquire skills that allow them to perform by themselves, the necessary changes to evolve and strengthen themselves and thus ensure full social participation, which, in an empirical way, is understood to give them an empowerment (UNESCO, 2010; 2014).

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