Algorithms and well formatted texts: Introducing Computer Science Activities in Lower Secondary Schools

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Abstract. In order to raise awareness on computational thinking among teachers in our lower secondary school, we started a collaboration with university (Università degli Studi di Milano, Computer Science Department) for a training. We invited a team of computer scientists in all our 6th and 7th grade classes asking them to carry out an unplugged activity with a computer based final task (called 'algomotricity'). The aim of the project was to engage pupils in a computer science activity, but even more important was to show teachers the potential of informatics for a computational thinking approach in math and science. We got positive results and teachers expressed their interest. Over the next year we hope to continue this effort to gradually improve teacher self-competence, enable them to give the course themselves and gradually build up a new curriculum for mathematical and scientific area.

1 Introduction

During the last decade, Italian teachers have been urged to teach computer science, even if the subject was not (and is not yet) part of a general purpose curricula and there are no specialized computer science teachers in non-vocational schools (A recent survey of the Italian context appeared in [2]).

Thus, this urge was mainly confused with the use of office automation tools, Internet browsing and other communication facilities. Or, even worse, it was wrongly understood as the introduction of digital technologies in the teaching process, such as the adoption of the 'Interactive Multimedia Board' (IMB), [1] Maths and technology textbooks introduce computer science mainly explaining how to use MS Word and MS Excel and teacher training often focuses on the use of applications rather than on the educational aspect of computational thinking. In fact, this misinterpretation of computer science is so common [8]that the term *"applimatics"* was proposed in [3] to distinguish the use of applications and digital technologies from *"informatics"*, the actual scientific discipline. As pointed out by several authors in informatics (for example [6], [7])computer

[1] The Italian Minister of Education proclaims to have distributed 9'000 IMBs, on a total of 11'234 requests[5].

science has the potential to foster important scientific skills such as problem solving, creative and critical thinking.

In recent years, efforts aimed to expose young people to programming and computational thinking have been made and they are spreading in several countries, including Italy. An example is the Coderdojo initiative[2]where pupils are engaged in programming activities with a mentor who introduces them to the Scratch [3] visual programming language. Often these activities are proposed to pupils in a context where they can behave creatively, partially in contrast with the more formal classroom rules. Collaboration and creativity are encouraged and pupils are invited to exchange information and ideas. Coderdojos, however, are thought as extracurricular activities and they seem not to fit well in our school environment.

Last year a project called'Programma il futuro'[4], designed to be introduced in school, was launched. The project is the Italian version of the 'Code.org' initiative[5] and aims at introducing computer programming in school with the explicit goal that *"Every student in every school should have the opportunity to learn computer science"*. In fact, the main emphasis is on 'coding', on programming.

Thus, with the the dual objective of exposing our pupils to programming and computational thinking and to promote teachers' autonomy and improve our skills to deliver computer science activities in our classes, we started a collaboration with the team specialized in computer science education of the University of Milan (ALaDDin, [6]) who proposed entry-level labs. This paper reports this experience that involved two aspect of informatics: algomotricity (Maze workshop) and digitally formatted texts (Wikipasta workshop). Maze workshop was chosen for 6th grade pupils and Wikipasta workshop for 7th grade pupils.

The algomotricity strategy developed by the ALaDDin team was meant as *'a strategy that focuses on algorithmic concepts through motoric activities, which imply a mix of tangible and abstract object manipulations'*[4]. Maze workshop shows the core of computer programming with no particular interest in the syntactic issues aiming instead to develop problem solving and computational thinking related competences[4]. Starting with the development and discussion of pseudo code, pupils are led to understand and to formulate an algorithm defined as *"an effective procedure to reach, in finite time, a goal"*[4] . Algorithms, intended as detailed sequences of steps based on a number of given conditions are actually quite common in other discipline such maths, although during the teaching activities these are not explicitly declared as such, and no emphasis is put on the underlying computational thinking process.

An additional issue that we wanted to introduce in lower secondary school is the concept of 'digitally formatted texts'. One reason is that our pupils will be writers of digital texts in the future (if they are not already). Traditional and

[2] `https://coderdojo.com/`. In Italy: `http://www.coderdojoitalia.org/`.
[3] `https://scratch.mit.edu`
[4] `http://www.programmailfuturo.it/`, "Program the future".
[5] `https://code.org/`
[6] `http://aladdin.di.unimi.it`

digital writing are totally different processes with completely different rules (and tools, of course). A personal computer allows the processing of well formatted and accessible texts, provided that one can properly use it. We cannot continue to use a computer as a typewriter, completely ignoring the basics of the mark-up languages. In order to change pupils mental model of formatted texts and to introduce them to the idea of mark-up languages we asked the ALaDDin team to work in our 7th grade classes with their Wikipasta workshop, which they developed with this goal[1].

2 The Context

The project involves the lower secondary school in the context of a school that includes primary school (40 classes) and lower secondary school (27 classes). The lower secondary school is distributed in three different buildings. With an average of 20-25 pupils in each class, the lower secondary school has about 550 - 650 students. For 27 classes, nine maths and science teachers are required. Each teacher gives 2 hours of science lessons and 4 hours of maths lessons in a week per class. Usually, a maths and science teacher teaches in one 6th grade class, in one 7th grade class and in one 8th grade class for a total of three classes.

In the lower secondary school 9 classes have an IMBs (the already mentioned 'Interactive Multimedia Board'). Interactive boards are located in all the 8th grade classrooms (9 classes) to allow all the pupils to take advantage of this technology at least in the last year of lower secondary school. A survey carried out two years ago revealed that about 40 per cent of the teachers working in IMB equipped classrooms used them during their lessons. The IBM is appreciated by both teachers and pupils. Some teachers prepare lessons for IMB, but most of them use it for video or pictures. Over the last year, three of us adopted the Edmodo virtual class [7].The IMBs have been quite useful to connect to the virtual class and discuss with pupils their digital homework at school showing the outcome.

There are three computer labs, one for each building, but they are rarely used because of the nonfunctional infrastructure. Computers are too few, too old and too different to be used for teaching activities with a whole class.

Some of us show to be interested in informatics rather than *"applimatics"* and spontaneously followed specific workshops on computational thinking. Two of us spontaneously participated in a workshop that the ALaDDIn team organized about *'algomotricity'* and Maze in the Museo Nazionale della Scienza e della Tecnologia Leonardo Da Vinci in Milan in the year 2013 .

In 2011 two of us also participated in *"Progetto EST"* about Robotics, again organized by Museo della Scienza e della Tecnica Leonardo Da Vinci but could not integrate the project in their own curricula in the following years. Some interest for programming is evident but occasional.

For the project we are discussing here we focused on 6th and 7th grade pupils for a total of about 400 pupils and their 9 maths and science teachers.

[7] `www.edmodo.com`

3 The Project

The aim of the project is to improve our (teachers') skills and to help us to look at informatics with new eyes and reconsider the computer science as an interesting matter, whose concepts could fit in maths and problem solving rather than the use of applications such as MS Word, Excel or Power-point. In the future the goal will be to integrate computational concepts in our maths and science learning activities. The objective is also to teach teachers and pupils to write well formatted digital texts.

With the ALaDDin team we have chosen two of their proposals: Maze for 6th grade pupils (nine classes) and Wikipasta for 7th grade pupils (again nine classes).

3.1 Maze and programming

Maze activity introduces pupils to programming. The ALaDDIn team explain their Maze workshop and ensuing results in the article to be published in ISSEP in the current year[4]. Here it is shortly resumed: in Maze workshop pupils work in groups and are asked to write a pseudo-code program to drive one of them (the robot) in a maze built by chairs and tables. The workshop starts with an unplugged activity and ends with a computer activity where pupils program using a Scratch derived environment. The ALaDDin team showed us their *"algomotricity"* method based on kinesthetic learning activities. In their activities computers and software tools are of secondary importance but the link between unplugged activity and the use of technology is clear. As the ALaDDin team explained it in [4]:

> *"Maze workshop proposes a little real problem. Students need "to formalize" it, they must find their own way to a solution, not just code a predefine one. Thus the activity works on the interplay between algorithms and programs. When the pupils drive a blindfolded mate with a finite numbers of instructions, they reason on what is effective and feasible: and the power of the interpreter is in large part a choice they explicitly do. Moreover, after the pupils themselves have checked that their problem solve the task, when they compare it with others' programs, they discover that some of the assumptions they made are not valid in the slightly different context of the other teams' settings. [...] AlMa (Algomotricity and Maze workshop) aims at giving the students a meaningful problem to be explored in an open context. We provide just a few restrictions designed to support their own inquiry. [...] The open-ended activities proposed in AlMa, indeed, encourage the participants to formulate original ideas. Moreover, the team setting forces the pupils to convince the other mates that their proposals work correctly: they need to describe them properly and devise a way to show the correctness of their hypothesis. Thus pupils happen to put into practice and experience the "scientific method", even though they usually are unaware of this fact."*

3.2 Wikipasta

In 7th grade classes ALaDDin team presented their Wikipasta workshop. This activity aims to make pupils understand the meaning of formatted text pointing at mark-up languages but without talking about it. A methodology similar to Maze, based on unplugged and computer activities, was adopted. Also Wikipasta workshops have been organized within maths and science lessons. When we read or write a text on paper we can easily recognize functional part of the text such as the title, the paragraph, an ordered list, a figure, etc. thanks to graphical effects. The title usually is centered, colored and has bigger characters that make it distinguishable from the paragraphs. An ordered list is clearly identified by numbers before each sentence. When we asked ours pupils to identify the different part in a text and to explain their meaning they had no difficulties in explaining the function of the title, ordered list, figures and so on. They perfectly recognized the important informative role of a formatted text. But, while on paper formatted text and its content are merged, in digital texts these are two separate pieces of information. Using cheap materials (pasta, colored buttons) and a paper with a text without any formatting information, the ALaDDin team proposed an interesting game that enabled our pupils to understand how in digital texts content and formatting information are separately managed. They asked to format a text using pasta and colored buttons. Afterwards they understood that, adding a legend, they could effectively send formatting information separately from the text itself. Later, as explained by the ALaDDIn team in [1], they discovered the use of tags:

> *"Teams were again requested to reproduce a formatted text with objects and write down codifications rules precise enough to be followed by another team. However the game was made fun by the introduction of a "cost" for the objects. In fact, the more an object could be used to mimic a piece of formatting , the more it cost in order to promote its* symbolic *use, e.g., since spaghetti pasta could be easily associated to* underlying*, its cost was very high. The winner would be the team able to hand in an unambiguous codification with the lowest cost. The cost incentive was enough to let the pupils discover what is commonplace in mark-up languages: the use of tags at the beginning and at the end of (possibly overlapping) regions".*

In Figure 1 and In Figure 2 we can see two products from the Wikipasta workshop before and after telling them the cost of pasta and buttons.

The Wikipasta workshop allowed us to introduce the basics of HTML language in one of the 7th grade class during science lessons. At the end of the course most pupils succeeded in preparing a single web page using the main HTML tags and some pictures about their scientific experiences. The activity is described in the poster session (From Paper to Web Pages - Some Help from PirateBox) here at ISSEP of the current year [9].

In Figure 3 we can see the first web page that the teacher showed to pupils to identify the functional parts of the document. In Figure 4 we see the same

Fig. 1: wikipasta1

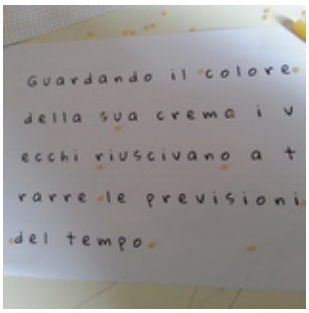

Fig. 2: wikipasta2

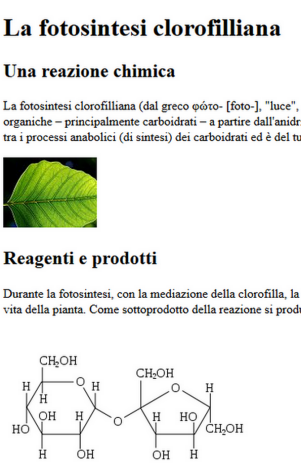

Fig. 3: web-page

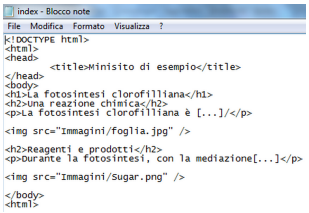

Fig. 4: html

page written in HTML with a text editor where pupils started identifying the symbols used instead of pasta and colored buttons.

4 Feedback and Results

The ALaDDin team prepared questionnaires to evaluate the impact of their Maze activities. Each pupil answered the questionnaires at the presence of their maths and science teachers. The ALaDDin team also organized a focus group with a sample of students from each class. The AlaDDin team examined and analyzed them for their academic research and publications [4]. From informal talks with students we can report that most pupils were enthusiastic and enjoyed the activities, which have been described as interesting and fun. It looks like most of the pupils changed their previous idea that informatics is just word processing and web browsing. We (the teachers) observed that also pupils with special educational needs enjoyed Maze and Wikipasta workshops. Thanks to the setting and the methodology adopted by the ALaDDin team, they could actively participate in the working group with their own contribution. Some of us teachers asked pupils to summarize the experience with the ALaDDin team on paper and they all confirmed the positive feeling of their teachers, including those with special needs. Most of them, in fact, wrote that they enjoyed the activities, mainly because they succeeded in actively participating and interacting with their peers. In their reports on the Wikipasta workshop, pupils showed to have understood digital formatting rules using tags (pasta or special symbols) and expressed their interest both for the content and for the setting of the proposed activities. Our post-course talks showed that we appreciated these activities too. We are a bit worried about class management and felt not yet confident to autonomously face informatics concepts the ALaDDin team proposed. We appreciated the involvement we observed in our pupils and also understood what informatics could really mean when intended as computer science instead of simple use of applications or communication tools.

5 Discussion

The collaboration with the ALaDDin team has been fundamental to understanding programming and formatted text topics. We all, Maths and science teachers and pupils, could taste what informatics should be: a computer science related with problem solving as well as creativity without the need for any specific application. In spite our interest, some of us felt not to be yet ready to continue the activities by ourselves. A training thought just for us would be required before, during and after workshops in the classes. A stable collaboration with informatics specialists from universities interested in the educational aspects of computer science would be essential to help us integrate *"informatics "*(not *"applimatics"*) in our curricula. The Maze workshop would be a perfect starting point to introduce an interactive way to teach and fostr computational thinking, involvement and creativity. Some maths and science contents could be presented using the

ALaDDin "algomotricity" strategy of learning. As an example we tested the procedure to calculate the surface of different "every day" objects like shoe-boxes, a tube of tennis balls, etc. (this was the given problem). Working in groups, pupils were invited to identify a way to calculate the surface of the object they chose, define the strategy they adopted and describe it to mates. These activities have just begun, but a strong involvement was observed in pupils making their own hypothesis, testing it with their tools (scissors, ruler, pencils ...), trying to formalize a description to convince mates their strategy was good. As already mentioned "Thus pupils happen to put into practice and experience the *scientific method*, even though they usually are unaware of this fact". This involvement in the manipulative activities was important to stimulate pupils curiosity and interest when we proposed them the usual formula for geometry area calculus. In addition, the Maze workshop could introduce pupils to programming using, for example, the Scratch visual programming language. An important question to be asked is when this can be done. Taking time from the 6 hours dedicated to maths and science contents? Which contents could be considered to be equivalent to a programming activity? And how? Can this activity be integrated in the maths and science curricula?

Another important concept about informatics would regard digitally formatted texts. In a summary a pupil wrote:"During the Wikipasta workshop we understood that in a document we wrote two different information: meaning and formatting. Computers use different symbols to send this two pieces of information". We think this is a fundamental concept to teach about digitally formatted texts. This mental model is essential in order to write well formatted texts. This allows such text to be accessible in different ways to people, including those with some disabilities, like, for istance, blind people that use screen readers or other electronic devices to read a text. We chose to show them the basis of HTML language for different reasons: first, pupils told us that they mainly use PC to browse the internet and read web pages (other then for videos, musics and video games); second, it is a mark-up language that perfectly fits in the Wikipasta workshop; third, only a text editor and a browser are required to write and read a web pages without facing the problem of using a specific word processor.

6 Conclusion

The project described here focuses on two aspects of informatics: programming and formatting digital texts. To introduce them in our lower secondary school we started a collaboration with the ALaDDin team specialized in computer science education of the University of Milan. The aim of the project was twofold: to introduce informatics concepts to pupils and also to their maths and science teachers. Both pupils and teachers have been faced with a new vision of informatics and expressed their interest. The project has been summarized in the last teachers' board and was approved for the next year. This project has no focus on specific computer applications but on the science of computer itself. Informatics is not yet a discipline in the lower secondary school but we think that many

informatics concepts regard also maths and science skills like problem solving and scientific method, which could be integrated in our curricula.

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