Mobile Application based on Design Thinking for Teaching Kinematics

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Abstract. Ignorance of the usefulness of technology makes it challenging to apply innovative strategies in the classroom, accompanied by a thought that educational technology is about introducing more technological devices to the school, and not how to use technological tools for the scope of the teaching/learning process. To these problems, a time circumstance is added since teachers need enough time to update themselves. In recent years some new trends have been emerging and have taken more strength in innovation, fostering new forms of teaching. Their intention in educational centers is to prepare students for a new type of society, which is the information society. For this reason, this work proposes the use of the design thinking methodology for the development of a mobile application, efficient and usable for teaching kinematics, obtaining a favorable result given to the acceptance of a sample of fifth-year students from a high school.

Keywords: Design Thinking · Education tecnology · Mobile Aplication · kinematics · innovation

1 Introduction

Today, the work of innovation and digital change is not a simple task for the teaching staff of schools. The misuse of technology makes it difficult to implement innovative strategies in the classroom. There is a misconception that educational technology is just introducing many technological devices to school, not on how to use technological tools adequately in the field of teaching and learning. Added to this problem is time, given that teachers need time to learn, explore, dominate, and put it into practice. Innovation in educational technology (EdTech) not only refers to the use of tools but also to pedagogy, teaching, strategies, processes, resources, and talent development [5]. Educational innovation is a compilation of ideas, methods, and procedures, which promote changes in instructional practices and taking advantage of technologies. The processes are more efficient, academic, challenging, and motivating, intending to become a disruptive education since they impact the entire educational context[3].

In recent years, new trends have gained more strength in innovation and promoting new ways of teaching. The intention is to apply them in schools and to prepare students for a new kind of society, the society information, not only seeking to teach the use of Information and Communication Technologies (ICT) but looking for new learning tools to meet the unique educational challenges. Design Thinking is an analytical and creative process that involves a group of people from different fields to generate innovative ideas. The focus is mainly on the user experience, modeling, and construction, with emphasis on the most critical part of the implementation of the model. We refer to the **redesign**, to detect problems and needs, and to find a quick and useful solution[9]. This article proposes the use of Design Thinking methodology for the development of a mobile application for teaching the course of the kinematics. To meet the objective of the proposal, we formed a group of experts in the field of software engineering and education, allowing the diversity of knowledge and empathizing with a more in-depth human approach to learn more about the needs of students.

2 Theoretical framework

2.1 Research Problem

The complexity is identified as a problem in the stage of digital transformation in regular primary education, which presents various challenges as a time circumstance, so that a teacher can adapt, and a slow process of adaptability to generate innovative ideas quickly and efficiently, in this case, in the process of ideation and development of the interfaces of the mobile application for teaching kinematics.

2.2 Hypothesis

The objective of this research is to propose a viable and efficient interface for the student to support the teaching-learning process of the kinematic course and redesign fast and efficient using design thinking, which is expected to achieve that through the use Design Thinking to able to respond quickly to the needs of users with a usable interface, friendly and efficient for students.

2.3 Design thinking

Design is a process that converts a requirement into a finished product or a design solution, this process mostly includes creativity, but is controlled and marked by the process so that a simple solution to the problem that meets the established considerations is achieved. The design process is essential to produce several possible solutions and uses several techniques that encourage designers to generate creative and innovative solutions [18].

In recent years, several organizations and individuals have discovered the power of design thinking by creating products with innovation. Design thinking

is an implicit activity in the design process and can change the way we work, changing the way we think, solve problems and develop products and services [18]. The design concept of the thought came to lift the state of design, discussed and documented in the latter part of the twentieth century, and is one described as a way of thinking or studying cognitive processes which later become the generation of design [19].

Design Thinking mainly focuses on the needs of the people who will consume the product and takes into account the perspective of various stakeholders [11]. These are mostly made up of end users and key actors in the service value chain, this is the reason for the multidisciplinary nature of the Design Thinking concept [18, 8]. An essential feature in the problem-solving process in Design Thinking involves the ability to simplify knowledge from a variety of sources [18],[17]. Design Thinking has been used widely and effectively in different disciplines, design, education, engineering, business, information technology for many years [8, 17].

The Stanford model is composed of five phases or stages of Design Thinking; all stages are indispensable, and these are, empathize, define, devise, create prototyping, and testing. These phases are not linear and will iterate in the process [18, 11, 6].

2.4 Mobile applications based on design thinking

Design Thinking, according to Brown [2], uses the sensitivity and techniques of the designer to meet the needs of users, this being technologically feasible, is an effective way to involve different stakeholders as software engineers.

Due to the fast and competitive market of mobile applications, it is necessary to have new skills to be able to design effective solutions; Design Thinking can supplement these skills that are necessary in the process of design and development of mobile applications [16]. According to Hiremath and Sathiyam [7], Design Thinking is increasingly used by software developers as an innovation tool.

In Valentim's work [16] an empirical study was conducted with the participation of 17 graduate students to identify their views on the use of Design Thinking in mobile application design. The first two phases of the Design Thinking process proposed by Brown were taken as a reference and during these different techniques were used, which are: person, which describes the objectives, interests, and abilities of the users; empathy map, to understand the environment, aspirations, concerns and user behavior; brainstorm, generate questions and that the team can generate ideas; Co-creation workshop, to bring together end-users and carry out a design process together with them. The results obtained through the students' perceptions were that they considered valuable the use of Design Thinking and the techniques in the design of a mobile application since it allowed them to understand the needs of the end-users better.

2.5 Case Study

The case study in the subject of Kinematics is a branch of physics that studies the movement of solid objects and their trajectory as a function of time, without taking into account the origin of the forces that motivate [12]. Therefore, the Design Thinking methodology is focused on developing a prototype of a mobile application that proposes experiments in virtual environments that students can develop and interact with their peers.

2.6 Population and sample

The proposal will be developed at the Antonio José de Sucre Educational Institution by agreement with the National University of San Agustín. The working group will be a subset of 24 students between 15 and 18 years of the 5th year of secondary level studies.

Design thinking process Design Thinking methodology focuses on the rapid creation of a prototype, which is to generate ideas and turn them into real products that will then be tested, iterated and refined with the comments provided by interested parties [11]. In this context, the interested parties are the students of the educational institution that take the role of end users, physics professors and other areas of science of the educational institution, and the interdisciplinary group that makes up the research project divided into 2 teams, team of development which is made up of developers, systems specialists, the mobile application designer and the pedagogical team made up of an education specialist, a teacher and the mentor of the research project, this can be seen in detail in Table 1.

Table 1: Participants in the process.

Pedagogical Team
PT1 María del Carmen Córdova Martinez
PT2 Sarita Lima Llanllaya
PT3 Jorge Joo Nagata
Development Team
DP1 Carlos Arbieto Batallanos
DP2 Reynaldo Alfonte Zapana
DP3 Luis Villanueva Montoya
DP4 Dewitt Chavez Ponce
Final Users
FU1 Students of the educational institution
FU2 Physics teacher of the educational institution
FU3 Laboratory teacher of the educational institution
FU4 Other science teachers of the educational institution

The design process of the mobile application was carried out following the non-linear stages or phases of Design Thinking proposed by Brown and Wy-

att [2], which consists of 3 stages or iterative phases: inspiration, ideation and implementation, as shown in the Table 2.

Table 2: Design Thinking phases for the mobile application design process.

DT Phases	**Activities**	**Objective**	**Participants**
Phase 1: Inspiration	Workshop 1	Identify the current situation, needs and challenges of final users. Understand the context of the problem.	DP3 DP4 PT1 PT2 FU3
	Personal interview	Know the specific content that is dictated in the subject and how it is currently dictated. Validate workshop 1 results.	DP3 DP4 PT1 PT2 FU2
	Survey	Obtain details of final users, demographics, knowledge of mobile applications and interest in learning with them. Know the attitude towards the technology of the final users. Understand user point of view.	DP2 DP3 DP4 FU1
Phase 2: Ideation	Workshop 2	Brainstorming. Propose creative solutions for the mobile application. Establish the requirements of the mobile application.	PT1 PT2 DP1 DP3 DP4
	Workshop 3	Sketch the main screens of the application.	PT1 PT2 DP1 DP3 DP4
	Workshop 4	Discuss the needs of the educational content of the mobile application. Define the main functionalities.	PT1 PT2 PT3 DP1 DP3 DP4
	Co-Creation Workshop	Discuss and generate innovative ideas in the mobile application interfaces.	PT1 PT2 PT3 DP1 DP3 DP4
	Workshop 5	Discuss, refine and adjust ideas. Receive comments on thecontent and preliminary design of the mobile application	PT1 PT2 PT3 DP1 DP2 DP3 DP4 FU2 FU4
Phase 3: Implementation	Workshop 6	Test the prototype of the mobile application. Explore user experiences with the prototype in practice.	PT2 DP1 DP3 DP4 FU1 FU2
	Survey	Collect information on the point of view of final users regarding the mobile application. Analyze information.	PT1 PT2 DP1 DP2 DP3 DP4 FU1 FU2

Phase 1 Inspiration: This phase focused on understanding the current situation the needs and challenges of end users in a normal physics lab session. Together with the physics laboratory teacher of the educational institution and the observation, the aim was to understand the problems encountered when dictating a laboratory session. A personal interview was conducted with the theoretical physics professor in order to know the specific content that dictates in his course and perform the validation of the data collected in workshop 1.

The pedagogical team together with the development team elaborated a survey that we carried out to 70 final students with the objective to gather information of their knowledge of mobile applications and interest to learn with them and to know their attitude towards the technology, the survey also included questions related to the demography and had an approximate duration of 2 hours distributed in 3 groups. The data collection focused on three themes: the current situation in which the physics course is being conducted, the students' interest in learning with technology, and technological knowledge and preparation.

Phase 2 Ideation: In this phase the collected data will be analysed and transformed into innovative ideas for change [11]. After a clearer understanding of the problem, a workshop was held with the pedagogical team and the development team, first a brainstorming session was held in order to propose creative solutions for the mobile application, after an extensive discussion the requirements for the mobile application were defined. A second workshop was held to sketch the main screens of the application. In a third workshop was discussed about the needs of educational content and the main functionalities that should have the mobile application, the relevant content of the application was validated by the connoisseurs of the pedagogical team. The co-creation workshop was carried out with the pedagogical team and the development team, seeking to generate innovative ideas by brainstorming the preliminary interfaces that had been developed by the designer. In the final part of this phase, a workshop was held at the educational institution where the pedagogical team, the development team and the final users were joined. In this workshop, the preliminary interfaces were presented in order to discuss and receive comments on the content and preliminary design of the mobile application. With all the feedback, the ideas, application content and design were adjusted and refined during this phase.

Phase 3 Implementation: In this phase the prototype of the mobile application was tested on intelligent cell phones, a workshop was held at the educational institution together with part of the pedagogical team, the development team and students of the educational institution, the prototypes were tested on a total of twenty-four students in a period of twenty-five minutes, this test was intended to explore the experiences of users with the prototype in practice, information was collected from this test through observation. After testing the prototypes on smart phones, a survey was taken that focused on the student's experience with the prototype using usability questions of these, in order to collect information from the point of view of end users. The results of the practical test and the survey were used to create a list of recommended settings for the application prototypes. In Fig.1, it is possible to observe evidence in the ideation process of the mobile application, captured in low fidelity prototypes(*wireframes*).

Application prototype After the previous processes, the experience gathered, a first interface was proposed, based on the expert judgment by the research team and a series of interviews that were conducted with the teachers of the school, this first interface proposal was developed, from a own interface perspective, and without design trend, proposing a playful and educational environment, based

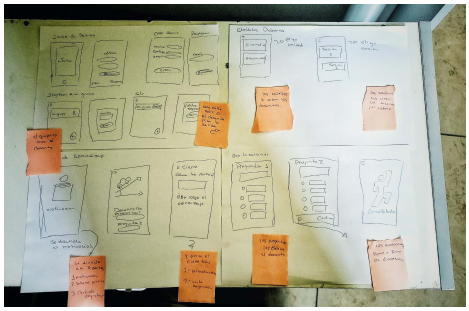

Fig. 1: Low-Fi interface design - wireframes, own elaboration.

on the comments, advice and experiences of the team and teachers, as seen in the following Fig. 2, these were presented to the teachers of the school, where their functionality and usability were evaluated, obtaining a negative response, collecting comments that observed a slow learning, a graphic distraction due to the use of colors and images, which made it difficult for students to have They give a correct understanding of what happened, so they requested a redesign, as well as the flow of the interfaces, if they were accepted so the following redesign should propose a better interface but with the same flow.

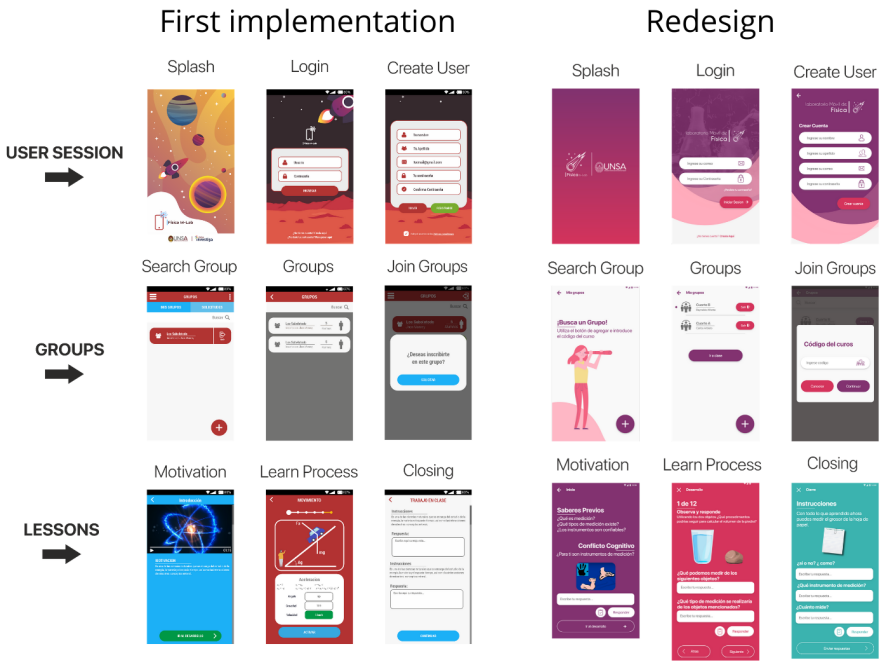

Fig. 2: Hi-Fi interface design - First implementation and redesign, own elaboration

Redesign After the first implementation, and due to the need for a redesign, and as indicated by the Design thinking methodology, a quick response was given, looking for an efficient solution, for which an investigation was determined that determined, that the design trends, they presented better signifiers in the interaction and acceptance of the users, within these, Google Material Design showed a preference on the part of the majority of users [14], and that is why, it was decided to make use of this trend, to redesign the application, seeking to reduce the use of many colors, and use design patterns for the different sections of the application, as seen in the right side Fig. 2.

Development The tools that were used are:

- Adobe XD as a tool for creating and designing prototypes in addition to offering a collaborative environment. [13].
- Google Material Design tool that helps design interfaces following good design principles [15].
- Interviews for the collection of information for restrictions and key features of the application [10].
- Likert surveys where the student must answer yes strongly agree, agree, undecided, disagree, or strongly disagree according to questions that focus on a usability attribute. [4].
- Brainstorm in a group made up of the developer team, the pedagogical team and the mentor. [1]

The questions of the surveys are made up of sections in which usability attributes are detailed, such as: Understandability, learning, operability, attractiveness and compliance, the questions are detailed in the Table 3:

Table 3: Usability survey.

Questions	**Usability Attribute**
1. You understood what the application is 2. You understood how to move on the screens	Understandability
3. Offers an opportunity to interact with the contents 4. Clearly define the contents of the course	Learning
5. The application is easy to use 6. Did you understand how each button works	Operatibility
7. The design (color, icons, structure) is nice 8. Offers a motivating environment	Attractiveness
9. Do you think you can learn through this application 10. Would you recommend that you use this application to other colleagues	Compliance

Application acceptance tests The application acceptance tests were made through usability questionnaire. The questionnaire comprises 5 dimensions of

usability and was applied to high school students. The number students tested were 24, however two students did not answer all the questions, so we had two missing values.

3 Results

In this section, we provide the results of the usability questionnaire. In Table 4, a descriptive information of usability is shown. We observe the usability has a mean value of 4.27 and standard deviation of 0.51, which means outstanding results.

Table 4: Statistics for different dimensions of usability

Statistics							
		Understandability	Learning	Operability	Attractiveness	Compliance	Usability
N	Valid	24	24	22	22	22	22
	Missing	0	0	2	2	2	2
Mean		4.2917	4.1875	4.2955	4.2045	4.3409	4.2727
Median		4.2500	4.0000	4.5000	4.5000	4.5000	4.2500
Mode		4.00	4.00	4,00a	5.00	4.50	4.20
Desviation		0.55003	0.68861	0.59078	0.86821	0.60526	0.51286
Variance		0.303	0.474	0.349	0.754	0.366	0.263
Minimum		3.00	2.00	3.00	2.00	3.00	3.20
Maximum		5.00	5.00	5.00	5.00	5.00	5.00

4 Conclusions

After all the processes involved in the development of this work and conducting the necessary tests to validate our proposal, we can conclude that the use of design thinking methodology contributes significantly to innovation because it involves all users in the process and can quickly respond to needs through re-designs. In the same way, we expect to see great results when testing different aspects of teaching physics.

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