The model of a competence based e-learning platform for primary and middle school students

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Abstract

E-learning systems tend to be more and more present in the life of students. Classic teaching based on the "magister dixit" paradigm tends nowadays to become obsolete. The student must not be forced to memorize information and then to be evaluated by the reproduction of that information in written and oral exams. The student must explore freely the tree of competences and try to develop those using different approaches. In this paper we will present the model of a competence development platform dedicated to primary and middle school students which acquired poor results. The competences are compiled from the national regulations and they are divided hierarchically into domains, general competences, specific competences, variables. On this hierarchy we designed a hierarchy of learning objects that we call actions organized in lists of activities, activities, lists of actions and actions. The learning object model, alias the action, has several parameters modelling abstraction levels like: concrete, representation, abstraction and relational. Regarding the difficulty we set three levels: beginner, intermediate and advanced. Regarding the content of these actions we include the classical exercises like: single choice, multiple choices, short answers, long answers and also more complex learning objects types like dialog games and board games. All these actions are linked to variables in order to be able to implement an adaptive behaviour of the assessment process for the student. The competence development platform suggests the student its learning path if the student is not able to pass some check points. This feature is implemented considering some evaluation metrics and thresholds complemented with the competence taxonomy. The assessment results are stored into a learning record storage which has embedded a rewarding system providing motivational virtual artefacts to the students. The competence development platform is implemented using .NET technologies on SQL based databases. The platform was piloted for three counties in Romania: Alba, Bihor and Olt and now is available for any Romanian language speaking student from around the world. As perspective we intend to apply the competence model to other curricula, to rate the tutor content and to apply data mining techniques to ameliorate the whole model.

Keywords: e-learning systems, adaptive behaviour, generative learning objects, learning management systems, competence management system, cultural stages, fundamental needs.

1 Introduction

In this paper we will present the formal model of a competence based e-learning platform for primary and middle school students. The e-learning platform graphical design is inspired after a story entitled "The Little Prince" written by Antoine de Saint-Exupery [17].

The simplest way to create online lessons for students is to install a LMS and to create lessons which will transmit the specific knowledge. The major problems which could determine a different approach arise when we need something more, like competence development [21,22]. In spite of the fact that that this problem was already signalled for a few decades and competence development became the goal of education we have no change in the educational major approach, respectively in the online set of instruments which tutors can use in this sense. Centring the learning system on the fundamental needs creates a solid foundation of transcultural education which overcomes cultural relativity. Culture and values are relative means which refer ultimately the satisfaction of needs.

In the development of the platform located at www.miculprint.eu we followed an approach on cultural level V [13]. In order to increase the autonomy we created visual images of the competence development levels starting from the competence domains to the variables which must be controlled for each competence. Thus, the

student becomes conscious of his possibilities and limits and he can manage better his own development. In order to satisfy the need of interconnection we presented for each competence concrete needs where he can contribute and we created interactive games inspired from daily activities.

The paper is structured as follows. In section 2 we present the rationale behind our approach. In section 3 we present the competence system taxonomy and the learning actions model. In section 4 we describe a special learning object action model namely the generative learning objects model. In section 5 we present the prototype implementation details. In section 6 we present a case study on the current implementation. Section 7 concludes and sets the future work.

2 The competence and the cultural levels

The main reason why the education changes are not happening (at least in Romania) is because the competence concept is not well understood. Any understanding of any concept is determined by the cultural level on which we study it. The result is that it is understood in a certain manner and the things and activities are implemented as such to lead to a development in that certain cultural level.

David Logan et al. identified five cultural levels [13] on a scale of evolution from: "life sucks" one level I to "life is great" on level V. On level two the individual realises that his life sucks, on level III he puts together his strength, he manages and he is convinced that "he is great". Passing from level III of individualism to level IV of partnership is considered by authors a real epiphany. The reason is simple enough because the individual must have the "revelation" of the fact that he is the result of his interaction with his mankind and that each of us exist and there is a need for interconnection which cannot be fulfilled in an individualistic approach. Thus, the individuals on level IV states that "we are great" because they see the power of the team. Less of them that pass beyond the group culture and beyond the joy of being together arriving on level V, they state that "life is great". These individuals know how to enrich the results of any group, for example they will consider religion but also science and philosophy, they reached a very high personal integration level this is why they resist the temptation of imposing other things to someone else together with the colleagues from their group. On this level the most important thing, even more than any ideology, is the human person, the culture serves for the individuals and not individuals serve the culture. Thus, we can deduce pretty easily what competence might mean on each level. Even the people on every level try to convince the others that they are right, but the self-sustainable learning approach appears only on level III: if I am great in the domain I activate then I can help you be great. From level IV education becomes a group need. Its culture must be transmitted to those who aspire to become members and to the entire society given the group importance for her. On this level competence is understood as a high specialization in a domain, the competent people are seen differently by the people in the domain which look and analyse. Because the main expressing vector is ideology, reality and theory visions transmission is the main goal of education. Through this, competence is developed and this is somehow true because vision involves also attitude. On level V competence does not mean that individuals should have a vision and a certain approach printed in his way of being, but group quality participation based on autonomy. This assumes the capability of critical comparison related to the culture of their group. It is one thing to be a member of a herd and to act together with it using brute force or ideological pressure and it is a different thing to develop the soft power of the group helping it to become better. On level IV we have indoctrination and servitude of the individual in the favour of the group he is obliged to, while on level V the student is made aware and helped to develop his competence in different domains.

3 The competence taxonomy and the action learning model

In order to develop competences we organized them into a hierarchy so that learning objects can be better organized and to able to behave according to adaptive behaviour we would like to implement. The first level is the domain level where the disciplines are set. In the current project implementation we created only the Mathematics and Romanian language domains but we can add very easily domains like Physics, Informatics, Foreign languages and others as we created support for the extension. The next level consists in general competences where the main topics of the domain are expresses. Next, specific competences were designed in order to detail the previous higher level. Finally, on the lowest level, the competence variables were designed in order to refer to very detailed aspects of competences which are important in the assessment process and in the competence development path. The graphical representation of the competence tree uses a metaphor of a universe inspired from "The Little Prince" story decorated with planets, satellites, continents, lands and regions. This tree of competences will act as metadata level for the concrete content the student will interact with.

The action learning model is based on several parameters like: i) type (single choice, multiple choice, short answer, dialog game, board game, etc); ii) abstraction levels (concrete, representation, abstract, relational); iii) difficulty levels (beginner, intermediate, advanced); iv) characteristic (visual, kinaesthetic, sequential, sensitive) v) mark weight factor. Actions are structured in action lists of several types: learning, training,

evaluation for a given variable. Action lists are structured in activities related to specific competences and activities are structured into lists of activities related to general competences.

4 Generating learning object based actions

The generative learning object (GLO) model is considered the second generation learning object (LO) [3,6,7,8,10]. The object model consists in a best practice pedagogical template or pattern which is instantiated with data in order to create a concrete learning object ready to be used in a learning management system. In our project implementation we used this concept for designing two player games like the dialog and the board game on one hand and to generate algebra and geometry evaluation tests on the other hand. Our GLO model benefits from custom formalisms based generation code for the initialization sequence.

The dialog game [4,5] is structured on 5 tables. The first table is designed for the game play roles. The player roles are set usually in pair, like: seller and buyer, boss and employee, father and son. Choosing certain roles will create a specific real life scenario for the dialog game where competences can be developed.

The second table is designed for symbols namely JavaScript variables in the current implementation. The symbols will be used for reading and writing during the dialog. Symbols have two roles: i) to make the dialog generative, meaning that at each run we will have a small variation of the imagined scenario; ii) to assess the correctness of the student answers and statements involved in the dialog. The first goal is achieved by symbol initialization with controlled random values. The second goal is achieved by verification conditions which are to be presented next.

The third table is designed for verification conditions which are mathematical expressions used to evaluate objectively by the computer the correctness of the answers. Student answers are captured in symbols and their values are part of the evaluation model which has to be designed by the dialog author. In the current implementation the assessment model allows any computation achievable by JavaScript expressions. The dialog author must design such a model based, for example, on Boolean expressions formed out of additive, multiplicative, relational operators. We consider that the capability of expressing evaluation models using JavaScript is quite large and the complexity is at a moderate level. More expressive facilities could be imagined in a domain specific language but this increases complexity reducing the access to author dialogs.

The fourth table is created for player messages. These messages will inform the player about its progress obtained at the end of the current learning object.

The fifth table holds the dialog sentences. The model of a dialog sentence is composed out of images, text literals, input and output fields. Thus, we can create the interaction between the two players and content diversity. The images are usually designed to reflect the actions of the real life scenario where the student has to interact. The sentences are organized logically as a graph and a runtime exercise is a path through that graph. All tables are expressed as XML lists in the current project implementation.

Board games are simulating real life board games based on a board with spaces to step, two dices and two pawns. On each regular space the student may achieve competencies. The part where students have to check their competences is enabled by spaces containing surprises and questions. The model of the board game consists in: i) the specification of the behaviour and position of each space; ii) an image file where the board is pictured; iii) the list of questions; iv) the list of surprises containing preprogramed events like: jumping to the start, jumping a few spaces backward or forward, rolling the dices again, ending the game.

The free game is an empty or free framework containing only the communication facilities between the game and the e-learning platform. The e-learning platform gives to the framework data about the identity of the student, while the framework has to report the competence progress development on each variable. In the current implementation we used this facility to implement supplementary interaction when the predefined learning objects were not enough. For example we implemented some geometry competence development objects where students can play with the half or full circle protractors in order to measure specific angles.

5 Prototype implementation

The prototype is implemented with Microsoft .NET technologies, is written in C# object-oriented programming language and is based on class hierarchies. The prototype runs as a web application formed out of ASPX web pages designed in the MS Visual Studio editor and deployed on the Internet Information Service (IIS) server connected to the Microsoft SQL database server.

The object persistence is implemented through SQL calls which enable stored procedures to run on the database server for best performance. The model of the application is designed using the relational database paradigm with indexed tables having primary and foreign keys. In the areas where variability is high the design was switched to hierarchical XML structures to be stored in heterogeneous content tables to be later instantiated in specialized subclasses.

The prototype includes a chatting feature developed as a service for plugin applications and is implemented using a server polling approach. Also, there is a partner selection service based on student invitations for plugins which implement two player games.

The platform has a plugin feature where third party learning model providers can upload their learning object engines and then facilitators can create and store their own learning objects. The plugins are expected to be written in JavaScript and HTML. Currently the available plugins are: Free plugin, Dialog plugin and Board Game plugin. The Free plugin allows to upload any JavaScript learning or gaming object which respects a minimal set of rules like: having a predefined starting function and calling at the end an ending function to report the assessed learning results in the database. The Dialog plugin allows playing dialog games using the chatting service offered by the platform. The Board Game plugin enables small animation and facilitates the peer game play with the dice and the board.

The current implementation is set on 3 IBM servers one in each county. The content data is the same on each server while student information is local. The administration model is set on four levels. One user may have simultaneously several roles. The user level allows accounts creation, configuration of specific student data by the students themselves. The account creation is based on e-mail validation. Even with no registration the content can be accessed but the history is not recorded. The class level allows creating, updating, deleting, grouping students in small workgroups and in virtual classes. The teacher role has the administration rights for this level. The school level facilitates administration of schools and teachers assigned to them. The school administrator role has the administration rights for this level. The county level is responsible for the administration of schools and school administrators. The country level is responsible for the administration of counties and county administrators.

6 Case study

The project results are reported comparing to the proposed evaluation indicators. A first image of the comparison shows that the project has reached its goal, some of them were even exceeded.

ID	Indicator	Proposed	Accomplished
201	Number of helped school units	30	58
202	The number of trained tutors	180	180
206	Number of participants to the instructing lectures	900	1096
4	Number of lessons created	500	>500
5	Number of adaptive 50 questions tests	400	>400
6	Percentage of students whose key competences were developed	100	100
7	Percentage of students whose performance was improved by participating to the recuperation activity	70%	83.15% Romanian 77.37% Mathematics

As case study we implemented the project in three Romanian counties: Alba, Bihor and Olt. Overall, we have created >47000 learning objects. For the Romanian language domain we developed >24000 learning objects distributed over 12 general competences, 72 specific competences and 284 variables. For the Mathematics domain we developed >23000 learning objects spread over 21 general competences, 125 specific competences and 466 variables.

In the competence development programme we had 1096 students fulfilling it out of the 1213 who were initially enrolled. Two students stayed less than two months and their results were not counted. Because of several objective reasons 50 students left the programme but they were immediately replaced. The programme duration was 6 months. The students were in a range from the third grade to the eighth grade. They spent 3 day per week and 3 hours per day in the programme. Each day of the programme they got lunch with 10 different menus. Some of them continued the competence development at home accessing online the Little Prince platform. During their competence development process the students created 8 million answers where the answers to the Romanian language domain were greater with a few tens of thousands than those given at Mathematics. We have to mention that in some games we record only the final answers and some actions are meant only for training with no answers recorded.

Ignoring the student presence and taking into account the work time of 2.5 hours/day at 3 days/week we get a medium of 34.5 answers / hour. Thus the student answered a larger number of questions than in any frontal teaching. Practically, in average, a student in a class where frontal teaching is performed cannot answer more than 1.4 questions / hour, counting that the teacher can ask 30-40 questions in one hour. The student implication can be increased by a factor of 25, like he or she would have a personal teacher. At such an implication the students progressed even those who were less involved or committed. The competence improvement percentages are: 83.15% for Romanian language domain and 77.15% for the Mathematics domain. The average grade performance progress is 1.39 points for Romanian language and 1.29 points for Mathematics.

Performance growth	Romanian language		Mathematics	
	Students	Percentage	Students	Percentage
<1p	7	0.70	5	0.53
1p	652	64.94	695	73.16
2p	317	31.57	212	22.32
3p	16	1.59	15	1.58
4p	14	1.39	10	1.05
5p	1	0.10	0	0.00
Total	1007	83.15	937	77.37

The content development team included >20 teachers. The platform development team included 8 programmers, 1 graphical designer and 1 system administrator.

7 Related work

In this section we present several related works in the field of learning objects (LO). Aspects like LO creation and pedagogical reuse are presented in the works of [1,2,9,23] . Adaptability and sequencing LO issues are discussed in [12,14,16,18]. In our approach we consider linking LOs based on the design of a competence tree. LOs are subject of conversion for online delivery in the context of MOOCs [11,20]. We keep the same classroom procedures thus supporting the concept of blended learning. In [19] is presented teaching of computer science using generative learning objects (GLO) and robots. In our model we included generative features especially in the dialog games and in the process of producing assessment tests. In [15] LO qualitative aspects are presented from the point of view of knowledge management.

8 Conclusions and perspectives

In conclusion we can state that we created a new e-learning platform model and we added a new educational tool in the Romanian e-learning product list for primary and middle school students. The designed e-learning system can be adapted to any potential need: competence development, on any level, even for corporations when needed. The approach starting with the question why is more attractive to students because helps in the identification of the need. They kept their motivation for the content for a very long work period. Many students, especially those who accessed the website from home, got significant mark improvements.

The website is very friendly and more different than the classical approach due to several facts: i) the respect for student autonomy; ii) the good integration of the proposed learning experiences in the competence domain and in the human base approach; iii) the suggestive and adaptable interface. The effective competence centring viewed as a need from the highest cultural level increased student interest, made the education process more natural than in the knowledge transfer based approach. They realized the connections between competences, they could see and even feel their participation need by interacting with the others, things that facilitated learning development.

The approach is fully a socio-constructivist one, learning is started from inside, with the help of our neighbours who propose learning experiences that enable for students to used tools and to ameliorate their attitude for a quality participation.

As perspectives we intend to: i) extends the model to other curricula; ii) identify and adjust and the content with issues; iii) enable content rating; iv) apply data mining techniques on student learning records in order to improve the content.

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