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Artículos Científicos

Propuesta de arquitectura para un sistema tutorial inteligente móvil

Architecture proposal for a Mobile Intelligent Tutoring System

Proposta de arquitetura para um sistema tutorial inteligente móvel

Magally Martínez Reyes
Universidad Autónoma del Estado de México, México
mmreyes@hotmail.com
https://orcid.org/0000-0002-2643-6748

Mauricio Flores Nicolás
Universidad Autónoma del Estado de México, México
mfloresn90@icloud.com
https://orcid.org/0000-0002-7172-8272

René Guadalupe Cruz Flores
Universidad Autónoma del Estado de México, México
rgcruzf@uaemex.mx
https://orcid.org/0000-0002-7816-8685

Anabelem Soberanes Martín
Universidad Autónoma del Estado de México, México
asoberanesm@uaemex.mx
https://orcid.org/0000-0002-1101-8279

Resumen

En el presente trabajo se propone una reestructuración de arquitectura para mejorar los módulos tradicionales de un sistema tutorial inteligente (STI) y para incorporar su implementación en dispositivos móviles. Para este fin se ha empleado una metodología basada en la ingeniería de procesos, la cual agrupa conocimientos, técnicas y estrategias provenientes de diferentes disciplinas para desarrollar un proyecto. Entre los resultados se puede mencionar que al añadir el módulo de diagnóstico al STI tradicional se elevan las alternativas para presentar los temas de estudio; esto, además, permite identificar periódicamente el nivel de conocimiento de los alumnos por medio de los componentes VAK, estado anímico, pretest y postest. Actualmente, el STI móvil se encuentra en versión beta, implementada en el sistema operativo Android 5.0 para incluir conceptos del tema *energía*. Se espera que con la arquitectura STI móvil se desarrollen aplicaciones que faciliten el aprendizaje en otras disciplinas que requieran un poder de cómputo alto en dispositivos pequeños; esto ayudaría a los usuarios finales cuando deban repasar, en cualquier momento y lugar, diversos temas del plan de estudios.

Palabras clave: dispositivos móviles, energía, servicios web, sistema tutorial inteligente, ubicuos.

Abstract

In the present work an architecture restructuring is proposed to improve the traditional modules of an intelligent tutorial system (STI) and to incorporate its implementation in mobile devices. For this purpose, a methodology based on process engineering has been used, which brings together knowledge, techniques and strategies from different disciplines to develop a project. Among the results it can be mentioned that adding the diagnostic module to the traditional STI raises the alternatives to present the study subjects; this, in addition, makes it possible to periodically identify the students' level of knowledge by means of the components VAK, mood, pretest and posttest. Currently, the mobile STI is in beta version, implemented in the Android 5.0 operating system to include concepts of the energy theme. It is expected that the mobile STI architecture will develop applications that facilitate learning in other disciplines that require high computing power in small devices; this would help the end users when they should review, at anytime and anywhere, various subjects of the curriculum.

Keywords: mobile devices, energy, web services, intelligent tutoring system, ubiquitous.

Resumo

No presente trabalho uma reestruturação de arquitetura é proposta para melhorar os módulos tradicionais de um sistema tutorial inteligente (STI) e incorporar sua implementação em dispositivos móveis. Para tanto, foi utilizada uma metodologia baseada em engenharia de processos, que reúne conhecimentos, técnicas e estratégias de diferentes disciplinas para desenvolver um projeto. Entre os resultados, pode-se mencionar que a adição do módulo de diagnóstico ao STI tradicional levanta as alternativas para apresentar os sujeitos do estudo; Isto, além disso, torna possível identificar periodicamente o nível de conhecimento dos alunos por meio dos componentes VAK, humor, pré-teste e pós-teste. Atualmente, o STI móvel está em versão beta, implementado no sistema operacional Android 5.0 para incluir conceitos do tema energia. Espera-se que a arquitetura móvel do STI desenvolva aplicativos que facilitem o aprendizado em outras disciplinas que exigem alto poder de computação em pequenos dispositivos; isso ajudaria os usuários finais quando eles deveriam revisar, a qualquer momento e em qualquer lugar, vários assuntos do currículo.

Palavras-chave: dispositivos móveis, energia, serviços web, sistema tutorial inteligente, onipresente.

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Introduction

Intelligent tutorial systems (STI) are audiovisual resources used in the field of education to support the student in their teaching-learning process (Cuevas, 1996, Pedroza, González, Guerrero, Collazos and Lecona, 2018). One example of this is the so-called cognitive selft-regulation instruction on-line, which focuses on helping improve the written competence of primary school students, as shown by Fidalgo, Arrimada and López (2018), who apply multiple strategies to encourage , through an online computer application, the process of planning, writing and reviewing texts. The problem with this system, however, is that it requires a high processing power, hence the implementation of a large number of current STIs is only possible through various desktops.

This limitation, however, has served to promote the emergence of mobile STIs, which are usually customized systems that do not require any artificial intelligence technique to use the adaptable part (Zatarain, Barrón-Estrada, Sandoval-Sánchez and Reyes-García , 2008). Thanks to this, authors like Kiger, Herro and Prunty (2012) and González et al. (2017), to mention only some, have been able to use mobile devices to strengthen learning, anywhere and at any time, in areas such as physics and mathematics, although with some observations, such as small screens and low power of processing and storage, which have served to pose challenges in the design of algorithms and the user interface (Zhuang, Kwok and Cheung, 2013).

For this reason, a restructuring of the traditional STI modules (student, knowledge domain, tutor and interface) should be proposed in order to improve their distribution through the development of mobile educational software. For this, logically, one must take into account not only the accelerated expiration of technology, but also that this, in many cases, is not usually created directly to respond to institutional needs or to facilitate the understanding and construction of knowledge (Trouche, 2005a, 2005b). Due to this, a specialty of engineering called educational software engineering has emerged, which focuses on establishing the particular difficulties that underlie the development of information programs for academic purposes, as well as the proposal of some methodologies (Valbuena, 2018). . However, it is worth noting that one of the most visible obstacles of this initiative has to do with the lack of experiences in laboratories, which complicates the resolution of problems and the mastery of vital scientific concepts to deepen the explanation of different phenomena (Cuevas, Villamizar y Martínez, 2017; De la Cruz, Montero, Martínez y Gazga, 2018).

A similar situation occurs in the field of mobile STI, specifically when trying to use to work on topics such as energy, as in some cases it is believed that students master other concepts (eg, units, transformations, etc.). associated to said content (Cuevas et al., 2017), which are determinant not only because they are mandatory to teach them from the basic level to the upper-middle level, but also because they allow to understand natural phenomena linked to change, movement, properties of the materials, the manifestations of energy, the sun and the moon.

For all of the above, this paper proposes an architectural restructuring to improve the traditional modules of an ITS and to incorporate its implementation in mobile devices; in this way it is intended that the process engineering allows a) delimit necessary roles to undertake a product of this nature, b) focus on functions and requirements by phases and people, and c) define a methodology to document and develop the application.

Method

In this research we have used a methodology based on process engineering, which brings together knowledge, techniques and strategies from different disciplines to develop a project. This allowed to achieve evaluable results in the different phases of the process thanks to the intervention of diverse people in charge of designing, planning and making decisions, assuming one or more roles (Fleischmann and Bachinger, 2014), which was concreted in the following stages:

a) Documentary review

It consists in documenting the theme of the project. In this case, a theoretical investigation is carried out on the most relevant aspects of the STI from the technological and educational point of view. In this way some elements of the educational software could be known.

b) Analysis

It breaks down the specificities of the architecture or the model of the technological application to identify opportunities for improvement. An analysis of the current STI processes highlights the weak points and serves as a basis for future improvements and for the optimization of the process. In this case, a technical investigation was carried out on STI and its architecture from the software functional point of view.

c) Improvement

One of the main objectives of process engineering is the continuous improvement / innovation of the projects. In this case, it was sought that the proposed architecture for the mobile ITS continue evolving until reaching the expected results.

d) Results

Although all projects must conclude, they must be analyzed to continue designing new ones. In the case of mobile STIs, the objective is to achieve its implementation. In this regard, it is worth noting that at this time the proposed architecture is only in the prototype phase.

In summary, process engineering is a strict methodology, since it seeks to get to the root of the topic to improve activities, which offers a competitive advantage for the development of educational software, particularly in the STI.

Materials

To describe the hardware and software requirements, Figure 1 shows four blocks: a) the server contains the software necessary to store and run the mobile application; b) the Web Service (WS) is the communication language; c) the mobile device is the means of interaction, and d) the mobile application is responsible for capturing the information.

Figura 1. Componentes mínimos para el desarrollo de STI en móviles

Fuente: Elaboración propia

a) Server

First, for the server hardware was thought of an Intel NUC workstation with Intel Celeron N3050 processor, solid state storage with 256 GB and 8 GB DDR3L-SDRAM RAM. Simultaneously, four programs were installed and configured: first, the operating system Ubuntu Server 18.04.1 LTS; second, Java Virtual Machine (JVM) and Java Runtime Environment (JRE); third, the web server Tomcat 8.5, which has the ability to execute web projects made in Java, and fourth, MySQL 5.6 to manage the database. With all the established configurations, the server acts as WS container to attend and respond to requests made through it.

b) Web Service

WS are web-accessible programs whose operation is described as a model of processes that detail the structure of control and data flow of the service, that is, the possible steps (typically initiated by the client) required to execute a service (Ankolekar et al., 2002). Because of the standardization in the web community, communication protocols emerged that allow to describe messages in a structured way, so that a Web Service Description Language (WSDL) adapts this need by defining an eXtensible Markup Language (XML) grammar, where network services are described as communication points capable of exchanging messages (Fokaefs and Stroulia, 2014; Tanenbaum and Steen, 2008). In addition, the use of WSDL regularly supports distributed systems, which facilitates communication between applications.

c) Mobile device

The introduction of information and communication technology (ICT) in education has presented stages of important changes in the processes of instruction because they enhance the role of the teacher and the student, which facilitates teaching-learning opportunities through the use of devices mobile These are considered minicomputers that have the capacity to perform more tasks, which has favored a change in the educational paradigm. Some of its main advantages are the flexibility and adaptability that they offer, since they can be customized according to the needs of the users. In addition, they are ubiquitous, because they can be used anywhere and in various devices (Mishra, Dash y Dash, 2012; Pérez-Mateo, Catasus, Maina y Romero, 2012).

d) ***Mobile App (end user)***

For the student to study the topics assigned to the mobile STI, it has an interface that allows authenticating with the server through the WS. Once the system establishes the connection, it is possible to find various topics of interest -in this case- about energy, which range from basic concepts to problems based on real phenomena. The app also shows the progress on the defined learning trajectory, as well as reminders that help the user to continue learning.

Also, and being an STI, the application has the ability to direct a student when a topic is very complicated for him, because it provides other learning alternatives. For example, if a student chooses a visual channel to study a certain topic, but in his attempt is wrong too many times, the STI automatically blocks the channel and offers other alternatives so that he will not be impatient and keep learning.

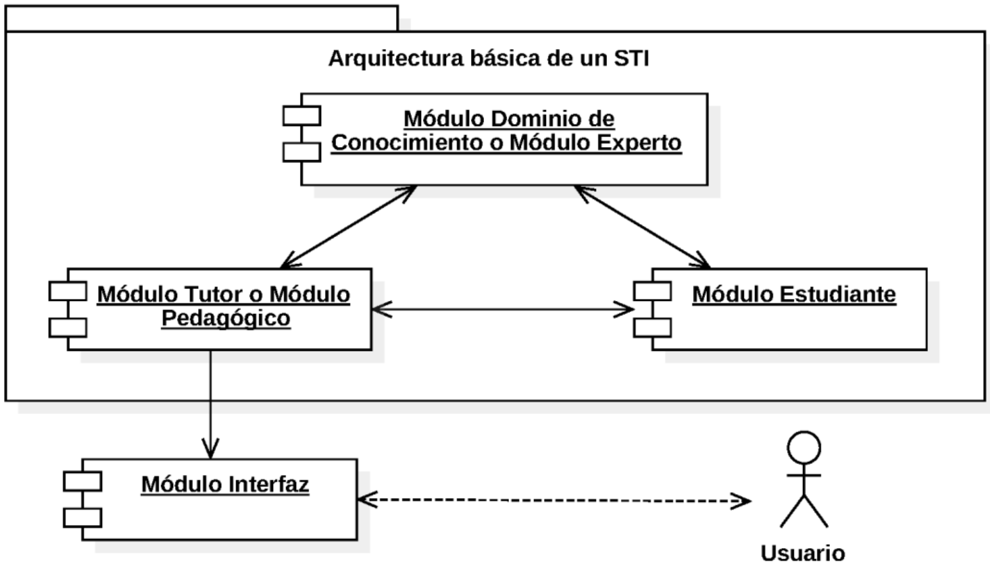
Developing

In the particular case of this work, the procedures performed to propose the architecture proposal for the mobile IMS are described below.

Documentary research

A consensual definition of STI is presented by Graesser, VanLehn, Rose, Jordan and Harter (2001), who consider it as a computer-based learning environment that integrates computational models taken from cognitive sciences, computational linguistics, science education, artificial intelligence, mathematics, computer science, among other areas. The traditional schematic structure of the STI is that presented by Nwana (1990) and Nyamen (2016) (figura 2).

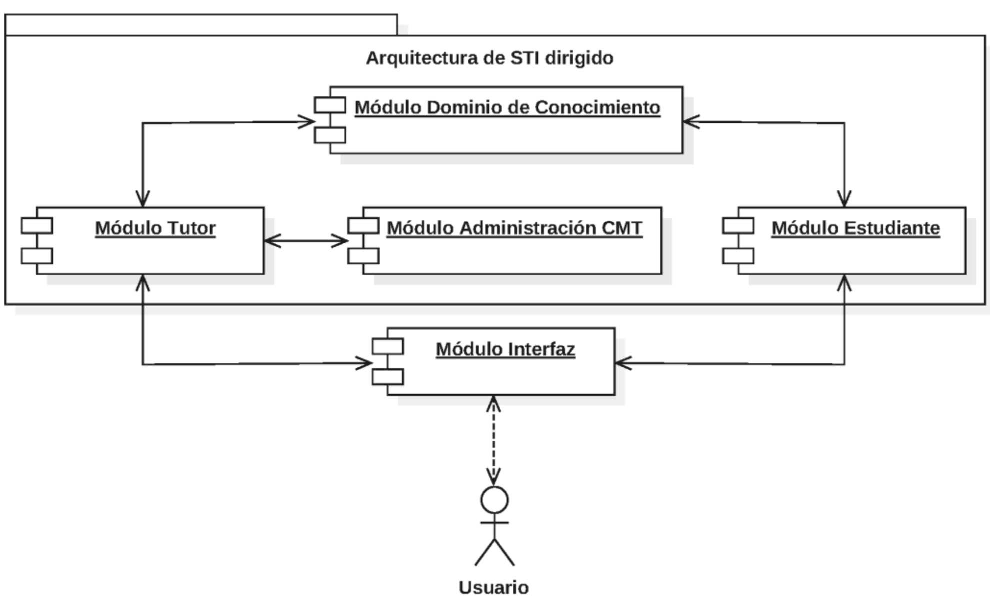
Figura 2. Arquitectura conceptual básica de un STI



Fuente: Nwana (1990)

There are some STI proposals for the area of mathematics that propose the integration of additional modules to the traditional scheme, as in the case of Mamoun, Erradi and Mhouti (2018), which is why it is proposed to add a working memory capacity module (CMT or WMC by its abbreviations in English), by means of which the capacity of the students is represented to improve their cognitive processes and of reflection (figure 3).

Figura 3. Arquitectura conceptual de los módulos del STI



Fuente: Mamoun *et al.* (2018)

Technical analysis on STI and its architecture from the functional point of view of the software

The following four STI modules are presented after applying the technical analysis:

a) Knowledge domain module

It fulfills three main functions: first, to serve as a source of knowledge to be presented to the student, which includes the generation of questions, explanations and answers; Secondly, to provide a standard for evaluating the student's performance and, thirdly, to have the ability to detect not only systematic errors, but also the gap in the student's knowledge and the possible cause of it. In this case, the level of knowledge of the student is estimated as indicated by the expert in the content presented.

b) Student module

It refers to the dynamic representation of knowledge and emerging abilities of the student because no intelligent tutorial can be carried out without the student's understanding. In this way, the knowledge that one wants to communicate with the same idea that the student has is explicitly represented.

c) Tutor module

Design and regulate instructional interactions with the student. This communicates with the student module, since it uses the knowledge of the student and creates its own structure of tutorial objectives to decide which pedagogical activities it can present and how they should be taught.

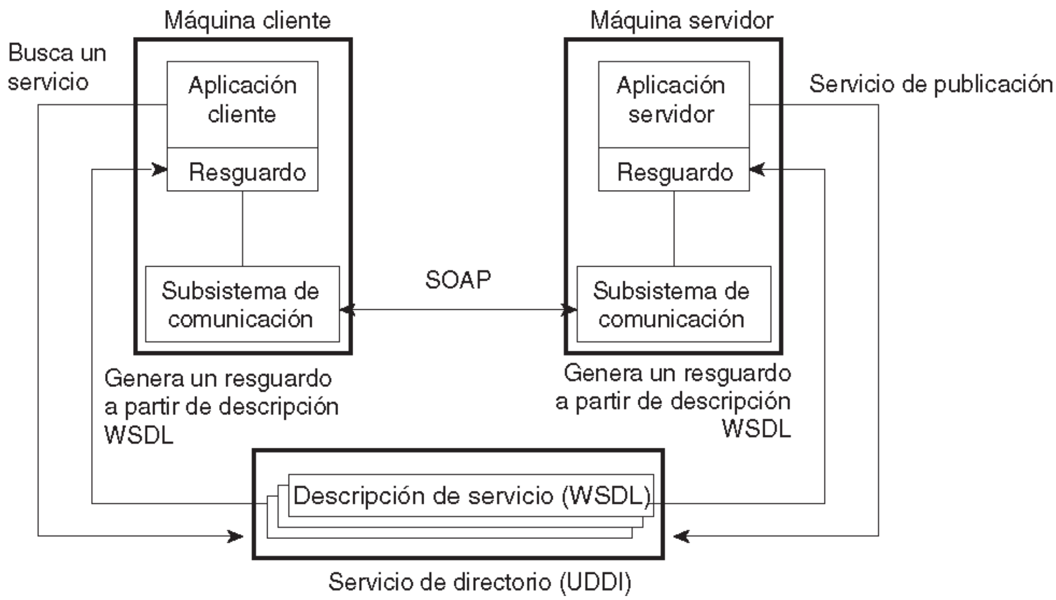
d) Interface module

It is the communication component of the STI that controls the interactions between the student and the system. The interface has its own module due to two main reasons: first, when the STI presents a theme, the interface can improve or decrease the presentation, since it is the final form in which the STI is displayed; that is, it is noticed that qualities such as ease of use and attractiveness can be crucial for the acceptance of the system by the student. Secondly, it is taken into account that the progress of media technology is providing more sophisticated tools whose communicative power strongly influences the design of the STI.

The improvement consists of an analysis and design of the functional prototype of an ITS

For the development of this section it has been decided to work with distributed systems. According to Tanenbaum and Steen (2008), these are a collection of independent computers that give the user the impression of being a single coherent system, which also allows expanding or scaling projects. The objective is to provide users (and applications) with access to remote resources to share them in a controlled and efficient manner. However, distributed systems are complex pieces of software whose components are, by definition, dispersed in various machines. To master this complexity it is crucial that the systems are properly organized. There are different ways of visualizing the organization of a distributed system, but an obvious way is to differentiate the logical organization of the collection of software components from the actual physical organization. The organization of distributed systems is basically about the software components that make up the system. These architectures stipulate not only how the software components should be grouped, but also how they should interact.

Figura 4. Principio de un WSDL



Fuente: Tenenbaum y Steen (2008)

The basic idea is to develop some client application to request the services provided by a server application, as shown in Figure 4. The standardization occurs as the services are described, so that they can be searched by a client application. In addition, you must ensure that the service request follows the rules established by the server application. Despite the fact that the development of this type of systems exists, the majority continues to implement STI on desktops. Despite the advantages of mobile devices, there will still be limitations that prevent developing an STI on mobile phones, hence the architectural proposal to facilitate its implementation through WS.

On the other hand, over the years, STIs have undergone important changes in their architecture. However, after being appointed in accordance with the evolution of a Computer Assisted Instruction (CAI) -which provided instructions combining activities to facilitate the acquisition of knowledge, aptitudes and skills (Balacheff, 1993; Yáber-Oltra, 2000) -, investigations have been limited to modifying the existing modules. Therefore, it is proposed to introduce a new module -called diagnostic in the architecture of a STI- that identifies the attributes of a student to know in which point to start with the explanation of the content. With instruments to measure prior knowledge, the learning channel based on the standard visual-auditory-kinesthetic (VAK) instrument and the state of mind will be possible to know not only the type of content and the most optimal way in which it can be presented, but also the previous evaluation and the disposition of the student to learn.

This, of course, implies the use of the XP agile methodology because a practical form is needed for the construction of functional prototypes that can be improved with each interaction. In this sense, for the programming language the Java tool was chosen, since it allows to integrate in environments of both desktop computers and mobile devices. Likewise, the topic of energy study was chosen, with basic definitions to build an STI that will work in a mobile version with a group of services that are consumed using the WS mechanism.

Likewise, it was determined that most of the students had inaccurate ideas about the chosen topic due to the lack of examples, which is why two cognitive models were used: the conceptual change, which takes advantage of the previous ideas to reconstruct the interpretation of the reality (Cuevas, Villamizar and Martínez, 2017) and problem-based learning, which favors skills, knowledge and attitudes to anticipate, adapt and propose actions in a changing work team (Mendoza and Bernabéu, 2006). In this way, students were made to understand the usefulness of the proposed topics.

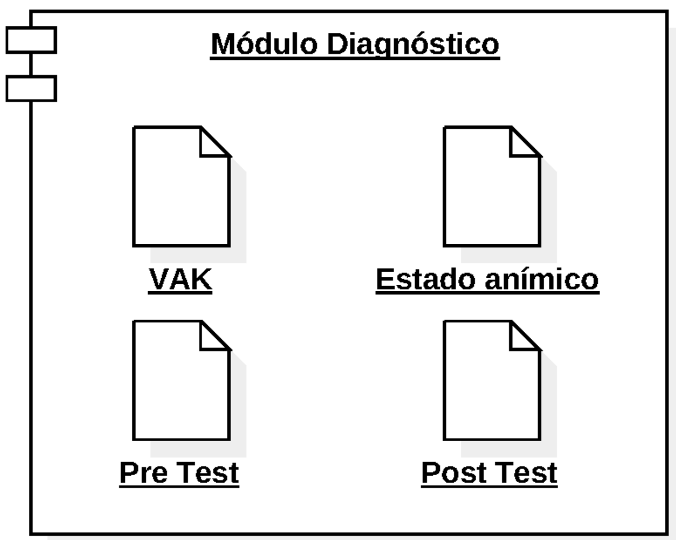
Preliminary results, proposal of diagnostic module and innovation in architecture

Essentially there are two preliminary results: 1) design a diagnostic module to obtain prior information about the students and 2) add the diagnostic module in the architecture for a mobile STI.

a) Diagnostic module

This is intended to identify the important characteristics in the educational process (figure 5), which requires four exams:

Figura 5. Módulo diagnóstico



Fuente: Elaboración propia

- The VAK standard instrument uses the three main sensory receptors that determine the dominant learning channel. As a result it is possible to adapt the presentation of the topics because the student chooses his style to perceive the information better; However, it is important to mention that not all activities are perceived with the same learning channel, so combinations can be made for other types of activities.
- To design an instrument that indicates prior knowledge on the subject of energy, it is essential to have the intervention of a content expert (Cruz, Soberanes, Martínez and

Juárez, 2012), as this can provide professional and formal information on the subject, as well as their experience, which not only contributes to the elaboration of the subject of study, but also to the evaluation (this instrument is known as pretest of knowledge) (Martínez, Soberanes-Martín and Sánchez, 2017).

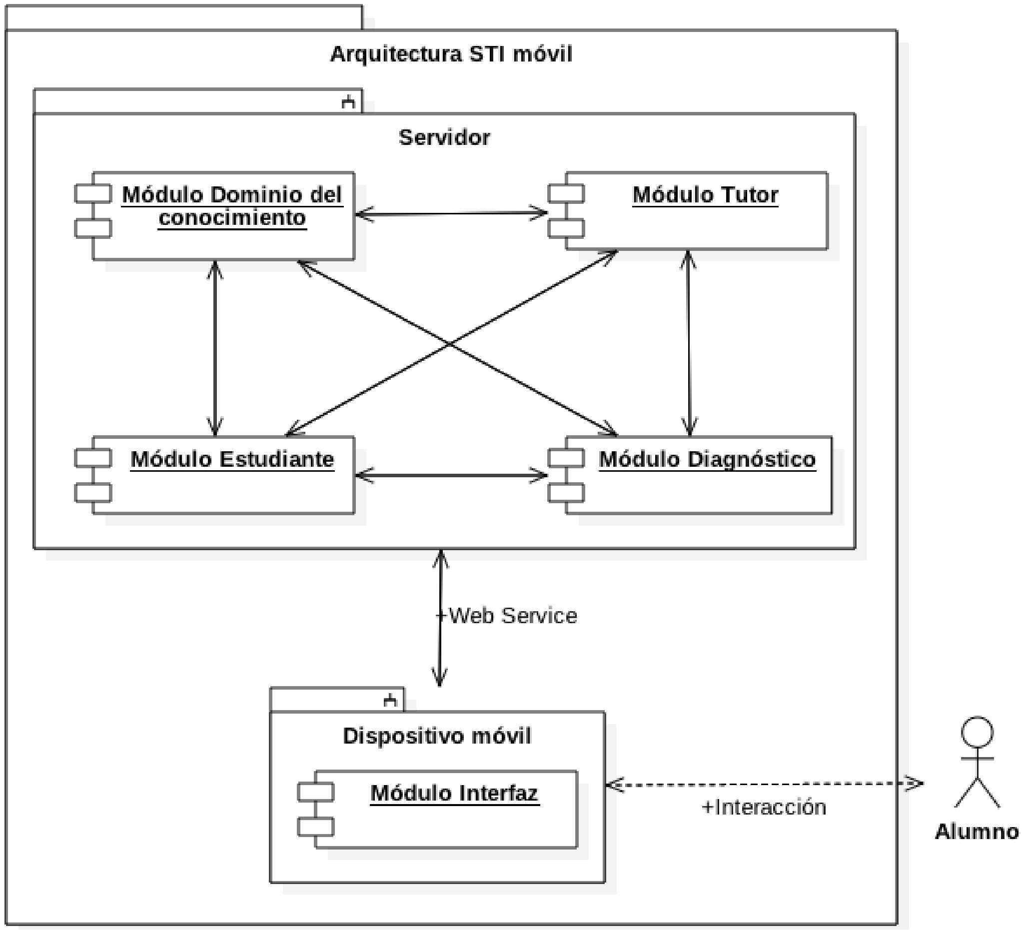
- In relation to mood, there are multiple ways to determine it: in this case, the theory of color will be used, which will identify patterns that favor the study.
- Finally, to verify the knowledge learned a posttest will be used, which will be equal to the pretest to compare and assess the degree of advancement of the student, as well as the acquisition of competences of the area (Martínez et al., 2017). In this sense, it has been taken into account that multiple times the evaluation focuses only on trying to verify how much information a student could memorize, and not on how much of that information could he use in practice; therefore, examples will be presented through videos and simulations so that the student develops skills in solving problems through critical thinking (Le y Huse, 2016).

b) Mobile STI architecture

The development of a traditional STI requires a multidisciplinary construction process, given that resources come from multiple fields of research, including artificial intelligence, cognitive sciences, education, human-computer interaction and software engineering, hence be a challenging task. That said, if you want to add the implementation of the STI modules in mobile phones it would be even more complex, hence the algorithmic divide and conquer design will be used.

Knowing the distributed systems and their operation is an additional step that could take the traditional STIs to mobile devices without losing their characteristics because they are becoming more accessible, although still limited for systems of this type. Therefore, Figure 6 shows grossly the restructuring of a mobile STI, which includes a server machine that communicates through WS requests and that contains the knowledge domain, tutor, student and diagnostic modules, as well as a client machine (mobile device) that contains the interface module, which is the interaction medium for the student.

Figura 6. Arquitectura STI móvil



Fuente: Elaboración propia

Results

To illustrate the layers that were added to the traditional STI, the mechanics of communication between the server and the mobile device through WS requests are detailed.

Client

Before starting, a prototype program for the server was developed following the agile XP methodology with the Java programming language, which resulted in the request of resources by the mobile device. Figure 7 shows that only a student's data is necessary to obtain their information (in this case, electronic mail is used as a unique identifier).

Figura 7. Petición de información por parte del cliente

```
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/" xmlns:ws="http://ws.uaemex.com/">
  <soapenv:Header/>
  <soapenv:Body>
    <ws:infoEstudiante>
      <idEstudiante>frosasf2010@outlook.com</idEstudiante>
    </ws:infoEstudiante>
  </soapenv:Body>
</soapenv:Envelope>
```

Fuente: Elaboración propia

Server

The response of the server to this request is a little more complex; however, the resulting information is easy to process for a mobile device. Figure 8 shows the result of logging in or consulting the status of a student. This result is made up of the interaction of three entities: 1) the administrative part of any application that shows the student's personal data, the access password and the date of birth; 2) the diagnostic module classifies the student with the type of VAK preferred, the state of mind, the score obtained in the pretest and in the posttest (observing an increase of 35 points), as well as a total score for these last two tests of 100 points; 3) the tutor module indicates the total number of questions asked (but not the total content to be studied), the message and the tutor code with instructions to the interface module for future content presentations, the number of correct answers, the errors and the attempts obtained throughout the use of the app. In both cases, both the request for information by the mobile device and the result of the WS are possible through the XML language.

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Figura 8. Respuesta del WS

```
<S:Envelope xmlns:S="http://schemas.xmlsoap.org/soap/envelope/">
   <S:Body>
      <ns2:infoEstudianteResponse xmlns:ns2="http://ws.uaemex.com/">
         <return>
            <message>Éxito: Información estudiante!</message>
            <uniqueResult xsi:type="ns2:infoAllEstudiante" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
               <!--Administración-->
               <apMaterno>Flores</apMaterno>
               <apPaterno>Rosas</apPaterno>
               <nivelEscolar>Primaria</nivelEscolar>
               <contrasenia>89fe673492124b02e1226304b6589b25</contrasenia>
               <cumpleanios>2010 09 21</cumpleanios>
               <edad>8 años</edad>
               <idEstudiante>frosasf2010@outlook.com</idEstudiante>
               <fechaRegistro>2018 06 03 17:53:28</fechaRegistro>
               <nombre>Fernando</nombre>
               <!--Módulo diagnóstico-->
               <vakPreferido>Visual</vakPreferido>
               <preTest>50</preTest>
               <animico>Verde - fuerte correspondencia emocional con la seguridad.</animico>
               <maxPreTest>100</maxPreTest>
               <postTest>85</postTest>
               <!--Módulo tutor-->
               <numAciertos>150</numAciertos>
               <numErrores>50</numErrores>
               <numIntentos>40</numIntentos>
               <totalPreguntas>150</totalPreguntas>
               <tutorCode>105</tutorCode>
               <tutorMsg>Se deshabilitó la presentación de temas en Kinestésico debido a la cantidad de errores presentados con este canal de aprendizaje</tutorMsg>
            </uniqueResult>
         </return>
      </ns2:infoEstudianteResponse>
   </S:Body>
</S:Envelope>
```

Fuente: Elaboración propia

Mobile app

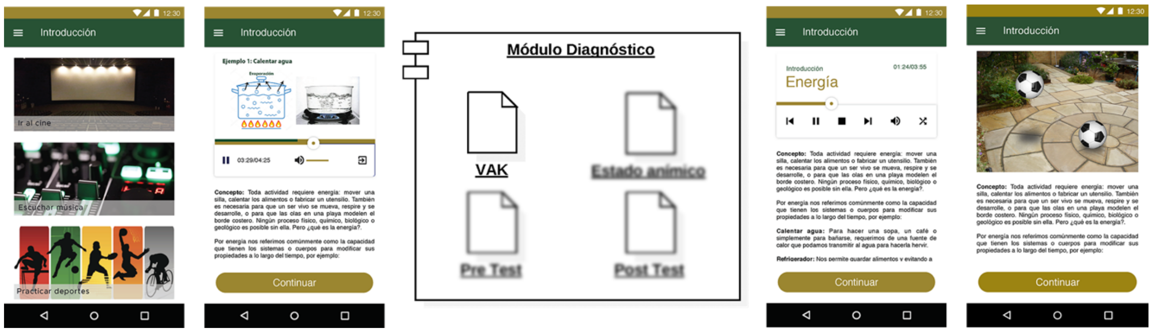
Next, the way in which the response of the WS in the mobile device to process the information is represented is explained. Figure 9 (a) shows the use of the VAK component of the diagnostic module, which asks the student what kind of activities he prefers (going to the movies, listening to music, playing sports) to show the topic of energy through audiovisual materials (videos), auditory (voice), kinesthetic (augmented reality, gyroscope, light sensor, etc.).

In the interface of figure 9 (b) it is seen that it is possible to use the mood state component, which shows a color palette; this allows to change the colors of some sections for the comfort of the student; In addition, it serves to divide it into three sections: the first (general) concentrates the basic information of the student, such as full name, password, date of birth, among others; the second (trajectory) obtains the data of the tutor module to graph the number of successes, errors, attempts, as well as the learning channel that has been satisfactory in most cases to resolve the issues; the third (alerts) is a section still in development that aims to show the subjects with more mistakes to reinforce them with the learning channel that has been more comfortable for the student.

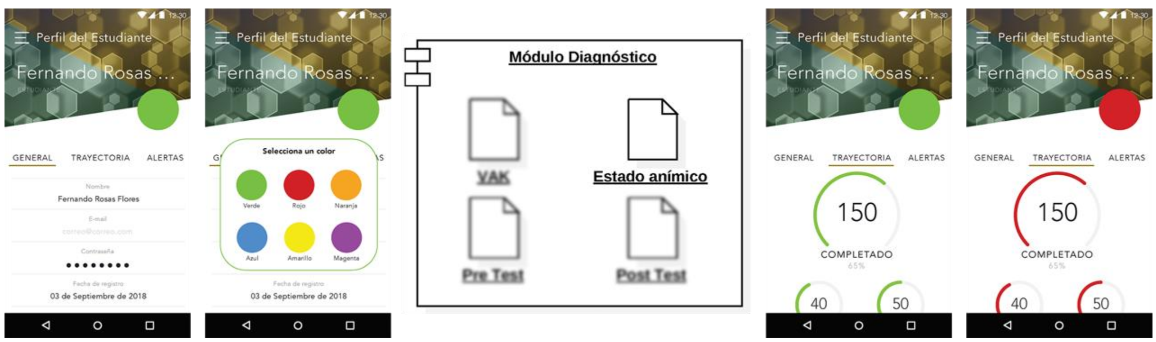
Finally, Figure 9 (c) shows a specific section of Figure 8 where the diagnostic module exemplifies the student's preferred VAK, the current color and a brief description of the mood, the highest score that can be obtained in the pretest, the pretest evaluation of the student (in this case, he got 50 out of 100 points), as well as the posttest evaluation, with a score of 85 out of 100 points (an increase of 35 points with respect to the first evaluation). This section continues in development on the mobile device; however, the requests that can be made in the WS are already functional.

Figura 9. Empleo de la arquitectura STI móvil y el módulo diagnóstico en la *app*

(a) Uso del componente VAK

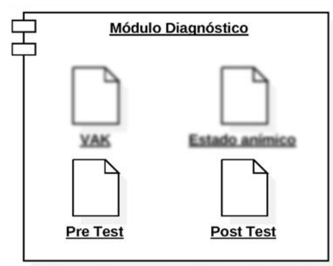


(b) Uso del componente estado anímico y el módulo tutor



(c) Uso de los componentes pretest y postest

```
<!--Módulo diagnóstico-->
<vakPreferido>Visual</vakPreferido>
<preTest>50</preTest>
<animico>Verde - fuerte correspondencia emocional con la ↩
    seguridad.</animico>
<maxPreTest>100</maxPreTest>
<postTest>85</postTest>
```



Fuente: Elaboración propia

One of the limitations of the study is the complexity of developing an application of this type. Also, as mentioned by Graesser et al. (2001), the characteristics of the STI requires computational models from different disciplines (cognitive sciences, computational linguistics, education sciences, artificial intelligence, mathematics and computational sciences, among others); In addition, the fact of implementing them in mobiles requires a different computational architecture, which satisfies the technological objectives and the educational requirements; it is precisely this last factor that determines the reduced speed of development of this type of systems, as the specialized literature in the area shows.

Regarding the strengths of the study, a new architecture to develop mobile STIs can be highlighted, which includes a diagnostic module to determine the prior knowledge on the subject to be explained (energy), the VAK learning channel and the state soul In this way, you can define the most appropriate type of content for the student.

Regarding the areas of opportunity for its application, the opportunity it offers to gather information about the user automatically stands out, which allows generating a better diagnosis. In effect, mobile devices can now capture the user's personal information (such as the type of music they listen to, the time they sleep, the applications they use) and process it through an artificial intelligence algorithm that serves to complement the module tutor of the mobile STI and to automatically detect the disposition and the user's learning channel. The GPS of the device, for example, can help determine if the user has an active (kinesthetic) or sedentary (visual or auditory) life, which would be useful to take into account when presenting the information.

Conclusions

The result of this investigation allowed to glimpse multiple contributions. For example, adding the diagnostic module to the traditional STI raises the alternatives for the presentation of study topics; This, in addition, makes it possible to periodically identify the level of knowledge by means of the components VAK, mood, pretest and posttest.

On the other hand, the applied engineering on the architecture of the traditional STI is useful not only to develop STI in mobile, but also to build ubiquitous applications using other devices (desktop) and systems (Windows, iOS and Mac), because the communication protocols Employees through the WS are recognizable regardless of the operating system.

Currently, the mobile STI is in beta version, implemented in the Android 5.0 operating system to include concepts of the energy theme. However, it has the same characteristics as a traditional STI because the operations provided by an intelligent system image (expert system and adaptive system) are processed by the server while maintaining, so the mobile device is only responsible for sending and receive information (access data, scores, topics studied, trajectory). According to the phases of the XP methodology for the development of systems, the implementation phase is pending, although at this moment the functional and usability tests of the application are being worked on.

It is expected that the mobile STI architecture will develop applications that facilitate learning in other disciplines that require high computing power in small devices; This would help end users when they need to review various subjects of the curriculum anytime, anywhere. Finally, it could generate awareness about the indispensable requirements to develop educational softwares that meet the educational and technological objectives.

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Rol de Contribución	Autor (es)
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Software	**Mauricio «principal», René, Magally, Anabelem «que apoyan».**
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Administración de Proyectos	**Anabelem «principal», Mauricio, Magally, René «que apoyan».**
Adquisición de fondos	**René «principal», Mauricio, Magally, Anabelem «que apoyan».**