# Smart learning technology for computer programming driven by research related to COVID-19

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**Abstract**

Two main categories of entities, material and immaterial, influence the design of smart learning technologies for computer programming. Material entities are manifested through various ICT solutions. Immaterial entities consist of mental and physical effort, as well as the impact of the social environment. This paper studies the impact of COVID-19, as an immaterial social environment factor, on smart learning technologies. Certain changes were made in the learning procedures for computer programming, according to COVID-19 related recommendations. Students were surveyed for their views on these organizational and content adjustments. The obtained results were interpreted and used for additional conceptualization and adaptation of the smart learning technology for the C++ programming language. The smart learning technology described in this paper, based on open source cloud solutions, was developed to satisfy the needs of a fully virtual learning environment and was gradually improved according to the students' views expressed in the research. The working concept of the technology enables adaptability of the course activities, according to the student's choice. Such program activities include qualitative opportunities for theoretical analysis and conclusions, source code writing, compilation and execution, monitoring changes after a source code edit, download of source code and offline work. This approach enables interactive lecture tracking and direct participation in the session, but also the ability to practice computer programming at any time, which makes this technology applicable and useful.

Keywords: C++programming, covid19, smart learning technology

## 1. Introduction

The emergence of covid19 is a significant immaterial factor that has marked all areas of human life worldwide, including the education. This unconventional situation leads to behavioral changes of all age groups, encouraging the use of ICT-enabled solutions for communication and working needs, as alternative of physical presence. Young people are best adapted to this new situation.Some relevant research shown that in the 21st century, for most young people, technology is significant part of their daily lives, presenting that by age 21 today's average person spend 15,000 hours in formal education, 20,000 hours in front of a TV and 50,000 hours before computer screen [2]. In terms of the necessary educational change, this situation leads to a solution where smart learning technologies, functionally very close to young people, compensate the negative impact of covid19. Even before the covid19 crisis many world-spread universities worked to improve the strategies used to maintain support systems to enhance students' online experience in meeting their educational goals, offering comprehensive online student support [1]. Imperative of each modern educational institution which enroll students in online degree programs, is to provide learning services of equal quality to those

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offered to campus based students. Furthermore, the use of ICT in education, followed by conceptual advances in technical paradigms, has grown rapidly in the last 10 years. In terms of material factors relevant to education, following market changes, desktop configurations have been replaced by laptops, and further, by tablets and mobile phones, which are more accessible and better manageable.

Regarding the organizational aspect of ICT solutions, the preferred way of communication between the devices is constantly changing.There have been major subsequent changes in the educational paradigm. The first step was the upgrade of e-learning, which was defined as computer training, toward m-learning (mobile learning), based on mobile and wireless technologies. The further changes move the m-learning environment to the u-learning environment (ubiquitous learning), which can be accessed in a variety of contexts and situations[3].The u-learning environment allows students to access educational content, anytime, anywhere through a variety of terminals, without restrictions on time, place or environment[3][6][7].

In practice, e-learning, m-learning and u-learning technologies are vertically compatible and complementary at the same time and can be used in parallel, if necessary, in a single learning environment. This concept leads to the development of a personalized learning system, equipped with multi-level services that offer a personalized scalable opportunity for education and practice[2]. It is a complete learning ecosystem, in which both the student and his environment, flexibly respond to constant changes, through interaction and mutual improvement, thus growing into a s-learning ecosystem (smart learning ecosystem)[7][9]. Each s-learning environment should have a set of multiple additional smart components to implement, maintain and actively use distinctive smartness features, also known as several levels of intelligence, such as adaptation, sensing, inferring, self-learning, anticipation, self-organization, and restructuring(optimization)[7].

The term smart has been used to modify a learning environment as well as technology[5]. Every s-learning process should be supported by smart learning technologies, and both of them, fusioned, grow into a s-learning environment[4]. Not every smart technology is a smart learning technology. Learning and training support should be the primary consideration. Learning and training support should be the primary consideration. In this context, the technology is seen as practical application of knowledge for a purpose that is of value to a group of people, includes physical things, as well as things that are conceptual or abstract (such as sorting algorithms, code, a way of interaction trough cloud-programming environments)[6]. Today, the working concept of s-learning environments is broad-spread also, in non-formal education and lifelong learning concepts. New unconventional forms of customized learning are emerging, such as open classrooms, where students have the opportunity for personalized sessions by dedicated professional. The project-driven curricula are adapted to achieve wanted skills and the competencies needed to find job, or to thrive on the job[4].

Smart learning environments supported by smart learning technologies should not only enable learners to digital resources and interact with the learning systems in any place and at any time, but also actively provides them with the necessary, learning guidance, supportive tools or learning suggestions[8], offer scalability, self-learning and self-training support. It is important to note that some courses and areas of education, are particularly relevant to the concept of smart education, which incorporates s-learning processes and smart learning technologies use. These include the various areas of application and use of ICT at various levels and situations, with a particular emphasis on the study of programming languages and technologies. The new reality in all domains of human

behaviour, conditioned by the emergence of covid19, strongly imposed the need to use smart learning technologies to build s-learning systems at different educational level and subjects of education. Also, in the context of covid19, smart learning technologies provide the opportunity for continuous improvement of pre-established smart learning systems. In both cases, the opinion of the students should be taken as a precondition for quality changes.

**2. Concept development of smart learning technology for computer programming**

According previous overview, every smart learning technology is developed to support some pre-existing smart learning system, ensuring and enabling the needed changes. To ensure the success of this process, it is crucial to identify the key influencing factors in order to enhance the strengths of the learning environment and to overcome and improve the weaknesses. The implemented smart learning technology presented in this paper is a functional complement to the existing smart learning ecosystem, applied for many years. The idea behind the development of smart learning technology is to regulate the transition from learning through practical physical presence to full online learning. The reason for such a change is the need to reorganize the various levels of social interaction imposed by covid19, including educational processes. Before presenting the functionalities of smart computer programming learning technology, a step-by-step overview of the development concept follows.

*2.1. New opportunities that smart learning technology for computer programming offer*

Experientially, in order to achieve good results, the methodology of learning computer programming should have some theoretical preparations, some practical exercises, and a process of practical testing of skills and abilities. In the conditions imposed by covid 19, the most critical part of the transition to full online learning is the process of qualitative and quantitative changes in the code, which requires repetitive activities such as code editing, modification of conditions and input variables, compile, debugging, linking, execution. All of these activities have different roles: the main goal is to make the code error-free and what can be done, but further goals include editing and advanced manipulation of an already functioning executable code, such as monitoring the impact of input data changes, the use of standardized libraries in C ++, and creating and executing custom headers. Based on the given notes, developed smart learning technology has the following features:

- The technology is used as an interactive book and compiler at the same time
- The user (student) does not need an account and login to start use it
- The technology can be used by several students at the same time, and the changes made by each individual have no impact on the basic educational content, which remains unchanged.
- The technology consists of multiple set lessons - examples with educational code, and each can be accessed, as needed several times and at any time.
- There is an opportunity for interactive change of the basic content-code, and both can be downloaded for future local exercising, if needed.

The basic concept of this technology, designed in addition to the existing smart learning system, is based on many years of practical experience, and an initial version has been prepared.

*2.2.Evaluation of the smart learning technology concept*

According to the practice in computer programming, the main evaluation of the concept of smart learning technology, made through an anonymous survey of students who used it during the semestar, in the time interval march-june, 2020.


*Figure 2: Survey results- covid19 realted research*

The rearranged contents on Figure.1 presents summary statistics from the research, conducted in in macedonian language on the link http://www.ramona-markoska.info/2020/05/2020-covid19.html. From the end of the semester until the end of June, students were interviewed for their opinion and experience in following main categories:

- Organizational items, which refer to the comparison of physical presence with the online presence, expressed through individual factors of importance and in general.
- Content changes - cloud training and interactive book for learning and practical work in C ++,
- Student's point of view about covid19 related changes

Furthermore, the questionnaire was answered anonymously by 86.2% of the total number of students who attended the lectures online. A summary of the research' conclusions, based on the obtained results, follows:

- Measurable satisfaction and acceptance of the complete transition to work via the Internet: from all students, only 16% said they prefer physical presence, as opposed to 84% of which 44% do not make a difference and 40% prefer online work, and even 74% are satisfied with the quality of digital communications and the Internet.
- Preferences for practising computer programming over the Internet using free access to content or personal accounts showed 84% of students, as opposed to 16% who preferred physical presence in laboratories.
- Impact of covid19 changes on the way of communication, the level of students' satisfaction and the overall educational needs, are positively evaluated: only 22% of students felt a decrease in quality, while 50% did not notice any changes, while 24% + 4% think that these improvements are very good, and should be maintained regardless of the covid19 situation.
- Opinion that smart learning technology facilitate the way of mastering the material, is an attitude agreed by 64% of students and 20% neutral, as opposed to only 16% with a negative perception.
- Students point out the benefits of using an interactive C ++ book in the following ways: 46% as a useful inventive form of work, regardless of the covid19 situation, 44% that the benefits are most prominent in covid19 situation, 26% as a resource replenishment, and 34% for downloading code for offline practice. (Students on this issue can make multiple choices)
- Asked about the overall evaluation from a personal aspect, on the transition to full online activities, 44% do not see significant changes, 38% see improvements, while for 16% of students, the teaching process is more difficult.

The multi-faceted analysis shows that, as a generation that spends a lot of time online, in front of the computer[2], the students are well-adapted to change and embrace new technologies for smart learning. Statistics show that the use of new technologies in computer programming contributes to better mastering of the material.

## 3. Smart learning technology for computer programming in practice

In the context of integration with the existing smart learning system, the new smart learning technology will be clarified from two aspects: through functional decomposition and through a practical demonstration of the upgraded options it offers.

### *3.1. Functional decomposition of smart learning technology for computer programming*

The developed technology for smart learning is based on customized open source solutions, which are functionally embedded in the already existing s-learning environment. According Figure 2, there are two main way to use it, marked as activity lines 1 and 2.

- Line 1: Access to smart learning technology, Selecting a working example, Compiling and Executing without any changes, directly on page, Displaying Results on Screen (Compiler Console) Optionally, downloading of working example, for future educational needs and offline use.
- Line 2: Access to smart learning technology, Selecting a working example, Option to change a selected example, by changing the code and input variables, by selecting Interactive mode,

Results on Screen (Compiler Console) Optionally, downloading of the selected and customized example , for future educational needs and offline use.

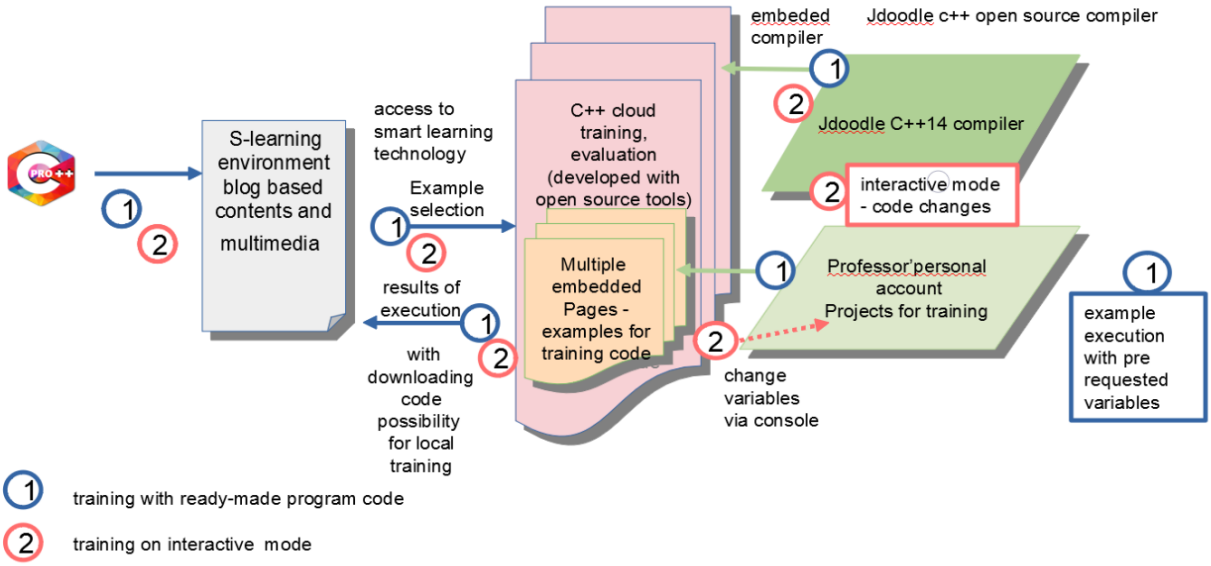


*Figure 3: Smart learning technology- functional decomposition*

Smart learning technology is conceived as an interactive book with C ++ ready to compiling and executing teaching examples. There is scalability and adjustment in the way it is used, according to the needs of the user. The "smartness" of this technology consists in the following functional features:

- A working example with a code can be accessed by multiple students at the same time, and each student can make individual changes to the code example in real time.
- Individual changes to the code made by students do not affect the initial working example. Despite the individual changes at work, the example remains in its original form given by the creator (professor), for further use.
- Custom settings allow online editing, compiling, and execution without the need for an account and system login
- The integration of the smart learning technology with the s-learning system enables the transition to personal work mode, and the possibility to log in to a previously generated personal account on iodoodle.

The described smart learning technology is completely based on open source solutions, and programming activities for embedding and customizing existing resources. The main challenge was to connect the various open source platforms with the new smart learning technology, in a way to became an integral smart part of s- learning environment.

### *3.2 Demonstration of smart learning technology' use in computer programming*

Executive Screens demonstrating the operation options of smart learning technology are shown in Figure 3, below. For traceability, activities will be explained by pointing to the numbers that mark the executive screens, (as parts of whole image).

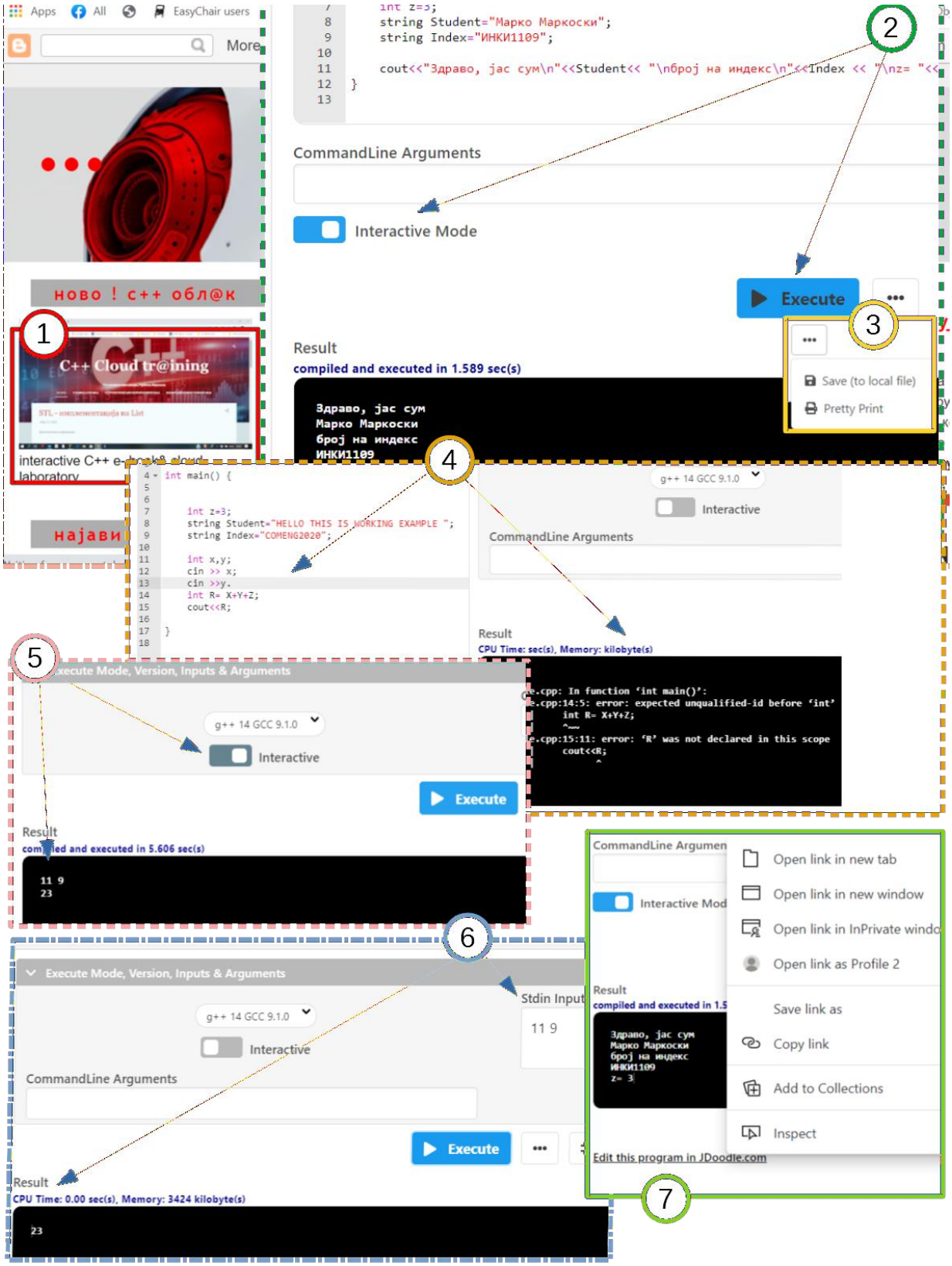


*Figure 4: Practical demonstration of the smart learning technology' options*

The main page, where is presented a pre-existing learning environment as a whole, contains the built-in link (1) of smart learning technology. The next window (2) gives the code from the called example. Depending on the needs, it is executed directly, or in interactive mode, input variables are entered. As mentioned earlier, there is a option to local download, (3) through options for saving locally or printing.The interactive mode offers the option to change the code, and different types of errors are possible (4)., which need to be removed. In this case, there are instructions on the screen to follow. When the modified code is ready for use, in interactive mode, the values of the variables can be entered during console execution (5) or before execution, with Stdin input option ( 6).Usually, if the working example is just executed without modifications, it is working on the basic screen of smart learning technology. In case of changes, it is configured to switch to the jdoodle service, (7 ) without the need to create an account.

**4. Conclusion**

Intense social changes are correlated with changes in the ICT environment. The imposed situation with the new reality conditioned by covid19, requires intensive adaptation of social living, which must be supported and enabled trough ICT solutions. According to the theories and practices of modern digital ecosystems, neither the largest nor the most equipped, but the most adapted to these new conditions, are progressing. Modern education, independent of the covid19 crisis, relies on the use of ICT solutions, following the habits of young people, to use computers and the Internet. Esspecilly, the smart learning technologies development and use, in this covid19 situation, is an imperrativ of sucsess and "surviving", because the great possibility of smart castomization and addaptation. The term "smart" can be considered as a series of choices and activities that are preceded by thoughtful analysis and backed by concrete results that achieve set goals. According to the given analyzes, the set goals, and the obtained results, the smart learning technology, described in this paper, has a factor of pronounced adjustment, compatibility with the learning conditions and correlation in the educational offers. It thus finds its place, both globally, within a modern and open digital learning ecosystem, with opportunities for wider application than the s-learning environment for which it was developed. As Einstein says, elegance is for tailoring salons, unlike science, where the same items are often considered and described from different points of view formally, repeating that in the descriptions of smart learning technology, certain functionalities were described and represented by different points of view. The term smart is not a privilege, but an obligation and aspiration for constant smart adjustments, in accordance with the changes in the educational environment.

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