The Evolution of Programming Education in the Digital Age

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Abstract: With all the changes taking place in the contemporary world, including the field of higher education, it is not necessary to prove that we are witnessing an undeniable revolution of "pedagogical practices" in light of the various didactic transformations that characterize our times, especially with the accelerating evolution of new technologies and the development of digital convergence. The paper focuses on the added value that information and communication technologies (ICTs) can bring, while it becomes inevitable to update current tools and practices for teaching programming, requiring interaction between different stakeholders within interdisciplinary and cognitive contexts.

1 INTRODUCTION

Often people associate ICTs with intercultural communication, which serves to create authentic communicative situations. However, online communication devices are often blamed for certain obstacles, which are primarily related to the motivation of the participants, their needs, perceptions, etc., as well as the organizational context and its time or technological and pedagogical constraints.

Many ICT projects demonstrate their limitations, especially in the context of online interactions, where various discursive events arise from both formal and informal communicative situations. Added to this are the problems caused by material conditions, which can sometimes reduce the quality of knowledge transfer, leading to misunderstandings between communicators. On the other hand, these constraints can be used to advantage, as participants are given the opportunity to exchange information directly in an effort to overcome technical or logistical problems. This facilitates the acquisition of language and programming skills, as well as harnessing the potential of ICTs through the wide range of digital tools available. This strategy is beneficial for improving communication and semantic skills.

2 LITERATURE REVIEW AND METHODOLOGY

Knowing that teaching programming and technology remains a promising field where the use of technology and the internet proves most beneficial, especially in the case of assignments offered to students in distance learning, we will focus in this report on teaching and learning programming in favor of its contextual aspects.

The contribution that digital tools can make is our main didactic orientation in the proposed approach, aimed at bringing audiences closer together through online technologies. However, it is important to understand that various contexts, primarily technological and social, determine the quality and extent of efforts to achieve a positive outcome.

Thus, the aim of this research is to develop didactic recommendations in the specified contexts to create sustainable online communication aimed at developing the necessary competencies in students who seek to develop their programming skills. Within this research, we will examine various types of online interactions, as well as specific situations that arise in programming education.

Before presenting the methodology we plan to use to implement our didactic approach, we will first focus on the theoretical context that would allow us

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to build a systematic foundation, providing the main principles for implementing the online interaction project based on a communicative approach. Then, we will look at the evolution of various learning environments with technology up to the era of multimedia and the Internet, which have contributed to changing pedagogical practices, allowing the concept of "distance" to be redefined in this context. Finally, we will propose didactic recommendations that can help us organize online communication opportunities based on our own observations and teaching experience in programming.

A wide range of tools available today due to technological development significantly facilitates interaction with others, allowing interaction with students as well as working individually and collectively. All these possibilities must be taken into account and should become the subject of real attention through thorough didactic research, which can provide a unique opportunity for interaction diversity.

Many researchers of information processes place information at the center of the real process, considering it first as data that can be transformed into knowledge, then evolving into knowledge that becomes a bridge for decision-making. Such information will develop into some energy (Dinneen & Brauner, 2015), which is necessary for expressing an opinion through arguments.

It is clarified that information seeks to acquire a certain energy through exchange, which is carried out by thousands, even millions of users, especially when it is addressed to a wide audience and acquires its true meaning only when it is shared by all members of the community.

In this context, it is also advisable to distinguish between information and knowledge, which represent two different but complementary concepts, or more precisely, one is a reflection of the other. In other words, the use of knowledge facilitates the immediate assimilation of information, which evolves into knowledge or wisdom, organized by deep understanding, the acquisition of which is the fruit of experience and competence (Sorochinskiy et al., 2023).

In a document or any other information carrier, data represent the simplest element of information. Information, therefore, requires intellectual interpretation of all data that constitute it, and once these data are decrypted and analyzed, the question of structuring all the information thus formed arises.

It is important to note that the relevance and richness of knowledge can become tangible only if they are considered in their real context, where meaning is formed naturally. Thus, information can be accessible even if it is interpreted differently by each recipient, even if it leads to different actions depending on the context in which it exists. Accordingly, "knowledge" defines the human process of transforming raw information to give it meaning.

The modernization of educational didactic tools and means has itself become an integral and inevitable part of the ICT evolution era, considering that it continues to occupy the minds of researchers in this field, promoting continuous interaction between various participants who can be involved in the dynamics of interdisciplinarity.

Compared to traditional communication methods that marked the 20th century, such as the telephone, television, radio, audiovisual media, etc., new technology prevails and is now used in the plural to denote information and communication technologies, digital technologies, educational technologies, etc. These new technologies define a new type of society based on the sharing economy and flow dynamics. Social interactions arising from the use of technology are also present in educational and programming training practices through the integration of technical aspects related to the use of various tools. In other words, the integration of technological and social contexts plays a defining role in acquiring quality education.

ICTs are considered computer technologies that allow information processing, organizing knowledge, solving problems, developing and implementing projects using a set of interconnected tools with minimal interaction (Dziuban et al., (2018). However, in terms of educational technologies, the ICT acronym pushes researchers to focus on pedagogical practices that place the learner at the center of the learning process, promoting the construction of their own knowledge using increasingly innovative methodologies. The key issue is the problem of aligning the use of technology with programming didactics, as well as connecting theory with practice.

Following Computer-Based Training (CBT) (O'Malley, 2012), associated with the behaviorist stream, and Intelligent Computer-Assisted Instruction (ICAI) (Dede, 1986), which evolved towards constructivist approaches, and their successors at the turn of the 1980s and 1990s, a new practice emerged - Information Environments for Human Learning (IEHL) (Stahl, 2000). IEHL is closely intertwined with the first applications of artificial intelligence (AI) and also leverages the possibilities of communication through computer networks.

The CBT era represents the dawn of computer technology applications in programming education. CBT was based on the principles of Skinner's old teaching machines (Kopstein, 1962) due to the technological limitations of computers at the time. This model clearly approaches the concept of a "black box," assuming that when a stimulus appears, the learner automatically produces a response without the possibility of providing a plausible explanation. In this case, the pursuit of satisfaction provided by reward plays a paramount role.

In practice, this is manifested in the development of software that organizes learning on a step-by-step progress basis, where moving to the next stage is only possible after successfully completing the previous one. This is achieved using a variety of learning tools such as trainers, tutorials, didactic materials, and other specialized programs designed for comprehensive learning.

CBT, in its tutorial form, begins to encounter limitations from the mid-1970s partly due to strong criticism, while learning through practice emerges as a replacement, contributing to the formation of cognitive representations in the learner, aligning with Piaget's constructivism and the development of cognitive psychology. The learning process is thus initiated and managed by the learner themselves, while the teacher-computer gives way to the tool-computer, which is only used as a means of carrying out tasks.

One of the first office applications using the computer as a tool was the word processor. The next stage of evolution—transitioning from teacher mode to tool mode—puts the learner in a realistic situation, similar to a simulation of action. Specialized programs are often used to simplify reality, immersing the learner in an environment that allows them to virtually recreate what they want to learn and apply. In the field of programming education, it is more accurate to speak of creating a real practice situation rather than simulation. The role of the computer in tool mode in this case is to provide the student with the opportunity to interact with the real world through game-like tasks in the guise of real practical knowledge.

The next evolutionary stage, spreading from the 1980s, involves the learner in the process of self-learning, where they participate in creating and programming learning materials, as well as analyzing the results obtained. The concept, which seems promising with all its advantages in the field of education, promotes increased autonomy and success in self-education.

Through the application of AI techniques and principles in education, the field of CBT has continued to evolve, generating new designations such as Intelligent Computer-Assisted Instruction (ICAI) or "intelligent tutor" (Maamari & Majdalani, 2019), which now offers functionality that responds to learner questions, as well as being able to detect and correct their errors. The limitations of this model lay in the difficulty of adapting AI tools and methods to programming education.

AI specialists soon turned their attention to interactive computer learning environments as a more advanced alternative to ICBT. In these environments, the main emphasis is on interactivity rather than AI, which allows the role of the human teacher to be restored and promotes teamwork.

Over the past thirty years of development in programming education utilizing the potential of ICAI, several other acronyms have emerged, such as DL (Distance Learning) (Moore eta al., 2011), CC (Computer Communication), and CCBT (Collaborative Computer-Based Training) (Stahl, 2005). Distance in modern education has lost its former significance thanks to advancements in online applications. These technologies provide not only synchronous but also asynchronous interaction between students and teachers, making learning accessible regardless of geographic location and time. The continuous improvement of digital tools allows for overcoming any spatial and temporal barriers. Internet technologies are becoming a bridge between didactics and technology, including in such specific areas as programming didactics, which focuses on integrating programming skills using modern digital tools.

With the wide range of resources available online, linguistic resources converge with technological ones (video, audio). For learning programming, resources from the internet include "data," "activities," and "tools." The most popular of these are those that facilitate information sharing, communication, and enhance interaction between teachers and learners.

Throughout its evolutionary cycle, it is clear how technological and social contexts influence each other, not always positively. The problem of maintaining balance remains relevant today.

Despite the fact that 1990s technologies were limited compared to modern achievements, instant messaging programs of that time allowed group members to interact in real-time, see and hear each other. Using a computer with an Internet connection, webcam, and microphone, these virtual meetings turned into video conferences with synchronous transmission of image and sound, promoting

interaction and information exchange between participants. Later, with the development of high-speed lines, specialized platforms with many functions appeared, allowing voice and image transmission to several people, which positively affected peer collaboration, especially in distance learning.

A little later, in the mid-2000s, the concept of virtual classrooms became a very popular pedagogical form in distance university and professional programming education. The main argument in favor of this form is its rapid growth and the ability to "create presence at a distance," allowing learners to feel in conditions similar to a university campus. However, the technical requirements (high bandwidth, high-performance equipment configuration, training in functionality, etc.) of this communication and resource exchange method seem to be the main drawback for its deployment, despite the recognized potential in terms of pedagogical effectiveness.

Web technologies opened a new era of social networks (Ansari & Khan, 2020), which bring together a huge number of people for interaction, information and resource exchange. These platforms, based on Web 2.0 principles, allow content distribution, sharing links, and creating specialized communities. Social media, providing instant synchronous communication, have become ubiquitous and gained particular popularity after the global COVID-19 crisis, which radically changed academic and professional habits. Platforms such as Skype, WhatsApp, Viber, and others (Correia et al., 2020) have become indispensable, offering not only internet telephony services (VOIP) but also a wide range of functions: sending files of any format, conducting video conferences, thematic discussions, and much more. These tools have united an important online community worldwide, ensuring continuous communication and collaboration.

In order to meet the requirements of the modern information and educated society, the palette of digital tools for learning continues to expand with the spread of knowledge on the network, which implies constant updating in terms of use, both material and software tools.

3 DISCUSSION AND RESULTS

In order to establish the right balance between technological and social contexts, it is important to identify the key factors of these contexts. When using ICT, various modes of teaching programming are possible, which are determined by the needs and goals of distance education, of which two are the main ones:

- E-learning in self-study mode;
- Hybrid learning.

The choice of the optimal learning format requires an analysis of the context, a clear definition of pedagogical goals and the development of an educational process that matches the design. In addition to online collaboration, there are two other main categories of distance educational technologies that actively use interactive capabilities. Most of them are implemented via the Internet, providing a wide range of tools for effective distance learning.

Since the early 2000s, the integration of digital and technological tools into distance education has become inevitable. Technologies such as hypermedia, multimedia, the Internet and Web 2.0 have begun to displace printed materials and classical audiovisual resources, which have long been the main means of teaching in distance education courses. In the current configuration of DL, self-study is a mode where the learner follows an online pedagogical path, completely planned remotely. The content offered responds to a structure organized, as a rule, in terms of web pages accessible via a browser, either on a local network, remotely or on the Internet. These pages differ from a simple information site by the nature of the pedagogical learning sequences, the activities offered and the paths to be completed.

With the help of collaborative tools such as forum, chat, video conference, e-mail, wiki, etc., the learner can communicate with his/her mentors without having any personal interaction with them. However, the main challenge that arises when using these educational devices is to optimize the use of communication tools to overcome the limitations associated with completely online learning, namely the feeling of isolation, fatigue and sometimes the lack of technical mastery of some multimedia tools.

The hybrid mode can boast the best achievements in connecting the technological and social contexts in teaching programming. The concept of hybrid learning (Raes et al., 2020) is characterized by a combination of face-to-face teaching and distance learning in the form of e-Learning. The integration of e-Learning into hybrid or blended forms of learning can be considered according to different pedagogical modes that respond to specific goals, leading to a variety of possible cases in the configuration of the intended learning device. This depends on the available technical and human resources and the implementation conditions, which can influence the pedagogical choices. Thus, participants can follow a distance learning path while simultaneously participating in face-to-face meetings with a mentor or teacher, and this in addition to online courses or

sometimes for the needs of assessment at the end of the path. Hybrid learning provides the greatest integration of technological and social contexts, as well as joint practical activities. Learners are organized into several working groups on the forum to complete a predetermined number of programming tasks in connection with various lecture and methodological materials. The final goal is to prepare projects in each group that include a class hierarchy, functional code files, and program execution results. Such activities encourage written activity by participants, allowing for a balance between members and groups. The traceability of contributions to the forum will be a real means of analyzing the interactions of participants and the role they played in creating the correct semantics of the program code, as well as the quality of structural and object relationships in the project.

4 CONCLUSION

Without formally concluding this discussion, we emphasize the value of merging interactions between technological and social contexts through the organization of diverse online forums. This will allow learners to significantly unlock their potential and refine their programming skills. The didactic value of our endeavor will only manifest after the actual implementation of pedagogical scenarios that include specific practical tasks combining written and semantic skills within the online forum environment.

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