



Using Adaptive Learning to Maintain Education and Improve Learners' Engagement during the COVID-19 Pandemic.

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ABSTRACT—I

In this paper we present a new approach of adaptive learning designed to help maintaining education and improving learners' engagement during the Covid-19 Pandemic [1]. This work is built, for the part of learning objectives, on a set of skills list provided by teachers, and for the student model definition, we used a specific of the learning styles of Felder and Silverman.

First, we list literature from existing work to provide a global review on education in time of covid-19 pandemic and a breakthrough adaptive educational system. In this direction, we have defined the different components of the adaptive educational Systems domain like the instruction, the distant school model, the learning object, and the student profile.

As structured, this proposal will provide an education path that takes into account the learning style and the pandemic context of learning. The challenge is to maintain education and replace the face-to-face activities by online ones without losing student engagement.

In order to validate and complete our model, we led a survey to evaluate the impact of covid-19 pandemic on education and student engagement, and appreciate the ways adaptive learning can reduce negative impacts.

This research have multiple goals, such as helping rural student to continue studying in a health crisis context, giving teachers an approach that can be used in their learning process, and finally associate effort to bring a unique learning experience that have a positive social impact on student.

Keywords—Adaptive learning; Covid-19, pandemic, learning styles, learning path, differentiated instruction.

1. Introduction

Since April 2020 and until 2022, schools and universities have been closed in most countries around the world in an attempt to limit the spread of the coronavirus disease (COVID-19), disrupting the learning for an estimated 1.58 billion learners (representing 91.4 percent of all learners) and forcing education systems to move forward to eLearning solutions. [2]

More than one billion students had been affected by school closures in more than 160 countries. Around the world, 40 million preschool children missed such an important first year of education. The COVID-19 pandemic will have a profound effect on the future of education.

Teachers and schools have been creative by using different strategies based on the latest technologies such as solutions that replace the traditional classroom, by delivering lessons on videoconference or through online learning platforms, by sharing learning materials and worksheets through school intranets and messaging platforms. Some countries used national radio and television channels to broadcast courses and educational materials, especially in areas where resources and technological infrastructure are insufficient. If the solutions brought to the disruption in education have been innovative and responsive, the fact remains that certain institutions and regions are better placed than others to take advantage of the means, technological resources and the universe of educational technologies to manage the crisis more intelligently and comprehensively. The e-learning switch can intensify existing inequalities in education, especially in emerging countries, marginalized communities and rural areas, where access to technology and reliable internet connections may be limited. Even within schools, some inequalities - especially in terms of family income or disability status - can hinder access to distance education. There is a high risk that education systems will show a high dropout rate during and after the pandemic, and as a result, that child employment will increase.

In this context, most of countries switched teaching into large-scale online learning while schools were closed. However, not all of the learning initiatives followed a standard education process, and as a result, implementation conditions, implementation process, and properties of the works remain uncertain. The success of the application process of the new strategy are worthy of careful reflection and study.

In this work, we are discussing the impact of pandemic Covid-19 on the normal education, whether eLearning can completely substitute the face-to-face education, to what degree could this type of education replace school? Moreover, how can the adaptive learning bring a solution to the lack of learners' engagement in this new ways of learning?

By working on this new subject, we are aiming to evaluate the use of adaptive learning systems to maintain the education activities in a pandemic context.

We will start the following section with a review of literature related to online education and Covid-19. Before going through our model of adaptive learning system designed for education in a pandemic context, we will present the use cases and learning process for this model, then, we will present the principal characteristics that distinguish our model from standard adaptive learning models. Finally, we will present the results, discuss the conclusions, and draw the perspectives of our work.

2. Literature review

2.1 Education in the time of Covid-19 pandemic

The COVID-19 is a humanitarian, economic and social crisis affecting the entire world on all levels, and Education like the rest of the fields, has not been spared.

The closing of schools around the world will cause a global disruption in student education; disorders in assessments and exams; and the cancellation of the competitions for selections or their substitution by an inferior alternative

According to Burgess & al. [3], learning at school is the best way to improve skills, it allows the learners to improve their social skills and social awareness, failure of school even in a short period, will costs significantly on skill development.

According to Carlsson & al., [4] even just ten days of extra schooling dramatically increases test scores in knowledge use ("crystallized intelligence") by 1% of a standard deviation. Extrapolating these statistics to twelve weeks of less schooling (i.e. 60 school days) implies a loss of 6% of a standard deviation. On the other hand, they did not find a significant impact on problem solving skills (an example of "fluid intelligence").

There are several works on closing educational institutions to reduce the spread of infectious diseases in the community by breaking the transmission chain [5], [6].

The first challenge is to shift from classrooms courses to online courses; this transition has raised up questions for schools about their ability to deal with the existing systems [7]. Moreover, laptops and IT tools at home are now in full use. Therefore, working at home will be a hard job for the school. In addition, many universities do not have necessary infrastructure and resources to simplify online education with immediate results [8].

In their works, Ting and al. talked about the case of student who have problems to get access to laptops and internet facilities, and the practical teaching and labs, music and art courses online, they listed the courses that cannot be taught online and the management of quality in online education, which is a critical concern that needs proper attention. [9]

Schwartz & al., [10] presented an adaptive approach based on the following tools and techniques as multiple videoconferencing applications user friendly that's allow for an entire group to simultaneously log on to a collective videoconference distantly, collaborating engagement with lecture presentations, interactive interrogations, case conferences and response sessions.

In this approach, the use of videoconferencing is strongly advised to support neutralize the pressure of social isolation such a crisis can produce because of social distancing recommendations.

The works that treat the covid-19 pandemic are not many; the low number of research on this subject is due to the recency of the pandemic covid-19. In order to adress this problem, we had to refer to the work on the impact of other epidemics on education such as Ebola and Influenza.

2.2 Adaptive learning systems and their impact on learner engagement

Several works have been involved in adaptive learning systems that offer the appropriate material in the fitting manner to the learner by considering its profile (Fig1); these approaches can be categorized into three classes:

The first class related to preferences of the learner where we organize the learning process based on the personality style. In this direction, we can cite the works of Oxman [11], Weber [12], Brusilovsky [13], Hwang [14] and Yang & Hwang [15].

These approaches consider the learner comporment [16], analyze it behavior [17], provides the student an electronic questionnaire to define their favorites and specific characters through their choices [18].

In our last publication [19] we presented an adaptive learning system built on approach that uses the Felder and Silverman's learner styles to adapt the learning experience to the preferences of the student.

The other type, related to the experience and the knowledge, is considered as the key component of the Adaptive Educational Hypermedia System [20].

This characteristic can be exposed in many ways. One of them is a ranked System that measure the level of the student knowledge in a domain by a degree (In our case a number from 0 to 5) or a status (superior, normal, inferior,), the implementation of this approach is simple but it not enough for some advanced systems.

Besides this model, Overlay, which illustrate the learner data [18], assigns a mathematical value, zero or one, to each ration, signifying the learner knowledge or not of a subject.

The most recent type uses the user objectives to choose the appropriate schooling experience for each particular learner.

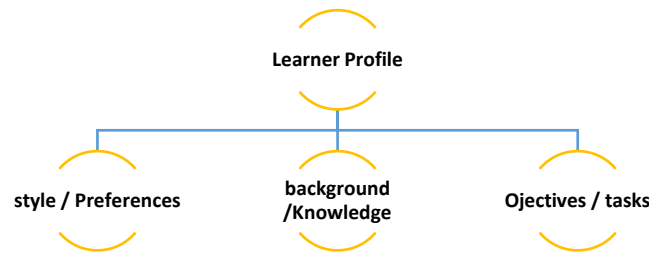


Fig 1: The learner dimensions

Today, the challenge is not to complete the school through systems which bring the auxiliary knowledge not acquired in the school, but, rather, to allow the learners to have the full knowledge which they need to enter the business and be able to meet professional requirements.

All of these models consider the learner at the center of their architectures; this will make it possible to establish the learning experience and adjust the path of education to his profile but will not replace the main role of school.

As the pandemic Covid-19 has spread around the world and schools switched to online learning, many teachers reported the students' lack of engagement and concentration during e-learning sessions, as explained by Bacher [21]. This problematic is due to several reasons as the access to home computers and broadband internet for low income and rural students, and the need of additional support to overcome the educational challenges created by Covid-19. on the other hand, The validity and reliability of unsupervised assessments cannot be established as students can use documents and the Internet to pass the assessment.

In order to improve students' learning concentration and engagement to achieve a smooth transition to online learning, Bao [22] suggested six strategies. The first one consist on making emergency readiness plans for unpredicted problems like hosting issues related to the number of new users. The second, dividing the learning content into reduced components to help students focus, Third, highlighting the usage of "voice" in education. The Fourth, working with teaching assistants and increase online supports from them. The Fifth, reinforcement learners' active education capacity outside of class, and the sixth, joining online education and disconnected self-education efficiently

3. Research Methodology

We will first present the learning scenario, which represents the theoretical basis of our learning model; this scenario takes into consideration the global context of learning which is the covid-19 pandemic, the learner model which remains a main component of any learning model.

A student, who cannot go to school due to the health crisis and the closure of schools, will connect to the learning system to follow classes according to the established schedule.

The first step will be to determine the student's learning style by asking him to answer a survey that helps us determine his learning style and his level of mastery and skills.

At the same time, the teacher informs the system of the learning objectives for the whole class, these objectives can be revised in view of the progress of the students. which represents interesting information for our model.

The learning experience takes place through the continuation of the learning path generated. Thus, it is possible to clearly distinguish three essential phases in the learning process:

- Registration form including information on the student.
- Questionnaire to determine the learning style.

- The definition of learning objectives by the teacher for each student and their update as the learning experience progresses
- The system builds the content and the learning path (corresponding to the learner profile, the learning objectives and the learning elements)

In order to meet the need for the described scenario, we have established an adaptive learning system based on the following models:

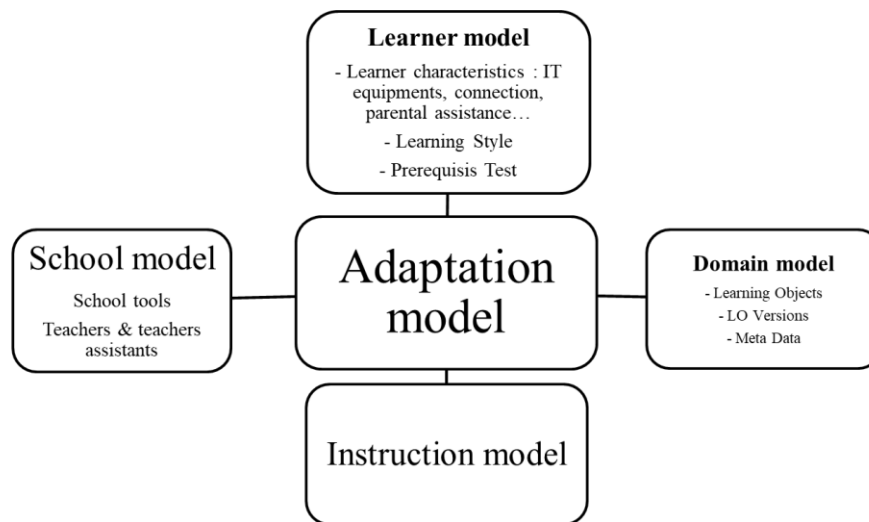


Figure 2: Adaptive Learning System Architecture

This architecture is mainly composed of:

- **The learner model**, which represents the characteristics relating to the student such as his learning style, preferences, and his own working environment (IT equipment, connection haut debit, satellite network, parental assistance, ...)
- **The domain model**, which represents the LOs learning resources with their metadata, these resources must respect the following rules in order to allow maximum concentration and continuous engagement of learners:
 - The quantity, size, and difficulty of the content must remain manageable.
 - The reading speed must be adjustable to the student's ability to follow in order to ensure good assimilation of the content.
- **The distant school model**, which describes the design of tools and parameters for the continuity of the functioning of the distance school as:
 - The availability of teachers' assistants
 - The content delivery tools
 - A real-time feedback to students, email exchange, and discussions
 - A sufficient Infrastructure ensuring the traffic overload and the number of connections to the learning platform.

In order to confirm our model we built our work on the following methodology instruments:

- A survey for teachers, which will allow us to evaluate the attitude of teachers to switch to online learning and take their opinions and recommendations in consideration in our model. This part will bring us mainly the teachers' perspective, which represents a pillar in our work. The main questions of the survey:
 - University/school, public/private, personnel infos, seniority, taught modules, ...
 - Have you already benefited from e-learning training (s)?
 - Did you already have online training experience?
 - During the confinement period, what solutions did you use to ensure pedagogical continuity?
 - Use of a distance education platform
 - Using TV-Radio
 - Use of email by exchanging lessons and assignments
 - Social media (Facebook, WhatsApp, twitter)
 - Other:

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- In case you have used a platform, Specify whether it is:
 - an online learning platform or website of the institution / university
 - Use of an online learning platform or on a personal website
 - Other:
 - Do you agree with the adoption of distance education to ensure pedagogical continuity? with 6 choices (Strongly disagree, Disagree, Disagree somewhat, Agree somewhat, Agree, and Strongly Agree)
 - Does your establishment have:
 - Recording studio
 - IT technicians
 - e-learning dedicated Unit
 - Institutional e-learning platform
 - Other:
 - What material (s) do you use to develop your online courses?
 - Desktop computer
 - Laptop
 - Smartphones
 - Microphone
 - Professional camera (or recording studio)
 - Lighting tools (Projector,...etc.)
 - Recording and / or editing software
 - Other:
 - What software (s) do you use to produce audiovisual tools adopted in your online course?
 - iMovie
 - VSDC Video Editor Free
 - Videoleap
 - Screencast-O- matic
 - Windows Movie Maker
 - Winamp
 - Other:
 - What platform (s) you use in distance education:
 - Moodle
 - Google Classroom
 - Microsoft Teams
 - Zoom
 - Coursera
 - EdX
 - Hangouts
 - Skype
 - Webex Meeting

- Other:
- How many class sessions are scheduled per week?
- What is the total duration of the planned weekly sessions?
- What tools and methods did you use to prepare for your online course?
 - Educational scenario of the lesson that you did in person
 - Adopting a course already taken online
 - Official documents (description of the program)
 - Educational objectives / Targeted skills
 - Textbooks or educational works
 - Student prerequisites
 - Teaching method or technique (by problem, by investigation, by project, etc.)
 - Other:
- What average weekly time did you spend on each step of preparing your online course? (Finding resources and references, Content preparation, Choice of teaching methods and strategies, Choice of tools and techniques, Recording and Editing, Development of course documents...)
- Did you encounter any technical problems during the preparation and supervision of distance learning courses?
- What do you think is most important when designing and developing an online course?
- What materials have you used in your online courses?
 - Pictures
 - Videos
 - Texts (PDF, word ...)
 - Power Point presentations
 - Audios
 - Other:
- What is the average length of a video used in your online course?
- What interaction modalities have you used in your online course?
 - Synchronous (simultaneous interactions)
 - Asynchronous (Interactions at different times)
 - Synchronous and asynchronous
 - Not Applicable
- Have you used online assessments? If not why?
- What types of questions do you use in assessments?
 - Open questions
 - Numerical response questions
 - Short answer questions
 - MCQ (Multiple-choice questions)
 - "Text with gaps" type question
- What techniques do you use in online assessments?
 - Homework to file

- Exercises
- Problem situations
- Reports submitted (summary, TP report, etc.)
- Peer review (workshops, presentations, forums, etc.)
- Automatic evaluation of activities (number of interventions in a forum, number of exchanges with other students, etc.)

Evaluation grids (series of criteria to be evaluated and for each criterion a series of levels)

Other:

- What are the constraints you have encountered in implementing your distance learning courses?
 - Technical problems related to the use of the platform;
 - Difficulties relating to direct contact with students
 - Connection issues
 - Lack of experience in this area
 - Scarcity of digital resources
 - Difficulties relating to communication and interactions with students
 - Low motivation and commitment from students
 - Other:
 - Do you think online education negatively affects Student motivation, interaction and engagement?
 - What do you think are the benefits of distance education?
 - More autonomy for students
 - Saving time invested
 - More collaboration
 - Faster learning
 - Reduced training costs
 - In your opinion, what are the disadvantages of distance education?
 - Lack of human contact and interactivity
 - Dropout rate
 - Technical constraints
 - Based on your professional experience and practice, do you prefer?
 - Completely face-to-face teaching
 - Completely online education
 - Online education supplemented by face-to-face education
- A survey for students that will collect information relating to the background of the different students and their feedback on the generalized online learning experience. Made up of two parts, the first one concern the personal information's and general instructions (Name, Age, Gender, level of studies, current place of residence (rural, urban)...etc.) , the second one contains questions about the impact of covid-19 on the way they continue to learn and their feedback about the new form of learning. Below are some extracts from questions from the questionnaire:
- Did you continue to study remotely? In what form?
 - What are the tools used in this new form of study?
 - Has the school set up an online learning system?

- Before this pandemic, did you try e-learning?
 - Did your school offer you online courses before covid-19?
 - Are you in favor of the spread of e-learning even after the lifting of the covid-19 restrictions?
 -etc.
- A series of interviews with education domain stakeholders, where we are interested on collaborating and brainstorming with education actors.

The participants were selected from a list of public and privates schools, located in Morocco. The objective is to have a representation of the e-learning experience in order to take into account all the constraints of the stakeholders.

As regards of the inductive part of our work, we built a novel model of an adaptive learning system (cf. the following section for details) which will be developed to be used in a pandemic context like Covid-19.

4. Results

Survey Results

To complete and validate our model of learning designed to maintain and improve the learners' engagement in Covid-19 pandemic; we explored the results of the survey taken by the participants.

On the topic of the impact of the covid-19 on the learning process, we received the interesting results detailed in the following tables.

Table 1: The use of the online learning to maintain education in the period of pandemic

Do you agree with the adoption of distance education to ensure pedagogical continuity?	
Strongly disagree	3%
Disagree	16%
Disagree somewhat	6%
Agree somewhat	6%
Agree	38%
Strongly agree	30%

The result shows that the majority of teachers agree with the adoption of distance education, and about 25% are against or still reluctant to this form of learning.

Furthermore, only 14% of teachers used a distance education platform to maintain the learning process in the pandemic period (6% Moodle, 3% Zoom, 5% others) the rest used other solutions (TV-Radio, Emails, meeting tools...) with more than 36% that used WhatsApp to exchange education content with students. Some teachers used their personnel website/ platform to provide content to their student. To prepare their content 92% of them said they use laptop or desktop computer, less than 2% use professional camera (or recording studio). Most of them uses with the iMovie, VSDC and Windows Movie Maker as audiovisual software.

The result shows that most of schools does not have any e-learning dedicated unit, even if they have in most cases IT technicians.

Table 2: Tools and methods adopted for preparing the online course

What tools and methods did you use to prepare for your online course?	
Educational scenario of the lesson that you did in person	20%
Adopting a course already taken online	12%
Official documents (description of the program)	10%
Educational objectives / Targeted skills	28%
Textbooks or educational works	3%
Student prerequisites	18%
Teaching method or technique (by problem, by investigation, by project, etc.)	5%
Others	4%

The search results showed that the content is composed mainly of videos, texts, pictures and audios:

Table 3: Type of material used in online courses

Type of material used in online courses	
Pictures	17%
Videos	31%
Texts (PDF, word ...)	28%
Power Point presentations	9%
Audios	10%
Other:	5%

In terms of interaction modalities, the results shows that about 43% uses both synchronous and asynchronous interaction and 31% uses only asynchronous one.

Table 4: interaction modalities in online courses

What interaction modalities have you used in your online course?	
Synchronous (simultaneous interactions)	17%
Asynchronous (Interactions at different times)	31%
Synchronous and asynchronous	43%
Not Applicable	9%

Regarding the assessment process, only 32% confirmed they used online assessment, the others justify their non-use of assessment to the difficulty of verifying the reliability of the process.

Multiple-choice questions is the most used online assessment method by teachers.

More than 60% of teachers reported having some technical problems during the preparation and supervision of distance learning courses.

Teachers' believe that the constraints blocking the adoption of online learning are often related to technical problems of the use of the platform and the lack of motivation and commitment from students. In this direction, teachers think that the low of motivation and engagement is essentially due the online learning context, the lack of human contact and interactivity. However, they think it gives more autonomy for students and save invested time.

Finally, results shows that most of teachers prefer an online education supplemented by face-to-face education than a 100% online education.

Student who are based in the rural areas were the last to take online learning than the ones who are urban based. These latter have shown a rapid adaptation to the new mode.

It was found that students who received an online learning from their schools were more predisposed to accept the renewal of the experience.

The results shows us that more than 70% of candidates were in favor of repeating the experience or recommending the learning to other people. The rest of student who did not follow up the online education or had a lot of problem to learn online were reluctant about continuing this experience in the future.

Interviews Results

Through the 12 person selected for the interview process, six of them are students and the rest are teachers. All of them have dealt with the online learning.

The interview results showed that 4 of six teachers were favorable to the e-learning experience, and they want to continue using the online learning platforms in the future, only two of the students were the same. The rest felt that online learning is not effective and that it does not achieve learning objectives.

Generally, results shows that the interviewed were more interested by a learning process that combine between e-learning and face-to-face learning.

5. Discussions

The main goal of this work was to evaluate the impact of covid-19 on the maintain of education online and the role of adaptive learning to improve the engagement of student on online learning...

Based on the results, the education was maintained for a part of students (mainly urban student who have the means.). The learning environment plays an important role in the continuity of education in a pandemic context. Indeed, we noticed through this study that most of the students from the rural world, where parents and schools do not have the same means that those in the cities, have not had the chance to take full advantage of the e-learning systems available.

On the other hand, the majority of online learning experiences have demonstrated their insufficiency to replace face-to-face learning, in fact, several teachers have pointed out the lack of student engagement, the large number of technical problems and the lack of a full learning environment.

according to the results of the study, the lack of student engagement is mainly linked to the fact that online learning systems, unlike the face-to-face system where the teacher adapts his course according to the progress and profile of the students, does not adapt their content to the profile of the learners. Our adaptive system will therefore make it possible to increase student engagement through adaptation mechanisms and techniques that generate a learning experience adapted to the profile of the distant learner.

The results showed that several teachers have difficulty in adapting to the new mode of teaching, indeed, there is a real resistance to change which negatively affects the implementation of online education, the lack of means, training, and work tools contribute significantly to the slowness of adaptation to this new mode. The current context has forced all teachers to try this approach, which has made it possible to highlight the learning difficulties and the obstacles to overcome. The first main obstacle is the lack of adaptability of traditional e-learning systems, which makes the learning experience inefficient and negatively affects student engagement. The second obstacle is the lack of tools and learning systems necessary to implement any online learning experience. In addition, the third principal obstacle is the student connectivity, especially in rural areas, which must be solved by ensuring network coverage as well as the accessibility of this service.

These conclusions confirm the works of Bao, [23] on the high-impact principles for online education in a pandemic context.

Seeing that the majority of teachers were not satisfied by the experience of online education as a replacement of the face-to-face education was predictable, several works have already discussed it [24], this can be explained by the fact that this need change management to help them accept this new way, the change management change management must consist of appropriate training, communication and support with tools and close assistance.

It is normal that the impact of the covid-19 was more visible on some students than others, indeed, the learner's environment plays an important role in the learning experience, not all students and schools have the same means and the same capacities. These findings support the studies of Burgess et al. [25] where they discussed the substantial disparities between families in the extent to which they can help their children learn, and cited for example the amount of time available to devote to teaching, the non-cognitive skills of the parents, resources...etc.

To sum up, this research revealed that the biggest remaining challenge to allow online education to take its place is to design the systems that help teachers as well as learners to accept this new way of learning and take advantage of the covid-19 boost in accelerating the adoption of e-learning.

During this pandemic, a huge digital background has already been acquired; we must capitalize on to start a new distance-training model specific to Morocco. A model that takes into account the strengths that universities have and the perception of distance learning by students and faculty.

6. Limitations

This study concerned a new line of research relating to the covid-19 pandemic that the world has never known like. Research work is very rare in this area, which has represented a major obstacle in the conduct of this research. In order to go beyond that, we had to base ourselves on studies that have treated epidemics like Ebola or the H1N1 flu or start from the beginning without references.

7. Conclusions and futures works

In conclusion, this unprecedented circumstance related to covid-19 will affect the way we instruct our students for at least years. This will require innovation and cooperation from governments and schools, and leadership from our educational actors to maintain the continuity of education under the best possible conditions.

In this sense, we will be based on this model to develop in detail the adaptive online learning model in order to make it more suited to the context of the health crisis and occupy a place in the field of future education:

- Choosing between the different adaptations strategies taking into account the conclusions of this study.
- Proceed with the implementation of this model in the form of an open source system, which will be made available to teachers in order to allow them to benefit from the power of adaptive e-learning systems.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Statement

1. Hereby, we, the authors, consciously assure that for the manuscript "Self-evaluative scientific modeling in an outreach gene technology laboratory" the following is fulfilled:

- (a) This material is the authors' own original work, which has not been previously published elsewhere.
- (b) The paper is not currently being considered for publication elsewhere.
- (c) The paper reflects the authors' own research and analysis in a truthful and complete manner.
- (d) The paper properly credits the meaningful contributions of coauthors and co-researchers.

(e) The results are appropriately placed in the context of prior and existing research.

(f) All the sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.

(g) All the authors have been personally and actively involved in substantial work leading to the paper and will take public responsibility for its content.

2. Moreover, "all the procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Consent Statement "Informed consent was obtained from all individual participants included in the study."

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