METHODS IN COMPUTER SCIENCE EDUCATION IN HIGH SCHOOLS

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Abstract

The objectives of this work study are to explain how new technologies can help students learn in a better way.

Being a computer science teacher since 2000, I noticed a considerable change in teaching this subject.

This change is not only due to technology that moves on faster but also to the way students think and study.

Teaching has changed from school of Knowledge to school of Competences.

What are competences?

They show the capability to use knowledge and skills in a specific context combined with personal, social, and/or methodological abilities in certain state of work or study or in professional and/or personal development. All the competences give the power to be autonomous and responsible.

Teachers have to help students to develop their competences using individual knowing and skills.

Nowadays students use technology every moment of their day and they spend a lot of time on videogames both on console or mobile devices.

So, teachers can teach Computer Science (but not only Computer Science subject) with the help of games, platforms and devices that make studying more fun.

I use online platforms in which I can build games to make studying easier. These are very helpful with young students and older ones, especially in learning more difficult topics like networking, client-server programming or high-level programming languages.

Students can use their mobile devices (Bring your own device BYOD) to interact with teachers and schoolmates and studying becomes easier.

Arduino and Raspberry Pi have been really useful to teach difficult or abstract concepts in a practical manner.

I let the students use these devices to build what they imagine so they learn different subjects and work in groups that is fundamental today.

I noticed that when teaching with online games platforms and Arduino and Raspberry it is possible also to promote the integration of students with special needs (special needs students: SN students) students into the regular classroom.

In conclusion I think that with these new tools teachers can help students not just to learn but learn to know, learn to do, learn to live together, learn to be.

1 INTRODUCTION

Since year 2000 I’ve taught a branch of computer science focused on computer architecture and networking. I teach in the last three years of a technical high school in Italy. I noticed a big change in the students’ attention. They tend to be distracted and they lose their attention in a short time.

In the last four years I’ve changed my way of teaching.

I focus my teaching on enhancing attention and curiosity in my students.

I want them to be curious and interested to know.
Curiosity is the only way of learning and to develop competences using individual knowing and skills. This is the reason why I use video games, mobile devices, drawings, maps and everyday life items to explain difficult topics.

I use these tools specially when students start to study more specific and more difficult topics. These tools are useful also with older students, particularly for SN students.

2 METHODOLOGY

E-learning as a methodology is useful because it offers the possibility to teach and learn from the internet and in a very easy way, but I think that students need more, so I mix the use of e-learning, books, computers, everyday life items.

I try to keep the students focused during all the lesson.

My goal is to help students build their own competences, from knowing in a light and funny way, when it is possible, and taking in account of individual skills of each student.

I construct every learning unit with different steps.

Usually I start with a sort of brainstorming, asking the students a question. Then they talk together trying to answer the question. Finally, we discuss together, we fix the topic, and have a kind of warm up on the topic. This is fundamental if in the class there are SN students, because they can express their opinion without fear, and feel equal to the other students.

During the lesson we see, touch, assemble or disassemble something. This part is important to understand that theory and practice are two sides of the same coin.

Second step is to design a mind map in which the students write terms and concepts related to the topics using free tools available online, like Bubbl.us [1]. These tools help the students better understand, fix and remember ideas.

The students also create word clouds to remember technical terms in an easy way [2]. The word clouds can be created in group or by an individual student.

At this point, third step, the majority of the students is focused on the topics and I can start with the real technical lesson and make something practical with Arduino microcontroller [3].

An interesting platform useful with the class is Tinkercad.[4]

Tinkercad is a free online collection of software tools that helps people think, create and make.

In Tinkercad platform there are a lot of interesting examples with Arduino in which students can create circuits just drawing them and simulate them in real time. They can change components, and components value just writing a new value and the drawing will change. The students can write the code they want to load into Arduino memory, they can see the code also in block form.

The use of this platform is to make the students able to build and simulate circuits without having a real one. The following pictures show some Tinkercad screen shots for a simple project (blinking led).

Fig. 1 shows how the circuit is represented with Tinkercad, fig. 2 shows the circuit program in blocks, in fig. 3 there is the program both in blocks and code, fig. 4 represents the circuit and the code. When students use simulation mode they can control if the program is correct, otherwise the program does not run, can correct it, and see the simulation in the same way as with a real Arduino.
Figure 1. Arduino circuit using Tinkercad [1].

Figure 2. Arduino circuit with program in blocks with Tinkercad [1].

Figure 3. Arduino program in code and blocks with Tinkercad [1].
Then I teach the student how to use Arduino Integrated Development Environment (IDE), so they can write programs to control sensors and use the mobile phone to create apps to interact with Arduino.

Making a project with Arduino [3], or other microcontrollers helps smart and SN students to create something of their own: smarter students will create more complex products and SN students will create simpler ones, but everyone will be proud to have made something by themselves.

This part is very important for different reasons:

- Integration: often smarter students help the weaker ones and sometimes it is amazing to observe how patient and how good some students are in teaching to the others.
- Self-esteem: it is important to improve students' self-esteem, in particular when they proudly show their work to the class.
- Promoting exceptional students: the best students will realize very interesting projects.

Fourth step. At the end of the learning unit I usually create quizzes, tests or games with the help of online platforms such as Learningapps [5], in which you can create quizzes or games, or Mentimeter [7] in which you can see students answers in real time on an Interactive White Board (IWB).

Last step is a classical written test with open and/or multiple choice questions, in which I can understand the different levels of comprehension for every single student.

How much time do you need to develop a learning unit in this way?

It depends on the topic, on the class and on the number of students you have.

In general I use this way of teaching at the beginning of the year, when I need the students to fix fundamental topics of the subject.

I found that creating the first unit of the school year, gives the possibility to have enough material for the following learning units, because from every single part of it, for example just expand the mind map created for that unit, it is possible to explain the following topics until the end of the school year.

The following example shows my typical learning unit.

Reference school is a Technical high school (referred to Italian school system), third year, students age 16-17, topic is “computer architecture”.

First step: brainstorming.

We usually have no more than one computer in the class, so, how can I speak about computers?

My question for brainstorming can be “where is your computer?”

The class can be a little stunned when I say: you have one in your pockets. Yes, because a lot of young people (not only young) don’t think a mobile phone can also be a computer.
Students start thinking about a mobile phone as a computer and write a list with the characteristics that let a mobile phone be a computer. Every student, also the ones with special needs, has a mobile phone, so it is an easy way to start the lesson.

If there is no possibility to work with mobile phones, we can do the same with videogames consoles, but instead of writing the characteristics of different kind of consoles in class, they have to do this at home, then discuss it in class.

My students and I prepare a table in which they can insert various characteristics of the different mobile phones models they have, and their values, like the one below:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>…</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>Storage</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>

To complete a table, often student have to run a search on the internet and read and compare different types of technical sheets.

After completed the table, I explain the meaning of the terms in the table. Some are very simple, like Random Access Memory (RAM) and others more difficult. I also explain the unit of measure, when there is one. Then I can show the class some electronic items like memories, wires, electronic components that are in a computer and in a mobile phone (in an integrated form).

Second step: students, in group, design a mind map (fig.5) of the concepts they have listened, and a word cloud (fig 6) like the following:

![Figure 5. Mind map example: computer terms ad concepts [1].](image)

![Figure 6. Word cloud example with computer terms [2].](image)
Third step: I can explain the topic in detail using the term and concept they learnt before, like what are pixels, resolution, network standards, measurements units and so on. I often use Tinkercad [4] and Arduino platform [3], to build an easy project, in which students can connect what they have learnt in programming, networking and basic electronics.

This practical part is very important because it gives the possibility to make something real to every student: the smart ones and the special needs ones. I have a lot of success with this section, that is very practical and fun. Students have to learn many different information to build something, and they learn without thinking that they are studying.

Then the class and I decide a day in which every student (or couple of students) present their work to the class. This is fundamental to learn to speak to the public. Every student becomes able to explain his work to the others and he is very proud of this.

Fourth step: Checking what students learnt. Before preparing a written test I make some games and quizzes for a fast verification using Learningapps [5] and Mentimeter [7].

In the following figure (fig.7) there is an example of a game created with Learningapps. In the reference there is the link to the full game [6].

![What is another word for the CPU?](image)

Figure 7. Millionaire game [5][6]

Using platforms like Mentimeter [7] I can keep the students’ attention, because they have to answer to a question in a fixed period of time and in real time they can see how many people are answering the question and at the end they can see the winner.

Fig.8 shows an example of a game made with Mentimeter:

![Checking a computer program for errors is called?](image)

Figure 8. Mentimeter example [7]
To answer the question students have to join the site with their mobile phone using the code written in the upper side, read the question and the answers, then in bottom left they see the remaining answer time and in bottom right they see in real time, how many people have answered. In the end they see the winner(s).

Both these platforms make the lessons more interesting and funnier and are useful if I see reduction of attention.

Last step is a traditional class work on paper useful to prove the understanding of principal concepts students have learnt.

The final class work can be open and/or closed answers. Generally I write the mark near every question so the student can calculate final mark if they answer in the correct way.

In the fig.9 there is an example of class work:

```
Name of the School

Written test
Teacher:

Date: ...
Class: ...
Surname: ...
Name: ...

You have 3 open answers questions. the answer must be no more than ... lines long
Every correct answer gives you ... point.

1) Question 1?

2) Question 2?

3) Question 3?

You have 3 multiple answer question. Every correct answer gives you ... points. No multiple answers allowed:

1) Question 1
   A. Answer1
   B. Answer2
   C. Answer3
   D. Answer4

2) Question 1
   A. Answer1
   B. Answer2
   C. Answer3
   D. Answer4

3) Question 1
   A. Answer1
   B. Answer2
   C. Answer3
   D. Answer4
```

Figure 9. test example

### 3 RESULTS

Every year I have interesting results in terms of attention, comprehension, knowledge, skills and competences, also if there are always differences between individual students depending on personal skills.

Starting with almost 40% of interest at the beginning of a learning unit, after the first step the attention has a huge increase that remains high in the second step and arises to more than 80% when students have to build something by themselves and to do this, they have to think a viable project, read technical papers to understand what kind of materials they need, find the right materials. Fourth step is important to arise the attention and helps the students to fix important concepts of the learning unit.
4 CONCLUSIONS
School is changing very fast. Students are changing faster. They way of learning is changing.
Teacher has to find every day something to make lessons interesting and capture the attention of the students. Teachers have to help students to learn and want to learn more. I think this is the key to have more curious citizens.

ACKNOWLEDGEMENTS
I want to thank my kid Sydney for support and assistance during the writing of this paper.

REFERENCES
[5] Learningapps - free online application used to create interactive module for easy learning. Retrieved from https://learningapps.org/