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Research based on the design of Co-CreHAs: co-creation of educational material adapted to high-ability students to improve their motivation

Investigación basada en el Diseño de Co-CreHAs: co-creación de material educativo adaptado a alumnos de alta capacidad para mejorar su motivación

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ABSTRACT. This study defines a process for co-creating educational materials (Co-CreHAs) which aims to improve the motivation of high-ability students, where not only do the students themselves participate, but so too their teachers and family. From the process defined here, a software platform, (also called Co-CreHAs), has been developed. This platform includes AdaptHAs; the adaptation model that considers the numerous variables for these students. To develop Co-CreHAs, a case study implementing five experiences was carried out using Design-Based Research (DBR) methodology. The results of the MSLQ-44 test (Motivated Strategies for Learning Questionnaire) showed that the self-efficacy, self-regulation, use of cognitive strategies and intrinsic value aspects of motivation improved throughout the experiences. It was observed that Co-CreHAs and the use of AdaptHAs helped high ability students focus on co-creating and group work since "assessment anxiety" diminished as the students went through the experiences. The results obtained allow us to see that co-creating educational materials that are adapted to the needs of high ability students helps them improve their overall motivation in the learning process.

RESUMEN. Este estudio define un proceso de co-creación de materiales educativos (Co-CreHAs) que tiene como objetivo mejorar la motivación de los alumnos con altas capacidades, donde no solo participan los propios alumnos, sino también sus profesores y familiares. A partir del proceso definido aquí, se ha desarrollado una plataforma de software (también llamada Co-CreHAs). Esta plataforma incluye AdaptHAs; el modelo de adaptación que considera las numerosas variables para estos alumnos. Para desarrollar Co-CreHAs, se llevó a cabo un estudio de caso implementando cinco experiencias utilizando la metodología de Investigación Basada en Diseño (DBR). Los resultados de la prueba MSLQ-44 (Cuestionario de estrategias motivadas para el aprendizaje) mostraron que la autoeficacia, la autorregulación, el uso de estrategias cognitivas y los aspectos de valor intrínseco de la motivación mejoraron a lo largo de las experiencias. Se observó que los Co-CreHAs y el uso de AdaptHAs ayudaron a los estudiantes de alta capacidad a concentrarse en la creación conjunta y el trabajo en grupo, ya que la "ansiedad de evaluación" disminuyó a medida que los estudiantes pasaban por las experiencias. Los resultados obtenidos permiten comprobar que la cocreación de materiales didácticos adaptados a las necesidades de los alumnos de alta capacidad les ayuda a mejorar su motivación global en el proceso de aprendizaje.

KEYWORDS: Learning activities, High ability, Cocreation, ICT, Adaptability, Motivation, Creativity.

PALABRAS CLAVE: Actividades de aprendizaje, Alta capacidad, Cocreación, TIC, Adaptabilidad, Motivación, Creatividad.

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1. Introduction

In the teaching-learning process, a student's motivation not only helps them to learn, but also encourages them to participate in their own learning. This is important since meaningful learning depends on each student's passion and motivation for a topic (Purnama, Rahayu & Yugafiati, 2019, Yanuarti & Rosmayanti, 2019, among others).

To promote high-ability students' interest in their learning, processes that promote their intrinsic motivation can be carried out (Renzulli, 2005). This allows students to do activities because they interest them, they generate curiosity and they are focused on achieving the objective (Clinkenbeard, 2012). This type of motivation can be worked through actions that allow them to take more responsibilities, develop activities according to the level of their abilities, include their interests in the academic process, and participate in a different way than usual within the learning process.

As indicated by Schunk & Usher (2019), students who feel competent to perform well are able to participate in activities that help them learn by increasing their effort and persistence. Schunk & DiBenedetto (2020) explain that motivation processes are personal (internal) influences that, among others, favor effort, persistence and achievement. According to Siegle (2013), achievement motivation is the difference between what a student is achieving at a given moment and what they are capable of achieving in the future. Therefore, the achievement orientation in high capacities is based on three variables: expectations of success (environmental perception), confidence in one's own abilities to perform the task (self-efficacy), and the value that the person gives to the task or outcome (significant interest). These variables rest on four theories: Lewin's theory of perceived environment (1935), Bandura's theory of self-efficacy (1986), Wigfield and Eccles's (2000) theory of the expectancy-value, and Weiner's theory of causal attribution (1986).

High-ability students stand out because their intellectual and non-intellectual skills allow them to perform better than people of the same age in one or different domains (Pfeiffer, 2012, 2013). For this reason, many people imagine that these students do not need any help with their daily tasks, especially in their education, but the reality is that on many occasions they need more help than other students. If they are not provided with the education they need and the right environment for their emotional and intellectual development, they are often bored and do not feel committed to or motivated by their learning and can suffer from school failure because of demotivation which may, in turn, cause them to drop their studies. Therefore, motivation is even more relevant when it comes to high-ability students.

Starting from this point, the objective of including co-creation is to promote, increase or instil motivation in students' own education since, as mentioned in Bedoya et al. (2013), meaningful learning depends on each student's passion for and motivation about a topic. Fernandes & Remelhe (2016) mention that, in most cases, the motivation of those who participate in this type of co-creation process is intrinsic, since the most important motivation is the acquisition of knowledge. Participants are motivated by the benefits of the resulting product, by reciprocal results, by feelings of altruism, by learning, by supporting other people, by participating in intellectually stimulating activities (because they have the opportunity to express themselves), by contributing creatively, etc. Considering that, in general, the kind of motivation that stands out in students with high ability is intrinsic motivation, and therefore co-creation is a process that can readily support the educational processes of these students.

The student is part of the process of creating academic materials together with the teacher. As the student is an active part of the process, we can speak of co-creation and its peculiarities directly affect co-creation (Prahalad & Ramaswamy, 2004). The objective of involving the students with high abilities in the co-creation of their educational material is to increase their commitment to the activities, creating both their own as well as external pressures or demands to carry out the tasks, and helping them to take responsibility for their own learning.

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In this sense, as indicated by Barroso, Cabero and Gutiérrez (2018), when students become producers they are more satisfied with the training action, more motivated in the teaching-learning process, they acquire the content and capacities provided for in the training action, and they acquire knowledge regarding the technology with which they work, perfecting their digital skills.

In this work investigating the co-creation process and evaluating motivation, variables such as multiple intelligences, personality types, cognitive styles and the learning preferences of the participants have also been considered. It should be noted that there are no studies that relate Information and Communication Technologies (ICT) with high-ability students and motivation, as shown by the results obtained by Fernández, Reyes & Montenegro (2019) in their bibliographic review carried out between 2008 and 2018.

The tools we adopted to evaluate the motivational orientations of the students in our study were the Motivated Strategies for Learning Questionnaire - MSLQ (Pintrich & and Others, 1991), along with the "Multiple intelligences detection questionnaire from C.M." by Gómez Masdevall (2009), the 16personalities test (NERIS Analytics Limited, 2011), a test on cognitive styles from Moruno, Sánchez & Torrego (2011) and a learning preferences test from Renzulli, Rizza & Smith (2002).

On the other hand, as indicated by García-Perales and Almeida (2019), the use of technology as a learning resource can be very important because it allows the individualization of a space (that the leaner feels is theirs). Along these lines, Uribe-Rios, Jové, Fabregat & Meneses-Ortegon (2018) proposed a process of co-creating educational material for high-ability students called Co-CreHAs (Co-Cre=cocreation, HA=high ability, and s=student).

Consequently, the present work has aimed to:

- actively involve HA students in the co-creation of their own educational materials to increase their commitment to the activities by creating their own external pressures or demands to carry out the tasks and therefore helping them to take responsibility for their own learning. Because high-ability students have special characteristics, which are not only academic, and that these affect their learning processes as well, we decided to include their teacher(s) and the learner's family in the experiences as well because they know the student's academic level and personal characteristics better than anyone. In addition, including the family gives them a feeling of gratitude and a sense of commitment to the education of their children (Ferlazzo, 2011).
- consider the personal data of each student during the co-creation process so that, with the use of technology, the process could be adapted to help the HA students promote and strengthen their own self-concept, autonomy, and creativity (Martínez Torres, 2008; Castellanos, Bazan, Ferrarri & Rodríguez, 2015).

With this in mind, this research project posed the following question:

By employing a process of co-creating educational materials adapted to the characteristics of high-ability students, can we improve their motivation for their studies?

Hence, the following objectives were specified:

- Improve student with high abilities motivation for learning via co-creating educational material using ICT and the adaptive co-creation system Co-CreHAs, which includes the AdaptHAs adaptation model.
- Involve high-ability students, their teachers and their families in the co-creation process.
- Observe the relationships between the different aspects of motivation via multiple intelligences, the diversity of personalities and cognitive styles and learning preferences, together with the roles assigned during the co-creation process.

To respond to these objectives, we carried out a case study with high-ability students and employed Design-Based Research (DBR) methodology that uses Co-CreHAs to motivate these students and improve their learning processes.

In the Theoretical background section, the concept of co-creation and how it relates to the use of ICT is explained. Next, in the Material and methods section, the methodology and design of the research project, along with the case study carried out using the DBR methodology through five experiences are described. The participants in the experiences, Co-CreHAs and AdaptHAs and their software implementation are also discussed. Finally, the Material and methods section details the different instruments used: reduced version of the MSLQ, multiple intelligences detection questionnaire, the 16personalities test, a test on cognitive styles and a learning preferences test. Lastly, Section 5 presents the five experiences, the results and the corresponding conclusions.

2. Co-creation and ICT

Co-creation is a term with various definitions according to the context it is used in. In general terms, it is defined as any collective act of creativity (Sanders & Stappers, 2008). Bovill, Cook-Sather, Felter, Millard & Moore-Cherry (2015) indicate that there is co-creation in the teaching-learning process when professional or administrative staff work together with students to create components of the plans of study or pedagogical approaches. In addition, Dollinger, Lodge & Coates (2018) comment that the student must be considered in the process of preparing educational material so that they can exercise their knowledge and become active in the process.

In this sense, Meneses-Ortegón, Jové, Puiggalí & Fabregat (2020) point out that co-creation processes seek to benefit from the contributions made by different participants, in order to achieve the same objective. For this reason, involving teachers, family members and students in a co-creation process allows everyone to contribute to the creation of a material that meets the needs of students from different points of view (p.161).

In studies such as that of Androutsos & Brinia (2019), it is stated that being able to use ICT within the co-design process helped each participant to develop their role within the group and that the results could be tested by more people. Blau and Shamir-Inbal (2018) reached a similar conclusion when co-design processes were applied to university studies. These authors mention that technology facilitated collaboration and communication between students, and between students and their instructor. Ranjbarfard and Heidari Sureshjani (2018) also carried out a theoretical analysis of some aspects of technology in educational co-creation processes and explain that while collaborative work, a co-creation process, can be done without technology, technology can facilitate interaction. Multisilta and Niemi (2014), among others, also reached the same conclusion.

A different application of ICT is presented in Matsui, Horiguchi, Kojima & Akakura (2014), where they used technology to detect the mental state of students at the time of doing the activities in the co-creation process to guide them in that process. Among the technology applications for co-creation processes, are platforms that can serve as a reference in relation to the ICT tools used to develop projects, the use of resources and the interactions between the roles involved. In an educational context some of the most well-known of these are: Sakai, Moodle, eXeLearning, LdShake and dScribe, although some of them cannot be used to carry out co-creation processes.

3. Material and methods

3.1. Research methodology and design

The methodology in our work is both qualitative and quantitative. A case study was carried out through observations made during the five experiments/experiences. It should be noted that in each of these experiments only three or four high-ability students, plus one teacher and one member of the student's family

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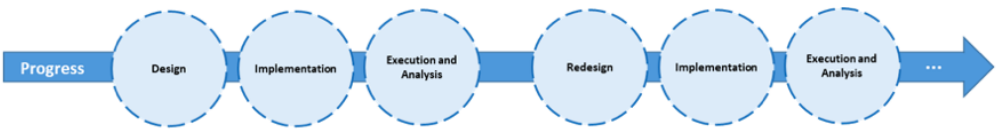
were involved. The reason for working with small samples was to better understand the process of co-creating the educational material the students were developing to be able to analyse in greater detail the changes that were taking place in student motivation, and to be able to observe the importance the presence of the teacher and/or the family member had. Although the number of students is not very high, a quantitative analysis was also carried out using the SPSSx v.27 program. This allowed us to analyse the results of the MSLQ-44 motivation test (self-efficacy, anxiety in assessments, self-regulation, use of cognitive strategies and intrinsic value) through means and standard deviations, as well as apply the Spearman Rho test to relate: a) cognitive styles with the motivational aspects obtained through the MSLQ-44, b) multiple intelligences of the Multiple intelligences Detection Questionnaire with the MSLQ-44 test and c) the 16personalities test with the MSLQ-44. It should be noted that the Spearman correlation coefficient is a useful non-parametric test when working with small samples (n <10) in which it is not known whether it is valid to assume the normality of the data. Finally, the Student's t test was also applied for related samples between different experiences to detect significant changes in motivation.

As previously mentioned, a DBR was carried out (Leinonen & Durall-Gazulla, 2014; Leinonen, Toikkanen & Silfvast, 2008; Barab & Squire, 2004 and Design-Based Research Collective, 2003). As indicated by Creswell (2014) and Creswell & Plano Clark (2018), DBR can be understood as an emerging paradigm in educational research that constitutes a problem-oriented research framework that usually uses mixed methods. This methodology is aimed at educational innovation and its main characteristic is to introduce a new element in each iteration that causes a transformation. Scientific theories or models available through programs, didactic packages, materials, didactic strategies etc., are used to solve problems detected in education. According to Salinas and De-Benito (2020), this type of research "emerged among researchers who were creating learning environments enriched by technology" (p.3).

In DBR methodology, designs made are subjected to tests and validation and then, finally, used in real environments. Being iterative allows for a process of revision and reformulation and in each iteration a reflection can be carried out that facilitates reviewing the co-creation model and adapting it to the problems detected during practical experience. Furthermore, this methodology also allows for collaboration between the different members participating in the research. The analysis of each iteration allowed us to define a new design proposal.

The research design is cyclical and in this work five iterations were carried out; each corresponding to one of the experiences explained below. And each iteration consisted of three phases (Figure 1).



In Design (first iteration) or redesign (subsequent iterations), the materials co-creation process to be carried out and the platform to be used are designed.

In Implementation phase, the platform required to carry out the defined co-creation process is developed or modifications made to the platform already developed in the previous iteration.

The Execution and Analysis phase carries out a co-creation process with a group of real users, using the new version of the platform, analyses the results obtained in the experience and, after joint reflection, detects the observed limitations, identifies the aspects of change or reinforcement for the software platform and the co-creation and experience model.

Figure 1. Research design. Source: Self-made.

3.2. Participants

The research team was made up of teachers and parents of high-ability students. It should be noted that the teachers had previously received training from experts on the subject and from professionals who

collaborate with the Aid Foundation for Children and Young People with High Intellectual Abilities (FANJAC). The actions to perform were planned based on that training.

As indicated by Torres, González, Bernal & Infante (2019), and following the indications of Lazar (2017) in research methods for interactions between humans and computers, in the case of a population with special characteristics (high capacities, disabled ...) it is recommended following the "in-depth case study" method: a small number of instances within a specific real-life context (from three to ten participants).

The student participants aged 11 to 14 were invited to participate (along with their parents and teachers) through an appeal made to all FANJAC families with children of that age.

A total of 12 students, eight parents (3 men and 5 women, most without co-creation experience), three teachers (2 women and 1 man, with medium co-creation experience) and two moderators (1 man and 1 woman, with high experience in co-creation) participated, from which five different groups were formed. Also, it must be kept in mind that almost all of them participated in more than one experience. The participants were informed of the anonymity of the tests and indicated where they could later check the results obtained in this investigation.

3.3. Co-CreHAs and AdaptHAs

Co-CreHAs was created using DBR methodology. In addition to the name of the designed co-creation process, Co-CreHAs is also the name of a software implementation developed to validate this co-creation process. It consists of six phases that are classified as active: "Plan", "Motivate", "Develop" and "Evaluate" and not active: "Pre-co-creation" and "Update", depending on the role that students had in them. In addition, to carry out the co-creation process, three roles were considered (Facilitator, Consultant/Expert and Generator). Note that all these phases are carried out in the "Experimentation and Analysis" phase of the DBR methodology.

The following explains what is done in each of these phases:

- Pre-co-creation. In this phase, the personal data of the participants in the co-creation process is obtained, the co-creation context according to the participants' data is started and roles are assigned to each participant. This phase provides the process through forms and tests, and all the data on the context of the co-creation and on the participants.
- Plan. This stage determines what topic to work on and what educational material to co-create.
- Motivate. Here, co-creators are encouraged to actively participate in the process and explain and contextualize the topic to work on in the co-creation process.
- Develop. This phase consists of four sub-phases: the Devise sub-phase generates as many ideas as possible to create the material, the Analyse sub-phase examines each idea generated with respect to its quality, the necessary resources and its viability, or the details of a material already created, the Select sub-phase determines which idea is to be co-created and the Create sub-phase is where the material co-creation process is carried out and verified.
- Evaluate: This step is so that participants can assess the work done by the co-creators during the process, the resulting co-created material and the final version of the material.
- Update: This phase updates the data concerning the participants in the co-creation process and the process itself, according to the results of the process and each participant`s response to the activities carried out.

Adapting Co-CreHAs according to the needs of the HA high-ability students was developed through AdaptHAs (Adaptation for High Ability students) (Uribe-Rios, Fabregat, Jové & Tesouro, 2020) which is the adaptation module of Co-CreHAs in which adapting four services is proposed: selecting the topic to work on, the activities carried out in each phase, the strategies assigned for each role in each phase, and the role assigned to each of the participants.

3.4. Implementation of the Co-CreHAs and AdaptHAs software

After evaluating the different existing e-learning platforms, it was decided to work with Moodle since, despite not being a platform specifically designed for co-creation, it was the most well-known platform for the teachers and students who were going to do the tests. In other words, working with Moodle made it easier for teachers and students to use Co-CreHAs as the process took place in an environment that was familiar to them and which also made it easier for the proposal to be validated in a real environment.

The agile Adaptive Software Development (ASD) methodology (Highsmith, 2013) was used as a framework for software development because it addresses rapid developments in changing environments. The ASD methodology consists of three phases: speculate, collaborate, and learn. Because the development of the software was not carried out by a work team but by a single person, none of the ASD activities that are directed to a team were carried out. For example, in the speculate phase, only one function was assigned to the person doing the development rather than to each person in the group, and in the learning phase it was not necessary to carry out the task of communicating knowledge to the other members of the group.

3.5. Tests used

The following tests have been applied to the HA high-ability students:

- The shortened 44-question version of (the original 81-item MSLQ) Motivated Strategies for Learning Questionnaire (Pintrich & Others, 1991) that assesses student motivation. This is designed using a social-cognitive view of motivation and learning strategies, so its components are: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy in learning and performance and anxiety. In this questionnaire, the student is seen as an active processor of information whose beliefs and cognitions are important inputs and characteristics of a task.
- The "Multiple Intelligences Detection Questionnaire from C.M." by Gómez Masdevall (2009). It is an adaptation of the McKenzie Questionnaire (1999). This test has one form for the student and others for the teacher and the parent. The result is based on the computation of these three forms. This result is a score (between 0 and 100) on each of the intelligences. The greater the value, the greater the "domain" of that intelligence.
- Test 16personalities (NERIS Analytics Limited, 2011) is based on a series of questions that the student must answer. The result is based on the 16 different personalities that are formed from the union of four "dichotomies". Each dichotomy is a division of two mutually exclusive groups, in this case type preferences, typically referred to with a letter abbreviation: Extraversion (E) / Introversion (I), Sensation (S) / Intuition (N), Thought (T) / Feel (F) and Judge (J) / Perceive (P). Based on these patterns of preferences, the instrument categorizes a person into one of 16 personality types, where each type is a combination of these four dichotomies (King & Mason, 2020).
- A test on cognitive styles. To develop the items on cognitive styles we have based our evaluation on the test composed of simple questions by Moruno, Sánchez & Torrego (2011), which considers that these can be independent or dependent in the field of the teacher and their teaching strategies and have a reflective dimension or impulsive. This test was adapted to apply to students.
- A test on learning preferences. We are based the items of this test on the work of Renzulli, Rizza & Smith (2002), where nine dimensions are described regarding learning preferences. From these nine dimensions, a form with 11 items was created concerning what types of activities the student likes the most: projects, independent study, instruction and recitation, discussion, reading, programmed instruction, simulations, teaching in pairs, game didactics, graphic representation or corporal expression. According to the theory mentioned in Moruno, Sánchez & Torrego (2011), there are certain preferences for a sensory channel to understand, interpret, process, and memorize the information used by the visual, auditory, and kinetic systems (predominant representation systems). To relate the visual and kinetic representation system with the IIMMs, the last two items were included in the learning preferences.
- A list of interests and modes of expression from Carol Tomlinson (Tomlinson, 2001) and a checklist of abilities that were defined in Tomlinson's research were also been used in our work.

4. Experiences carried out

4.1. E1 experience

It should be noted that the E1 experience was the only one designed without the use of ICT and was carried out by what we have called Group A (Table 2). The participants had to co-create educational material within the framework of Co-CreHAs, but without the use of ICT and with the help of a moderator who guided them in the co-creation process. In each phase there was a document that explained the activities to be carried out and a form where the participants recorded the development of the process. The objective of carrying out the E1 experience without the use of ICT was to validate the design of the Co-CreHAs co-creation process, the flow of the phases considered, their order and their objectives. We wanted to verify if it was feasible, understandable and could be developed by high-ability students without any problems. Once these elements were validated, Co-CreHAs could be implemented using ICT.

The actions carried out in each of the four active phases of this experience are explained below:

- Plan: Some options of topics and material to work on were proposed. Participating students following the activity proposed by Co-CreHAs selected the topic "Physics". The material agreed on to co-create was an interactive scenario in Algodoo (Algoryx, 2019) to show the operation of a pulley considering the force of gravity and the behaviour of fluids.
- Motivate: Motivation for the topic was worked on in a talk/clarification made by the moderator with the support of the father of the family and the teacher. The motivation process towards the type of material to be co-created was not totally satisfactory because one of the two videos that were used to explain the interactive Algodoo scenario was long and slow, which is why the students began to be distracted. When this happened, the moderator made the decision to switch to the next video, thus recapturing the students' attention again.
- Develop: This was divided into four sub-phases:
  - o Devise. The setting was chosen to create and implement the physics concepts that were to be worked on. Two activities were proposed: brainstorming or matching two random words from a list. The students selected the second and, as a result of this activity, nine ideas were generated.
  - o Analyse. The nine ideas were analysed and two of them were discarded due to their infeasibility because they were fanciful ideas that could not really be applied.
  - o Select. A new idea that arose from the union of two of the seven possible ideas was selected.
  - o Create. The final design was divided among all the participants. Each of them developed sketches and designs on their part and gave ideas about the work of the others, which was then integrated into the final design that was implemented in Algodoo with the participation of all the group members.
- Evaluate: The students carried out the different types of evaluation (process evaluation, co-evaluation, self-evaluation, and evaluation of the co-created material). To assess motivation, the MSLQ-44 test was applied.

4.2. E2 experience

The objective of this second experience was to verify, in the Co-CreHAs extension implemented for Moodle, the behaviour of the AdaptHAs services and the aspects identified in the E1 experience that needed to be changed or reinforced.

Specifically, the following changes were made regarding the E1 experience:

- Modify the "Plan" and "Motivate" phases to work on issues related to the interests of the students and thus make the process more effective.
- Allow a more flexible timeframe in the development of the phases according to the level of each student.
- Reinforce the role of the moderator of the process so that students have the freedom to express themselves, speak and share, and to help them focus the work that they had to do.

- Give students the opportunity to choose the topic and decide what content they were going to create.
- Present a new self-assessment format based on the metacognition ladder (Rahnev & Fleming, 2019).

Since the behaviour of both Co-CreHAs and AdaptHAs would be verified, experimental variables were defined (such as accessibility and ease of understanding to validate the co-creation process) and adaptation variables (such as the amount of material/requested data, the calculation time of the algorithms, etc.) to validate the implemented adaptation.

We worked with Group B and Group C (Table 2). In these groups the ages of the students were between 11 and 14 years old. Although the size of Group C may appear to be very large, it should be noted that the number of students was not that different from the other groups.

The actions carried out in each of the four active phases of this experience are explained below:

- Plan: Participants in both groups were enthusiastic about the themes proposed by AdaptHAs. For Group B the themes proposed were: "Changing Camel Cup", "Surviving in the Poles" and "Countries in the First and Second World Wars" and for Group C the themes were: "Changing Camel Cup", "Surviving in the polo "and" Starting from Catalan". The topic "How to survive in polo" was proposed in both groups, and initially both groups were inclined towards this topic, but on seeing that Group B had selected it, Group C, using the idea initially proposed as a springboard, decided to create the topic "How to survive in the desert".
- Motivate: This phase was very quiet. Both groups dedicated themselves to researching the subject and the possible ways to create the content individually.
- Develop: This phase was very eventful. All the participants were very enthusiastic about each of the sub-phases and wanted to participate in each activity. In both groups the participants divided the tasks to be carried out and all collaborated. Group B stood out for the high number of ideas given. In this phase, leaving the order and development of the sub-phases flexible turned out to be a wise decision for high-ability students, since several of them carried out all the sub-phases simultaneously, especially when they were highly motivated.
- Evaluate: This phase proceeded calmly. As in the E1 Experience, it was necessary to force them a little to move from the "Develop" phase to the "Evaluate" phase, since the participating students were especially extremely entertained in the co-creation of the contents. The performance of the evaluation tests took a bit longer and some of the students were tired when it came to answering them.

4.3. E3 experience

As the E2 experience could not analyse the AdaptHAs services, the E3 experience was designed to do this. In addition, the adaptation corresponding to the assignment of roles was included in AdaptHAs through an algorithm based on the 16personalities test (NERIS Analytics Limited, 2011).

To assign the roles according to the personality of each student, an analysis was made of the theory of the 16personalities test, and the characteristics defined for each role in Co-CreHAs. From this analysis, the personality factors selected were those that, according to their theoretical characteristics, have a greater relationship with the roles of the co-creation process. The objective was to try to match the characteristics of the roles with those of the personality according to what the research needed, that is, not to fit a role in a personality, but a personality in a role. Table 1 shows the relationship between the roles defined in Co-CreHAs and the personality factors provided by the 16personalities test.

Personality Factors	Role		
	Facilitator	Generator	Consultant / Expert
Outgoing	X		X
Introvert		X	
Intuitive		X	
Observer	X		
Thoughtful		X	X
Emotional	X		
Judging	X		
Prospecting		X	
Assertive		X	X
Cautious	X		

Table 1. Role assignment. Source: Self-made.

The algorithm proposed for assigning roles to each participant uses this table to assign the roles to each participant at the beginning of the co-creation process and to prioritize the participation of each student. The steps of this algorithm are:

1. Verify that participating students meet the personality factors for each role. For a student to be assigned a role, they must fulfil half plus one of the characteristics assigned to that role. In the case of which are 3 for the Facilitator and the Generator this is three characteristics, while it is two for the Consultant/Expert.
2. Assign the roles following the order of Facilitator, Generator and Consultant/Expert. Among all the students who fulfil three or more personality factors corresponding to Facilitator, this role will be assigned to the student who fulfils the highest number of personality factors assigned to this role. Once the Facilitator role has been assigned, the same criteria will be applied among the remaining students to assign the Generator role. Finally, the same will be done to assign the Consultant/Expert role. Students who have not been assigned a role will be assigned the Builder role.
3. If the Facilitator or Consultant/Expert roles could not be assigned to any student, each of these will be assigned to a teacher or a parent.

In the E3 experience the participants were almost the same as in the E2 experience. A student from the E2 experience was unable to attend, but a new student and her mother and also a parent who had not been able to participate in the E2 experience joined the experience. The ages of the students in this experience were also between 11 and 14 years old. It must be taken into account that in this experience the groups were different from those used in the E2 experience, since the students were redistributed to balance the number of participants in each group (Group D and Group E) (Table 2). As we have previously mentioned in the E2 experience, although the number of participants in both groups is quite large, this is mainly due to the participation of a parent of each of the participants.

The actions carried out in each of the four active phases of this experience are explained below:

- Plan: Group D was given the themes: "Changing Camel Cup", "Basic elements of physics" and "Surviving at polo" and Group E the themes: "Changing Camel Cup", "Surviving in the desert" and "Starting from Catalan ". Group D chose the topic *"Basic elements of physics"* because it was the one that caught their attention, even that of those students who had not worked on this topic at school were very involved in the co-creation process. Group E chose the song *"Changing Camel Cup"* which turned out to be very motivating for the group.
- Motivate: This was a very active phase. As mentioned before, both themes motivated all the participants. Group D focused on finding different practical exercises, videos, and learning about the topics of physics they were going to work on. Group E focused on finding videos about the game and relating it to other games.
- Development: This stage was much more fluid compared to the development of the E2 Experience in which, as we have mentioned, they were almost the same participants. They mentioned that both in the

co-creation of the material and in the interaction with others it was better and more "pleasant". The most active sub-phase was "Create" because the students were very involved in their activities. Group D decided to make videos of the experiences in a real way, so they decided to recreate each exercise by themselves and document them. The co-created material was a slide show with videos of real experiments where they explain the behaviour of the chosen elements of physics. Group E looked for various changes to the Camel Cup based on the students' own experiences with other games. The co-created material was a document explaining an improved version of the Camel Cup.

- Evaluate. This phase was very quiet, the participants already knew what to do and did it faster in comparison to the E2 experience. There were no problems and none of the participants felt self-conscious when taking the different evaluations.

From the development of the process, it should be noted that the majority of parents and students wanted to adjust the development of the activities of each phase according to their role. This allowed the group work to be enriched and spaces were opened up for generating different ideas, for an in-depth analysis of the contributions given, and to carry the co-creation through a more productive work.

4.4. E4 and E5 experiences

Once the results of the use of Co-CreHAs and AdaptHAs in the E2 and E3 experiments were known, two new experiences were defined: E4 and E5. These two experiences were defined to firstly analyse the behaviour of AdaptHAs (which had been used in the E3 experience but not in the E2 experience), and secondly to compare the response of the students with high abilites in the co-creation when they had not used ICT and when ICT is used. To make this comparison, two of the three who participated in the E1 experience and a new student participated in these two experiences. We call this group Group F. To identify each of the students individually, we named the two students who had already participated in the experience, E-S and E-B and the new student E1 and E-D. These two experiences were carried out 16 months after the E1 experience, whereas between the E4 experience and the E5 experience only two days had passed.

AdaptHAs in both experiences assigned the Facilitator role to the E-D student. The other two students swapped the other two roles (Generator and Consultant/Expert) in each of the experiences. In the E4 experience, E-B mentioned that she forgot to use the role strategies that were proposed, but the two other students did use them.

The actions carried out in each of the four active phases of this experience are explained below:

- Plan: The proposed topic options caught the attention of all the students in both experiences, but as there was no agreement on which topic to work on, they decided to select one that was not among those suggested.
- Motivate: In both experiences, motivation was driven by the participants' own interest in the selected topic. In the E4 experience they focused on seeing how the Camel Cup was played and what could be improved in this game. In the E5 experience, they carried out an individual investigation about water recycling and then, matching words on the topic, they contributed ideas on how to work on recycling.
- Develop: It was similar in both experiences. All the participants contributed various ideas according to what had been done in the "Motivate" phase and after analysing each of these they decided to work on all the ideas given, dividing the tasks among themselves to develop a prototype. In Experience E4, the material co-created was some changes for the Camel Cup game that consisted of designing some cards to define skills for each camel. In the E5 experience, the co-created material was a 10-question test using an online questionnaire tool and arcade-style games.
- Evaluate: It was also similar in both experiences. Starting it in both cases was a bit difficult because the students were highly engaged and entertained by creating the materials. Once the phase started, it flowed rapidly, especially in Experience E5 since the participants already knew its development having done it two days before during Experience E4. All the participants agreed that the co-creation process helped them not

only to learn about the topic studied but also to improve their group work and their interaction with the other participants. It is important to note that, when evaluating the work done by the other participants, all were very sincere and recognized the work done by the others both in co-creation and in the performance of the roles. In general, the use of Co CreHAs was to everyone's liking.

On a general level, we can mention that the E5 experience was more fluid than the E4 experience, as was to be expected, because the participants already knew the process, and for this reason they felt more comfortable with it and took greater ownership of the co- creation.

EXPERIENCE E1 17/02/18 WITHOUT ICT	Group	• A: 3 students (2 boys and 1 girl) aged between 11 and 12 years, 1 parent, 1 teacher, 1 moderator.
	Aim	• Validate the Co-CreHAs process: its phases and its development.
	Improvements for the next phase	• Implement a Co-CreHAs extension for Moodle (including AdaptHAs). • Check its operation. • Modify the "Plan" and "Motivate" phases to work on topics related to the interests of the students. • Allow more flexible time and reinforce the role of the moderator. • Improve the self-assessment format.
EXPERIENCE E2 27/04/19 WITHOUT ICT	Group	• B: 3 students, 1 parent, 1 teacher, 1 moderator. • C: 4 students, 4 parents, 1 teacher, 1 moderator.
	Aim	• Check the behaviour of the Co-CreHAs extension for Moodle in relation to the services of the AdaptHAs model and the changes made in the definition of Co-CreHAs taking into account the results of the E1 experience.
	Improvements for the next phase	• That the participants use AdaptHAs because although it was implemented in the E2 experience it was not used in this phase by the participants. • Extend AdaptHAs with a role assignment algorithm.
EXPERIENCIA E3 4/05/19 WITH ICT	Groups D & E	• D: 4 students, 4 parents, 1 teacher, 1 moderator. • E: 3 students, 3 parents, 1 teacher, 1 moderator.
	Aim	• Check the behaviour of the AdaptHAs model and the changes made taking into account the results of the E2 experience in the use of the Co-CreHAs extension for Moodle.
	Improvements for the next phase.	• Compare student motivation with the development of Co-CreHAs "on paper" (without ICT) and in the implemented Moodle extension.
EXPERIENCE E4 **EXPERIENCE E5** 4/07/19 6/07/19 WITH ICT	Group F	• F: 3 students, 1 parent, 1 teacher, 1 moderator.
	Aim	• Check the behaviour of a group of HA students with and without the adaptation process (AdaptHAs).
	Improvements for the next phase.	• Use the role strategies that were little used in the E4 experience in the E5 experience.

Table 2. Summary of experiences. Source: Self-made.

5. Analysis and results

The results of the MSLQ-44 motivation test for experiences E1, E4 and E5 (Table 3) show that some of the aspects of motivation (self-efficacy, anxiety in evaluations, self-regulation, use of cognitive strategies and intrinsic value) increased:

•Self-efficacy, anxiety in evaluations and intrinsic value were better in the E1 experience. This could be attributed to the fact that the E1 experience was a freer experience, and that ICTs were not used in the defined work environment.

•Self-regulation improved with the use of the Co-CreHAs extension in the E4 experience and remained

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so with the correct use of AdaptHAs by all participants in the E5 experience. It can be said that these tools helped the group focus on co-creation and group work.

•The aspect of motivation related to the "Use of cognitive strategies" was better in the E5 experience, which shows that the support of adaptation in Co-CreHAs allowed the cognitive elements to be better directed within the group work.

•Anxiety in evaluations decreased with the development of the experiences and we assume that this could be due to the incorporation of ICT. The change from the E1 experience to the E4 experience was in the use of the Co-CreHAs extension, and from the E2 experience to the E5 experience the use of AdaptHAs in co-creation. It can be interpreted that with the use of technology and with the assigned roles, a sense of responsibility has been created in the students' participation, therefore increasing their confidence in their work and decreasing the anxiety they have during the evaluations that are applied in the co-creation processes.

Aspects of motivation	E1		E2		E3		E4		E5	
	x	σ	x	σ	x	σ	x	σ	x	σ
Self-efficacy	**5,9**	1,4	5,6	1,7	5,3	1,3	5,0	1,6	5,5	1,1
Anxiety in evaluations	**5,8**	0,2	4,7	1,8	4,4	1,8	**4,2**	1,7	3,5	2,6
Self-regulation	4,6	1,7	6,1	0,6	5,8	0,8	**5,0**	1,4	**5,0**	1,2
Use of cognitive strategies	5,3	2,0	6,2	0,6	6,5	0,4	5,7	0,7	**6,0**	0,6
Intrinsic value	**6,5**	0,7	6,2	0,9	6,3	0,5	5,6	1,1	5,9	0,7
x: Average **σ: Standard deviation** **(Values are between 1 and 7, where 1 is "not at all true for me" and 7 "very true for me")**										

Table 3. Motivation results of E1, E2, E3, E4 and E5 experiences. Source: Self-made.

Table 4 shows the values obtained in the motivation of the three students who participated in the E1, E4 and E5 experiences. It should be borne in mind that the E1 experience also reflects the values of the E-L student who did not participate in the other two experiences:

•For the ES student (who participated in the three experiences) three aspects of motivation improved ("Self-efficacy", "Self-regulation" and "Use of cognitive strategies") but two others did not ("Anxiety in evaluations" and "Intrinsic value") In this case we can assume that the roles, role strategies and activities helped him to improve his performance within the co-creation.

•For student E-B (who also participated in the three experiences) the results were better in the E1 experience than in the E4 experience and the E5 experience. Analysing her way of being, it was observed that the E-B student is a little more outgoing and her attention was more scattered than her classmates. We assume that having to follow roles, role strategies, and activities may be limiting for her. However, it should be noted that "Anxiety in evaluations" improved as the experiences progressed.

•In relation to the E-D student, who participated only in the last two experiences, in general an improvement in the aspects of his motivation was seen in the E5 experience (which was done two days after E4).

All these results show the diversity of personalities and characteristics of the high-ability students.

Aspects of motivation	E1			E4			E5		
	E-S	E-B	E-L	E-S	E-B	E-D	E-S	E-B	E-D
Self-efficacy	5	6,6	6,1	5,6	5,1	4,4	6,0	5,6	5
Anxiety in evaluations	7	6,3	5,3	5,7	4,7	4,7	4,0	4,7	5
Self-regulation	3	5,8	4,0	4,4	5,6	5,1	4,9	5,2	5
Use of cognitive strategies	4,6	5,9	5,8	5,8	5,7	5,8	6,9	5,3	5,8
Intrinsic value	6,1	6,9	6,4	6,1	4,6	6,0	5,9	5,8	6,0
(Values are between 1 and 7, where 1 is "not at all true for me" and 7 "very true for me")									

Table 4. Average of Individual motivation results of E1, E4 and E5 experiences. Source: Self-made.

The Spearman Rho test was applied between cognitive styles (teacher's field and dimension) and motivational aspects. A significant relationship was observed between the "Impulsive" dimension of the cognitive style and the "Anxiety in evaluations" aspect of motivation (0.874) (p=0.01). This indicates that the more impulsive the student is, the more anxiety they present in the evaluations made in the co-creation process.

To observe if there was a relationship between multiple intelligences and motivation, Spearman's Rho was also applied. It was observed that students with higher musical intelligence have higher "Anxiety in evaluations" (0.798) (p=0.032).

Moreover, in the analysis between the diversity of personalities and motivation, it was observed that the more something or someone is judged or perceived, the less self-regulation occurs in co-creation (-0.815) (p=0.037) and that the more something or someone is judged or perceived greater is the "Anxiety in the evaluations" in the co-creation (0.801) (p=0.030).

Starting from Table 3 and doing the same analysis for experiences E2 and E3, in which the participants were mostly the same, in the first instance it was observed that:

- Between Experience E2 and Experience E3 there was an improvement in the aspects "Use of cognitive strategies" and "Intrinsic value", showing that adaptation improves these aspects that are important for high abilities.
- The standard deviation was lower for "Self-efficacy", "Use of cognitive strategies" and "Intrinsic value", showing that adaptation helped the perception and management aspects of motivation in co-creation to be more similar among students.

This can be interpreted as that working through the roles, role strategies and activities in each phase helped the students to be more motivated in co-creation.

The normality of the data obtained in experiences 2 and 3 was verified with the Shapiro-Wilk test (Table 5). In the case of the data from the experiences E2 and E3, a comparison of the five aspects of the motivation test was made through the T-test for related data. The results show that the p-value is greater than 0.05 in all aspects of motivation. This means that motivation did not significantly change between the development of the E2 Experience and the E3 Experience.

Aspects of motivation	E2 Sig.	E3 Sig.
Self-efficacy	,052	,523
Anxiety in evaluations	,945	,963
Self-regulation	,685	,123
Use of cognitive strategies	,335	,251
Intrinsic value	,217	,950

Table 5. Shapiro-Wilk of E2 and E3 experiences. Source: Self-made.

With these results, it is observed that AdaptHAs improves some aspects of motivation in co-creation with high-ability students, but this improvement is not significant. It should be clarified that the perception of these aspects depends not only on the co-creation experience but also on the way of being of each person (which is reflected in the standard deviation) and for this reason each experience can be very different compared to the other.

6. Discussion and conclusions

In relation to the improvement in motivation mentioned in the first objectives, with the development of experiences E1, E2 and E4 (even taking into account that not all participants used the role strategies in E4 experience) it could be observed that the mere fact of participating in Co-CreHAs, even if partial use is made of the adaptation model implemented in AdaptHAs, motivates students not only to co-create but also to work

in groups, to interact with other people, and to investigate and learn about unknown topics.

Regarding the second objective, involving high-ability students together with their teachers and their family in the co-creation process, it can be observed that with the development of experiences E3 and E5, the adaptation methods of AdaptHAs guide and positively intervene in the development of co-creation. This occurred not only for high-ability students but also for their parents. The development of co-creation through AdaptHAs made them step aside, observe their children, work as equals, and understand how they can offer useful support within their child's educational process. The fact that both students and parents found a real use for Co-CreHAs in the school life of their children shows that it meets the real needs of these students.

Regarding the third objective, which relates motivation to cognitive styles (reflective or impulsive) and personality, together with the assigned roles, it was possible to observe how the aspects of motivation evaluated with the MSLQ-44 test had a high value from the E1 experience and how these values continued to improve with the completion of more co-creation experiences. This could especially be seen from the improvement observed between the development of experiences E2 and E3, and between experiences E4 and E5. In a general way, it can be observed that, of the motivational aspects of the test, "Anxiety in the evaluations" was the aspect that changed the most during the experiences and that it depends a lot on each individual, their role and their own concept of self. This is because self-concept is a characteristic that fluctuates a lot among high-ability students and, therefore, this aspect of motivation can influence the outcome of experiences depending on the group of students and the context of co-creation.

Another point to highlight is that the other aspects of motivation (Self-efficacy, Self-regulation, use of cognitive strategies and Intrinsic Value) were positively influenced by Co-CreHAs and AdaptHAs.

Co-creation and the use of User Adaptation allow participants to take advantage of their skills while, at the same time, takes them out of their comfort zone and has them experience different skills at the individual and group level. It was observed that, in particular, students work better with the cognitive strategies with the support of Co-CreHAs and that they themselves are aware of the personal work carried out.

Finally, for all the students, it can be said that in the experiences the use of an adaptive system in the process of co-creation of educational material adapted to the needs of high-ability students help them improve their motivation in the learning process.

It should be noted that similar studies that relate motivation with co-creation in high-ability students have not been found and, therefore, we have not been able to compare our results with those of other studies.

Based on this study, a future line of research is proposed which will carry out more experiments with the CoCreHAs and ADaptHAs software with groups of high-ability students of the same age and of other ages to analyse if there are any differences based on age.

Furthermore, whether the use of co-created materials is more or less effective in terms of motivation, in a heterogeneous educational environment (i.e., children with and without high abilities). Moreover then materials created only by teachers could also be analysed.

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