Received 2 April 2015
Revised 5 June 2015
Accepted 7 June 2015

Kamachiy – Mayistru: adaptive module to support teaching to people with learning difficulties

Diana Lancheros-Cuesta
Facultad de Ingeniería, Universidad Cooperativa de Colombia, Bogotá, Colombia, and
Angela Carrillo-Ramos and Jaime A. Pavlich-Mariscal
Department of System and Computing Engineering, Pontificia Universidad Javeriana, Bogotá, Colombia

Abstract

Purpose – The purpose of this paper is to propose Kamachiy-Mayistru (KM), an adaptive module to support teaching to people with learning difficulties. In Colombia, learning disabilities and difficulties are frequent in the integration classroom. Proper learning can be achieved as long as teaching strategies and didactic tools are the most adequate to the specific student characteristics and follow the suggestions given by experts for each learning difficulty. This module assists the teacher to prepare a course taking into account the disability profile, the student profile and pedagogical model suggestions. In this way, the student can learn utilizing the format and didactic tools more appropriate to their specific necessities.

Design/methodology/approach – The design and implementation of the KM comprises the following phases: identify the most important student, teacher, difficulties and course parameters to take into account in the adaptation process; design the data model that supports activity adaptation, based on student characteristics and difficulties; implement the platform; and validate the approach through a case study of teachers and their students with difficulties.

Findings – The application of KM in the case study indicated the effectiveness of KM to assist teachers in organizing course activities for students with and without disabilities or difficulties.

Research limitations/implications – KM addresses specific student difficulties: attention, memory and languages. KM does not address severe cognitive disabilities. Regarding the validation, it is recommended to pursue new case studies to further demonstrate the effectiveness of the approach in a broader population.

Practical implications – The main approach in KM is to suggest activities or pedagogical strategies to teachers to best support learning in students with difficulties or disabilities. The core of KM is an algorithm, called "Adapt Course", that takes as input student and disability profiles, the course contents and the pedagogical model and creates course structures that are specially tailored to each student.

Social implications – This model recommends teachers different activities, based on the specific student difficulties, to create personalized courses. It is able to address specific educational issues that are associated with learning difficulties and disabilities, such as educational integration, through content organization and personalized information display, which are based on the inherent characteristics of each student in the classroom.

International Journal of Web Information Systems
Vol. 11 No. 4, 2015
pp. 510-526

1744-0084
DOI 10.1108/IJWIS-04-2015-0010

The authors thank the Jazmin School of Bogotá (Colombia) for their collaboration in the case study of this research. The authors also thank the teachers of that school for their help in the design of the diagnostic instruments and the definition of the courses that were provided through the platform.

Originality/value – It is based on a conceptual model that provides the essential architecture to design and implement virtual learning environments for students with learning difficulties or disabilities.

Keywords Communities on the web, Web media, Web-based education

Paper type Research paper

1. Introduction

Students with learning difficulties or disabilities (Tuedor, 2006) require special didactic and pedagogic strategies to guarantee that their specific learning requirements are satisfied (Boujarwah *et al.*, 2011). Many teachers lack the knowledge to ensure the effective learning of all of the required contents, which occurs, in part, due to the diverse types of behaviors and necessities of these students [3]. Learning difficulties are "learning problems that are primarily the result of visual, hearing, or motor disabilities, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage" (ElSayed, 2012). Virtual learning environments (VLE) provide teaching advantages in specific environments (Zaina and Bressan, 2008), focusing on the specific student necessities (Boujarwah *et al.*, 2011; Shih *et al.*, 2009; Cowan and Khan, 2005) through adaptation, that is, modifying techniques and display formats to present the information according to their specific characteristics. To address the above issue, our previous work proposed Kamachiy-Idukay (KI) (Lancheros-Cuesta *et al.*, 2013), an educational services platform for people with learning difficulties and disabilities, which assists the teacher to generate didactic activities in a VLE that help specific kind of students in learning. Our previous work focused on describing the overall architecture of KI, without further detailing its specific components. This paper describes Kamachiy-Mayistru (KM), the adaptive module of KI. KM focuses specifically on utilizing the disability profile, the student profile and pedagogical model suggestions to adapt the information to different students according to their specific necessities. The remainder of the paper is as follows. Section 2 discusses related work. Section 3 describes the design of KM and its integration to KI. Section 4 describes the application of KM in two case studies. Section 5 analyzes the results of the case studies. Section 6 concludes this paper.

2. Related works

There are several approaches to assist teachers with information systems and adaptation. These approaches do not explicitly support the learning process of people with disabilities or learning difficulties. Mylonas *et al.* (2004) designed an e-learning system focused on the teacher. The system extracts student profiles based on preferences and available course materials. Bouhadada *et al.* (2006) developed an e-learning system in which the teacher can implement pedagogical activities based on the student profile. Tobar and de Freitas (2007) designed a rule-based system that assists the teacher in creating student groups, based on the student profile. Zaina and Bressan (2008) created a system that evaluates learning profiles, based on student preference categories. These categories are based on the Felder–Silverman model. The teacher can assign the activities that he/she assess as the most adequate to the student categories and preferences. Martin *et al.* (2009) developed a system called Sigma. This tool diagnoses student capabilities and conveys the results to teachers through a user interface that suggests activities and strategies according to the student profile. Besbes *et al.* (2010) created a system adapted to the teacher that suggests pedagogical models and didactic activities, based on the student profile. An expert system classifies teachers according to professions and capabilities to determine the compatibility between

the teacher, the student and the course. Nedungadi and Raman (2010) implemented an e-learning system to support teaching of math and experimental physics. The system adapts contents taking into account student performance. The system allows students to progress at their own pace, based on a dynamic individual profile that includes content and presentation preferences. Lahti (2011) created a system that adapts conceptual maps based on the student profiles. The goal is to apply visual perception in the teaching–learning process. Bremgartner and de Magalhaes Netto (2011) created a multi-agent system with a competence-based learning model. The system adapts activities in a Moodle site to assist students who have questions or errors when performing the activities suggested by the teacher or who have low grades. This work does not mention any student or disability profiles. Table I is a comparison between all of the above related works, based on the following criteria: Student Profile (SP), Disability Profile (DP), Pedagogical Model (PM) and Course Structure (CE). The table also summarizes the main characteristics of each approach.

As shown in Table I, most of these approaches adapt didactic activities based on pedagogical models and take into account the student profile, evaluation feedback and, sometimes, the teacher profile. None of the above approaches takes into account

Work	Description	SP	DP	PM	CE
Lee and Cho (2013)	Adapts tests taking into account skills. It creates a learning profile	X		X	X
Mylonas *et al.* (2004)	Adapts content taking into account automatically generated student profiles. Teacher-oriented systems	X		X	X
Boujarwah *et al.* (2011)	Adapts the display of pedagogical activities through an interactive simulator. This system assists the teacher in using focus groups or personalized education	X		X	X
Tobar and de Freitas (2007)	Provides suggestions to the teacher to create study groups, based on student profiles				
Zaina and Bressan (2008)	Adapts different scenarios, based on the learning styles of the students	X		X	X
Martin *et al.* (2009))	Provides suggestions to the teacher, based on the teacher and course profiles Provides feedback of pedagogical strategies	X		X	X
Besbes *et al.* (2010)	Utilizes an expert system to generate pedagogical profiles from the teacher competencies, to adapt the activities to students	X		X	X
Nedungadi and Raman (2010)	Interactive platform to teach science and math Adapts simulations and activities based on the student profile	X		X	
Lahti (2011)	Adaptative system with a focus in visual representations and pedagogical motivations. Takes in to account the student profile and the pedagogical model, based on concept maps	X		X	
Bremgartner and de Magalhaes Netto (2011)	Ontology-based multi-agent system that adapts activities based on the student errors and personalization based on recommendations			X	

Table I.
Related work comparison

disabilities to suggest activities or utilizes a pedagogical model that is adequate to the specific necessities of students with disabilities or learning difficulties.

3. Kamachiy-Idukay

To address the issues of the related approaches (see Section 2), we created Kamchiy-Mayistru (KM), a component that adapts and enriches educational services based on the student characteristics, his/her disabilities and learning difficulties, the course structure and the pedagogical model. KM is a part of a bigger system called Kamachiy-Idukay (KI). The latter is an entire platform to provide educational services for people with disabilities and educational difficulties (Lancheros-Cuesta *et al.*, 2013). KM is the component of KI that provides the course adaptation service, which suggests activities to students based on their specific characteristics. Our previous work focused on describing the overall architecture of KI. This paper focuses in detailing KM and the way it performs adaptation.

3.1 Kamachiy-Idukay Architecture

To better understand KM, it is necessary to briefly describe the overall architecture of KI. For more details about this architecture, the reader can refer to Lancheros-Cuesta *et al.* (2013). Figure 1 is a data flow diagram that describes the overall architecture of KI. The main processes are as follows:

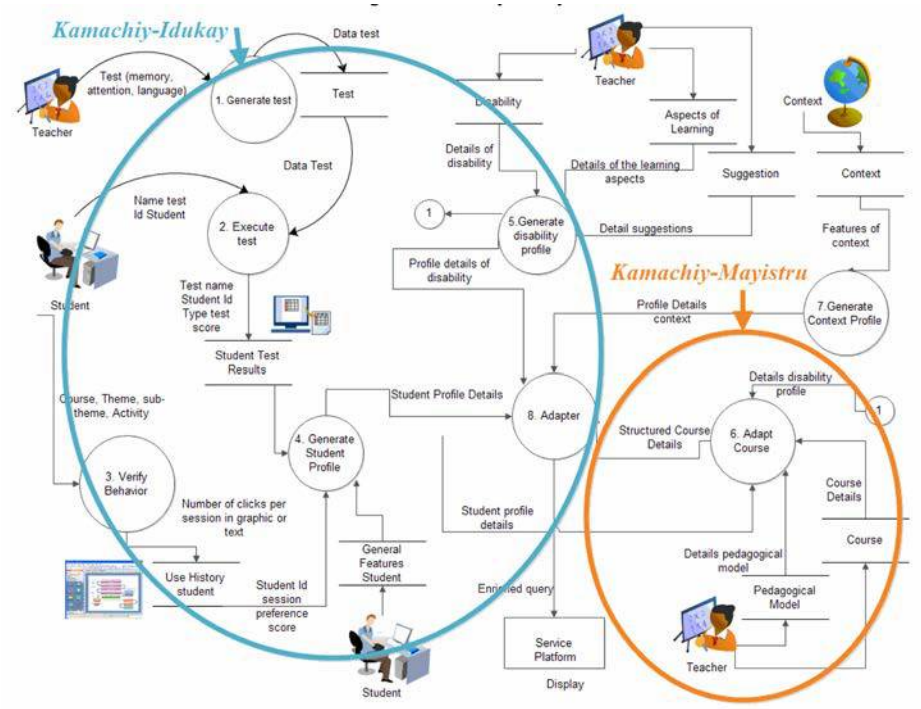

Figure 1.
Kamachiy-Idukay

- *Generate aspect test or learning style*: It assists the teacher to create a diagnostic test to detect learning difficulties and learning styles.
- *Execute test*: It assists the student to perform the diagnostic test.
- *Verify behavior*: It stores a usage history, based on student preferences in perception and navigation.
- *Generate student profile*: Based on the test results, general student characteristics and usage history, it generates and stores a student profile.
- *Generate disability profile*: Based on disability information (e.g. cognitive, sensor disabilities) provided by experts, learning aspects (e.g. memory, attention) and suggestions (e.g. types of activities and display formats), it generates a disability profile.
- *Adapter*: Based on the student and disability profiles and the course information, it determines the way to convey the information to the student.
- *Adapt course*: This task is the core of KM. It utilizes the course information, topics, sub-topics and activities to automatically organize course contents, based on student learning difficulties and disabilities.

3.2 Kamachiy-Mayistru

Figure 2 details the Adapt Course process that is the core of KM. This process takes as input the disability profile, the student profile and the pedagogical model. The output is the structure (activities, precedencies) of the course.

Figure 3 details the DP repository that stores information about disabilities (ElSayed, 2012), learning difficulties (Khalid *et al.*, 2009), aspects associated to these two, such as memory, interpretation, language, and suggestions from experts. A more detailed explanation of this profile can be found in Lancheros Cuesta *et al.* (2012).

Figure 4 details the SP repository that stores specific student characteristics, test results (academic and diagnostic tests), learning styles and preferences. For a more

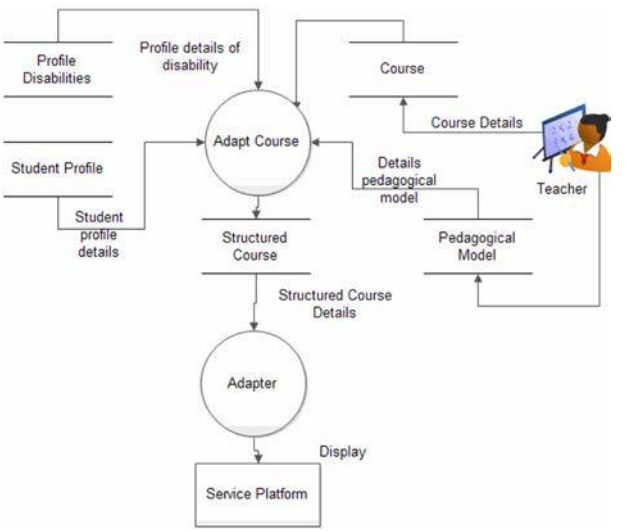

Figure 2.
Adapt course process (KM)

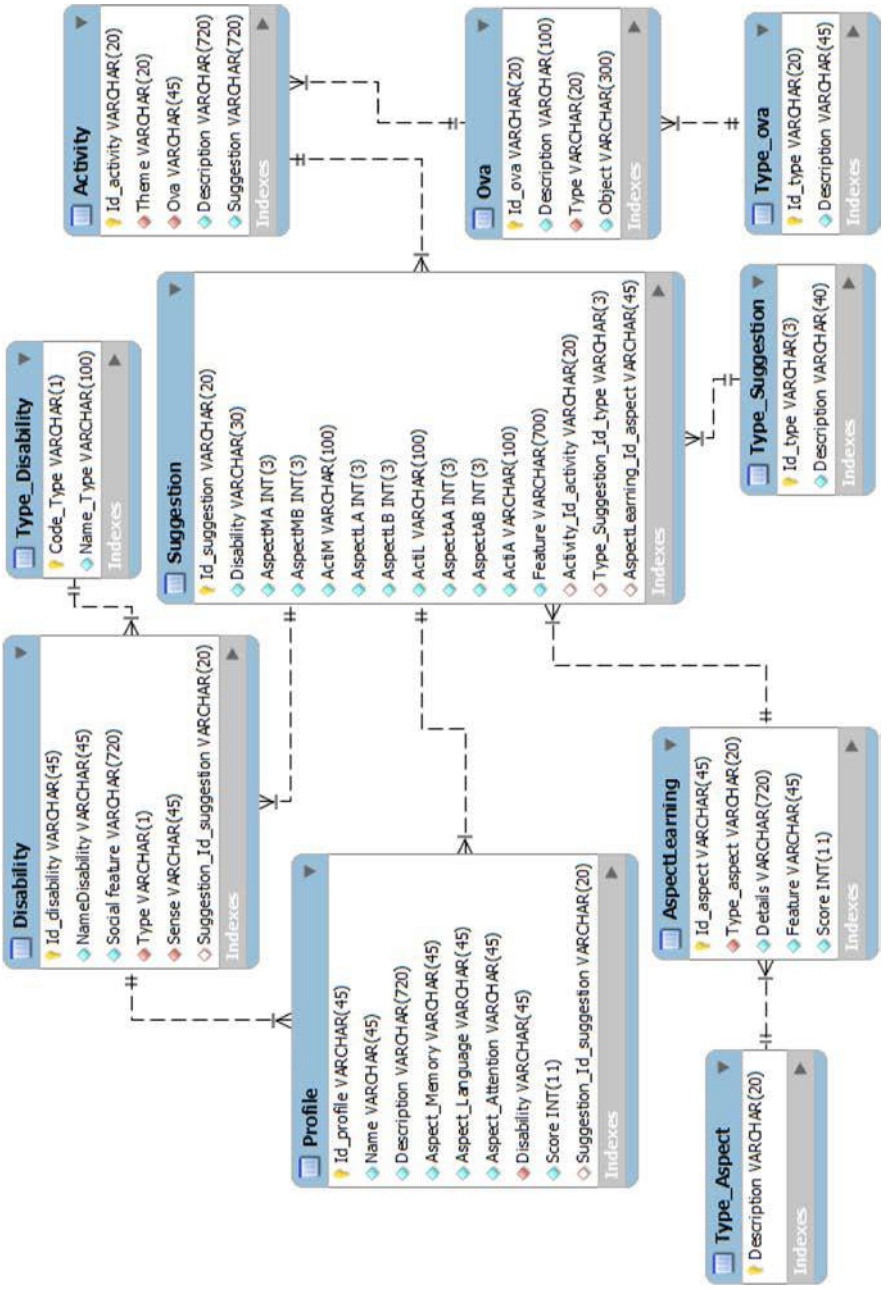

Figure 3.
Disability profile

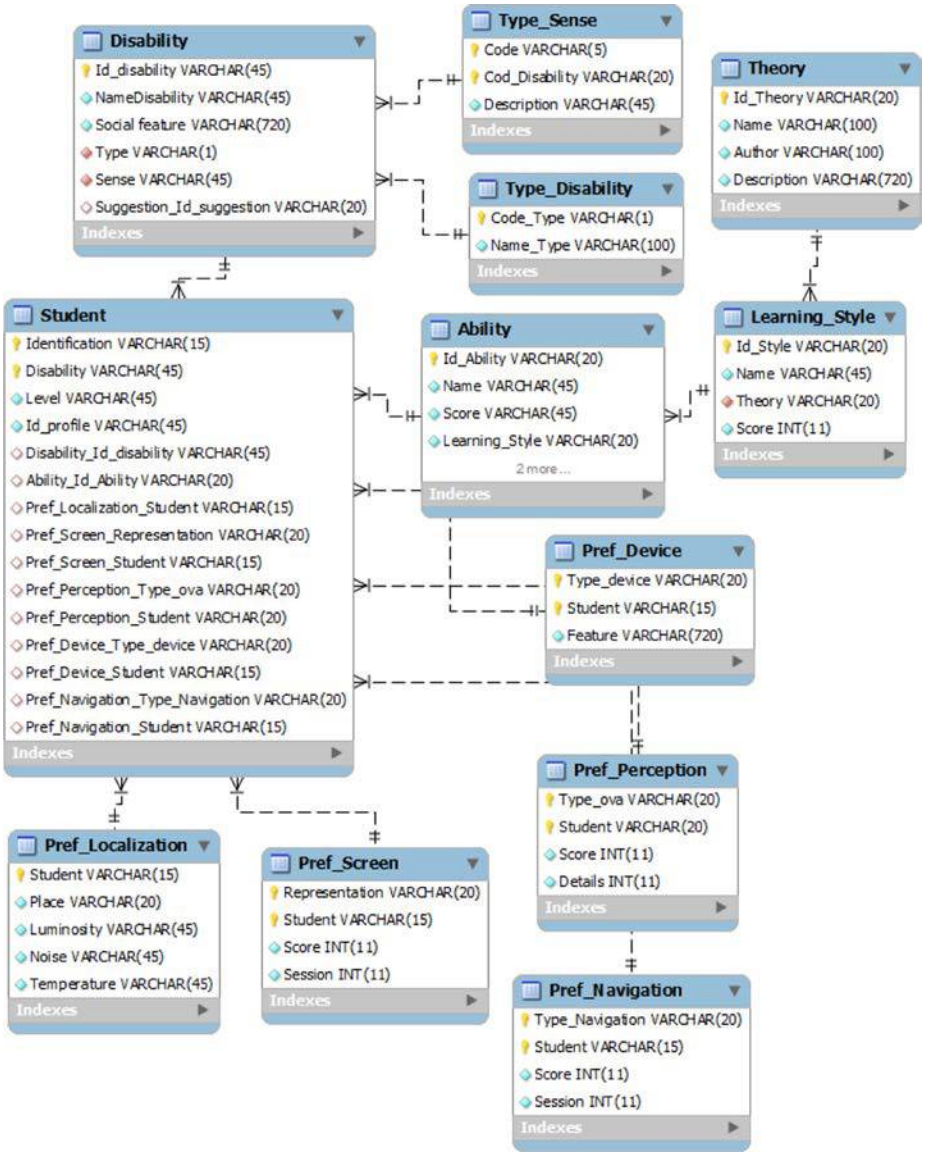

Figure 4.
Student profile

detailed description of the process to create the SP, the reader can refer to Lancheros Cuesta *et al.* (2012). Figure 5 details the course repository. This repository contains the topics and sub-topics of a course syllabus.

The Adapt Course process is fed with all of the above information. The output of this process is stored in the CE repository (Figure 6). This repository contains suggestions in terms of didactic activities, virtual learning objects and display formats that are most

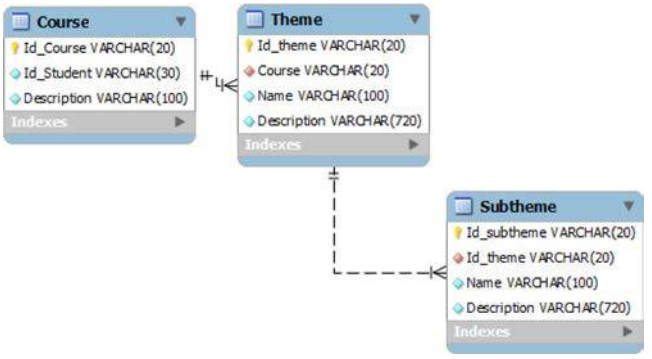

Figure 5.
Course repository

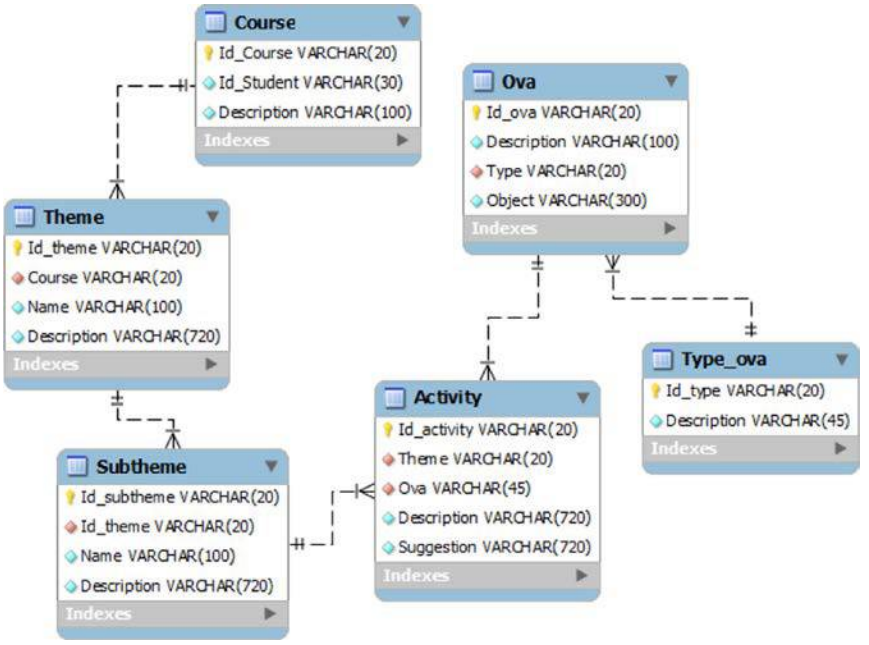

Figure 6.
Course structure repository

adequate to specific student characteristics. The information stored in the CE repository is later utilized by the Adapter process to finally display the information to the student. The Adapter process is another part of KI that is outside the scope of this paper. The Adapt Course process is the core of KM. This process suggests the teacher the pedagogical model and the activities that are most adequate to students with disabilities or learning difficulties.

Algorithm 1 describes the algorithm of Adapt Course. The inputs are stored in three tables: DP, suggestions, SP and course profile. The output of the process is a structured course. The algorithm has three procedures:

(1) Select student queries the system to obtain the learning aspects that are affected by the student disabilities or difficulties.

(2) Select PM obtains the most adequate pedagogical models for the student and suggests them to the teacher, who finally selects one of them.

(3) Create structured course assists the teacher in adding topics, sub-topics and activities based on the specific student characteristics.

```
Algorithm 1 Adpat Course
  Data Input: Tables
  Table1 ← Profile Disability
  Table2 ← Suggestions
  Table3 ← Profile Student
  Table4 ← Profile Course
  Result: Generate Course Structure
  Table4 ← Structure Course
  Actual Id ← IdTeacher
  while (Actual Id ≠ "") do
    procedure Process1-Student Selection
      Id Student Selection
      ExecuteSQL("Select Table3 * where IdStudentSelection=IdStudent")
      IdDisability ← IdDisability Student
      IdentifyIssuesLearning(Id Student)
    end procedure
  end while
  procedure Process2- Teaching Model Selection
    IdSelected disabilities ← Execute SQL("Select * from Table1 where
Id-ProfileDisability=IdDisability")
  if SelecDisability ≠ "" then
    Suggested Model ← Execute SQL("Select * from Table2 where IdSe-lected
disabilities=IdDisability")
    end if
  end procedure
  procedure Process 3- Create Course Structure
    Execute SQL("insert into Table4 values Course, Thematic, Activities, Model
Suggestions")
  end procedure
```

The Adapt Course process begins by retrieving the student disability and learning difficulties. Using the student-filtered information, the algorithm selects the pedagogical model characteristics (methodology and advantages). The pedagogical model in KM is the description of a learning environment that combines teacher motivations, tools to convey knowledge and the students with difficulties in the teaching–learning process. KM utilizes Joyce's educational environment models for people with learning difficulties, such as non-directive behavioral teaching (Lancheros Cuesta, 2012).

The student information and the pedagogical model are combined to create the course structure. For instance, for a student without disabilities or learning difficulties, the pedagogical model would be programmed instruction; thus, the course structure would comprise topics and sub-topics with prerequisites associated to knowledge areas. On the other hand, for a student with disabilities or learning

difficulties, the pedagogical model would be personalized and the structure of the course would comprise several activities oriented to his/her particular necessities and without specific prerequisites.

4. Case study

This section describes the application of KM in two case studies. The first case addresses students with reading difficulties. The second addresses students with Asperger Syndromme (Chan and O'Reilly, 2008). The overall application of KI (Lancheros-Cuesta *et al.*, 2013) assists the teacher to create the course and its associated activities. A specific application was created to test the KM component, called ALS-TEACHER (Figure 7).

The validation of KM was performed in the Jazmin IED School. The following activities were performed:

- diagnosis of 100 students to find learning difficulties;
- special cases selection based on the diagnosis;
- storing the special cases information in KM;
- automatic course structure definition for those special cases utilizing KM; and
- evaluation of KM.

These activities are detailed as follows:

- *Student diagnostic*: A diagnostic test was applied to students. The test includes questions and activities to diagnose disabilities and also language, attention and memory difficulties. The tests were performed in different levels: two pre-school levels and first and third grade levels.
- *Special case selection*: From the diagnostic information, the following special cases were selected: a student called Ana, who has reading difficulties, but no disabilities; and Samuel, a student who has reading difficulties and has Asperger Syndromme (Chan and O'Reilly, 2008).
- After special cases are selected, test results are included in KM.
- *Teachers utilize the platform to organize the course*: At that moment, the adaptation is performed. For instance, when the teacher creates activities for a topic called "Reading" of the course "Spanish", the system indicates the student that must be selected to assign specific activities.

Figure 7.
Main screen of ALS-TEACHER

4.1 Case 1: student with reading difficulties and no disabilities

The system performs the Process 1 of the "student selection" algorithm and determines that the student Ana requires activities to improve her reading process. To do this, the system analyzes the student profile, which indicates that Ana has reading difficulties and shows the teacher different suggestions of activities for the student based on this specific difficulty that she has.

Figure 8 shows the suggestion provided by KM (marked with an oval). The system specifically tailors the course to Ana, providing tale-telling activities with simulations that use voice recordings.

When Ana uses the system, she selects the first topic of the "Spanish" course; the system will show her the tale of Snow White using a simulation that includes images and synchronized audio and highlighted text. This activity is based on a strategy that uses spoken word to convey the linguistic meaning of the text and also emotions and feelings generated by the text.

4.2 Case 2: student with reading process and Asperger syndrome

In this case, the system performs Process 1 of the "Adapt Course" algorithm and determines that the student Samuel requires activities to improve the reading process, taking into account that he has Asperger syndrome (Cheng *et al.*, 2005). Figure 9 shows the suggestion given by the system to the teacher (marked by an oval), which is different than that of Ana's. This activity is tale-telling based on pictures associated with the reading.

When Samuel uses the system, he selects the first topic of the "Spanish course" called "first reading". The system will show him the tale of Snow White using a PDF file that includes the text and pictures [that is adequate for students with Asperger (Cheng *et al.*, 2005)] and highlighting words associated to each picture and using spoken word [that is adequate for people with reading difficulties (Chan and O'Reilly, 2008)]. This activity is based on a strategy that includes simple indicators that facilitate temporal sequence

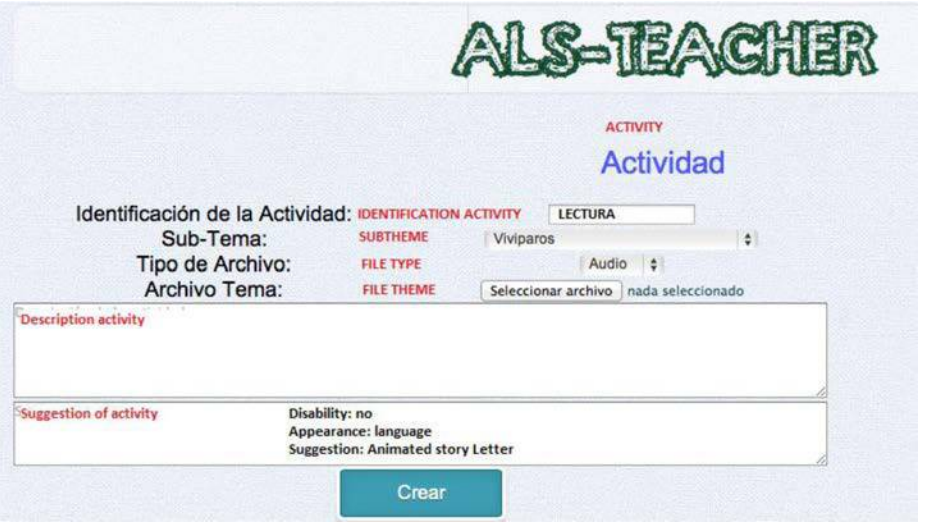

Figure 8.
Activity suggested by KM to Ana

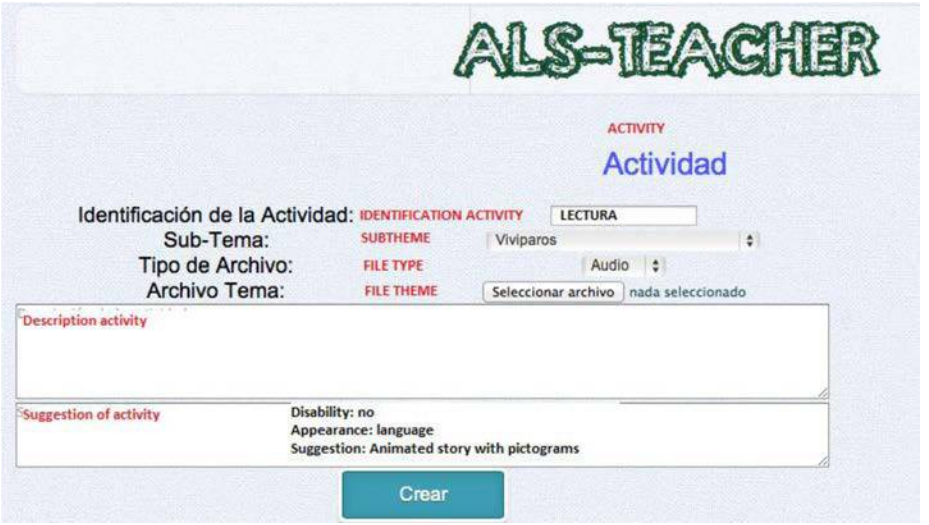

Figure 9.
Activity suggested by KM to Samuel

comprehension and anticipate changes for students with Asperger syndrome (Belinchón *et al.*, 2009). If KM did not provide these recommendations and the teacher did not organize the course based on specific student characteristics, the platform would show the same activity for Ana and Samuel.

5. Analysis of results

To evaluate usability and refine certain aspects of the platform, we surveyed a group of teachers in the school. Some of the main questions asked were:

Q1. Which activities would you recommend to address memory, attention and language difficulties?

Q2. Do you have any students with disabilities?

Q3. Do you believe that a platform, such as KI, can support the teaching–learning process?

Q4. The platform shows activities according to specific student difficulties. Do you believe that this contributes to your teaching process?

Q5. Which aspects do you believe are wrong in inclusive education?

In addition, we evaluated the following aspects related to the platform:

- The ability of KM in organizing an inclusive course.
- The ability to motivate students, to be attractive and of interest in an educational environment.
- The ability to adjust content and activities to each student.
- Its flexibility to assign activities.
- The ability to adapt to different students. Figures 10-12 show the results of the first question.

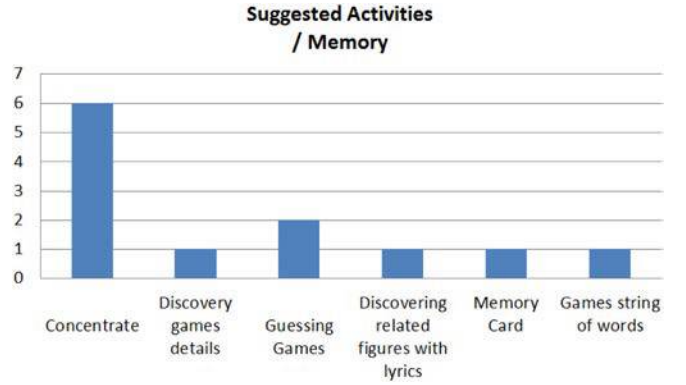

Figure 10.
Suggested activities to address memory difficulties

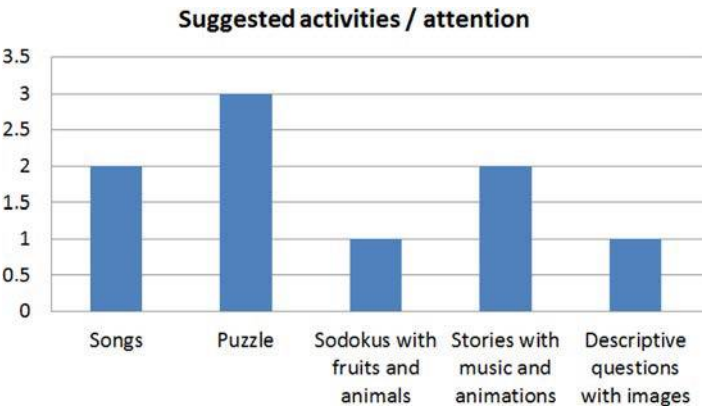

Figure 11.
Suggested activities to address attention difficulties

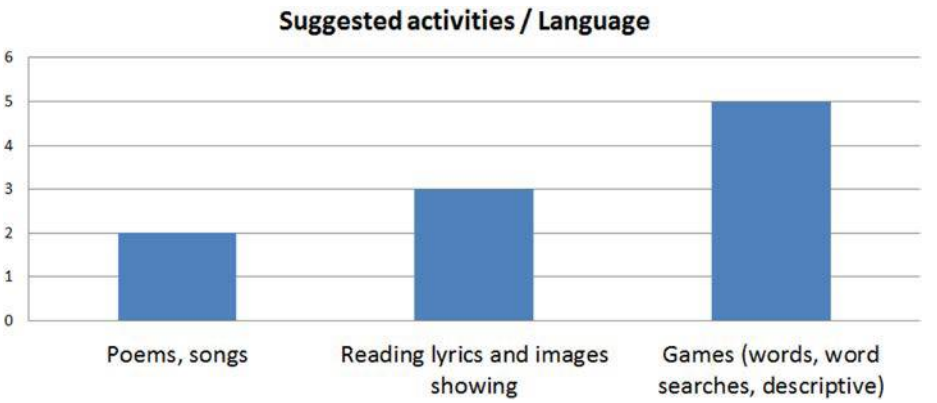

Figure 12.
Suggested activities to address language difficulties

Figure 10 shows the activities suggested by teachers to address memory difficulties. Teachers preferred concentration activities and guessing games. Other preferred activities are detail discovery games, discovery of relations between figures and letters, memory games and word chaining games.

Figure 11 shows suggested activities for students with attention difficulties. The most preferred is jigsaw assembling, followed by singing, tale-telling with music and animations. Other suggestions are Sudoku games with fruits and animals and visually descriptive questions.

Figure 12 shows suggested activities to address language difficulties. Most teachers prefer word game activities, letter soups and descriptive games, followed by spoken word activities with sound and images. The lowest preferences are poetry and singing activities.

As it can be observed, suggested activities differ significantly depending on the type of difficulty. Figure 13 shows the answers to the second question. The result is that 92 per cent of teachers have at least one student with difficulties or disabilities.

For the third and fourth questions, 100 per cent of teachers indicate that the platform supports their teaching–learning processes and contributes to their teaching.

In regard to the fifth question, the main facts indicated by teachers is that students require personalized activities, diagnostic centers, classrooms and that many teachers lack knowledge to address disabilities. Figure 14 shows the consolidated results of the evaluation of KI. As shown in Figure 14, for the aspect (i), five teachers agree that the platform is totally adequate to organize an inclusive course; six consider that the platform is very adequate; and one teacher considers the platform adequate. For the aspect (ii), five teachers consider the platform totally adequate to motivate, be attractive and interesting in an educational environment; and seven consider the platform very adequate for those purposes. For the aspect (iii), five teachers consider the platform totally adequate to adapt content and activities; and seven consider the platform very adequate. For the aspect (iv), four teachers consider the platform totally adequate to flexibly assign activities; six teachers consider it very adequate; and one considers it adequate. For the aspect (v), four teachers consider that the platform is totally adequate to adapt to different students; and eight consider the platform very adequate.

Most teachers evaluated KI as totally adequate or very adequate for all of the considered purposes. They evidenced the necessity of technological tools focused on student characteristics. In addition, teachers required to invest sufficient time to design the educational material, which may increase the implementation effort for these platforms.

6. Conclusions and future work

KM is an adaptative module that supports teachers to address people with disabilities or learning difficulties. This module is a part of KI [8], a platform to provide educational services for people with disabilities or difficulties. KM assists the teacher to adapt the curriculum based on a characterization of disabilities and learning difficulties that uses a student profile and a disability profile. The provided adaptation examples and the

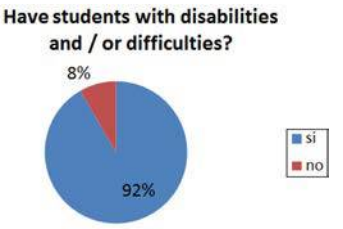

Figure 13.
Percent of teachers with and without students with disabilities or difficulties

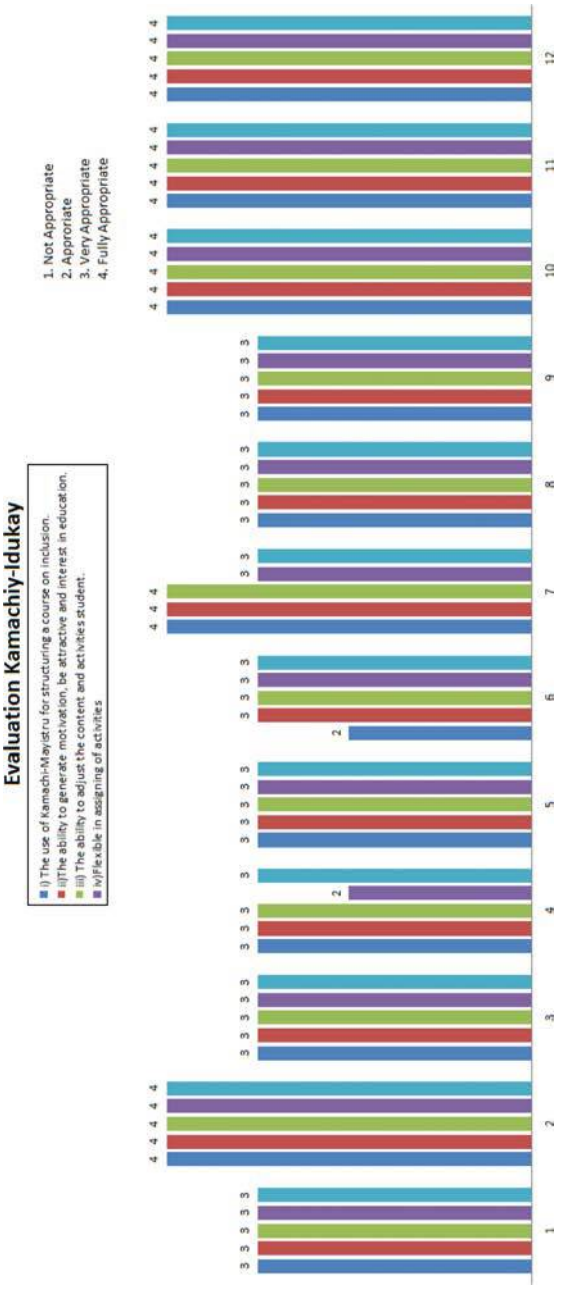

Figure 14.
KI evaluation

evaluation of the platform in a real-world environment demonstrate the usefulness of this module to adequately organize a course for students with different characteristics and to properly address inclusion concerns.

The social impact of KM is related to the support it provides for the teaching–learning process that takes into account specific student characteristics. The system assists students with mild sensory or cognitive disabilities. As a consequence, it is expected that these students could better integrate into the regular classroom.

Future work includes the validation of KM in other cases of disabilities and learning difficulties, and the creation of a feedback process to automatically update the profiles utilized in the adaptation process.

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Corresponding author

Diana Lancheros-Cuesta can be contacted at: dlancheros@hotmail.com