A Cross-platform model for an adaptive play-based assessment tool for school readiness

Iyad Suleiman[1], Maha Arslan, Reda Alhajj, Mick Ridley

Abstract— This paper will describe a three-tier adaptation mechanism to personalize educational web-based games according to several special characteristics of preschool children. These games compose the user interface of Adaptive Cross-Platform Hypermedia System for Adaptive Assessment of School Readiness (ACPHSAASR), a Cross-Platform adaptive hypermedia system designed for assessing pre-school children. This mechanism is based on a JSON configuration file. The schema of this file is easily extensible to other adaptation parameters.

Index Terms— Adaptive, Cross-Platform, Hypermedia System, Adaptive Assessment, School Readiness, Data Mining, Web-base assessment.

1 Introduction

SCHOOL readiness is an essential process to assess the level of a child before he/she joins grade one. The target is to determine whether a student is ready to smoothly adapt to the new educational system which differs from the preschool education attended by the child for almost six years though the period differs from country to country and from one educational system to another. Applying the same static assessment process is not effective and may lead to failure. Thus, it is required to provide a dynamic process that could smoothly adapt to the specific child under assessment. However, adaptation cannot be easily achieved without an automated system that strongly captures expertise in the domain. Further, to provide for wider availability of the system, it is important to develop a Web-based interface.

2 Structural design and application of knowledge assessment systems

Knowledge assessment is an integral part of the learning process. However, it is a very time and effort consuming activity in the traditional learning process, because it demands from the teacher to prepare assessment tasks or questions, to conduct assessment activities, to check and evaluate children's works, to provide feedback, among others. This is a main reason for the development of an automated system. Further, to increase the availability of the framework, it is important to provide a web-based assessment system.

The mentioned systems are used, on the one hand, to detect children's knowledge and skills, but, on the other hand, to regulate teaching and learning process on the basis of informative and tutorial feedback generated automatically by the system.

- The key factor of a successful application of any web-based assessment system is the level of its intelligence and adaptively. Intelligence mainly refers to the intelligent analysis of solutions provided by children, but the adaptivity is related to the adaptive presentation of assessment content. Children have different needs and these differences should also be taken into account by providing an individualized approach to each child. Otherwise, a *unified assessment* style can have a *negative impact* on the assessment process which may lead to worse results. Therefore, developers should provide an appropriate level of intelligence and adaptively in their web-based assessment system.

2.1 Concept of web-based assessment

According to [44] web-based assessment is a common term for the use of computers in the assessment of child learning. However, today there is a variety of other widely used terms such as e-assessment, Internet-based assessment, online assessment, Computer-assisted assessment, etc. Actually, all of them mean the same, that is, the application of computers or, more precisely, of a web-based assessment system to knowledge assessment activities. In [16] the following tasks of web-based assessment systems are mentioned:

- The delivery of assessment tasks and results to children;
- Assessments taken in whole or part on computer;
- Computer marking of assessments;
- Electronic collation and transfer of grades and assessment data;
- Electronic delivery of training and support materials.

Web-based assessment systems can be used for initial, formative and summative assessment. *Initial assessment*, as a rule, is performed at the beginning of the learning process in order to gather diagnostic and prognostic information concerning children' knowledge and skills. *Formative assessment* is carried out during the instruction in order to obtain information about the regulation of the teaching and learning process, to identify obstacles that can be found in the learning process and to detect topics that need to be reinforced. *Summative assessment* takes place at the end of learning with aim to determine children's achieved level of knowledge and skills in a given do-

- [1] *Iyad Suleiman, Ph.D. is currently a lecturer in Max Stern Emek Yezrael Academic College, Israel, E-mail: iyad.suleiman@gmail.com*
- *Maha Arsla, Ph.D. is currently a lecturer in Sakhnin College, Israel, E-mail: maha.arslan@gmail.com*
- *Reda Alhajj, Full Professor in Computer Science in Calgary University, Canada, Email: rsalhajj@gmail.com*
- *Mick Ridley, Lecturer in Bradford University, UK, Email: M.J.Ridley@bradford.ac.uk.*

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

main. [17] [5]); [20] the same term "web-based assessment" is defined narrowly and refers to the use of computers in assessment, encompassing delivering, marking and analysis of assignments or examinations, as well as collation and analysis of data gathered from optical mark readers. This definition clearly distinguishes two basic forms of web-based assessment which exist nowadays:

- *Systems*, where children submit their works or answers using a computer that further makes their analysis and evaluation;
- *Optical mark readers*, which scan, interpret and evaluate paper forms of tests completed by children through the marking answers on test questions.

The first mentioned basic form of web-based assessment can be divided into systems providing objective testing and systems supporting subjective testing; [41]. Systems based on objective tests are the most widespread systems of web-based assessment. They offer the child a set of questions, answers to which are pre-defined [20], in other words, assessment is not subjective, because no judgment has to be made on the correctness of an answer at the time of marking, [13]. Thus, in such systems the child is offered a question and he/she inputs an answer. The system compares the entered answer with the answer defined by the teacher/instructor and provides the feedback to the child. There are different types of questions, but the main ones are the following, [16]

- Multiple choice questions (children are asked to select one answer from a list of possible answers);
- Multiple response questions (children are asked to select any number of answers from a list of possible answers);
- Graphical hotspot (children are asked to select areas of the screen by moving a marker to the required position or filling in a block in a particular position linked to a graphic illustration on a specially designed paper answer sheet);
- Text/numerical questions (children are asked to input text or numbers in the particular field using the keyboard).
- Once the mouse is controlled, further training should introduce young learners in the use of pressing buttons. Since "drag and drop" and "double click" are too complex actions at this age, they should be practiced to prevent children's rejection of using a mouse.

Computer-assisted objective testing systems vary significantly in their functional complexity. Simple systems act as authoring tools providing the possibility for the teacher to construct questions manually. Complex testing systems are able to create questions automatically on the basis of the dynamically selected learning content provided by the teacher. Such systems combine various techniques of natural language processing to construct questions.

2.2 Advantages and drawbacks of web-based assessment systems

In general, the use of web-based assessment systems provides a number of advantages, [17]; [41]; [7]; [31]; [15]; [37]:

- A wide range of topics can be tested quickly;
- Large groups of children can be assessed quickly;
- Provision of the potential for frequent assessments and, as consequence, the regular monitoring of the progress of children;
- A variety of media (images, video, audio, etc.) can be included in assessment questions or tasks;
- Extensive feedback can be provided to teachers through various diagnostic reports;
- Decrease in time needed for supervising and marking of assessments;
- Greater flexibility regarding place and time of assessment;
- Elimination of any prejudices in relation to children;
- Instant feedback to children;
- Reduced mistakes in comparison with human marking;
- Results can be automatically entered into administration systems.

Despite all the advantages, web-based assessment systems have also some drawbacks, [17]:

- Implementation of an assessment system can be costly and time-consuming;
- Difficult to reproduce freedom of paper examination – e.g. scanning exercises to choose which to make;
- Assessors need training in assessment design, IT skills and examinations management;
- Children require adequate IT skills and experience of the assessment type;
- Good system maintenance is required to avoid downtime during examinations.

Considering objective testing the following advantages can be identified in addition to the already mentioned advantages of web-based assessment systems:

- It is easy enough to define questions, because a wide experience is accumulated in the development of knowledge assessment systems based on objective tests;
- Objective testing can be used for initial, formative and summative assessment, as well as for other kinds of assessment, for example, self-assessment.

Moreover, one of the most promising advantages of the application of web-based assessment systems based on objective tests seems to be the possibility of automatic bidirectional translation of questions and answers from one language to other language(-s), as it is implemented in the web-based assessment system, [6]. Thus, it allows an assessment system to be used by children and teachers from different nationalities, because the author of a course simply writes the questions in

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

his/her own language (for example, in Spanish) and the child (for example, an English speaker) receives the question translated automatically into English, writes the answer, and the system automatically translates it into Spanish and compares it against the teacher's answer.

However, systems of *objective testing* have the following drawbacks:

- Objective testing does not allow the child to offer original answers, so there are restrictions on knowledge and skills which can be assessed. According to [13]; [37] such systems allow evaluation only of the first four levels in widely accepted in pedagogy Bloom's taxonomy, [45], which includes three levels of lower order skills (knowledge, comprehension, and application), and three levels of higher order skills (analysis, synthesis, and evaluation). In [13] this assertion is said to be erroneous, but it is pointed out that designing test questions to assess higher order skills can be time consuming and requires skills and creativity;
- Objective testing assesses only factual knowledge instead of child's understanding about their interconnectedness and significance in the learning course;
- Objective tests encourage children guessing.

Subjective testing, in turn, provides the following advantages, Module III: [36]; [18]:

- It allows the child to offer original answers and judgments, to demonstrate ability to organize knowledge and express opinions, thus, higher order cognitive levels can be assessed;
- Children can display a broader range of knowledge about a particular topic;
- Children less likely to guess.

Systems of subjective testing use methods of artificial intelligence, especially natural language processing and classification algorithms. This fact is the reason for the main drawbacks of such systems: dependency on a subject and natural language, as well as complex structure and functional mechanisms. Moreover, the use of essays and free text responses for systematic assessment is a questionable issue due to a high cognitive load for children. Other drawbacks are the following, Module III: [36]; [18]: limitations of the extent of content covered by assessment and more subjective assessment due to the taking into account such factors as style and originality of assignments.

2.3 General architecture of a web-based assessment system

In general web-based assessment systems are designed to be used by three types of users – an administrator, a course instructor (a teacher) and a child. The administrator updates records of courses, instructors and children are also gives access rights to both instructors and children. The course instructor organizes curriculum, designs tasks and views assessment results. The child takes published tests or performs tasks, [34]; [35].

The analysis of web-based assessment systems intended both for objective and subjective testing shows that almost each system has its own architecture, [22]; [21]. There are two main reasons for such architectural differences. Firstly, each web-based assessment system has its own behavioural model. Secondly, each developer has its own preferences on dividing system functionality into structural units.

Trying to recap information about available architectures and their similarities a general architectural model of a *modified* web-based assessment system is presented in Figure 1.

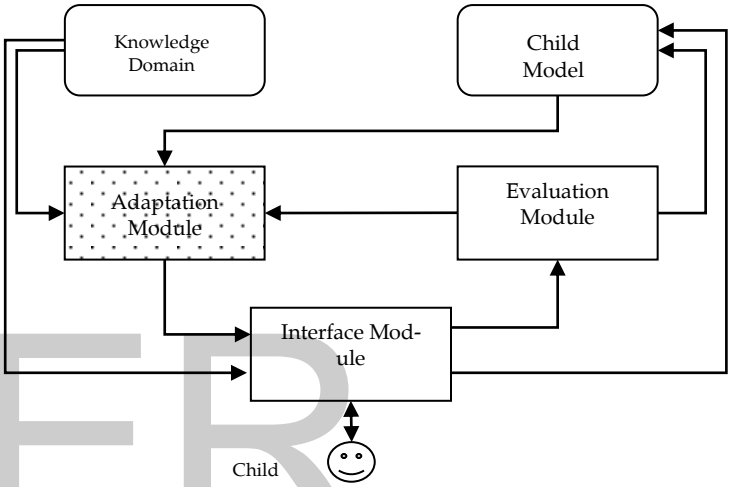

Figure 1- General architecture of a *modified* web-based assessment system, *Source*: [33]

The architecture above incorporates the following structural units:

1. *Interface* (*or Interaction*) *Module* that is responsible for the provision of interaction between a user and the system. The main tasks of this component are the following: to present tasks and feedback, to activate the other modules according to the child's actions, to collect data concerning the child's observable behaviour and to update the child model with the newly acquired information. The interface module passes child's solutions to the evaluation module for their evaluation. If the child set some preferences regarding the interface and behaviour of the system the interface module also stores these parameters in the child model.
2. *Adaptation Module* that is responsible for the selection of tasks suitable for a particular child taking into account the child's level of knowledge, skills and preferences. Adapted tasks from the adaptation module are passed to the interface module for their presentation to the child. The mentioned module is the core of the web-based assessment system because it provides

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

the intelligent solution analysis, [10]. There are two fundamentally different types of instructional (or selection) models for adaptation module: rule-based model and algorithm-based model. [19].

3. *Evaluation (or Diagnostic) Module* that is responsible for the evaluation of child's solutions and generation of feedback. Evaluation results are used further mainly to update knowledge level in the child model. Results of each completed task are also passed to the adaptation module and to choice the next assessment tasks. They are also passed after each task to the adaptation module for the selection of the next assessment task.
4. *Domain (or Expert) Knowledge* which stores all possible questions and solutions defined by the teacher or the instructor. Domain knowledge is passed to the adaptation module to adapt assessment tasks to the child needs before assessment takes place, and to the interface module to show the child the correct solutions after assessment is completed.
5. *Child (or Learner) Model* which stores information about a child such as general information, knowledge level, preferences, etc. The child profile is passed further to the adaptation module to adapt assessment scenario to the child needs.

The adaptation module is depicted by the dot filled box in Figure 15 because this component is optional and there are systems which do not provide adaptively to a particular child and, therefore, offer the same assessment scenario for all children regardless of their level of knowledge and skills and preferences, i.e., such systems are not able to generate individual assessment plans.

2.4 Intelligent and adaptive support in web-based assessment systems

The analysis of web-based assessment systems shows that there are two important features of such systems, level of *intelligence* and level of *adaptively*. A system is called to be *adaptive* if it uses principles and methods of artificial intelligence, [10] (such as the processing of natural language, knowledge representation, inference mechanisms and machine learning) in its structure and operation.

In turn, *adaptively* is defined as the capacity of the system to change behaviour automatically without a deliberate action on the user's part, [42]. The *adaptively* and *intelligence* are features of high importance due to the fact that children have different needs and these differences should also be considered in web-based assessment through the provision of an individualized approach to each child. Otherwise, if a unified assessment style does not match the style of a particular child it can have negative impact on assessment process by leading to worse results, [43]. Therefore, in order the assessment process implemented through the use of a web-based assessment system to be effective an intelligent and adaptive approach should be applied. Web-based assessment systems become more flexible and useful for children with different preferences and learning needs by incorporating a certain level of intelligence and providing a certain level of adaptively.

According to [10] intelligence is concerned with the intelligent solution analysis and the intelligent problem solving support. Unlike systems which do not incorporate intelligent solution analyzers and, as a result, are capable of telling only whether the child's solution is correct or not, systems performing the intelligent solution analysis can tell what is wrong or incomplete and which missing or incorrect pieces of knowledge may be responsible for the error. The intelligent problem solving support concerns with the provision of intelligent help during the problem solving process and the generation of tutorial feedback to the child both during the assessment process and at the end of it.

The intelligent help can be given in forms of hints or leading questions relevant to the current situation in problem solving, Its main task is to allow the child to activate his/her thinking processes in order to obtain the correct solution of a task. In turn, tutorial feedback can be directed towards filling in gaps in knowledge simultaneously with the knowledge assessment by providing pieces of relevant learning material or towards facilitation of further direction of learning.

It is possible to conclude that systems of subjective testing are mainly intelligent systems because they perform not only the analysis of text in natural language through the use of corresponding methods of artificial intelligence, but also checking of matching of the text to criteria corresponding to the content, style, originality and identification of reasons of mismatching. In turn, the greater part of objective testing systems is not intelligent because they do not provide the intelligent solution analysis and the intelligent problem solving support. The mentioned systems typically compare the child's submitted answer with the teacher's predefined answer without the identification of the reasons of the mismatching between the mentioned answers, as well as the provision of very simple feedback in form of short sentences pointing out whether the answer is/ is not correct.

In other knowledge assessment systems, [23]; [43]; [3]; [29]; [32] both previously mentioned terms - the intelligent solution analysis and the intelligent problem solving support - can be closely related. If a system is not able to perform the intelligent solution analysis then no tutorial feedback or individualized help can be generated.

The adaptively in web-based assessment systems refers mostly to the adaptive presentation of assessment content and means the ability of a system to generate an individual assessment scenario (tasks sequence). If a system is not adaptive then for all children the same assessment scenario is applied. In contrast, an adaptive web-based assessment system, [6]; [29]; [32] provides an individual assessment scenario for each child taking into account child's prior knowledge level, preferences and already given solutions.

Objective testing can be adaptive. In this case the terms "com-

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

puter adaptive assessment" or "computer adaptive testing" are used. In adaptive testing questions of knowledge assessment are adjusted to the learner's knowledge level. In most cases the widely known Item Response Theory (IRT) is used to generate an individual assessment scenario. In accordance with IRT selection of the next question depends on answer given to the previous question(s). The procedure is described in [14] in detail. At the beginning of the assessment the child receives a question of average difficulty. If he/she gives a wrong answer, he/she receives a less difficult question. Otherwise, the child receives a more difficult question. This process continues until the predetermined test termination criteria have been met. In such an approach each child receives a unique set of questions, which allows more accurate determination of his/her achievement level. Thus, children at a low achievement level are not required to respond to questions that are very difficult and far beyond their achievement level, but children at a high achievement level are not required to answer questions that are too simple for them.

In [29] the system's ability to support an individualized approach is divided into adaptively and adaptability. *Adaptively* requires the system to automatically adapt to the child's current level of domain competence and other similar attributes, whereas *adaptability* requires the system to provide suitable interfaces by which the child can customize the system according to his own preferences.
The intelligent and adaptive support in web-based assessment systems can be achieved by the use of a child model which is discussed in the next section in detail..

2.5 Use of the child model in web-based assessment systems

Child or learner modelling is related to the task of keeping a record of many aspects of a child. This record is called a child (or a learner) model. The child model reflects specific characteristics of the child and thus it is used as the main source of the adaptive behaviour of any web-based assessment system, [6]; [22]; [43]; [40].

The information held in the child model is divided into domain dependent information or dynamic information that changes during the assessment process and domain independent information or static information that is constant through the assessment process. Regarding the domain dependent information, the child model keeps information about the child's knowledge level, the child's errors, the child's behaviour during his/her interaction with the system (number of help asked, frequency of errors made, time of response, etc.). The domain independent information is the general information about the child such as the username, child's favourite feedback components and knowledge units (i.e., definition/description, example, and image), last time/date the child logged on/off, etc. The child model is dynamically updated during the child's interaction with the system in order to keep track of the child's "current state".

Information about the child can be obtained from different sources:

- From user-filled forms at the initial stage of the use of the system when the child is asked to answer a questionnaire about his/her personal data and preferences; in some cases psychological tests can be applied in order to get information about child's preferred learning style;
- From child observable behaviour when he/she works with the course (e.g., pages visited, time spent in each page, navigation path followed, chosen options, etc.);
- From results concerning solving of practical problems and tasks;
- From the observations of the child through the use of different sensors [25]; [38]; [28].

Thus the process of the acquisition of information about the child can run in different modes, [40]: *passive* (when the system infers the model of children without explicit help from them), *active* (when children may be asked questions by the system to assist it) or *interactive* (when children play an active role in the development and maintenance of their own model). According to [32] storing all the information in the child model in standardized formats allows for alternative externalizations of the child models and sharing of the information with other systems. Child models are thus reusable by different assessment and teaching systems and other applications.
Different applications could interpret and portray the available data differently.

3 Implementation of the Model

Children at preschool acquire knowledge and language skills associated with different abilities through educational games. The game introduces learning activities by using playful elements as a source of motivation. The success of the game depends on an optimum relationship between challenge, fantasy, curiosity and control. This is also applied to educational computer games. Moreover, if these games contain features which have the capacity to adapt the instructional presentation dynamically according to the characteristics of a particular child's progress, these are referred to as adaptive computer games.

In this sense, the *web-based adaptive hypermedia system* (WAHS) makes the individualized assessing school readiness at preschool possible by means of adaptive computer based educational games. In the process of generating interactive games, the professional/admin chooses a set of games as appropriate for the child's educational level and domain of knowledge. The client side of WAHS sends both the child's identification and the identification of the selected game to the server side, which in turn selects the most appropriate multimedia elements (graphics and audio) in the content database. These elements, which are associated to the game according to the child's characteristics -the educational level and the psycho-

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

motor skills captured in the mouse interaction style-, are adapted by WAHS.

The architecture that makes both content and presentation adaptation feasible and presenting how WAHS dynamically choose the next educational activity/game considering the child's characteristics and the result of the played educational activity/game. Likewise, the process of generating several educational adaptive games, Count Balloon Strings, Incomplete Shadow, Picture Recognition, Match Rhyming Words etc. by modifying their difficulty, mouse interaction style and the content according to a particular child's features and progressing level in solving the games.

The personal computer is now the most used resource in the preschool classroom, ICT in Early Learning is much more than this. Highly innovative work, [26]; [27] is being carried out using programmable toys, floor robots, digital cameras, scanners, mobile telephones, cassette recorders and video recorders.
Playing games to learn basic life skills has been an important learning strategy from the earliest times, and remains so today, especially for early instruction at home.

Preschool children acquire learning, approaches and skills associated with different abilities through educational games. The game introduces learning activities by using playful elements as a source of motivation. The success of the game depends on an optimum relationship between challenge, fantasy, curiosity and control, [24]. This is also applied to computer-controlled games where a video display such as a monitor or television is the primary feedback device. They are seductive, deploying rich visual and spatial aesthetics that draw players into fantasy worlds that seem very real on their own terms, exciting awe and pleasure. The fact is that, for children and youth, computer games "are the most frequently used interactive media", [8].

Educational computer games motivate via fun ('part of the natural learning process in human development'), via challenge and instant, visual feedback within a complete, interactive virtual playing environment, whereby ambience information creates an immersive experience, sustaining interest in the game. To encourage development they should allow the children to choose and to control the activity they want to develop. There are higher levels of creativity in children that use games whose structure is less rigid, i.e. facilitating free choice, [1]. Also, children show greater interest in computer games that respond in real time to their interactions, [30]. The multimedia content that combines in an effective way the audio, the text and the images (static as well as dynamic) can stimulate the children's learning and keep their attention during long periods of time, [9]. In this stage where they have not yet acquired reading and writing skills, the audio presentation of the instructions to complete the activities is very important.

If the educational computer game has the capacity to adapt the instructional presentation dynamically according to the characteristics of a particular child and his/her progress, it is called an adaptive game. This kind of game offers personalized learning experiences to preschool children. Dynamically generated educational games compose the visible user interface of WAHS, [2], a web based adaptive hypermedia whose aim is to assess the child if he/she ready for school, and WAHS adapts both the content and the navigation according to child learners' characteristics.

4 What is an adaptive hypermedia system?

Hypermedia is developed as a result of linking two technologies: multimedia and hypertext. A computerized multimedia application involves different audiovisual means to represent the information (e.g. text, images, sound and video). The online play-based assessment, on the other hand, consists of a series of activities connected or linked among them in a way that users can pass from one activity to another in the order they wish and according to the user's needs, interests and/or point of view. Consequently, the hypermedia allows us to structure the information in a non sequential way and that information can integrate different means (i.e. text, graphics, sound and video). Hypermedia benefits in the learning process are unquestionable. On the one hand, it enables the child to freely explore the knowledge depending on their necessities and goals. On the other hand, the information is transmitted by using different sensory channels, important in the didactic process. However, in these systems the child can freely explore the knowledge (information) appropriate or not to their cognitive level.
Intelligent tutoring system (ITS), in the tool mentioned in Section 6.4, is developed by *WebGL*, is a computerized system designed to teach knowledge in a subject and skill. An ITS presents the child an activity (game) whose level of difficulty is appropriate to the child's age and background. The ITS compares the child's solution with the correct solution registered, and then, informs the child of the result as a feedback answer (see figure 2). The results model is updated with the activity result and a Machine Learning Algorithm, [39] (discussed in the next chapter) will choose the next educational activity/game considering the child's characteristics and results and then the task model presents the next activity. The ITS is interesting because depending on the child's response it modifies in an automatic way its proposal to adapt to the learning speed and the detected knowledge level. However, it is a highly instructive system where the child has little or no control over the learning process.
Feedbacks are performed whether the child answers correctly or not. The feedback is performed audibly and graphically.

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

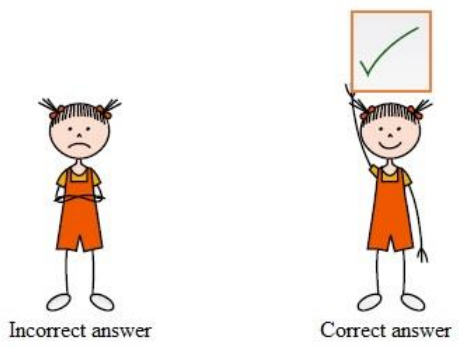

Figure 2- Feedback answers

The integration of an intelligent tutoring system in a hypermedia system originates an *adaptive hypermedia system* (AHS),[11]; [12]. The AHS profits from both systems: the tutoring part takes advantage of the flexibility and use of different audiovisual methods that the hypermedia part provides. And the latter one benefits from the adaptation to the child so that the tutor performs as a more customized educational system.

In this sense, the web-based adaptive hypermedia system makes the individualized assessing at early ages possible. Thanks to its hyper textual structure and multi-sensorial richness, children can develop their innate curiosity and complete the educational activities / games they wish as soon as they are adapted to their level.

5 Adaptive Cross-Platform Hypermedia System for Adaptive Assessment of School Readiness

This section will describe the architecture that makes possible both content and presentation adaptation and will present how *Adaptive Cross-Platform Hypermedia System for Adaptive Assessment of School Readiness* (ACPHSAASR) chooses the appropriate educational activities/games by activating the Machine Learning Algorithm on a suggested set of activities/games depending on their difficulty level of the activity/game, the weight of the specific category/subject, the weight of the specific skill, the given activity/game time, the terms the skill have to meet, the actual play time of the child, the number of correct answers, choosing one of the solve, help, backward, forward, start buttons on the screen, mouse interaction style like random clicks, random moves, if the activity meet one of the restrictions on the current activity, and the content according to a particular child's features.

5.1 Cross-Platform architecture

ACPHSAASR has a three-layered architecture. This type of architecture is an enhancement of the traditional two-level client/server architecture. Just like in such a conventional type, the three layered architecture separates user interface from business logic (programming) by distinguishing access to information from business (working with a database).

The Cross-Platform_system presents the information to the user with *WebGL with Java Script* (User Interface) and provides the adaptation in the server by means of *Java Servlets* that decide the best task/activity for the child (Machine Learning Algorithm), the Intelligent Tutor will build the game according to child age and difficulty level.
The ACPHSAASR is divided into five parts (Figure 3): Navigation Control, Child management, Task and Rules management, Assessment Content management, and Testing Management. The Navigation Control allows connecting User interface. The Task and Rules management according to the task and rules database and the results model consults the Machine Learning Algorithm in order to decide (according to the rules and results) the next task to do. The Child management handles the user model that stores the child's characteristics. The Testing Management stores the games' results. Lastly, intelligent tutor builds the next activity by consulting the Assessment Content management that stores the information on each task.

5.2 Adaptation Parameters

The characteristics which compose the user model of ACPHSAASR and will adapt educational video games to preschool children are determined by the educational level which refers to the child's knowledge regarding the domain of knowledge, the psychomotor and cognitive skills captured through the observation of the interaction style with the mouse, cognitive abilities, arithmetic readiness, Language Development, Phonological Awareness, and the acquired knowledge. Since prereading and pre-writing stages emphasize educational input such as visuals, listening, and gestures, learning styles should differ significantly at these early stages. Because multimedia activities, which combine video, sound, text, animation and graphics to stimulate different senses, are addressed to heterogeneous groups of children, such tasks should be developed by accounting for all children's needs and preferences.

The three-tier architecture of ACPHSAASR keeps the structure and the multimedia components that compose the didactic domain (hyperspace) independent. This fact allows extending the user's model with more parameters of adaptation.

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

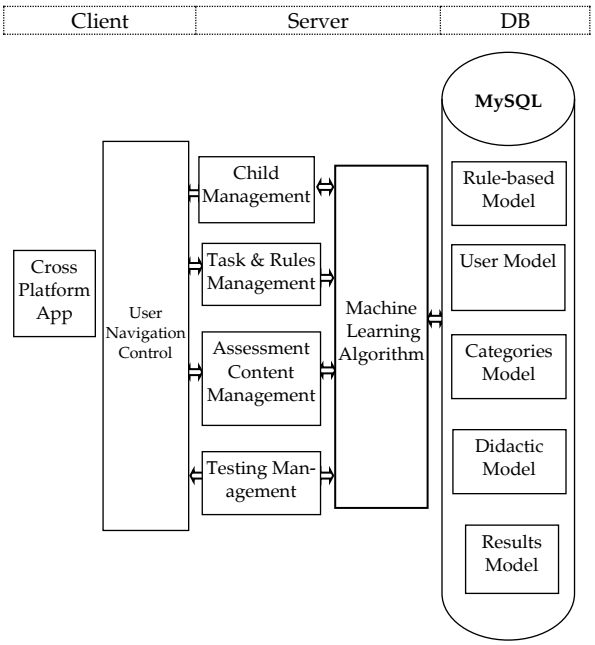

Figure 1- **The three-tier architecture of ACPHSAASR**

Three educational difficulty levels will be distinguished according to pre-school curricula: level 1-*easy*, involving a conceptual phase addressed to four year old children, level 2-*intermediate*, corresponding to five years old, and level 3-*hard*, addressed to six years old. In terms of knowledge, both the initial mental capacity and his/her progress with the use of the system are considered. Advancement is recorded in the user model so that the system can adapt to the child's progress.

Whereas many children are proficient in their interactions with computers, tablets and smart phones and some others have even adapted to electronic game interfaces, this condition is not easily applicable for all children. As ACPHSAASR computer games must be accessible to all children, the system will adapt the young user's mouse interaction style to the psychomotor skills of the child.

These adaptation parameters affect the choice of the content of the next activity/game. The multimedia elements that comprise each game according to the content management adapt to the child's educational level in terms of concepts and content, enabling the most appropriate multimedia element to be loaded from the ACPHSAASR subject assessment content database. As these games are interactive, the mouse interaction style will be accommodated to the psychomotor skills of the child. In the ACPHSAASR, the mouse interaction style is linked to the educational level, which means that specific psycho-motor skills are assumed for all children in each level. In future developments, ACPHSAASR will evaluate the learning activities of each child and his/her psychomotor skills independently when using the mouse, computer interaction which can be assessed by examining the speed at which children execute the operation, the number of mistakes they make and how comfortable children feel while using the mouse, [46].

5.3 Didactical Domain and Adaptation Mechanism

The didactic domain consists of five units and comprises points of interest for pre-schoolers: Mouse Training, Arithmetic Readiness, Cognitive Development, Language Development, and Phonological Awareness.
Each game unit includes four parts of activities: vocal instructions, presentation, playing and evaluation. The first part is aimed to direct the child how to play the game by listening to information and descriptive hints; the second part is aimed to familiarizing the child by reviewing a demo of the game by interactive means. The third part is the playing time aimed by means of interactive game. The fourth part is saving the evaluation of the acquired knowledge into the didactic unit according to the child's results. So, before accessing the evaluation part, input and interaction parts should have been successfully achieved. Each part includes one activity scene which compose the educational game that child must complete. The educational level and the acquired knowledge determine the following task to be faced.

When the Assessment Content Management selects an educational activity, the intelligent tutor looks up the corresponding user model to determine how to mount the activity and with which multimedia elements. With this information the intelligent tutor builds a configuration file. This file is sent to the child host and the browser loads the adaptable HTML5 Canvas game template and the multimedia elements, then, dynamically builds the most suitable activity for this particular child (Figure 4).
The configuration file is a JSON document that stores the specific values for each adaptation parameter. By means of this file, content (educational objectives), language, difficulty, and mouse interaction style (double click, drag & drop, one click, etc.) will be decided.

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

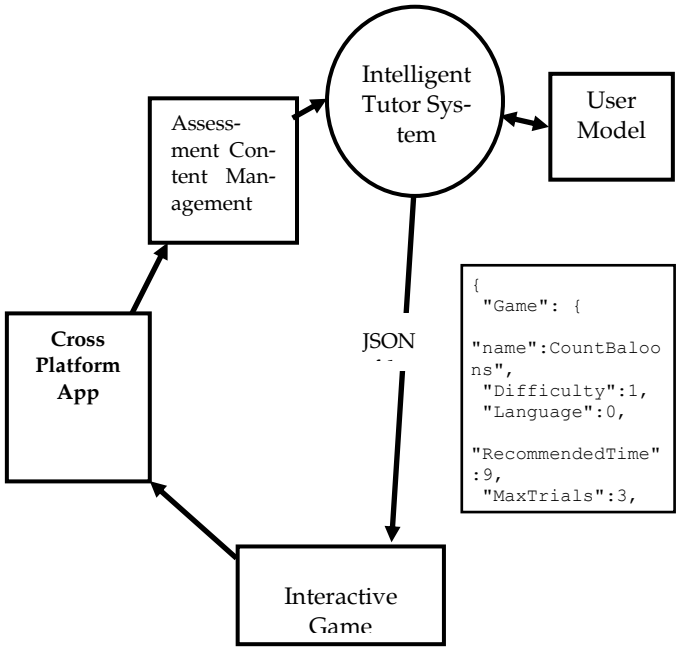

Figure 2- Game adaptation mechanism

When the child finishes up an activity, the information is registered and evaluated by the system. This assessment updates the user model, enabling the child to complete educational activities which adapt to the newly acquired knowledge.

6 Conclusions

Most of the adaptive systems integrate some textual information in their user interface because they are addressed to users who are expected to have some reading/writing skills. However, in this case, the users are children (3 to 6 years old) who do not have reading/writing skills. In other words, at this early age, children have not yet acquired reading and/or writing skills, so the multimedia content plays a leading role, and adapting it to the user's characteristics is pedagogically beneficial.

This chapter has described a three-tier adaptation mechanism to personalize educational web-based games according to several special characteristics of preschool children. These games compose the user interface of ACPHSAASR, a Cross-Platform adaptive hypermedia system designed for assessing pre-school children. This mechanism is based on a JSON configuration file. The schema of this file is easily extensible to other adaptation parameters.

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

7 REFERENCES

[1] Adams, K. (2006) *The Sources of Innovation and Creativity*, National Center on Education and the Economy.

[2] Agudo, J.E., Sánchez, H. & Sosa, E. (2005). Adaptive hypermedia systems for English learning at Preschool. *Recent research developments in learning technologies.* , pp.300-304

[3] Aguilar G., Gomez A., & Kaijiri K. (2001). Question model for intelligent questioning systems in engineering education. *Recent research Proceedings of the Frontiers in Education Conference, 2001. – Washington: IEEE Computer Society.* pp.7-12

[4] Aguilar G., Gomez A., & Kaijiri K. (2007). Learners and Knowledge: A New Personalization Factors Perspective for Adaptive Computer-based Assessment Systems. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications. Chesapeake, VA: AACE.* (), pp.2143-2148

[5] Aguilar G., & Kaijiri K. (2007). Design Overview of an Adaptive Computer-based Assessment System, *Interactive Educational Multimedia*, vol. 14, pp.116-130.

[6] Alfonseca, E., Carro R. M., Freire M., Ortigosa A., Perez D., & Rodriguez P. (2005). Authoring of Adaptive Computer Assisted Assessment of Free-text Answers. *Educational Technology & Society*. vol. 8, pp.53-65.

[7] Anghel, C., & Salomie I. (2003). JADE Based solutions for knowledge assessment in eLearning Environments [Electronic resource] , TILAB & University of Limerick. – http://jade.tilab.com/papers/EXP/Anghel.pdf – 03.10.2008.

[8] Beentjes, J. W. J., Koolstra, C. M., Marseille, N. & Van der Voort, T. H. (2001) Children's Use of Different Media: For How Long and Why? In: Livingstone, S. & Bovill, M. (Eds.), Children and Their Changing Media Environment (pp. 85-111). A European Comparative Study. Mahwah, NJ & London: Lawrence Erlbaum Associates.

[9] Berk, L. E. (2006) *Child Development*, Boston: Allyn & Bacon.

[10] Brusilovsky, P., & Peylo, C. (2003). Adaptive and Intelligent Web-based Educational Systems // *International Journal of Artificial Intelligence in Education*. – Vol. 13, pp. 156-169.

[11] Brusilovsky, P. (1998). *Methods and techniques of adaptive hypermedia*. In: P.

[12] Brusilovsky, P. (2001). Adaptive hypermedia. *User Modeling and User Adapted Interaction,* Vol. 11, No. 1/2, pp. 87-110, Ten Year Anniversary Issue (Alfred Kobsa, ed.).

[13] Bull J. (2003). *Introduction to computer-assisted assessment*. [ONLINE] Available at: http://asp2.wlv.ac.uk/celt/download.asp?fileid=44&detailsid=200008. [Last Accessed 05.05.2006].

[14] Computer adaptive assessment [Electronic resource] / Castle Rock Research Corp., (2005). – http://www.castlerockresearch.com/caa/Default.aspx – 01.10.2008.

[15] Computer aided assessment-the pros and cons [Electronic resource] (2000). / The Learning Technology Development Unit, Learning and Information Services,– http://www.herts.ac.uk/ltdu/learning/caa_procon.htm – 10.12.2007.

[16] Computer Assisted Assessment: The future, right here, right now [Electronic resource] / SQA, 2004. http://www.sqa.org.uklfiles_ccc/Computer_Assisted_Assessment_article.pdf 03.10.2008

[17] Computer-assisted assessment. (2004). Using computers to design and deliver objective tests [Electronic resource] – http://etudeedl.free.fr/annexes/assess.pdf – 03.10.2008.

[18] Designing Test Questions [Electronic resource] (1998). The University of Tennessee at Chattanooga. – http://www.utc.edu/Administration/WalkerTeachingResourceCenter/FacultyDevelopment/

[19] Desmarais, M., & Baker, R. (2012). A review of recent advances in learner and skill modeling in intelligent learning environments. *User Modeling and User-Adapted Interaction*, Vo. 22, No. 1-2, pp. 9-38.

[20] General CAA topics [Electronic resource] (2002). /Web-based assessment (CAA) Centre – http://www. caacentre.ac.uk – 01.10.2008.

[21] Georgouli, K. (2008). Adapting Assessment Goals to the Child's Profile [Electronic resource] / T.E.I. of Athens. – http://www.emis.de/journals/AUA/acta7/Georgouli.pdf – 03.10.2008.

[22] Gouli, E., Gogoulou, A., Papanikolaou, K., & Grigoriadou, M. (2004). COMPASS: an adaptive web-based concept map assessment tool / Proceedings of the First International Conference on Concept Mapping – Pamplona, 2004.

[23] Gütl, C., Dreher, H., & Williams, R. (2005). E-TESTER: a Computer-based Tool for Auto-generated Question and Answer Assessment // Proceedings of ELEARN 2005. – Vancouver, 2005. – P.2929-2936.

[24] Habgood, M. P. J., Ainsworth, S. E., & Benford, S. (2005) 'Endogenous fantasy and learning in digital games', *Simulation and Gaming*, Vol. 36, No. 4, pp. 483-498.

[25] Hartley, D., & Mitrovic, A. (2002). Supporting learning by opening the child model // Proceeding of the 6th International Conference on *Intelligent Tutoring Systems ITS* 2002. – Biarritz, pp. 453-462.

[26] Hoppe, H. U. (2006). Technology Facilitated Integration of Learning Processes in Classrooms and Virtual Communities. In: Redondo, M.A., Bravo, C. & Ortega, M. (Eds.), Diseño de la Interacción Persona Ordenador: Tendencias y Desafíos (pp. 5-8). Puertollano – Ciudad Real.

[27] Jerónimo, C. & Gabriel & Sturm, C. (2006). Edumóvil: Una Alternativa para la Educación Primaria en Méxi-

International Journal of Scientific & Engineering Research, Volume 9, Issue 1, January-2018
ISSN 2229-5518

co. In: Redondo, M.A., Bravo, C. & Ortega, M. (Eds.), Diseño de la Interacción Persona Ordenador: Tendencias y Desafíos (pp. 537-546). Puertollano – Ciudad Real.

[28] Kapoor, A., & Picard, R.W. (2005). Multimodal affect recognition in learning environments // Proceedings of the 13th *Annual ACM International Conference on Multimedia.* – Singapore. – pp. 677-682.

[29] Kinshuk, C. (2008). Application of Adaptivity in Quiz Systems [Electronic resource] / http://www.col.org/pcf3/Papers/PDFs/Cheng_Kinshuk.pdf – 01.10.2008.

[30] Kolucki, B., & Lemish, D. (2011) *Communicating with Children, Principles and Practices to Nurture, Inspire, Excite, Educate and Heal*, New York: UNICEF.

[31] Lambert, G. (2004). What is computer aided assessment and how can I use it in my teaching? [Electronic resource] / Canterbury Christ Church university college, – http://www.canterbury.ac.uk/support/staff-development/brochure/computer-aided-assessment.asp – 01.10.2008.

[32] Lazarinis, F. & Retalis, S. (2007). Analyze Me: Open Learner Model in an Adaptive Web Testing System //*International Journal of Artificial Intelligence in Education*. Vol.17, pp.255-271.

[33] Lukashenko, R., & Anohina, A. (2003). Architecture and Application of Knowledge Assessment Systems: An Overview. Proceedings of the *29th Annual Conference of the International. Association for Educational Assessment*. – Midland, Vol. 15, p. 13.

[34] Lukashenko, R., Vilkelis M., & Anohina, A. (2008). Deciding on the Architecture of the Concept Map Based Knowledge Assessment System // Proceedings of the *International Conference on Computer Systems and Technologies* (CompSysTech'08). – Gabrovo. – P.V.3-1-V.3-6.

[35] Marinagi, C. C., Kaburlasos, V. G., & Tsoukalas, V. T. (2007). An architecture for an adaptive assessment tool //Proceeding of the *37th ASEE/IEEE Frontiers in Education Conference*. – Milwaukee, – P.T3D-11-T3D-16.

[36] Module III: Objective and Subjective Tests and Construction of Test Items, Advantages/Disadvantages [Electronic resource] / University of Minnesota, 2008. – http://www.nursing.umn.edu/preceptors/evaluation-in-nursing-education/ModuleIIIObjectiveandSubjectiveTestsandConstructionofTestItems/index.htm – 01.10.2008.

[37] Mogey, N., & Watt, H. (1996). The use of computers in the assessment of child learning [Electronic resource] / Learning Technology Dissemination Initiative, http://www.icbl.hw.ac.uk/ltdi/implementing-it/cont.htm – 01.10.2008.

[38] Nkambou, R. (2006). Towards affective intelligent tutoring system // Proceedings of the Workshop on Motivational and Affective Issues on ITS at the *8th International Conference on Intelligent Tutoring Systems*. – Taiwan, pp.5-12.

[39] Oxman, S., & Wong, W. (2014). *White paper: Adaptive Learning Systems*. A white paper from DVX/ DeVry Education Group and Integrated Education Solutions

[40] Perez-Marin, D., (2007). *Adaptive Computer Assisted Assessment of free-text children' answers: an approach to automatically generate children' conceptual models*, PhD thesis [Electronic resource] / Universidad Autonoma de Madrid, http://orestes.ii.uam.es/dperez/tesisDianaPerezMarin.pdf – 01.10.2008.

[41] Seale, J. (2002). Using CAA to support child learning, Learning Technology and Support Network, Available at: http://www.alt.ac.uk/docs/eln004.pdf – 01.10.2008 [Electronic resource].

[42] Thévenin, D., & Coutaz, J. (1999). Adaptation and plasticity of user interfaces // Proceedings of the *Workshop on Adaptive Design of Interactive Multimedia* Presentations for Mobile Users. – Barcelona.

[43] Wen, D., Graf, S., Lan, C. H., Anderson, T., Kinshuk, C., & Dickson, K. (2007). //Adaptive Assessment in Web-Based Learning / Proceedings of the IEEE *International Conference Multimedia and Expo* 2007. –Beijing, 2007. – P.1846-1849.

[44] What is Computer Assisted Assessment? (1999). [Electronic resource] / University of Leicester. – http://www2.le.ac.uk/Members/rjm1/talent/book/c3p2.html – 01.10.2008.

[45] Bloom, B. S.; Engelhart, M. D.; Furst, E. J.; Hill, W. H.; Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York: David McKay Company.

[46] Donker, A.; Reitsma, P. (2007). Young children's ability to use a computer mouse. *Journal of Computers & Education*. Vol. 48 Issue 4, May, 2007. pp. 602-617. Elsevier Science Ltd. Oxford, UK, UK