Deep learning with Hopscotch

Traditional ways of teaching are losing ground. Knowledge and work methods in science and technology are changing exponentially. Knowing that computer programming, in the form of simulation, radically transforms scientific experimentation, we will see how to change the learning culture to inspire our class. There will be examples of astrophysical simulations that students can develop in class with Hopscotch in space or mathematics units. There will also be some examples that will inspire your students to understand the basis of artificial intelligence. It will be presented following Michael Fullan's Deep Learning transformation model.

1. Title Page

Do you have students like mine? Here is one, at the very beginning of Grade 6.

For those who do not follow me online, here's what I did during my summer vacation. '

Many people did not even notice the eclipse of the sun, but with my FLIR infrared camera attached to my iPad, I took many pictures of the eclipse, without damaging my vision. I analyzed the solar corona during the eclipse and I tried to detect Jupiter, Mercury, Mars and Venus in addition to the Regulus star that were hidden by the sunlight. With the help of my friends online, I learned about the relationship between eclipse and the development of Einstein's theory of relativity. I then developed a mathematical model of Einstein's theory by coding with Hopscotch. I shared my work on social media and I discovered other inspiring examples.

We can notice the motivation of the student who is fascinated by space since the 3rd grade. His passion for space motivates him to continue to develop, at home, his mathematical skills, by developing models by coding with Hopscotch. With the support of parents, he consults the public library, applications on the iPad, and goes to astronomy sessions organized by amateurs and university professors. We also notice the online science culture. This is a radical change from what happens regularly in the classroom. (1:45)

2. The relevance of deep learning

Programming with Hopscotch is very much related to mathematics. This allows us to compare the work of 3 students according to the thinking criteria of the provincial mathematics program. According to our mathematics program, our students must use the skills of planning, information processing, critical thinking and creative thinking with great efficiency. It is required by the math program.

We see on the left a worksheet, in the middle an understanding of fractions created with Hopscotch and on the right, a programming of fractions created with Hopscotch, but integrated into a real situation of an exoplanet moving in front of a star.

The worksheet allows the student to understand the problem, make a plan to solve and model the solutions, but the activity itself does not allow students to show critical and creative thinking.

With isolated programming, the student can understand the problem, make a plan, elaborate model to solve the problem, and form a conclusion. The student uses critical thinking.

Did you know that David St-Jacques, the next Canadian astronaut to visit the space shuttle, is an astrophysicist? With deep learning, the student goes beyond all thought expectations. He has a glimpse of the work of astrophysicists, in addition to having a glimpse of what David St-Jacques had to do to become an astronaut. Deep learning allows the realization of an elaborate, critical and creative plan to show fractions using the code. The student's understanding is situated in an example of real life, in a field that fascinates and inspires the student and that could open doors for him in a specialty in high demand. He builds new knowledge.

Mathematics is only the beginning of deep learning. (1: 40)

3. The pace of deep learning

The student with difficulties does not take regular school seriously. He needs a particularly powerful force to attract him to sustained and rewarding efforts. What gives meaning to the life of a struggling student? It may be a strong sense of identity around a purpose or a passion. When the student chooses a meaning to his life or a passion, in a good environment, he will be able to surpass himself.

I read recently in the Quebec Science magazine that dropping out of school has nothing to do with school. It was a crisis, a recent stress, a family conflict, a health problem or bullying that ended their studies. For the school dropout, passion takes second place. Support for these students should not only be academic, but also the other factors.

My family comes from Mégantic. There are not only train accidents over there. It is a beautiful region where people are quite innovative at the observatory of Mont Mégantic. Each of our students can be inspired by it.

Exoplanets, outside the solar system, are typically observed with the transit method. The transit method has some limitations. For example, if it takes 10 years for a planet to return to the same place in its orbit, it will take 10 years for observations to be repeated to confirm the presence of the planet. With the method of direct photography, we can see the planets right away. This new detection method was developed at Mont Mégantic.

They take 2 pictures with different techniques. They then subtract pixels from one photo from the other photo. What remains is the brilliance of an exoplanet around a star.

The student is inspired by these innovations to develop a simulation of a system of exoplanets discovered by direct photography while developing mathematical simulation skills. (2: 00)

4. The challenge

We all have students doing well. Our Challenge: can we create an environment where each of our students, even those who are struggling, can make a difference in our society? Can we mobilize the strengths, motivation, ideas that drive our students to excel?

One wonders what is the relationship between the STAR TREK film and the curriculum that one has to teach. We want to encourage students to choose Jim T. Kirk's growth mindset to explore their surroundings, use science and critical thinking to break the irrational, use science to improve their society, to build peace.

Captain Kirk's opponent, Krall, has a fixed mindset. He does everything to lengthen his life. He goes as far as to destroy other civilizations, to accomplish his goal. Krall, lost in space, did not know how to adapt and kept an intense hatred for his civilization.

The Challenge of Deep Learning: Can we inspire all of our Captain Kralls to change their mindset in order to make a meaningful difference in our society? (1: 20)

5. Reimagining learning

We need a new learning process. The teacher and the book are no longer the only sources of information and interaction during learning. There is a whole community, a multitude of sources of inspiration.

Hopscotch is just one example of deep learning. What can we do with Hopscotch AND all the resources that the internet offers us?

Hopscotch will work without the Internet, but learning is much more powerful using the internet.

5a. You do not know how to code? No problem. Hopscotch offers several videos for students, explaining step by step the basis of programming. There is a video for your weakest student to the most advanced.

5b. The application is easy to use. To code, it is only a matter of dragging blocks that we organize in a logical way about subjects that fascinate us.

Student creations can be shared with the Hopscotch community.

5c. Every programmer can watch, follow, love and learn from the programs of others.

5d. There is an increasing number of programs already written to inspire students to continue their learning.

5e. Hopscotch also provides feedback on all programs that are published. Hopscotch analyzes the programs published by the student and offer ideas to improve the student's program, to improve his programming techniques.

Combined with Twitter, radio, television, internet research, and the teacher, who also wants to make a difference, we provide a lot of tools for our students to thrive. (2: 00)

6. The character

We reserve one hour per week for programming: it's time for genius hour. During Genius Hour, we can challenge all our students to create something that they value and that interests them. Is this a reasonable solution considering your context? It's the same concept that Google uses with their employees. They have the autonomy to work on a fascinating project of their choice if they follow the vision of the corporation.

Students have the chance to develop their character and learn to learn, to show their perseverance during learning and a responsibility and integrity in the choice of ideas they choose to develop. Projects can then be shared with Hopscotch and social media.

One must learn to read and write in another way. Let's see an example: In your opinion, is it the code on the left or on the right that makes it possible to draw the hexagon?

The circle surrounds an artifact of the Voyageur spacecraft while the hexagon shows the shape of a mirror segment of the future James Webb telescope.

(1: 20)

7 - Civic Education

With civic education, we must open our minds, expand our horizons to the whole world. We need to develop compassion, empathy and interest in others. Can we consider finding our place in the universe to do this?

Each new image of the simulation is approximately 10 times larger than the image of the previous space object, placed in comparison.

We see the Earth that we know well, with all its immensity. The Earth is much smaller than the planet Jupiter, with a diameter of 12,742 km. Jupiter is much smaller than the exoplanet Tres-4 and the sun with its diameter of 1.39 million km. If we continue, we realize that the sun is much smaller than other stars including Aldebapan or KY Cygni with its diameter of 2.3 billion km. These stars are however much smaller next to the entire solar system, black holes, nebulae or our galaxy, the Milky Way with its diameter of 53 million trillion km. The Milky Way is much smaller than other galaxies, the Virgo supercluster, the local universe and the observable universe with its diameter of 880 billion trillion km.

What is the size of the universe? Why does the world exist? What is our place and function in this universe? How does the universe work? What forces are at the basis of our universe? How did it develop? Are we alone in this universe? These are multi-generational and multicultural questions that push scientists to understand the world in which we live. (2:15)

8- Collaboration

Do you have trouble with technology and math? Do you have any reluctance to innovate? I would like to encourage you because you never work alone with Hopscotch. The Hopscotch app offers extensive support to the student and the teacher. Gifted students in mathematics can write programs even beyond the teacher's comprehension, because the Hopscotch app provides the necessary support. The teacher ceases to be a transmitter of knowledge and becomes a facilitator of learning.

In this example, the picture comes from a host of the Royal Astronomical Society of Canada. The idea of creating artificial intelligence comes from Google's Siri system. The information about artificial intelligence comes from the site of the program Découverte of CBC. The artificial intelligence algorithm was written with Hopscotch commands and an iPhone. Hopscotch also allows you to recognize speech. So, instead of saying OK Google, for the phone to answer us, we will say OK Hopscotch and our Hopscotch program recognizes the sound of our voice and responds to us as explanatory text programmed by the student. We see in the image a galaxy that "eats" another galaxy. The AI makes comments in English or French, responding to the sound of the user's way.

A collaboration like that, I find it fascinating. Try to imagine the reaction of students who have successfully coded a project like this and their new motivation towards mathematics? (1:45)

9- Communication

Communication includes communication for various audiences.

Hopscotch allows students to write long texts with a medium they like. For a student who lacks motivation to write, the medium may be what makes all the difference. Students can write letters, books, a newspaper article, design posters, develop a website, write interactive stories, and explain the program they wrote. The program may also be a response to a fictional text reading or documentary.

Here we see a website explaining the difference between rocks coming from Earth and meteorites, these rocks coming from space.

Websites are the basic resources of the internet. Websites also form the basis of online business.

There is the text, but the communication also includes the mathematical expression. The code allows learning for various types of learners. Programmers develop critical thinking, problem solving and mathematical communication in a visual and concrete way. They code to learn. For some, the code is so much fun, they learn math by playing. Code is another form of mathematical communication. (1:25)

10- Creativity

Creativity is about pursuing new ideas and solutions. Most people think that not many people can be creative, but in fact, everyone has enormous creative potential. The other misconception is that creativity is a little crazy, when in fact, most creative people are also informed, controlled and have a deep vision. There is an urgent need for creative and innovative people who know how to code and who know how the code fits the world of work and society.

For example, NASA is working with companies in several countries to develop their next projects. With introducing deep learning, you may allow your student to create the next Lunar Space Station, the next Martian mission or a brand new venture. (1:00)

11- Critical thinking

Here is the student who experiences, thinks and takes action from real life events. Here, the eclipse of the sun (of last summer) stimulates the student to understand the theory of Einstein. Einstein had calculated the trajectories of the planets of the solar system using his new theory, and had noticed that the orbit of Mercury had an anomaly that Newton's theory of gravity could not explain. Einstein's theory also predicted that the light of the stars passing near the Sun would be curved by gravity.

To understand. First, we take a picture at night. Secondly, we take a picture during a total eclipse of the sun. During the eclipse, we could see and take pictures of the stars that are behind the sun. Comparing the two images, it was possible to confirm the movement of light under the influence of a massive object like the sun. With Hopscotch, we create a model of what has been observed. This type of observation allowed Einstein to understand that our universe is a bit like a piece of cloth.

Critical thinking is not only the foundation of mathematics, but is also essential for any good scientist. (1: 20)

12- Equity

Many students arrive in class not even ready to learn. They come from disadvantaged backgrounds through poverty,

alive in the terror of being a refugee,

after the Quebec massacre, in fear of their physical safety,

to live in the perception of not being welcome anywhere,

to be homeless,

neglected,

or lacking stimulation.

Many, even here in Canada, have the fixed mindset that science, mathematics and technology are not open to women. Very few women hold faculty positions at the University in this field. Yet women are as qualified as men.

Every teacher, without exception, will admit that she wants each of her students to succeed in mathematics; however, our attitudes sometimes hidden from ourselves, the stereotypes that we maintain towards certain students, have a contrary effect.

Black students are less likely to have access to computer classes at school than white students. 47% of black students have access, compared to 58% for whites. 68% have a computer at home. Girls (at 48%) are less likely than boys (at 65%) to be aware of the possibilities offered by computers. Boys (46%) are more likely to be encouraged by their parent or teacher to computer than girls (26%).

It is up to us to reduce these injustices and put in place deep learning for all. I know that it is possible to leave aside our most boring mathematics lessons and replace them with attractive and teachable mathematics for each of our students. (1:45)

13 - Culture change

Many teachers agree that changes must be made to make a difference. That's the reason they are in teaching. But, how to make a difference on a large scale?

We use Twitter or other social media every day! Social media is for teachers and students. Every student becomes free to learn deeply.

With Twitter, we are no longer isolated in our class. You can access the best ideas by following other people from all walks of life who want to make a positive change. By chatting online with a professional learning network, it will be much easier to support every child in your class.

For example, I created the hashtag #girlswhohopscotch to share my best Hopscotch programs for free. It's only a beginning. You are in the best position to lead your students. (1:00)

14- Lead the transformation

Do not have a Bachelor of science? No problem. When you talk to scientists who are doing frontier research, you learn a lot.

They told me that methods of work in science and mathematics are constantly changing. We are in the age of computer simulation. Several important scientific fields use computer simulations. It is used when the phenomena to be observed have little data. For example, it is really difficult to do experiments in the center of the sun. However, we need to know the cause and frequency of solar flares to protect our electrical infrastructure. Observational computer simulations become our sources of information.

With the Hubble telescope, for example, scientists often take a full day to visualize a tiny dot of the cosmos. Simulation becomes essential to obtain information about the entire system that one wishes to observe.

Astrophysicists tell us that astronomical observations, alone, with a telescope, do not deepen our knowledge of the universe. Experience alone is not enough. We need the theoretical model, coded in the computer simulations. Simulations often replace experience as a source of information. The simulations must however be validated. The validation process determines whether the theoretical model, behind the simulation, is a satisfactory representation of the real system.

Here we see the millennium race, which is the most precise and detailed simulation of the Universe. The simulation traces the evolution of the large-scale structure of the universe, how the observed galaxies were formed.

Simulations are used by cosmologists to compare their telescope observations with theoretical predictions. The goal of the simulation is to accumulate data in order to accurately predict phenomena.

Here we have a radical transformation of scientific experience in an important area of science. Our students must be aware of it. (2: 30)

Deep learning in action (1)

Here we see the work of one of my students in grade 4 French immersion. I am particularly proud of this student. He did well in school, but with his mother's cancer treatments, he was not the same. He had lost a lot of his motivation. The deep learning system put in place at our school board with Hopscotch and social media allowed him to find something that fascinated him. During genius hour, I gave my students project suggestions, but they also had the choice to create whatever they wanted. He created a simulation of a comet approaching the sun. It was not me at all who gave him the idea. This came from the general culture surrounding this child. In Grade 4, we study rocks and minerals in science. He discovered the nature of rocks on Earth and in space. For space objects, the trajectory of comets and asteroids must be calculated precisely if one wants to have access to mine or to protect ourselves, if necessary. There is even a NASA program specifically designed to detect dangerous asteroids because they could impact the Earth. This student, with all the difficulties of his family situation, went well beyond my expectations of mathematics, science, character and creativity. (1: 30)

16- Deep learning in action (2)

I had another really good student in my class. In Grade 4, at age 9, she gave music recitals in Mississauga. I went to one of her recital. I wondered how to inspire such a talented student. I wanted to use her gift of music. I thought that music also has a digital side that is used in film productions that are worth millions of dollars.

I created a lesson that uses digital music on my YOUTUBE account. She had access to it at home and created her own projects at home that she showed me the next day. In class, this talented student spent a lot of time helping a struggling student and teaching her how to code using music during genius hour.

PLAY

Forgive my English. In immersion class, I teach mathematics half in English and half in French. I explained the algorithm to follow to write this program. If I believe You Tube, 210 people have viewed this video and benefited from this learning. I do not even know the vast majority of those who have benefited from my work. (2: 30)

17- Promotion of powerful conversations

These examples that we see daily in the classroom change the way students think, feel and interact in the world. They are free to follow the thread of social media, but even more important, they can ask their own questions and find answers right away in the language of their choice on Wikipedia for example. Their research can then take them to YouTube, Radio-Canada, Netflix, TED talks or any other good conversation distributor.

Here, one wonders if life exists elsewhere than on the Earth and in what form.

The Curiosity mission verified the presence of water on Mars. The rover analyzed the geological composition of many places on the surface of Mars. The mission of Mars exploration is still going on. Will we be able to find life on Mars? Either microbe fossils or microbes still alive in the rock?

It will only be after the launch of the ExoMars mission in 2020 that we will be able to dig up to 2 meters deep on Mars to see if there are bacteria or traces of bacteria in the Martian basement. (1: 15)

18- Cultivate a deep learning culture

For deep learning to work, everyone must see themselves as a learner. Teachers as students. These are our questions, our investigations that teach what really matters. Our attitude, having a growth mindset is what will make all the difference. During learning, you develop personal goals, and you learn to evaluate yourself.

As for the black hole, it was a University of Toronto scientist, Charles Thomas Bolton, who discovered the first black hole with the David Dunlap observatory in 1971. Black holes exist in the center of almost all galaxies. Our Milky Way contains a black hole, Sagittarius A, four million times the size of the sun. Around a black hole, gravity is so intense that space-time becomes infinitely curved and creates a gravity so intense that nothing escapes from it, not even light. We cannot "see" the black holes, we can detect them by observing the matter that moves around. Here you see a simulation of the vibration around black holes. I would like my students to be the next Charles Thomas Bolton.

(1: 30)

19- Think big - start small

To begin using deep learning with our students, we need to model learning ourselves.

We start with a deep learning skill and we continue.

For example, equity. It is important to include the contribution of cultures from around the world to introduce all our students to scientific culture.

Several craters and plains on the moon have been named after Muslim astronomers of the Middle Ages. There is the crater alfraganus which is named after the chief scientist al-Farghani. His book Book of the Summary of Astronomy was a major influence of the Italian poet Dante Alighieri. The Almanon crater is named after Harun al_Rachid who is known for the Arabian Nights. In 829, he built an observatory in Baghdad for scientists. Albategnius is a plain named after al-Battani. His observations from the sky were very detailed. He used an astrolabe and an observation tube, similar to a telescope without a lens. The plain Arzachel is named after al-Zarqali who worked in Muslim Spain in collaboration with other Muslim and Jewish astronomers. He prepared the Toledan tables that influenced Copernicus.

The image students have of science and scientists affects their interests and motivation in the study of science. Their motivation is an important element in their level of scientific literacy. (1:45)

20- New pedagogies

Students need new capacity for their learning.

The Hopscotch app offers even more learning options. There are notifications. Everyday, the user will see someone online who is interested in his work.

Before the student's project is made available to others, it is approved by an adult. This ensures that the photos in the Hopscotch program are really appropriate. For example, we do not want the child to publish his own photo on Hopscotch. He remains anonymous.

Each user has a portfolio of programs he coded himself and programs he loved from the Hopscotch community. The student can consult the portfolios of his friends and draw inspiration from them.

Here, I looked at the portfolio of a Hopscotcher who liked my program ‘the size of the universe’. There was an interesting roller coaster program. This gave me the idea to code another similar program, but that represents the electromagnetic waves of a message sent to aliens. Sometimes inspiration is found in completely different contexts.

Hopscotch has won several international awards for its design.

(1: 20)

21- New role for the student

The result of the students is greatly affected by what they think of themselves and what others think of them. This is paramount in the success of the student.

If the students do not believe in themselves, they will not put the necessary effort into their projects, believing either that one is skilled in math understands immediately or either that one is not skilled and that we do not understand. According to studies, 40% of students have a fixed mindset and 40% have a growth mindset towards mathematics. Students with a growth mindset have results that show at least a year ahead of other mathematics students, assessed by PISA mathematics tests. This is the kind of encouragement that is given to students that makes the difference.

Teachers who take advantage of students' natural curiosity and interest can use their motivation to help students choose interesting and authentic projects. Students are more engaged when given the choice. They can co-plan and co-design their projects in order to co-learn with the teacher.

With Hopscotch, we see here a system of double stars and a cluster of new stars. (1: 20)

22- The teacher as activator

As important as the students' growth mentality towards their mathematical learning is the adult mindset towards their students. If a teacher believes that her students are limited, she will have very low expectations from her students and will not give appropriate challenges to the students. Students become smarter when they have a growth mindset and have challenging mathematical work. The teacher must become a catalyst and a coach.

This does not take away everything the teacher does regularly like highlighting misconceptions. Here we see an excellent Hopscotch program. The technical side is perfect. Mathematics is advanced. The student is engaged and has created something that fascinates him: one more shooting stars. But, oops. There are many at a time. We must still validate this scientific model of shooting stars with what we observe from the sky at night. The teacher must give feedback, a feedback that informs the student's next challenge. (1: 15)

23- New role of leaders

Leaders in the school must influence culture and processes so that each student is able to learn. The leader must try new approaches to learning alongside the students. It must model learning and create an environment of trust.

The cosmos, Einstein's theory, astrophysics, it's intimidating. I'll tell you something. I never had a problem with mathematics or programming, I learned that in high school. But to teach it was new. I had to think for a long time to know what it is the best way to teach it. Often, to their credit, students found algorithms, ways of doing things that were simpler and more effective than mine. My specialties are in teaching French as a second language and technology, not mathematics. Moreover, when I went to school, astronomy and the study of space were not part of the school curriculum. Even at the university, in the science department, astronomy was not part of the program. I learned by myself, reading a lot of books and articles and going to conferences.

I developed all that with my personal motivation.

Does deep space interest you? (1: 20)

24- New role of families

Families play a vital role in the development of children. We need to develop a strong partnership with them.

Parents go out with their children and use their own devices (iPad and cameras) with their children. We can integrate the educational experience at home with what we do at school.

At the Long Sault Conservation Area, Jeff, a volunteer, shows with his telescope objects from the night sky, away from the light pollution of the city. Parents can easily get there with their kids and see the Milky Way, the moon, the planets, and some galaxies.

The camera can take pictures of the Milky Way, with or without a telescope. In Long Sault, the sky is dark enough to see the Milky Way, which is not possible in the city. We must learn to use the camera. A lens with a wide angle is used to see the entire horizon. Jeff graciously gave the pictures used to write the Hopscotch programs.

We have encoded here the electronics of a digital camera. In the mind of the programmer, it is the next super-powerful camera that will be on the market soon.

This type of program would not be possible without the participation of parents unless organizing a trip for the whole class in a starry reserve at night. (1: 30)

25- New role of the community

The boundaries between the classroom and the outside world become blurred. One must speak to the experts and / or use the resources of a large learning network from around the world.

An artificial intelligence has been coded here that detects unidentified flying objects in the sky and decides what action to take when the object has been detected.

First, we use the application STAR WALK with an iPad to know the objects of the starry sky. STAR WALK shows constellations, stars, galaxies and satellites. It is possible to know what time the International Space Station will switch to our position in order to, second, take a picture in infrared with the FLIR camera. You can see the International Space Station on the left in one pixel.

Third, in our Hopscotch program, the flying object moves in the sky. When it reaches a predetermined point, the artificial intelligence must decide what to do. We zoom in and we notice that it is the International Space Station and not an airplane or an alien spacecraft. The artificial intelligence lets the flying object pass.

To develop several projects of this type, you really need a very large learning network. (1:25)

26- The learning environment

The new learning environment includes physical space and virtual space. It is the environment, the ambient culture, which is the other teacher.

There are innovative ideas everywhere, for example in virtual discussions organized by TED. In one of the discussions, we can listen to Fei-Fei Li who discusses the vision of artificial intelligence that I transformed here into a Hopscotch program.

Artificial intelligence will be found in all areas, including space. The AI will be able to recognize space objects, including galaxies, in order to classify them. To do this, the AI must learn to see and interpret images. It's about supervised learning. Supervised learning is like showing a child a picture book. We show an image and we say it's a galaxy. Is there another image, is it a galaxy or not? After a few images, the IA realizes what a galaxy is. To be really useful, the AI must be able to recognize that what it sees is really a galaxy, and its characteristics. (1: 15)

27- The student asks questions

In our new environment, it becomes important for the student to ask his own questions. They do not passively receive the knowledge of teachers.

In this example, with the predictive learning of artificial intelligence, we learn to predict the future. We have to invent the rest of the image to predict things that are reasonable. We see here an impression of what would happen when a star of our galaxy explodes and becomes supernova. The intensity of the light would be such that it would be visible even during the day without any instrument. (0: 40)

28- Appreciation of the questions as well as the answers

In our new environment, questions are as important as answers. The learning process, how to learn, is as important as the end result.

In this example, with deep learning, artificial intelligence will predict what will happen in the future. In the image on the left, we see the two galaxies as they are today. In the right image, artificial intelligence predicts how the galaxy will be in thousands of years. We see the arms of the new spiral galaxy that combined the two ancient galaxies. The Hopscotch code here is not really an Artificial Intelligence, it's just lines drawn in a circle. But what is coded is quite detailed and it gives an appreciation of what artificial intelligence does. (0: 55)

29- Various models of learning

In our new environment, we choose approaches that correspond to the needs and interests of students. There are students who learn better outside with movement and their senses, others visually with the videos. Others learn better with books. If the book fascinates the student, we use the book! The paper book or the book, digital format.

Here we see a model of the expansion of the universe. The universe is expanding not at a steady pace but accelerated. Three scientists received the Nobel Prize for this discovery. (00: 40)

30- Explicit connections to real applications

In our new environment, mathematics is so interesting, we choose explicit connections to real applications. Mathematics is relevant and meaningful.

In this example, we use some online images of the Spatial Hubble telescope, our most powerful telescope. We simulate the Sloan Digital Sky Survey, a catalog of galaxies that can be seen from our course at the back of our house. We see for example M87, the largest galaxy, M101, the most common and LMC, 1000 times smaller. (00: 45)

31- The collaboration

In our new environment, students have the skills to collaborate in class and beyond the classroom.

Here we see a simulation of the supernova remnant that can be seen in infrared while pulsing in the radio waves. These supernova remnants have become candles of the cosmos. They make it possible to calculate the cosmic distances between the galaxy in which it exploded and the end of the universe. (00: 35)

32- Authentic assessment of learning

In our new environment, the student defines their own goals, controls their own progress, and evaluates their learning with feedback from others.

He looks at his portfolio and realizes, like the scientists who study dark matter and dark energy, that he has done a great creative and innovative job but that there is still a lot to learn. (00: 30)

33- Take advantage of digital

We have had computers and tablets for decades, but their potential has not been realized at a high level. We see professors here and there who use technology well, but it's far from systemic. Pedagogy is essential and technology helps accelerate student learning. It allows you to create new knowledge, to be innovative using an unlimited amount of resources.

Today, our most powerful telescopes allow us to observe the electromagnetic waves coming from time, shortly after the Big Bang, at a time when no star or galaxy existed yet. 380 000 years after the Big Bang we notice the cosmic microwave background or the fossil radiation. It is very far in the past, if we understand that our universe is 13.8 billion years old. The cosmic microwave background was detected for the first time in 1965. (1: 00)

34- Teaching practices

Does that mean that everything I did before was bad? NO. It's all about leaving out what's not working well and replacing it with what works best. We only want to create richer environments for our students where they can use deep learning.

Infrared allows us to see the invisible. In this simulation, we can see the difference between the vision of the cosmos with visible light and infrared. The infrared allows us to see more deeply in the cosmos and also allows us to see beyond the dust present in the universe. The vast majority of the electromagnetic spectrum is blocked by the earth's atmosphere and space must be observed with space telescopes. (00: 50)

35- Cultivating collaboration

Students can no longer rely on one teacher. We need an approach that mobilizes entire schools, whole districts and whole systems.

It's a bit like scientists. A scientist will spend a whole day photographing the GN-11 galaxy with the Hubble telescope. It is the most distant galaxy that can currently be seen. We see it with coarse grains, not in great detail. To do research in cosmology, we have no choice, we must investigate collaboratively. (00: 40)

36- Change of the whole system

In the current context, with our technological and digital world, I wondered what kind of mathematics is most needed. Is something missing in our current mathematics teaching? I think the mathematics behind technology, the mathematics behind science and engineering, are fundamental to continuing to build our economy.

The job opportunities for future engineers, for students who know how to code, are enormous. Here are the statistics of CODE.org. In the field of mathematics, science and technology, 60% of the jobs available are jobs for people who know how to code. And if we look at the number of graduates in mathematics, science and technology, only 2% have the necessary training to be able to work in this field. Of those who are qualified, only 27% are women. 9 out of 10 parents want their child to learn programming but only 1 hard director 4 offers programming in their school. Can we improve this situation? (1:00)

Here are 10 ways to move on to deep learning

37- Move from simple ideas to complex ideas

38- Have learning that is both personal and collective

39- Have learning that changes relationships and pedagogy

40- Have learning that sticks

41- Have learning that involves a critical mass of others

42- Have an innovation-based learning on key issues

43- Have learning that attacks inequity to achieve excellence for all

44- Have learning that commits the world to change the world

45- Have learning that creates the citizens of tomorrow today

46- Have learning where young people help older people (1:15)

47- Help humanity

I would like to conclude with a thought from astrophysicist Neil deGrasse Tyson.

It reminds us that many people kill and are killed because they have a different conception of God, that others kill because of personal needs or political dogma. Faced with the extent of the universe, the multitude of galaxies, the possibility of meeting other intelligent life forms outside our planet and our very small size in this extended, we are forced to revise our perspectives, our identity and to become much more humble and even, taking into account our human nature, become aware of the deepest values and meanings by which we live. With a greater and deeper vision of our universe and our place in the universe, it becomes much easier to look beyond our immediate problems and circumstances in order to explore and think about solving the problems that we face. face humanity. (1: 10)

(48: 30) ***