Do not ask what Instruction-following Large Language Models can do for teaching

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Abstract

In this paper, we want to explore how and if the Italian School System has adapted to the evolution of the machines that are replacing humans in many repetitive cognitive tasks. Indeed, Instruction-following Large Language Models are only the last evolution in this trend of replacing activity. Calculators, symbolic equation solvers, information retrieval engines, and much more have appeared during a long period. Many reforms of the Italian School System have been approved during this period. We show that this cognitive evolution of machines has yet to be completely taken into account in the different reforms. Finally, we propose a possible novel route to investigate how to take into account that machines can help humans in repetitive cognitive tasks.

Keywords

Large Language Models, Cognitive Tasks in Machines, Italian School System

1. Introduction

Students are right when they cheat. Indeed, everyone *"cheats"* in the student sense during the normal working routine. It is commonly accepted. When cheating during exams, students are only simulating their normal use of the knowledge resources and tools during their working life.

Years ago, students cheated by using small hand-written notes carrying relevant information and, for the braver, by using textbooks. During exams, students were exactly doing what was done during a normal workday: consulting notes and specialized texts. The needed capability was to search and select what is relevant among physically available books and personal notes, which may be stored on shelves near the desk. Occasionally, additional information can be retrieved in libraries. The required skill was to know that some additional information may exist and then be able to perform the search.

More recently, students' cheating ability has been largely improved by small devices that allow them to access the complete available knowledge as they were workers at the desk who are improving their ability by using a desktop computer - nothing that is forbidden in real working life. This is the information retrieval age.

Even asking someone else to perform the task for you – the apparently worst form of student cheating - is a commonly accepted working practice: *consulting*. It is true that *consulting* is expensive, and it should be used only when definitely necessary. In this case, the required skill is to be able to understand whether the cost represents the added value in the current job.

Today, Instruction-following Large Language Models (IFLMs)[1], [2], such as the notorious ChatGPT, may play the consultant role, and thus, these models are *democratizing* access to consultancy. These IFMLs can solve the task for you using the body of knowledge available in the information retrieval era and relieving workers and, consequently, students from the burden of selecting relevant information and aggregating a response. This is the age of large language models.

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Indeed, wherever there is physical or cognitive repetitiveness, machines can do a better and faster job than humans. Taylor captured physical repetitiveness and transformed the way of producing physical goods. Taylorism \cite{Tailorism} combined with machines has reduced the required workforce in industrial production processes focused on producing physical goods. Indeed, Taylor had the idea to reduce complex production processes into more straightforward, repetitive tasks. Hence, dedicated machines at first and general-purpose programmable robots later have taken these simple repetitive tasks and replaced workers, shrinking the workforce needed for producing goods. Along with algorithms and knowledge representation, computers – or artificial intelligence – are conquering tasks with cognitive repetitiveness. This is an opportunity and a compelling challenge for the school system.

In this paper, we want to explore how and if the Italian School System has adapted to the evolution of the machines that are replacing humans in many repetitive cognitive tasks. Indeed, Instruction-following Large Language Models are only the last evolution in this trend of replacing activity. Calculators, symbolic equation solvers, information retrieval engines, and much more have appeared during a long period. Many reforms of the Italian School System have been approved during this period. We show that this cognitive evolution of machines has yet to be completely taken into account in the different reforms. Finally, we propose a possible novel route to investigate how to take into account that machines can help humans in repetitive cognitive tasks.

2. Machines and the conquering of cognitive tasks

Machines have been always invented to help humans with tedious, hard, repetitive tasks or to empower humans with superhuman abilities such as flying. The first tasks that have been automated are physical tasks such grinding the grain but the idea of automating also cognitive tasks such as adding numbers dates back in centuries.

In these days, technology is overwhelming and many cognitive tasks can be automated at least partially. Then, the compelling question is why young humans should learn to do these repetitive cognitive tasks?

In this section, we analyze how the evolution of the machines conquered cognitive tasks to try to understand what humans should learn to do since they are relieved from repetitive cognitive tasks.

2.1. Calculators in Our Pockets

Basic calculus has been and is one of the most important abilities thought in primary school. It is a must for human beings to understand numbers and how they can be combined by using simple operators like sum, subtraction, multiplication, and division. This is the basis for living a life with numbers that may represent value – money – or quantities in the real world. Basic operations are then used to build more complex calculus operations in later stages.

After a first, small period of understanding the basic ideas around numbers, nearly five years of the fresh minds of young children are forged to become executors of the calculus algorithms of the sum, the subtraction, the multiplication and, then, the division that is more complex. These young minds are rewarded for their ability to perform the repetitive task of executing stable and well-known calculus algorithms. Teaching future adults to perform basic, increasingly complex computations is one of the primary goals of primary school.

However, since basic calculus is a repetitive task, the attempt to automate it dates back prior the advent of electronic computers. Between 1642 and 1644, Pascal used gears to build the first arithmetic machine, which was able to sum two numbers up to a given length. Electricity has pushed these machines to the ability to solve multiplications and divisions. In the late '50, Olivetti's Divisumma combined mechanical parts with electromagnetic components and offered the possibility to reduce the burden of computation. These machines were already faster than average humans to perform basic calculus. Transistors and micro-transistors gave the final acceleration to the development of the spreading of computing machines able to perform basic and advanced calculus of standard mathematical functions. Hence, performing calculus was not more necessary at work and even at shops. Afterward, calculators and scientific calculators became portable around the '80s and then invaded students' pockets and backpacks. Students could start to "cheat" in the sense that they could start behaving as if they were at their future office desks.

2.2. Computers and Personal Computers

Computers, firstly, and personal computers, after, have deeply demonstrated that many of the repetitive cognitive tasks may be replaced by using a software program. The majestic film "Hidden Figures" clearly depict the situation. If tasks are cancelled by the ability of machines, humans should start to know how to use the machine to go beyond. Then, the wide spread of computers and personal computers in the '70 wiped out many repetitive cognitive tasks but opened the doors to different jobs. Hence, students should use these tools as soon as possible.

However, the first era of personal computers did not give the possibility to carry these wonderful machines everywhere and, hence, students could not use it in classrooms. The real game change happened when these machines where reduced to pocket size and have been called *smartphones*.

Around 2010, smartphones have brought the full power of personal computers and the web in the pockets of the students. From that point on, it has been possible to "cheat" at large scale. Eventually paired with smartwatches, the full possibility of accessing the network and the cognitive abilities of the information technology suddenly entered the classrooms. There is a wonderful possibility of simulating the real working environment during an exam.

2.3. Symbolic Calculus in Our Pockets

Smartphones gave the possibility to use symbolic calculus during lessons and exams. Indeed, many of the exercises that students are asked to resolve fall in the idea of searching in a graph where nodes are equations and edges are transformation laws. There are many apps that may start from hand-written equations and may resolve them in matter of milliseconds. For example, PhotoMath (**Figure 1**) easily resolves equations, does function analysis and so on.



Figure 1: PhotoMath: an app for symbolic calculus

These symbolic calculus resolvers are very useful tools from the point of view of a potential job involving resolving equations. Then, apparently, there is no need to bother students with these repetitive exercises. It is more convenient to spend time of students in different activities such as deeply understanding the principles that are the basis of these equation transformations and what their limitations are.

2.4. The Knowledge of the World in Our Pockets

Moreover, smartphones gave the possibility of accessing the whole knowledge of the web during exams. This strongly replicate how people work today. It is generally neither possible nor useful to try to remember every detail when it is possible to access details when needed. Students should be able to:

- Search efficiently and to have a clue to where to search. Having all the information on the tip of the fingers may be useless if there is not the capacity to search it.
- Fastly grab useful information from the results of a search engine. This is a very difficult task as it consists of selecting the right documents to read and extracting the relevant information.

Hence, when only search engines were there, exams should be designed to test these abilities in students. There was no reason to stop students using these machines.

3. The reaction of the Italian School System

The school system underwent many reforms since the unification of Italy (see **Table 1**).

The first goal of the school of the united Italy was combatting the analphabetism of the Italian population and giving the possibility to understand basic calculations. Legge Coppino introduced sanctions for parents which were not respecting the compulsory and free education offered to their children. Attending classes was compulsory for elementary cycle. Then the age was progressively increased to the age of 14.

The second goal of the school system was preparing the elite and the working class. Until 1962, the choice to be in one of the two classes was made just after the primary school. Only with Legge 31/12/1962 n. 1859, a unified cycle for children aged 11-14 has been established and this cycle gave access to all secondary schools. Moreover, only with the LEGGE 11 dicembre 1969, n. 910 many secondary schools gave the possibility to access to any university faculty with one eventual additional year of study. Then, the school system become a way to train citizens that may perform any role.

Table 1

Some of the Italian Laws related to the School System

Year	Law
1859	Legge Casati (Regio Decreto 13/11/1859 n.3725)
1877	Legge Coppino (Legge 15/07/1877)
1904	Legge Orlando (Legge 08/07/1904)
1911	Legge Daneo-Credaro (Legge 04/06/1911)
1923	Riforma Gentile (Many different Laws)
1939	Carta della Scuola Bottai
1962	Legge 31/12/1962 n. 1859
1997	Legge Bassanini (Legge 15/03/1997)
2003	Riforma Moratti (Legge 28/03/2003)
2008	Riforma Gelmini (Decreto Legge 01/09/2008 n. 137)

Although Legge Bassanini (1997) gave autonomy to schools, local schools had the freedom to define the content of the courses only in 2003 and 2008 with the two reforms Moratti (2003) and Gelmini (2008). These two reforms introduced the National Guidelines (Indicazioni Nazionali) that replaced the Ministerial Syllabi (Programmi ministeriali). This change has given the possibility to local schools and to local instructors to adapt the syllabus of their course to the local curriculum provided that this adaptation is in line with the National Guidelines.

Moreover, the National Guidelines expressed in the Attachments to the Gelmini Reform are extremely detailed for what concerns the use of machines. Many of the Attachments contains the following words:

"The computer tools available today provide suitable contexts for representing and manipulating mathematical objects. The teaching of mathematics offers numerous opportunities to become familiar with such tools and to understand their methodological value. The path, when this proves appropriate, will encourage the use of these tools, also with a view to their use for processing data in other scientific disciplines. The use of the tools information technology is an important resource that will be introduced in a way that is critical manner, without creating the illusion that it is an automatic means of problem solving and without compromising the necessary acquisition of mental calculation skills.

The wide range of content that will be addressed by the student will require the teacher to be aware of the need for a good use of the time available. While maintaining the importance of the acquisition of techniques, dispersion in repetitive technicalities or sterile case studies that do not contribute in a meaningful way to understanding the problems. The in-depth of technical aspects, although greater in the scientific high school than in other high schools, will never lose sight of the goal of understanding in depth of the conceptual aspects of the discipline.

The main indication is: few fundamental concepts and methods, acquired in depth."² It seems to open the doors to what is needed, that is, imposing an overture to the use of machines in teaching and, thus, to Large Language Models too. However, this is not the case in many public Italian schools. Nevertheless, the option is open.

4. The Game Changer: Large Language Models

As discussed in the previous sections, machines have conquered many cognitive tasks in the past and the Italian school system is "legally" open to use these machines during teaching. However, in these days, teachers are trying to understand how to incorporate the new game changer that is represented by the accessible part of these large language models (LLMs) [2]–[5], that is, ChatGPT³, BARD⁴, and others.

Indeed, Instruction-following Language Models (IFLMs) seem to be able to cover many of the repetitive tasks. As partially demonstrated in [6], [7] for Language Models, these LLMs may be particularly good in remembering and applying patterns for solving tasks. If a pattern is constantly repeated in training documents, it can be learnt and it can be used to solve exercises.

In Physics, Chemistry and so on, asking students to do exercises is the current tactic for helping students to memorize rules in a deductive teaching manner. This result in a request of doing many times the same "kind" of exercises. In this way, they are not focusing on the principles, but they are focusing on the repetition. This is the major ability of Instruction-following Language Models (IFLMs).

In the future job, these students will possibly use all the technology they can to solve faster assigned tasks and IFLMs are one of the possible technologies.

IFLMs tease the Italian school system and, more in general, all the teaching activity with a tantalizing question: "What is worth to be taught to the new generations?". In this sense, IF-LLMs are real game changers. The question on how to use these systems to improve teaching is not completely the right point to address. Indeed, if the perspective does not change, teachers may end up in being replaced by donating their knowledge to these greedy IFLMs [8]. Moreover, in a dystopian future, these students may not become active members of the society because they can do what machines can do.

² In Attachment (Allegato) F of DECRETO 7 ottobre 2010, n. 211, Ministero Istruzione, Univeristà e Ricerca, Translated with www.DeepL.com/Translator (free version)

³ http://chat.openai.com/

⁴ http://bard.google.com

5. Discussion and Conclusions

Conditions in working environments and in study environments should be similar in order to prepare students to future working life. For this reason, intelligent machines should be used in classrooms as these are used in offices.

In this paper, we analyzed the relationship between the Italian school system and the advancement of machines doing cognitive tasks. In principle, the Italian school system is open to the use of these cognitive machines during student training and, thus, this is good news. However, it is completely unprepared to the challenge imposed by Instruction Following Language Models such as ChatGPT.

We believe that the teaser of these models can help the Italian school system to renew from the basis if students keep "cheating" as we all normally do during our working day.

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