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ALGO Initiative to Re-Invent Education

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ALGO initiative to re-invent education

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***Abstract*— Human beings do not stop learning methods to carry out the various works with which they can be confronted. By replacing the term Method with the term Algorithm, which is more precise, we recommend that the study programs can be completely oriented by algorithm to make study more efficient than before and upgrade to high level of education. This paper presents new methods of education based on algorithms to re-invent the Tunisian education.**

***Keywords*— Computational Thinking, Algorithm, Education, Wolfram Language**

I. Introduction

With the proliferation of the use of technology and humanity development, the need of searching for new types of development in all areas becomes very important such as the medical field, business, technology and the most important field the education, where this latter is the basis of the development of each country. The only interested solution for all problems is the integration of Computational Thinking in all areas such as Education. Where, many countries (1) have introduced computer thinking or as we call it Computational Thinking to all students. The United Kingdom has CT in its national curriculum since 2012. Singapore calls CT as “national capability”. Other nations like Australia, China, Korea, and New Zealand embarked on massive efforts to introduce computational thinking in schools.

As presented by Wing (2) that "if computational thinking will be used everywhere, then it will touch everyone directly or indirectly. This raises an educational challenge. If computational thinking is added to the repertoire of thinking abilities, then how and when should people learn this kind of thinking and how and when should we teach it?"

Based on Wing research, we intend in this paper to empower our Tunisian education based using computational thinking as the most effective solution in our education system. Firstly, we will focus on Higher University Education, make a new strategy of education based on CT.

Our paper begins with brief Introduction, then, we give an overview about computational thinking area, In section 3 we make an overview about Education problems and Issues, in section 4 we present our Tunisian Education, and in section 5 we present a higher education that is based on learning Algorithms, then in section 6 we present the benefits of learning algorithms and eventually we finalize our paper by a Conclusion.

II. Computational Thinking

According to JEANNETTE M. WING (2) the Computational thinking is taking an approach to solving problems, designing systems and understanding human behaviour that draws on concepts fundamental to computing. Also, Computational thinking is a kind of analytical thinking. It shares with mathematical thinking in the general ways in which we might approach solving a problem. It shares with engineering thinking in the general ways in which we might approach designing and evaluating a large, complex system that operates within the constraints of the real world. It shares with scientific thinking in the general ways in which we might approach understanding computability, intelligence, the mind and human behaviour.

In education (3), computational thinking (CT) is a set of problem-solving methods that involve expressing problems and their solutions in ways that a computer could execute. It involves the mental skills and practices for designing computations that get computers to do jobs for us, and explaining and interpreting the world as a complex of information processes.

A. What is a Computational Thinking?

From computational thinking site (4) the Computational thinking is a process in which you creatively apply a four-step problem-solving cycle to ideas, challenges and opportunities you encounter to develop and test solutions. The emphasis is learning how to take real-life situations and translate—often to programs—so a computer can calculate the answer.

- DEFINE: Think through the scope and details of the problem, defining manageable questions to tackle. Identify the information you have or will need to obtain in order to solve the problem.
- TRANSLATE: Transform the question into an abstract precise form, such as code, diagrams or algorithms ready for computation. Choose the concepts and tools to use to derive a solution.
- COMPUTE: Apply an appropriate level of computational power to the abstract form, be that modern

computers or mental agility, to obtain answers. Identify and resolve operational issues during the computation.

• INTERPRET : Take the abstract answer and interpret the results, re-contextualizing them in the scope of your original questions and sceptically verifying them. Fix mistakes or refine by taking another turn around the solution helix.

B. CT Characteristics

The characteristics (1) that define computational thinking are decomposition, pattern recognition / data representation, generalization/abstraction, and algorithms. By decomposing a problem, identifying the variables involved using data representation, and creating algorithms, a generic solution results. The generic solution is a generalization or abstraction that can be used to solve a multitude of variations of the initial problem. The "three As" Computational Thinking Process describes computational thinking as a set of three steps: abstraction, automation, and analysis.

Another characterization of computational thinking is the "three As" iterative process based on three stages:

• Abstraction: Problem formulation;

• Automation: Solution expression;

• Analyses: Solution execution and evaluation.

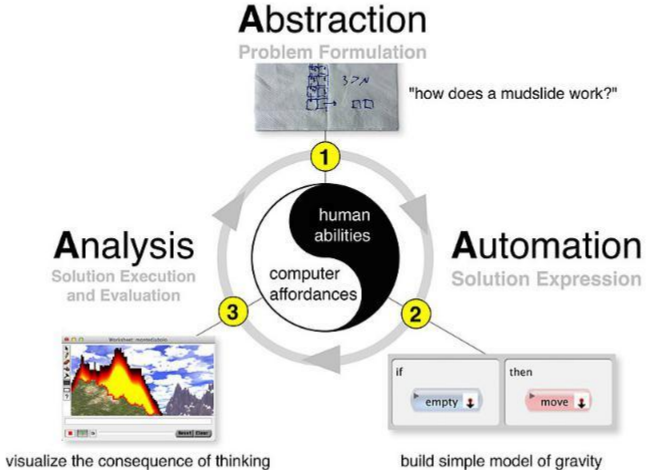

Figure 1: The "three As" Computational Thinking Process describes computational thinking as a set of three steps: abstraction, automation, and analysis(1).

C. CT Education

Charoula Angeli (5) addressed that there is a need for future research to assess the CT either as a holistic measure or as an array of subskills within the context of authentic problem-solving across all subjects and disciplines.

Thereby, she presented a five-step as a cycle plan about how these five research areas can be addressed in future research studies.

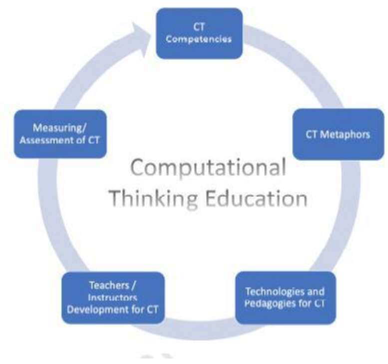

Figure 2: A five-step research plan for CT Education (5).

The first step aims to define CT competencies in order to provide a baseline and common language across different contexts about the concept of CT.

The second one is to create a powerful metaphor as a mechanism for transforming abstract CT concepts to more concrete and easier notions to understand.

The third step aims to research the effectiveness of pedagogies and technologies in enhancing and enabling the development of CT competencies.

The fourth is based on the crucial issue of preparing teachers and instructors to teach CT and integrate appropriate technological tools to enable the teaching of CT in their respective teaching contexts.

The last step created by Charoula Angeli aims to deal with the measurement and assessment of CT competencies, an area of research that is currently in its infancy.

D. CT for K-12 curricula

arr and Stephenson (6) reviewed that K-12 education today is a highly complex and highly politicized environment, where multiple competing priorities, ideologies, pedagogies, and ontologies all vie for dominance. Simultaneously, it is subject to wildly diverse expectations, intense scrutiny, and diminishing resources.

Thus they thought that embedding computational thinking in K-12 requires a practical approach, grounded in an operational definition. It requires that they begin with a set of questions focused specifically on K-12 implementation:

— What would computational thinking look like in the classroom?

— What are the skills that students would demonstrate?

— What would a teacher need in order to put computational thinking into practice?

— What are teachers already doing that could be modified and extended?

Tedre and Denning in (7) reviewed that the researcher "Seymour Papert" gave a "new vision of student-centered, project-based discovery learning using new technology where the vision was envisioned that computational ideas could serve learning in a broad variety of subjects, from Newton's laws to music and the most important is that the children or student can learn everything else". The idea of Papert was followed by many researchers, where they worked on emerging Computational Thinking in everyday activities.

In 1999, the K-12 courses has been occurred when the National Research Council published a report Fluency with Information Technology, which laid out an intellectual basis of a national education program that went beyond "computing literacy" by teaching capabilities, concepts, and skills. Tedre and Denning presented that many proponents of programming in K-12 education argued that learning how to pro-gram would have beneficial cognitive side-effects, such as rigorous thinking, understanding of general concepts, art of heuristics, generalized capability to "debug", problem-solving related metacognition, relativistic thinking, and epistemological commitment.

Integrating computational thinking (1) into the K-12 curriculum and computer science education has faced several challenges including the agreement on the definition of computational thinking. Currently, computational thinking is broadly defined as a set of cognitive skills and problem solving processes that include the following characteristics:

- Using abstractions and pattern recognition to represent the problem in new and different ways.
- Logically organizing and analyzing data.
- Breaking the problem down into smaller parts.
- Approaching the problem using programmatic thinking techniques such as iteration, symbolic representation, and logical operations.
- Reformulating the problem into a series of ordered steps (algorithmic thinking).
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources.
- Generalizing this problem-solving process to a wide variety of problems.

Where the Integration (1) of CT into the K-12 curriculum comes in two forms: in computer science classes directly or through the use and measure of computational thinking techniques in other subjects. Teachers in Science, Technology, Engineering, and Mathematics (STEM) focused classrooms that include computational thinking, allow students to practice problem-solving skills such as trial and error.

III. EDUCATION PROBLEMS AND ISSUES

The Education problem is around the world (8) " where it is facing a learning crisis. While countries have significantly increased access to education, being in school is not the same thing as learning. Worldwide, hundreds of millions of children reach young adulthood without even the most basic skills like calculating the correct change from a transaction, reading a doctor's instructions, or understanding a bus schedulelet alone building a fulfilling career or educating their children. Education is at the center of building human capital. The latest World Bank research shows that the productivity of 56 percent of the world's children will be less than half of what it could be if they enjoyed complete education and full health.

As a global learning crisis, the biggest reason of learning crisis persists is that many education systems across the developing world have little information on who is learning and who is not. As a result, it is hard for them to do anything about it. And with uncertainty about the kinds of skills the jobs of the future will require, schools and teachers must prepare students with more than basic reading and writing skills. Students need to be able to interpret information, form opinions, be creative, communicate well, collaborate, and be resilient."

IV. TUNISIAN EDUCATION

The crisis of education is not only in few countries but it seems also in Tunisia, where the crisis began from 2009/2010.

At first lets make an overview about Tunisian Education System.

A. Education System

Since gaining independence from France in 1956, the government of Tunisia (9) has focused on developing an education system which produces a solid human capital base that could respond to the changing needs of a developing nation.

Tunisian education begins from primary to higher university education is free, and it is structured as follows:

Basic Education: consists of nine years of school education and is divided into two distinct stages: 6 years of primary and 3 years of preparatory education (lower secondary). At the end of 9 years students sit for National Examination for the Completion of Basic Education, success in which leads to the Diploma of the Completion of Studies.

Secondary (upper) education: The four years of secondary education are open to all holders of Diploma of the Completion of Basic Education where the students focus on entering university level or join the workforce after completion. The secondary education is divided into two stages: general academic and specialized.

Higher education: Higher education (10) is divided into three levels, each leading to a degree as follows:

- Academic (Fundamental) and applied Bachelor degree: Holders of the baccalaureate get a Bachelor degree after the successful completion of three years of study. This academic training is equivalent to 180 ECTS (over six semesters). The semester includes at least 14 weeks of study and from 5 to 6 teaching units representing 30 ECTS.

- Academic and Professional Master training: Holders of a bachelor degree get a Master degree after the successful completion of two years of Master studies. The two years are equivalent to 120 ECTS.

- PhD: Holders of a Master degree (fundamental) receive their PhD when successfully finishing three years of research (equivalent to 180 ECTS) and defending their theses.

V. HIGHER EDUCATION BASED ON CT

A. Algorithm

The word "algorithm" comes from the name of the mathematician Al-Khwarizmi, who, in the 9th century, wrote the first systematic work on solving linear and quadratic equations. The concept of an algorithm is historically linked to numerical manipulations, but it has progressively evolved to apply to increasingly complex objects: texts, images, logical formulas, physical objects, and so on. An algorithm is a statement of a sequence of operations that allows one to find the solution to a problem.

Denning and Tedre (11) present and according to Donald Knith (1977)that " an Algorithm is a set of rules for getting a specific output from a specific input. Each step must be so precisely defined that it can be translated into computer language and executed by machine." Algorithms are the procedures that specify how the computer should do a job.

As presented in (3) "human activities may be assimilated to algorithmic executions. Asking a person to perform a work means giving him a specific algorithm to execute: the specification of the algorithm guides and measures its development and implementation."

Marah Altaher present in (3) that an algorithm is "Action (work, task, activity, process, stage) is necessary in many matters, and is done (accomplished, achieved, requested) by a specific body, in a specific context, in response to a specific specification, through the implementation (use, application, activation) of a specific algorithm (method, guide, approach). The specification identifies a specific issue (problem, question) related to a specific object (subject) to be transformed from a specific initial state (opening state, starting state, input state) to a specific final state (closing state, final state, output state) having a specific value for a specific reason (purpose, goal, objective)."

Marah (3) gave an example of planting Olive plant as an algorithm and she presented the steps of planting algorithm, this algorithm prove that human life is based on algorithm and every work he does is an algorithm. That's why in our paper, we intend to implement algorithm in education, where in place of learning many courses we will learn an algorithm in each lesson, then apply the learned algorithm using Wolfram language.

B. Wolfram language

To apply our contribution we aims to use the Wolfram language where as present wolfram in (12) that "learning the Wolfram Language is a bit like learning a human language. There's a mixture of vocabulary and principles, that have to be learned hand in hand. The Wolfram Language is immensely more systematic than human languages with nothing like irregular verbs to memorize but still has the same kind of progression towards fluency that comes with more and more practice."

The Wolfram Language (12) is a general multiparadigm computational language developed by Wolfram Research and is the programming language of the mathematical symbolic computation program Mathematica and the Wolfram Programming Cloud. It emphasizes symbolic computation, functional programming, and rulebased programming and can employ arbitrary structures and data.

The Wolfram Language (13) represents a major advance in programming languages that makes leading-edge computation accessible to everyone. Unique in its approach of building in vast knowledge and automation, the Wolfram Language scales from a single line of easy-to-understand interactive code to million-line production systems.

Also the Wolfram Language (14) is knowledge based: it knows about things in the world—like cities, or species, or songs, or photos we take—and it knows how to compute with them, and when you write in it, you're doing programming. But it's a new kind of programming. It's programming in which on's as directly as possible expressing computational thinking—rather than just telling the computer step-by-step what lowlevel operations it should do. It's programming where humans—including kids—provide the ideas, then it's up to the computer and the Wolfram Language to handle the details of how they get executed.

C. Learning based on Algorithms

Our basis work will focus on how to introduce algorithms learning in our education system.

As we presented in table 1, each level of higher university level have a set of algorithms to learn.

In License we have three levels, for Master we have two levels and three levels for Doctorat, where each level is divided on two semesters S1 and S2.

In student each semester, the student will learn an algorithm, So the student will learn at least 16 algorithms in his higher education.
We consider that S_A is the set of desired algorithms to learn.
$S_A = \{S_{AL}, S_{AM}, S_{AD}\}$
S_{AL} : is the set of Licence Algorithms.
$S_{AL} = \{S_{AL1}, S_{AL2}, S_{AL3}\}$.
Where $S_{AL} \geq 6$.
S_{AM} : is the set of Master's Algorithms.
$S_{AM} = \{S_{AM1}, S_{AM1}\}$
Where $S_{AM} \geq 4$.
S_{AD} : is the set of Doctorat Algorithms.
$S_{AD} = \{S_{AD1}, S_{AD2}, S_{AD3}\}$.
Where $S_{AD} \geq 6$.

Table 1:Algorithms learning for Higher education

<table>
<tr><td rowspan="3">Licence</td><td colspan="2">level1</td><td colspan="2">level2</td><td colspan="2">level3</td></tr>
<tr><td>S1</td><td>S2</td><td>S1</td><td>S1</td><td>S2</td><td>S1</td></tr>
<tr><td>A_{11}</td><td>A_{12}</td><td>A_{21}</td><td>A_{11}</td><td>A_{12}</td><td>A_{21}</td></tr>
<tr><td rowspan="3">Master's</td><td colspan="3">level1</td><td colspan="3">level2</td></tr>
<tr><td colspan="2">S1</td><td>S2</td><td>S1</td><td colspan="2">S2</td></tr>
<tr><td colspan="2">A_{11}</td><td>A_{12}</td><td>A_{11}</td><td colspan="2">A_{12}</td></tr>
<tr><td rowspan="3">Doctorat</td><td colspan="2">level1</td><td colspan="2">level2</td><td colspan="2">level3</td></tr>
<tr><td>S1</td><td>S2</td><td>S1</td><td>S1</td><td>S2</td><td>S1</td></tr>
<tr><td>A_{11}</td><td>A_{12}</td><td>A_{21}</td><td>A_{11}</td><td>A_{12}</td><td>A_{21}</td></tr>
</table>

To emerge algorithm learning in our education system there is many questions that would be in our minds, like:

- How to emerge the computational thinking in higher education?
- How to transform a course to algorithm?
- How could we get the same target of the course using algorithm?
- How could we insert Wolfram Language in learn?
- How could Algorithms change our life and our thinking?

The only answer is to use the algorithm package that Marah worked on it in (3).
K=(Q,S,R,A,B,T)

Q: first problem statement.
S: state of algorithm.
R: function to be performed by the algorithm.
A: the algorithm.
B: function performed by algorithm.
T: quality of algorithm.

Let's make an example of algorithm.

The student have to calculate the following derived function $F(x) = 3x^2 - 2x + 12$ and then to calculate F'(2).

To get the desired result, the student should calculate F'(x) and then F'(2).
Step 1 : calculate the derived of $3x^2$.
$3x^2 = 3 \times 2x^{2-1} = 6x^1 = 6x$
Step 2 : calculate the derived of 2x.
The derived of $2x = 2 \times 1x^{1-1} = 2x^0$
Where $x^0 = 1$, so $(2x)' = 2$.
Step 3 : calculate the derived of 12, where the derived of equal to 0. Step 4 : the final result of F'(x)= 6x-2.
Step 5 : calculate F'(2).

We have F'(x)= 6x-2, so we have to place x by 2 and calculate.
$F'(2)=6\times2-2=12-2=10$
So these five steps are an algorithm of calculating a function derived.

VI. BENEFITS OF LEARNING ALGORITHMS

Using computational thinking in learning or algorithmic education, the teaching method will provide a learning opportunity for both the teacher and the student, such as the teacher will prepare lessons as algorithms where the student can apply it in several issues such as in education or in normal life.

Learning algorithm is not just based on mathematics or physics/chemistry but it could be integrated in all fields of learning such as philosophy, learning arabic, geography, history ...etc.

Learning algorithms means learning a new ways of thinking, new ways for solving several problems, new way to live and get many personal opportunity like be more confident than before.

VII. CONCLUSION AND FUTUR WORKS

Teaching and learning Computational Thinking is a right for everyone in anywhere from primary schools to higher education. Many researchers have worked on integrating this field into education with the goal of improving it. One of the most effective ways to enhance the learning system is to teach students how to think and how to solve various types of problems, whether in education or in everyday life. Therefore, we incorporate algorithm learning, where each course becomes an algorithm to be learned, allowing students to acquire the knowledge and apply the learned algorithms to similar types of problems.

In this paper we made an overview about computational thinking, its characteristics and we address the use of CT in education by some reviewers, then we intended to the problems of education and we presented our Tunisian system for education. Then we grant our new system of education which is based on learning algorithms in place of learning courses while preserving the contents of the courses.

As a future work we intend to work on integrating the CT in Tunisian education system in the education from primary schools to higher education, and we will work on creating a bibliography of algorithms packages to be learned for everyone.

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