An Agent Technology based Digital Marketplace for Education

Master Thesis

on definition, improvement and architecture of a digital marketplace for education model, focusing on the learner’s interaction

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Abstract

This study is aiming to provide for a review and analysis of a Digital Marketplace for Education. Additionally, its purpose is to illuminate the dark spots of the model and to bridge the gaps that exist in certain operations of the system. The delineated model of this document arises from the correlation of information that exists in different studies which complement each other. The resulting system, as a whole, is presented through the various intelligent agents and their operations. In addition, a lot of attention is paid to the sequence of these operations, the regulations that will exist and the interaction between the student and the system. The desired performance of such a system is based on the exploitation of the existing techniques and technologies as well as, on the identification of the areas that require improvement and further research. For that reason, the outcome of this document is an assessment of the suggested model and an accentuation of the parts that need to be revised in order to contribute to the optimization of the model’s efficiency.
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1. Introduction

If we had to identify one field on which every human society has based its evolution, that field would be education. Although the amount of resources spent by every society or country is not the same, there is a wide acknowledgement that high quality education is the key to overcome fundamental societal issues. Among the countless utilities and values conveyed through education we can identify the fact that usually, educated people can stand out in the crowd and get the chance to be given more opportunities compared to others. In other words education is used in societies as a mechanism to filter people and undoubtedly has a big impact on the economic growth of the person (Phillips, D.C. & Siegel, Harvey, 2015). Not only has the individual attracted respect and recognition, but also he or she has been provided with the means to recognize and pursue his or her goals in an easier and more accurate way. However, the question that arises to everyone’s mind is the following. Does everyone get the opportunity to receive high quality education? Not many years ago the answer to this question would be very easy. No. The development of the digital sector has given the chance for information to be widely spread and education has given the chance for the digital sector to develop.

Of course, it would be naïve for someone to believe that the problem is solved. Information is not education the same way as data is not information as Clifford Stoll said. Undoubtedly, the digital age has given a new perspective to information and education. However, new issues have appeared. Big data is one of the major contemporary issues that have been bothering experts a lot. In relation to education and its digital form, there are two ways that big data, as a concern, appears. First of all we have all this knowledge that can be found online in huge quantity and so many different forms. How is it possible to exploit all this unstructured amount of information if you don’t first filter it and organize it in a logical sequence according to your needs? Talking about needs, we can use this opportunity to refer to the second issue that relates big data with digital education, the personalization of education. By personalization of education we refer to the adjustment of the educational process or the course according to the exact needs and profile of the student. How hard would that be if we tried to correlate the individual’s digital profile with student modeling techniques? By digital profile we mean the individual’s information that already exists online in relation with specific information that can be asked according to the nature of the educational process.

Our motive while addressing this issue is to try to unhook the culture and nature of education from its supply centered mentality. All these years, knowledge seekers were able to choose among a limited variety of courses and training. The provided programs were built according to the trends and the needs of the society. However,
it would be very interesting to try to approach the needs of the individual. This groundbreaking approach will be put under investigation at the assignment that follows. The general idea on which the following model will be based belongs to the authors of the article “A Digital Marketplace for Education”, Beverly Park Woolf, Victor Lesser, Chris Eliot, Zachary Eyler-Walker and Mark Klein. The issues that will be cited are the analysis of a very condensed idea and the effort to simplify it, the focusing and enrichment of specific parts of it, as well as the research and description of new mechanisms and ideas to be integrated so that we can reach even closer to its optimization.

2. State of the Art (the initial model)

2.1. A Digital Marketplace for Education

In this chapter will be described the state of the art of the research related to this thesis. The incentive for this work is to analyse and improve a concisely described model. The publication where the model is presented is called “A Digital Marketplace for Education”. This article was published in August 2000 in the frame of the International Conference on Advances in Infrastructure for Electronic Business, Science and Education on the Internet (SSGRR 2000) in L’Aquila of Italy. The authors are Beverly Park Woolf, Victor Lesser, Chris Eliot, Eyler-Walker Zachary and Mark Klein. In this paper, the authors are describing a web-based educational marketplace that can help the knowledge seeker (which can be shown as a student) to meet and interact digitally with the knowledge provider (which can be named as teacher), in order to receive the desired information in the form of a course. The system will be able to match the student’s request to the available and appropriate resources (Beverly Park Woolf et al., 2002) based on information concerning the seeker’s profile, the provider’s characteristics and the complexity of the request.

2.2. Issues Addressed

The issues that are worthy to be addressed and are called in the article are of two kinds, technical and societal.

- Technical issues (Beverly Park Woolf et al., 2002)
a. Resource acquisition and data mining techniques to facilitate access to large-scale educational repositories.
b. Negotiation, contract execution and verification of instructional resources.
c. Digital repository testbeds to evaluate agent behaviour.

- Societal issues (Beverly Park Woolf et al., 2002)
  a. Understanding web-based educational interactions.
  b. Individual learning processes.
  c. Organizational dynamic in the distributed, digital instructional realm.

According to the authors, this educational marketplace described, will be different from other spaces which provide similar services via the internet. This is because it suggests a unique evaluation process for the resources and a special sequence according to which the teaching activity will be received by the student. Additionally, mechanisms will enable negotiating, contracting and monitoring the procedure aiming to the system’s integration.

### 2.3. The Model’s Objective

In order to dive into the details, we need to understand the reasons that forced the scientists into considering and designing the model. At this point we will go through the problem that represents the stimulus and the suggested solution to that problem in brief.

#### 2.3.1. The Problem

The trigger that led the authors to start searching for a solution was mainly the people’s inability to maximize the value of the knowledge that exists on the internet. The amount of this knowledge is huge and it appears in the form of images, video, sound, text or combination of these. This problem can be also identified in the field of digital education, since more and more universities or colleges offer digital courses as well as degree programs by distance (Boettcher, 2000).

The resources offered for pedagogical purposes vary in context, material and interactivity type. Some examples of different kinds of available materials are intelligent tutors, simulations, hypermedia, or papers (Woolf & Hall, 1995; Beck et al, 2000; Brusilovsky, 2000). Anyone that appears as a knowledge seeker or as a student searching for a course will come across difficulties caused by the available quantity
of unfiltered answers. The diversity in the quality of the provided services, the cost, the prerequisites in order for the course to be valid, the approach or the availability of the resources are some of the reasons that cause the seeker’s inconvenience and inability to locate, appraise and manipulate the resources according to his or her special needs.

Another issue is the current monopolistic way in which the universities and the colleges operate in the market. This problem leads to the adoption of a faculty centred teaching method that follows strictly the pedagogical strategy of the institute, without giving due attention to the seeker’s unique needs and profile. The resources and the courses are fixed by space, context and time and they refer to a specific audience. The whole operation of the market is based on the producer’s push and the instructor’s offering and not in the customer’s pull or the student’s demand. From another point of view, many faculties are not used to distribute their knowledge to mass audiences and search for external publishers to take over marketing and distribution. Another driver for this innovative idea was the problem of the distance between the knowledge provider and the seeker. Of course, almost everyone nowadays has access to some tutors, but globally recognized experts are not available to provide their services to anyone that is interested (Beverly Park Woolf et al., 2002).

Last but not least, it is worthy to be mentioned that this field can be considered very fertile to invest at. Since we are talking about education and knowledge, we have to consider the large size of the market, the huge space for innovation and further development and the importance of it for every country and human being (Dunderstradt, 1997).

### 2.3.2. Delineation of the Suggested Solution

Keeping in mind the abovementioned and the problems that arise, we can proceed with the delineation of the suggested solution. Miss Beverly Park Woolf and the other analysts and producers of the article remark that mechanisms should be developed and implemented in order for this vast number of resources to be managed and for the interaction between the producers and the seekers to be optimized.

The general idea of the model lays in the need to tailor the materials that constitute the online knowledge and assemble them into customized end products. This process will be based on information regarding the student’s query but also his or her background and knowledge. Agents will be responsible for modelling the seeker’s knowledge and by machine learning techniques used by the educational network, the resources will be transformed into final products. The different profile,
experiences, needs or capabilities of the potential seekers require tools and techniques that prevent any overlaps and ensure that the teaching process is accurate and valid. Therefore, to make sure that this is happening, the student should have access to classes of objects, which will be allocated to different repositories and will be personalized by mediating software that will compensate the variations between different locations (Beverly Park Woolf et al., 2002).

The Digital MarketPlace for Education as described by the producers is a model that will be different in many aspects from the various, already existing, internet marketplaces. The student will be provided with a considerable number of learning options and the teaching process will have specific characteristics. Independent scoring of instructional materials will be required, so that effectiveness is checked and the student’s progress is monitored. Certification for tutors and materials will be included, so that reputation is built step by step. Also, certification will be provided to the student according to his or her progress. Additionally, the certification will be particularly checked and verified. The phase of the contract fulfilment will be a very important part of the process and will underline the engagement between the knowledge provider and the knowledge petitioner, ensuring that they both agree to proceed to the financial transaction according to which tutoring services will be exchanged with money.

The described model will also encourage competition in tutoring. The rising educational needs and the adjustment of the cost will be influenced from the evaluation process, the height of the demand, but also from the competition among the different providers who will constitute the volume of the offer and claim their fee. Likewise, the Educational MarketPlace is aiming to convert the current monopoly in education to an open environment where the student is free by options, time and space. Additionally it will become a place for the universities that may be looking to outsource the disposal of digital courses or educational material.

Conclusively, the goal of the paper’s described model is to broaden the available choices for the knowledge seeker, to automate core processes and to establish an online teaching system that will be one of the most popular and effective sources for education (Beverly Park Woolf et al., 2002).
In this chapter we will describe in detail the model that will form the basis of the thesis. This model can be considered as an integration of the material found in the articles “A Digital Marketplace for Education” and “Knowledge Extraction for Educational Planning”. The actors of the system are going to be addressed one by one, focusing on the operations that each one represents and the technologies that support them. This analysis will help us understand the requirements of the model that play a significant role for the people that will undertake its implementation. Additionally, the requirement analysis will help us reach to the clear description of the phases that the digital marketplace for education will be consisted of. These phases will cover every operation of the system, from the first moment of interaction until the completion of the tutoring phase.

3.1. The Actors of the System

There are three big categories of actors, the knowledge seeker (student), the student agent and the pedagogical agent (knowledge provider). The last two of categories are containing subcategories. Each one of them will be described subsequently. Additionally, the marketplace can also be considered as an actor that includes every category of the above mentioned.

3.1.1. The Knowledge Seeker

One of the main goals of the suggested system is to replace the existing monopoly in education that the colleges and universities enjoy. What is envisioned is a customer centric market that will intend to offer the potential student with a vast array of educational choices. For that reason, the whole system will be built around the knowledge seeker; and therefore this actor has to be very clearly analyzed.

First of all the potential student is the actor that enters the query (topic) which will be the trigger for the rest of the operations. The query can be of many kinds. It can be a simple or generic query, like a demand for an English language course, or a specific and complicated query, like a demand for a special biomechanical engineering course (Beverly Park Woolf et al., 2002). Generally, the topic can be considered as the basic unit of our ontology. If we had to provide for a definition of
the topic, which could fit to our analysis, that would be “something that can be can be taught or learned by a person” (Peter Cassin, Kyle Rawlins, Chris Eliot, Victor Lesser, Beverly Woolf, 2003). At the same time, the actor “student” is characterized from certain attributes that are very interesting for the process. Information of primary interest is considered the age and the professional background as well as the educational background and experiences related to the query. This information can help us deduce the state of the pre-existent knowledge of the person in relation to this particular subject. Moreover, key importance information is the time and money that the knowledge seeker is willing to dedicate into this educational course (of course this decision is not only dependent on the student’s statement). Lastly, it is essential to know if the person is in need of a special treatment due to disabilities or other reasons. This information will help in deciding the type of material that will be used, the terms and conditions of the interaction and the way in which the courses will be provided.

Besides that, the student is also providing crucial information concerning the operations of the system. Continuous feedback is part of the evaluation process of the teaching activity. The whole evaluation process will be dependent mainly to information deriving from the student, like his or her performance and also personal opinion about the teaching techniques and experience. The last action that the knowledge seeker is in charge of taking is the signing of the teaching contract. By signing this contract he or she states that the suggested course and teaching method are approved and can get started according to the arranged schedule. Additionally, it is stated that the suggested cost of the course is accepted and will be paid.

3.1.2. The Student Agent

This actor is one of the most interesting parts of the system. The core of the innovative operations of the model is built in relation to the student agent. However, at this point of the thesis, the basic responsibilities and principles that are related to the student agent will be described. The student agent can be expressed in many ways like student assistant or student representative. The main responsibility of this character is to serve the knowledge seeker.

When a new student is registered in the system, a student agent will be assigned as his or her assistant and will have certain responsibilities beginning at the time of the registration and finishing with the end of the educational process. The first responsibility is the acceptance of the knowledge seeker’s query. As mentioned already, this query may be complicated or simple. The student agent’s task is to analyze it and to understand it in order to be able to proceed with the search of an
instructio

nal plan. After the query’s nature has been analyzed (maybe has been broken into sub topics) and the complexity level is very well identified, it comes the delineation of the student’s profile. As described earlier, information concerning the student’s background is of huge importance in order to achieve high quality performance and efficient tutoring. Therefore, the agent will collect all the relevant information that is needed in order for the framework of the tutoring to be built. This information is explained in the previous paragraph and will be the basis of further interaction by making the content better defined and understood.

After the basis of interaction between the student and the assistant (SA) is built, the student agent (SA) will be ready to forward the query in the marketplace. This action will be done on behalf of the student. The post will be indicating the topic of interest and the level of specialization. Subsequently, responses from potential pedagogical agents, that have noticed the query, will probably appear. These pedagogical agents (PA) will claim that they are able to provide the requested services to the student. The SA will collect the suggested options and will request for bids. During the bidding phase the PAs will cost estimate their services and the SA notice the student in order to decide what is the best option based on the value for money principal. Of course the cost and time limitation preferences have already been made clear by the student in a previous phase.

The next step will be the choice of the most attractive option and the formulation of the exact planning and schedule according to the goals that have been identified and have to be addressed. At that point the student agent’s task will be to take care of the contract fulfilment. Both the student and the educator will state, by filling the contracts that they agree to exchange money for the agreed services. The SA will be the mediator for this agreement and will also make sure that the needed resources will be available, for the actual tutoring process to get started after this phase.

Lastly, the student agent’s responsibility will be to closely monitor the ongoing learning process and ensure that everything is flowing as decided. During the monitoring phase, the SA will have the opportunity to collect valuable information for the whole system’s performance as well as for the tutoring process and the student’s response to it. This operation will include feedback from both the student and the teacher and other forms of extracting of information. Additionally the SA will be responsible to provide immediate help if there is a special need, a change in planning or a problem with the availability of the resources.

As it can be derived from the above, the responsibilities of the student agent are complicated and many. Moreover, it is clear that the success of the model and the effectiveness of the tutoring are very much dependent to its performance and efficiency. For that reason, much of our interest will be put on this actor and the ways that we can optimize its performance. Most of this model’s intellectual
contributions and innovative ideas are also aiming to this goal. Additionally, there are two special types of agents that integrate the SA and will be responsible to undertake parts of the SA’s tasks. These are the searchbot agent and the course assembly agent. These agents may be coupled with the student agent from the beginning, if this is necessary for the needs of the course and according to its complexity. Each one of them will be assigned with certain responsibilities conforming its expertise.

3.1.3. The Searchbot Agent

The searchbot agent’s (SB) expertise will be to assist the SA to find instructors (PAs). For this job it will make use of the information concerning the student’s background. Also, it is assumed that the SB has a very clear view of the query essence, for that reason it will plus draw information from the SA concerning the query refinement. When the potential PAs that satisfy the conditions are clear, the searchbot agent (SB) will request for bids in order to provide the SA with the available options concerning the time and cost (Beverly Park Woolf et al., 2002).

3.1.4. The Course Assembly Agent

After the student is coupled with a student agent (SA), it is very probable that a course assembly agent (CAA) will be needed. The word “probable” is used because in some cases, the query may be very simple and straightforward, so the SA may proceed without a course assembly agent (CAA). However, in the vast majority of the cases, the CAA is considered fundamental. The reason for this is the fact that the CAA is most of the times an agent that specifies in a certain domain, compatible with the corresponding query that has been expressed. This type of agent will be considered as the main responsible for carrying out the goals that have been put by the student through the SA. For that reason, it is understood that the CAA has to be very well informed (programmed) about the clear objectives. Practically this agent is the one responsible to generate the complete educational course. This will be achieved; by making use of information concerning the student and his or her background, the query and the available resources and educational material. The CAA’s delineation and part can be considered as the most challenging, since it has to accomplish serious issues that require a lot of attention.
Mainly, the course assembly agent has to build a coherent educational plan and this is going to be achieved by firstly by interpreting deeply the nature of the query. In other words it will analyze the query and decide the resources that will be used and the sequence that they will follow for an optimized course to be built. Secondly, the CAA will break activity into sub-units, if this is needed and applicable. For this task, the student’s background and experience have to be our guide, in order to avoid overlaps. Thirdly, the CAA will construct the resource planning of the course by putting the activities into a logical order. For this operation, IF-THEN rules are going to be used in order to optimize the sequence, based on the post condition and the prerequisite satisfaction. The philosophy of the “IF-THEN” technology is not as complicated as the previous ones. The idea here is to generate a logical sequence for the resources that were qualified during the previous filtering. The course planning operation can be considered simple if we think that the resources will be accompanied by a detailed description that will reveal their ontology identity and their prerequisites and post conditions which will lead us to generate the sequence. This operation can be imagined according to the following schema (Figure 1).

The fictive resource chain that will be developed will be connecting the student’s prior knowledge, with the desired goal. Additionally the CAA will take care of the availability of the needed resources. Every subunit will need to be coupled with the appropriate resources that are indispensable for the tutoring process to take place. These resources will also have attributes like cost or quality, which the CAA has to consider when suggesting them. When the alternatives have been prepared, the student will interact with the CAA in order to choose the preferred educational plan and resources or, if this is not possible yet, will further configure the demands in order to filter once more the options and produce more of them or structure them differently. When the final plan is agreed, a query will be resent by the CAA to the marketplace. Potential pedagogical agents (PAs) will appear to undertake the task of representing the resources to the student.
At that point the CAA will examine the PA alternatives and will suggest the most convenient or suitable according to their attributes in relation with the student’s demands. Among the suggested alternatives the knowledge seeker (that is considered as a customer) will take the final decision. The negotiation phase will be running in parallel and the CAA will be exchanging offers with the PAs. This is another important (and challenging) task for it. When the most suitable solution is decided, the CAA will take care of the contract fulfilment. The last responsibility of the course assembly agent is to inform the responsible for the financial issues of the marketplace about the completion of the agreement and the type of the payment that will take place (Beverly Park Woolf et al., 2002).

3.1.5. The Pedagogical Agent

The pedagogical agent (PA) will be responsible for representing the instructional resources to the student. This actor of the system will be further analyzed in later chapters. The searchbot agent’s requests for bids will filter the potential PAs in the first hand (by using information of the student’s background and the query). Subsequently the course assembly agent, after breaking the activity into subunits, will send a second request. The marketplace will send the decided goals to selected PAs. The PAs that respond should be related with instructional resources relevant to their expertise. The resources and educational material will show proven capability and effectiveness. This will be certified by the system through endorsements by independent human professionals that will recommend the tutoring process and develop its reputation. Of course, the suggested price by the pedagogical agent and also the end price will be directly affected by the reputation and the ratings.

After the negotiations end, the bids are collected and the price is decided, the CAA formulates the contracts between the PA and the student. The PA will follow certain teaching methods that will be more effective for the particular process. Also it will enter and present the educational resources according to its best effectiveness. By the time that the tutoring process starts, the only agent that interacts with the student is the PA or a human tutor (if there is one). The other agents are only monitoring the process in case there is a problem, an availability issue, or something extra is needed. Lastly, the SA will constantly extract information/feedback from the student and the PA. The information will concern the evaluation of the instructional events that take place during the tutoring phase as well as the student’s progress. There is also a special category of pedagogical agents, the resource agents.
3.1.6. The Resource Agent

This type of agent is specialized in making use of existing internet resources for educational purposes. On the web, they track relevant material like web pages or online databases and wrap it together. Also, the resource agent is able to track human tutors and add them in the course. For this process the RA will use shells (wrappers) to place the existing online resources. The interaction between the RA and the marketplace is the same as the PA’s (Beverly Park Woolf et al., 2002). The resource agent will be further discussed in paragraph 3.1.10.1.

3.1.7. The Resource Classifier

The resource classifiers will contribute to the transformation of the resources into a consistent ontology. The implementation of our classifier will be based on the MALLET system which is developed mainly by Andrew McCallum (Peter Cassin et al., 2003). Our effort to improve the classifier will be achieved by refining the prerequisites and post-conditions of the resources and also by using IF-THEN methods to order them. That way, the course assembly agent (CAA) can combine them and produce useful sequences in the terms of a course that answers a query. This type of tool will be developing also over time, since the performance of the courses will be checked in practice and evaluated form evaluation agents, students and the tutors (Beverly Park Woolf et al., 2002).

3.1.8. The Marketplace

The market institutions will ensure that the instructional plans are working the way they should, for the needs of the certain knowledge seeker and tutor. Additionally, methods and certain procedure are going to be provided for contracting and monitoring. Communication between agents is going to be held in a peer to peer fashion in order to support coordination of resources, planning, negotiating, contracting, instructing, evaluation and handling of exceptions or unexpected issues (Beverly Park Woolf et al., 2002).
### 3.1.9. The Evaluation Agent

The evaluation agent’s (EA) responsibilities start after the student has signed the contracts and has gained access to the educational resources. The resources are presented to the student according to a specific sequence and the knowledge seeker is entering them one by one (one at a time) (Christopher Eliot, Beverly Woolf, Victor Lessor, 2001). The student also has by now a clear goal which is expected to be achieved when the educational sequence reaches the end. Through this process the student and his or her progress will be monitored. The model’s task will be to overcome difficulties by re-planning and to record the performance and the grades of the student.

The evaluation agent will aim to track the effectiveness of the resources. For that reason, resources that are claiming to be teaching the same or similar topics or courses, will be checked and graded. One indicator for that will be the feedback concerning the communication and relationship among the tutor and the student (this feedback will be asked frequently by both). Another measure will be the student’s preconditions and post conditions, or in other words the level of knowledge that the student had before the course and the skills and competences (including the grade results) that claims to have earned after the interaction with the educational resources. By entering to a new resource, the student is assumed to have satisfied some certain preconditions, probably from the attendance of the previous resources. By checking his or her performance, time of completion or mastery, the effectiveness of the previous resources can be measured. This information will be compared among different resources and students that deal with same or similar subjects. After this comparison, the resources and the resource-producers will be evaluated accordingly (Christopher Eliot et al., 2001). More information about the monitoring/evaluating phase will be found in chapter 3.3.3 and figure 7.

### 3.1.10. The Ontology Agent

A very effective tool for the student agent (SA) is the ontology agent (OA). The ontology agent is used by the SA in order to formulate the student’s goals and sequence of resources. It is clear by now that this is the most important task of the marketplace and it determines the effectiveness of the model. We aim to create ontology agents that will be able to produce a certain educational plan according to each knowledge seeker’s query. It should synchronize educational resources from different producers, into a concrete lesson. After this operation, the negotiation for
the cost of the resources will be simpler and clearer and also, each educational subunit will be connected with a lesson plan. The suggested model for the OA will be described subsequently.

First of all, the planning knowledge will be extracted from existing online repositories. These repositories can be university course catalogues, a certain curriculum concerning a particular course, online textbooks or technical ontologies (Christopher Eliot et al., 2001). In order to make this easier, specialized OAs will be developed for sources of information that deal with special types of courses. The first thing to be analyzed and isolated will be the prerequisites and the post conditions for every educational resource to be used. For these resources, a description will be created, using the ontologies as a target language (Christopher Eliot et al., 2001). As it is mentioned in the article “Knowledge Extraction for Educational Planning”, the precondition and post condition terms will be found in existing taxonomy web databases and other texts. The web has over 30 taxonomies of teaching topics and within these taxonomies, higher education topics are broken into subtopics (Christopher Eliot et al., 2001). A problem that can be identified here is the action that will be taken in case of new subjects and complicated queries that involve innovative subtopics not very much investigated. The ontology agent in this case will extract information from the most recent papers and journals available and use keywords or table of contents from this material.

Another issue that the OA will have to deal with is the similarity issue. There are millions of different queries that may show up and of course there are millions of resources that can be used for teaching every subtopic of every query. For that reason, similar terms should be identified and managed according to our needs. Information retrieval methods that are currently used by search engines to measure similarity among documents can be used to measure course similarities using the course description. Probably similar courses may have same textbooks and vice versa. Additionally similar courses can be detected by using information from the universities concerning the structure and the prerequisites of courses that they provide. Another course similarity indicator that the OA will use is the examination of the subtopics of two or more courses. Similar subtopics, obviously lead to similar courses (Christopher Eliot et al., 2001).

Once the resources and the documents that will be used are decided and the course syllabus is clear, the next step is the structuring of the exact planning and the sequence according to which the resources will be organized. The strategy that will be followed here will be based on the IF-THEN principles. According to that, the OA will model the prerequisites and the effects of each of the resources. In other words, it will simply be indicated that IF a student satisfies certain prerequisites AND completes successfully a certain learning activity THEN he or she will have gained
certain knowledge expressed in terms of post conditions (Figure 7). It is already mentioned that for the precondition and post condition specification and extraction (from documents, metadata tags or other descriptions), information retrieval techniques will be used. After this the formalization of the planning knowledge will follow. This will be expressed by using ontology language.

By ontology language we mean terms and expressions that are related to, or refer to, the learning resource’s description. It is proven that if we have the description of a sub course or an educational resource, including the description of its prerequisites and post conditions, in established natural language, we can make use of information retrieval techniques and transform it into formal computer terms. Thereby, the creator of the educational material will just have to make use of natural language to write the description of the material (something that he or she should easily be able to provide). Of course there will be some basic rules that the language will follow in order to ensure the ontological consistency. An example of this would be the Dublin Core that requires some certain attributes to be present when a document is stored in order for it to be easily tracked and retrieved when needed. The marketplace will encourage the creators of the educational material to provide an explanation of the material’s content, including the preconditions and post conditions.

Figure 2, the actors' grid
**Figure two** depicts the different actors interacting. 1. The knowledge seeker that enters a query. 2. The SA is immediately assigned to the student. 3. The PA is also interacting with the student and represents the pedagogical resources. 4. The CAA is one of the main tools and is related to 5. The SB requests for bids, 6. The OA helps to refine the query, 7. The RA tracks and wraps existing resources and 8. The RC enables wrapping. Lastly, 9. The EA takes care of the evaluation of tutoring services.

### 3.1.10.1. The Ontology Extraction (Ontology Identity Generation)

Based on the provided schema (*Figure 3*) the process of the ontology extraction will follow certain steps. To begin with, the system will conduct a web search in order to find educational resources. The results of this process (which actually will be web pages) will be downloaded and locally stored (Peter Cassin et al., 2003). The problem that pops up here has to do with the diversity, the number or the content of the retrieved pages. Many possible results may offer valuable information but there is undoubtedly a need to classify the extractable results into useful and not useful. For this purpose, a document classifier (resource classifier RC) has to be built and added to the process. The classifier will make use of three categories for the pages:

- **Particular course pages**, which will contain course info, textbooks, syllabus pages and other relevant to the course data.
- **Department course pages**, which will contain department info, provided course’s info, university description etc.
- **Unrelated pages**, which will provide little or no relevant information.
The RC starts operating from the last category which actually represents “the garbage” that we should get rid of (Peter Cassin et al., 2003). The remaining material is in the form of semi-structured web data. Our intention is to formulate this data into a structured ontology. The effort to extract pedagogical topics and other important info and transform them in a structured ontology is a complicated information retrieval problem. Once more, the MALLET system will be preferred instead of trying to produce a solution of ourselves (Peter Cassin et al., 2003). The role of the extractor will undertake the resource agent (RA) that will build a wrapper aiming to find and add valuable information for the ontology extraction. According to the web-page that the RA will be scanning, the information of our interest will vary. For the particular course pages, the information of our interest will be the course name and number, the university, the prerequisites, textbooks, professor names, syllabus (lecture notes, readings, assignments and ordered topics) and course description. Syllabus is the most interesting type of information that we need to locate and retrieve correctly for the structured ontology to be produced. For the department course pages, the most valuable information will be the course name and number, the prerequisites and the course description (Peter Cassin et al., 2003). The resource agent as an extractor is a very challenging part of the system and requires a lot of research in order to operate as needed.
3.1.10.2. The Relationships between the Ontology's Concepts

The ontology consists of specific concepts that characterize it and delineate its meaning. It is very important for our research to try to define the relationships between these concepts (Peter Cassin et al., 2003). Except of the general terms that can define our relationships which are transitivity, reflexivity, symmetricity, etc, we are very interested in understanding the relational strength among our concepts (Peter Cassin et al., 2003). The fact that it is very difficult for the strength to be defined restricts us just to two kinds of relationships. We only identify the “equivalent to” and the “similar to” relationships (Peter Cassin et al., 2003). In the first case we refer to two concepts where one can be exchanged for the other. This case, although it is straightforward, it is not very useful. Most of the times, we have to deal with the second one. In this case, similar concepts have to be identified and used for the generation of our course. The problem is that “similar to” is difficult to perfectly define theoretically. A solution (Peter Cassin et al., 2003) to overcome this issue would be the use of a standard hierarchical algorithm that only operates on the text of a concept. This operation occurs after a processing that includes stemming and normalization (Peter Cassin et al., 2003). However, this solution only is useful for small data set because it is easy to terminate the algorithm and choose the correct number of clusters (Peter Cassin et al., 2003). In addition the clustering is based on word content and not on semantic content (which we would prefer). In order to try to approach a semantic analysis, WordNet or something similar would be a solution (Peter Cassin et al., 2003). Lastly, the prerequisites that usually are required in order to understand a concept or a topic may prove to be a useful tool for defining its relationships (Peter Cassin et al., 2003).

3.2. Operations of Each Actor and Embedded Technologies

<table>
<thead>
<tr>
<th>Student Agent</th>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Serve student</td>
<td>Student modelling in interactive systems (Beverly Park Woolf et al., 2002)</td>
</tr>
<tr>
<td></td>
<td>Delineation of student’s profile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inspect fee negotiation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor tutoring process and interaction</td>
<td></td>
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</tbody>
</table>
Course Assembly Agent

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Provide extra resources or assistance if needed</td>
<td>Planners, fuzzy operators; machine learning, TAEMS, IF-THEN</td>
</tr>
<tr>
<td></td>
<td>techniques (Beverly Park Woolf et al., 2002)</td>
</tr>
<tr>
<td>● Domain specified agent</td>
<td></td>
</tr>
<tr>
<td>● Carry out the student’s goals</td>
<td></td>
</tr>
<tr>
<td>● Select resources that will be used</td>
<td></td>
</tr>
<tr>
<td>● Build coherent educational plan</td>
<td></td>
</tr>
<tr>
<td>● Manage the resources and their sequence</td>
<td></td>
</tr>
<tr>
<td>● Check availability of resources, cost, quality</td>
<td></td>
</tr>
<tr>
<td>● Decide educational plan and resources to be used</td>
<td></td>
</tr>
<tr>
<td>● Search for potential PAs</td>
<td></td>
</tr>
<tr>
<td>● Negotiate with Pas</td>
<td></td>
</tr>
<tr>
<td>● Formulate contracts</td>
<td></td>
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</tbody>
</table>

Searchbot Agent

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Use student’s profile/background</td>
<td>Information retrieval techniques (Beverly</td>
</tr>
<tr>
<td>● Assist SA to find PAs</td>
<td>Park Woolf et al., 2002)</td>
</tr>
<tr>
<td>● Request for bids</td>
<td></td>
</tr>
</tbody>
</table>

Pedagogical Agent
<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Represent instructional resources to student</td>
<td>Pedagogical modelling, economic modelling (Beverly Park Woolf et al., 2002)</td>
</tr>
<tr>
<td>● Negotiate contracts</td>
<td></td>
</tr>
<tr>
<td>● Choose the teaching methods</td>
<td></td>
</tr>
</tbody>
</table>

**Resource Agent**

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Make use of existing internet resources</td>
<td>Provide a set of simple shells for wrapping common types of resources (Beverly Park Woolf et al., 2002)</td>
</tr>
<tr>
<td>● Provide wrappers for resources</td>
<td></td>
</tr>
<tr>
<td>● Track and add human tutors</td>
<td></td>
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</tbody>
</table>

**Resource Classifier**

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Enable resources to be wrapped</td>
<td>Machine learning to gauge effectiveness of resources (Beverly Park Woolf et al., 2002), MALLET system(Peter Cassin et al., 2003)</td>
</tr>
<tr>
<td>● Measure effectiveness of resources</td>
<td></td>
</tr>
<tr>
<td>● Reduce overtime by automatically finding pre- and post- conditions</td>
<td></td>
</tr>
</tbody>
</table>

**The Marketplace**

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Enable assembly of resources</td>
<td>Market institution development, agent technology (Beverly Park Woolf et al.,</td>
</tr>
<tr>
<td>● Manage large dynamic open systems</td>
<td></td>
</tr>
</tbody>
</table>
● Enable operations
● Provide methods for contracting, monitoring and communicating
● Help anticipate, avoid and detect non-compliant resources

**Evaluation Agent**

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Track effectiveness of the resources</td>
<td>Every technique, model or programme needed for the EA to perform will be created in the frame of the digital marketplace development.</td>
</tr>
<tr>
<td>• Check and grade resources</td>
<td></td>
</tr>
<tr>
<td>• Exploitation of the requested feedback</td>
<td></td>
</tr>
<tr>
<td>• Measure student’s performance according to prerequisites and post-conditions</td>
<td></td>
</tr>
<tr>
<td>• Contribute in optimization of the course</td>
<td></td>
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</tbody>
</table>

**Ontology Agent**

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Embedded Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Formulate student’s goals</td>
<td>Information retrieval techniques (similar to those used by internet search engines), IF-THEN techniques, metadata analysis of resource description</td>
</tr>
<tr>
<td>• Create resource planning</td>
<td></td>
</tr>
<tr>
<td>• Create detailed educational plan and build a concrete lesson</td>
<td></td>
</tr>
<tr>
<td>• Formalize planning knowledge</td>
<td></td>
</tr>
<tr>
<td>• Extract knowledge from online repositories and the marketplace’s digital library</td>
<td></td>
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</tbody>
</table>
### 3.3. The Phases of the Model

In this part of the assignment, the operations of the system will be explained. The digital marketplace for education will start operating by the time a knowledge seeker’s query has been registered and will finalize its operations by the time the student’s goal is either considered achieved or dropped (in the second case maybe the student has quit the educational process). During the system’s operation, the authors of the article and designers of the model identify two phases of interaction between the student, the agents and the marketplace. These are the scheduling phase and the instructional phase. However, from my point of view, the operation can be separated into three phases in order for the delineation of the process to be better explained and less complicated. The phases are, the student registry and query refinement phase, the resource gathering and course planning phase and the tutoring and monitoring phase. Each one of them will be analyzed subsequently.

#### 3.3.1. The Student Registry and Query Refinement Phase

The student registry and query refinement phase is the first phase of the system and besides its importance, the fact that it is not explained very clearly in the articles, has to be underlined. However, we will make an effort to gather all the provided information and describe this phase the best way we can. The stimulus or the main characteristic of this phase is the student’s demand for a course that is expressed in the form of query postage. The query can be of three types; it can be a classical course request (e.g. I need to refresh my calculus in preparation for the physics 101 course next week (Beverly Park Woolf et al., 2002), a query that combines many disciplines (e.g. I want a summer long course in biomedical engineering (Beverly Park Woolf et al., 2002) or a query from a highly focused topic that demands high expertise (e.g. I need to model turbulence using computational fluid dynamics.
It is easily understood that every type requires different addressing. When a new student is registered in the marketplace, a student agent (SA) is assigned to him or her. The rest of the agents, that practically support the SA and the operations of the marketplace, are managed by the SA and can be considered as tools that most of the times are provided automatically (except if the simplicity of the query does not require every agent’s involvement).

The prior task of the SA is to analyze the student’s background, prior knowledge and unique profile. During the generation of the student model the system will aim to gather all the relevant information that will be useful towards the generation of the ontology that will be the basis of the construction of the course. This information is divided into two categories. The domain specific information refers to all the data that is relevant to the topic of the course or the nature of the query. This information describes the level of knowledge familiarity or understanding that the student has in relation to the certain domain. Stereotyping is called the act of categorizing students according to certain criteria. Knowing the students level of knowledge means that we know his or her stereotype and vice versa (Ani Grubišić, Slavomir Stankov & Branko Žitko 2013). This process helps us avoid overlaps or gaps during the tutoring phase. With this categorization we can classify students from novice to expert level. The domain independent information refers to the data related to the student’s character personality or behaviour. Additionally, information concerning the goals, motivation, experience or skills is also very useful for the model and the course’s quality. This second type of categorization focuses on adapting the behaviour of the tutor or the PA in the digital knowledge marketplace. That way we can reach to optimization of the learning as well as the teaching efficacy (Ani Grubišić et al., 2013). Our goal is to offer to the right student, the right information that he or she needs and in the right time (Vatcharaporn Esichaikul, Supaporn Lamnoi & Clemens Bechter 2011). The way in which we are planning to extract all the needed material can be a pre-test for the domain specific information and a special questionnaire for the domain independent. Moreover, since we are living in the age of BIG DATA, information could be extracted (if permitted by the owner) via the social media that could delineate the student’s character and preferences. The SA will undertake these procedures in the beginning of the student’s interaction with the system.

The next task of the SA and the course assembly agent (CAA) that normally is already in use is to refine the query and to analyze deeply its domain in order to understand the type and content. By this analysis, the educational goals of the student will be clarified. With the refinement of the query the ontology will be further developed and become even more concrete. Normally the query will be presented in easily recognizable terms. If this is not the case, further information will be requested from the student. In this phase the terms of the query’s domain will be extracted. These
terms will be used to retrieve information from existing taxonomies later. The last action that will be taken at this point is the query to be raised to the marketplace for the first time.

3.3.2. The Resource Gathering and Course Planning Phase

The second phase is basically referring to the generation of the educational course. This phase is characterized by highly innovative techniques and operations. The main actors that are performing during this phase are the course assembly agent (CAA) and the ontology agent (OA). The CAA will make use of the information gathered in the previous phase concerning the student’s background and the query’s content to determine which educational resources can be used potentially. This process will require the assistance of the OA. The OA will use the ontology identity of the query (generated in phase 1 by the OA) and match it with the ontology identity of the potential resources. The second ontology identity will be extracted through the resource’s description that will be written as explained in chapter 3.1.10.
After the filtering of the resources, IF-THEN technique (based on resource prerequisites and post-conditions) will help to put the decided material into an order and a type of chain will be created. This chain is connecting the student’s prior knowledge with the educational goal. The suggested planning alternatives will be gathered. By using TÆMS (Christopher Eliot et al., 2001) the time, cost and quality constraints will be applied and a new group of suggested solutions will be generated. The student at this point will be able to choose the preferred option. If no option is acceptable yet, he or she will be able to alter the parameters in order to get more options. In the end a course will be decided.

A very important part of this phase, undertaken by the ontology agent (OA), is the extraction of the ontology knowledge. Once again we are aiming to extract planning knowledge (in order to produce the course’s end form and sequence) but now we are using information retrieval techniques applied on existing repositories. As explained in the OA’s delineation, the processes here are formulating the core of the system. They can be considered the system’s backend. Various internet sources and taxonomy databases are used, preconditions and post conditions of resources are extracted and analyzed and the ontology is maintained through the terms extracted in the previous phase. Additionally, similarity in topics and educational material is identified and managed by quality, date of production or reputation attribute checking. The planning suggestions are generated following IF-THEN rules. Last but not least, resource description is stored in the marketplace’s database for future use. The storing will be using ontologies as target language and planning knowledge in order to maintain high quality and improve further.
Figure 5 describes the course planning process. 1. The CAA sends to OA profile and query information to receive the ontology identity. 2. The CAA uses the ontology identity to extract the relevant resources. 3. The CAA uses IF-THEN rules to put the relevant resources in a logical order and build course alternatives. 4. The alternatives are sent to student to decide. 5. The decided solution is sent back to CAA and the second request for PAs is sent.

The second phase proceeds with the CAA’s resending of the query and requesting PAs for bids. The marketplace is requesting bids from the most relevant judged PAs according to the decided course. The PAs will represent the educational resources and will assist during the tutoring phase. The negotiation between the PAs and the student represented and guided by the SA will now take place with the SA aiming to provide the best value for money solution to the student according to the regulations described in the upcoming paragraph. When the alternatives are decided and presented to the student, he or she will decide the preferred option. The last part of this phase is the contract fulfilment between the student, the PA and the resources formulating the course.
3.3.2.1. General Pricing Regulations applicable to this model

Part of the resource gathering and course planning phase is negotiating and reaching to an agreement which will lead to contracting. No reference of the pricing mechanism that will be used exists in the articles that delineate the initial idea. It is clear though that the pricing mechanism in a market place is a guarantee of stability in performance and professionalism. The monetary value of a course has to be a result of many parameters. It is easily derived that the evaluation process will influence the prices. Additionally, since we are trying to present a system that is claimed to be customer oriented and not university-centred, we are obliged to express the supply and demand in economic terms like two co-existing interactive forces.
The assumption that the tutors and the resource owners are aiming to long term, rather than short term, profit has to be agreed in order to continue with this analysis. Another assumption that gives meaning to the scope of our research is the fact that the prices, before the bidding processes and the negotiations, are defined by the resource owners and the tutors themselves. Of course, it is reasonable that they will comply with the evaluation and reputation results but this should not be imposed (Hai Zhuge & Weiyu Guo, 2007, 1834). The digital knowledge marketplace for education will be designed to run as explained in the previous chapters but for the sake of our analysis we can summarize the operations and focus on the transaction between the seller and the buyer.

The process will be held as follows:

- The buyer describes his or her demands for knowledge and also his/her cost or time preferences. Ontology is created.
- The seller (PAs, resources, human tutors etc.) has provided a description concerning the scope of the demands that can be satisfied and the price that is required. Ontology is created.
- Matching mechanisms (CAAs, OAs etc.) track down potential collaborations.
- The Student Agent supports the bidding/negotiation process between the buyer and the potential sellers for an agreement to be reached. The negotiations are based mainly on evaluation/reputation information.
- The Student Agent undertakes to carry out the contracting phase.
- The tutoring process can take place. Evaluation information is collected here.

A very interesting question to answer is “where does the value come from (?).” In order to build a steady pricing and money transaction mechanism, we have to be sure that this question is clearly defined. First of all we have knowledge or information that has a relatively low price compared to its real value. This is happening because reproduction of already existing knowledge is not priced very high. Secondly, we have knowledge transmission services which add value to the previous amount because it contains the tutor’s effort and methodology. Thirdly, we have the effectiveness of the knowledge transmission service, in other words, we have the reputation that stems from the evaluation processes and adds additional value to the good. Conclusively, we observe that the value of the tutoring services is a function of three quantities, the knowledge value which is probably fixed, the service value and the reputation of the services which are variable (Hai Zhuge & Weiyu Guo, 2007, 1834).

Now that we have defined the origin of the digital course’s value, it would be helpful to refer to the bidding process or in other words the bargaining mechanism that will be held between the seller and the buyer (student) and will be supported by the SA. The price that the buyer is willing to pay can be \( P(b) \) and the price that the seller is
willing to charge can be $P(s)$. The reserved price for the buyer (which can’t be exceeded) and the reserved price for the seller (that can’t be reduced), can be expressed as marginal prices $M(b)$ and $M(s)$ respectively. Also, the increment of each bidding step can be $I(b)$ if it is registered by the buyer and $I(s)$ if performed by the seller. Of course it is obvious that $I(b) \leq 0$ since the buyer is unlikely to suggest an increase to the price of the course. The pricing system will be based on some basic regulations.

- If $M(b) < M(s)$, then the operation can’t be completed or in other words it fails.
- If $P(b) = P(s)$, then the transaction can be completed with the agreed price and the operation can proceed successfully with the course.
- If $P(b) > P(s)$, then the transaction can be completed again successfully with the price being equal to $P(s)$.
- If $P(b) < P(s)$, then the bidding process will be activated. The negotiation phase will allow both sides (seller and buyer) to suggest new prices according to their benefit. The new prices will be equal to the previous ones reduced by $I(b)$ or increased by $I(s)$. (Hai Zhuge & Weiyu Guo, 2007, 1836)

According to the regulations above, the negotiation process (when activated) seems feasible. However, before reaching to the bidding phase, the initial prices need to be defined and as explained earlier this process is affected by three parameters. Trying to integrate reputation into the pricing mechanism, Yamamoto and Ohta (Yamamoto, H. & Ohta, T., 2001) as well as Zacharia and Maes (Zacharia, G. & Maes, P. 2000) made a proposition for the pricing decision to be made. According to this proposition, the price of the buyer $br(n)$ and the price of the seller $sr(m)$ are calculated as follows:

$$
sr(m) = \left(1 + \frac{rep(m)}{\lambda}\right) \times s(m)
$$

$$
br(n) = \left(1 - \frac{rep(n)}{\lambda}\right) \times b(n)
$$

At the above equations we used the following notation. By $s(m)$ we refer to the initial price asked by the seller $m$ and by $sr(m)$ the adjusted price. Accordingly, by $b(n)$ we refer to the original price asked by a buyer $n$ and by $br(n)$ the adjusted price. By $\lambda$ we refer to the range that the price can be adjusted and by $rep(i)$ to the reputation degree of $i$. The value of $rep(i)$ can vary between 0 and 1. (Hai Zhuge & Weiyu Guo, 2007, 1835)
3.3.3. The Tutoring and Monitoring Phase

When everything is ready, as agreed in the contracts, the system enters the tutoring phase. This phase is characterized by three different but related operations. These are the tutoring process, the monitoring process and the evaluating process. By the time the SA has terminated the contract fulfilment, the student is ready to enter the resources and start making use of them. According to the educational plan, generated already in the previous phase, the chain of resources is presented to the student in a certain sequence. The student is entering them one by one separately in order to satisfy the post conditions of resources that constitute prerequisites for other. The performance of the student in each one of the sub courses (resources) is monitored and it is measured by the observation of the relevant attributes like time of completion, difficulties faced and exam performance. This activity is continuous and it ends when the sub courses of the chain reach to the end. The termination is defined either by the achievement of the educational goal, or by the student’s decision to drop the goal or the tutoring process for any reason.

During the tutoring process the agents (except the PA) are observing the interaction and are not participating in any way to it. They are extracting useful information and making sure that the needed material is available and everything is as agreed in the contracts. In some cases, the tutoring process requires human involvement. A human tutor may be needed in the frame of a course. The evaluation agent is responsible of gathering and processing the requested feedback, both from the student and the tutor. This feedback, in comparison with the information gathered during the monitoring process (grades, time etc.) will be collected and used to produce statistical reports that will be very useful for general evaluation and future needs.
Figure 7 refers to the tutoring process. The student and PA go through the educational resources one by one. Every resource has prerequisites and postconditions that have to be met, until the end-goal is achieved (it is easily derived that post1 is equal or at least part of pre2). The SA is constantly monitoring and the EA extracts the needed information for evaluation.

### 3.4. The Principles of the Model

The Digital Market Model for Education will be a revolutionary idea in the field of education and the corresponding market. Thereby, it is important at this point to mention some things about the principles on which this model will be built on. Having a clear view about the system’s principles will be very useful for understanding better the existence and the meaning of its requirements and its goals.

This system can be considered as a digital university, which is providing its services with the assistance of technology. In particular, we are describing the development
of a digital repository that will try to demonstrate reliability, accuracy and efficiency by being based on information retrieval techniques, machine learning and agent technology. The educational marketplace is aiming to exploit all this online knowledge to people and offer to almost everyone the chance to be taught by recognized professionals. Before starting to build such a platform, it is worthy to set the boundaries in which we will operate. Privacy is one of the basic principles, since the system makes use of sensitive data in order to operate. Also, honesty among the actors is of great interest and also a big challenge, since money is involved. For that reason contracting and registration regulations will exist. Additionally, honesty and fairness should be also ensured during the evaluation processes and the endorsements. Another crucial goal of the producers of the model is to build it in a way that duration is ensured in combination with constant improvement over time. Finally, the systems main principle should be the customization of the services according to the student’s profile. Every individual’s certain attributes, should lead to certain adjustments in the tutoring service providing, so that the goals and the needs match his or her unique profile.

3.5. The Model’s Major Requirements

In the following part we will examine the requirements of the digital marketplace for education. If we consider the width of this idea and the complexity of the operations included, as well as the principles that represent our boundaries, we will understand that the requirements of this model will be a lot. However, it would seem pointless to name every small operational requirement since the aim of this document is not to become the detailed guide for the developing team during the implementation phase. What would be useful at this point is to quote the structural requirements that will cover the major issues. The methodology that we will follow to organize the requirements will be firstly to categorize them according to the phase of the model that they belong to. Secondly, for our convenience, we will also separate them according to the characteristic of the system that they influence. In other words we will distinguish three different areas of interest, the usability, the reliability and the performance of the resulting system and for each one of them we will present the corresponding requirements.

3.5.1. Requirements related to the system’s first phase
### The Student Registry and Query Refinement Phase

#### Requirements related to the system’s usability
- The system should be able to accept and “understand” a query.
- A student agent (SA) should be assigned to the student and provide assisting services.
- The SA should construct a complex model of the student’s profile and background.
- The SA should raise the student’s query to the marketplace with a brief description.
- The SA should have a course assembly agent (CAA) available or should be able to locate one.

#### Requirements related to the system’s reliability
- The system should access large scale repositories by making use of data mining and resource acquisition techniques.
- The terms in the descriptions should be found and identified in existing taxonomy databases (Christopher Eliot et al., 2001).
- The system should use student modelling and machine learning techniques to assemble and tailor resources.
- An educational solution should be extracted and suggested using TÆMS. (Christopher Eliot et al., 2001)

#### Requirements related to the system’s performance
- The SA should serve student.
- The SA should delineate the student’s profile.

### 3.5.2. Requirements related to the system’s second phase

#### The Resource Gathering and Course Planning Phase
<table>
<thead>
<tr>
<th>Requirements related to the system’s usability</th>
</tr>
</thead>
<tbody>
<tr>
<td>o The CAA should be able to produce a detailed educational plan.</td>
</tr>
<tr>
<td>o The CAA should be able to resend the query to the marketplace.</td>
</tr>
<tr>
<td>o Pedagogical agents (PA) should be able to respond to the query.</td>
</tr>
<tr>
<td>o The marketplace should be able to filter the resources according to the needs of the student and the course.</td>
</tr>
<tr>
<td>o The marketplace should send requests for bids to those judged most suitable after the filtering.</td>
</tr>
<tr>
<td>o The return of the bids should be sets of resources formulating a course (if the query is simple).</td>
</tr>
<tr>
<td>o The return of the bids should be sets of course-decomposition services for the query (if the query is more complicated and there is no already existing tutoring system to cover it).</td>
</tr>
<tr>
<td>o The SA and CAA should break the course into manageable sub courses.</td>
</tr>
<tr>
<td>o The SA should be able to negotiate with the providers and also to inspect student’s negotiation.</td>
</tr>
<tr>
<td>o The CAA should be able to choose the appropriate resources or the appropriate decomposition (based on value for money principles) to be followed.</td>
</tr>
<tr>
<td>o The CAA should interact with the SA to adjust the decomposition planning or the course to the student’s unique profile and background (for example to prevent potential overlaps)</td>
</tr>
<tr>
<td>o The RA will make use (add or track) of existing internet resources or human tutors if needed.</td>
</tr>
<tr>
<td>o The CAA should be able to provide a planning at its primary form by relating each potential subtopic to resources.</td>
</tr>
<tr>
<td>o The CAA should be able to evaluate resources by using information provided by the evaluating mechanism and the resource description.</td>
</tr>
<tr>
<td>o The CAA should be able to identify prerequisites and postconditions for each one of the resources or components of the course.</td>
</tr>
<tr>
<td>o With the evaluation process, the CAA should be able to decide which of them should be used.</td>
</tr>
<tr>
<td>o With the evaluation process, the CAA should be able to decide the sequence according to which they will be</td>
</tr>
</tbody>
</table>
presented and used. In other words the CAA should build a coherent educational plan.

- The complete educational plan or course should be presented to the student for approval.
- The SA and CAA should take care of the contracts among the student, the PA and the resources or educational materials.
- The student should be able to enter the educational resources.
- The marketplace should be able to make sure that all the services provided are contracted according to the regulations.

<table>
<thead>
<tr>
<th>Requirements related to the system’s reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>❖ Information retrieval methods should be used to build formal representations of the available learning resources (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ The OA should use information retrieval techniques to extract planning knowledge from existing repositories through the material’s descriptions or preconditions and postconditions (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ Information retrieval methods already used by internet search engines to measure the similarity among documents should be used to compare course descriptions, textbooks, precondition and postcondition terms or subtopics (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ The system should use IF-THEN rules to model the prerequisites and postconditions of the educational plan (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ The system should use terms from the ontology to express and store planning knowledge and resource descriptions (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ Authors and educational resource developers should be encouraged to provide the preconditions and postconditions of the material, as well as an explanation of the content (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ The CAA should perform the planning by using IF-THEN rule, referring to preconditions and postconditions. A chain of planning rules should connect the student’s educational goal with his or her prior knowledge (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ The final solution should be produced after the student’s approval (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>❖ Negotiation protocols should be followed by every agent contracting in the marketplace in order to receive full</td>
</tr>
<tr>
<td>Requirements related to the system's performance</td>
</tr>
<tr>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>- The system should represent and deliver instructional material (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>- The system should support competition and new competitor’s entry.</td>
</tr>
<tr>
<td>- The system should encourage producers of educational material to register it in the network.</td>
</tr>
<tr>
<td>- The system should autonomously search for resources and material.</td>
</tr>
<tr>
<td>- The system should be able to retrieve resources and material.</td>
</tr>
<tr>
<td>- The system should be able to schedule and plan courses and educational interaction.</td>
</tr>
<tr>
<td>- The system should be able to measure effectiveness resources, material and courses.</td>
</tr>
<tr>
<td>- The system should provide mechanisms to identify and recognize the differences in quality cost or content among similar educational resources.</td>
</tr>
<tr>
<td>- The marketplace should coordinate resources according to the student’s unique profile and educational goal.</td>
</tr>
<tr>
<td>- The system should be able to manage millions of web based educational resources.</td>
</tr>
<tr>
<td>- The system should be able to access large collections of educational material accurately and efficiently.</td>
</tr>
<tr>
<td>- The marketplace should provide a safe and secure environment respecting the privacy issues.</td>
</tr>
<tr>
<td>- The system should be able to put together resources and formulate a course.</td>
</tr>
<tr>
<td>- The system should be able to disassemble a course into its resources.</td>
</tr>
<tr>
<td>- The system should support negotiations on many different disciplines.</td>
</tr>
<tr>
<td>- The system should identify prerequisites and post-conditions of resources and pedagogical material.</td>
</tr>
<tr>
<td>- The system should be able to create student models and knowledge models.</td>
</tr>
<tr>
<td>- The system should accept classical course requests, multidisciplinary queries, highly focused topic queries.</td>
</tr>
<tr>
<td>- The marketplace should support only certified resources.</td>
</tr>
</tbody>
</table>
3.5.3. Requirements related to the system’s third phase

<table>
<thead>
<tr>
<th><strong>The Tutoring and Monitoring Phase</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Requirements related to the system’s usability</strong></td>
</tr>
<tr>
<td>- PAs should represent the educational resources of any kind.</td>
</tr>
<tr>
<td>- The agents should be able to monitor the interaction.</td>
</tr>
<tr>
<td>- The agents should be ready to provide potential extra material or resources needed.</td>
</tr>
<tr>
<td>- The marketplace should be able to make sure that the agents communicate as they should.</td>
</tr>
<tr>
<td>- The marketplace should be able to keep track of the system’s performance before and during the tutoring phase.</td>
</tr>
<tr>
<td><strong>Requirements related to the system’s reliability</strong></td>
</tr>
<tr>
<td>- The RC should make use of machine learning techniques to gauge effectiveness of resources.</td>
</tr>
<tr>
<td>- The system should use digital repository testbeds to evaluate agent behaviour.</td>
</tr>
<tr>
<td>- The system should record the completion of each learning resource and any grades given or other indicators of the student’s performance (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>- The recorded statistics should lead to evaluation of the resource’s effectiveness (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>- Machine learning and statistical methods should be used to evaluate learning resources (Christopher Eliot et al., 2001).</td>
</tr>
<tr>
<td>- The system should require appraisal and rating from the agents to the educational material and publish the ratings.</td>
</tr>
<tr>
<td>- The marketplace should guarantee a certain base level of quality of provided services.</td>
</tr>
<tr>
<td>- The system should require registration when a new event or instructional phase occurs.</td>
</tr>
</tbody>
</table>
**Requirements related to the system’s performance**

- The student should be able to provide feedback and evaluation concerning the interaction with the resources.
- The marketplace should provide mechanisms that identify and encounter unexpected situations.

#### 4. The Student’s Interaction

As it is already explained, the knowledge seeker represents the customer of the digital marketplace for education. Therefore, the whole system’s philosophy and concern is built according to his or her needs. The goal of the digital marketplace is to constitute a comprehensive environment for education. The features of this environment, plus the agent technology will provide the seeker with all the required elements and will offer a complete learning experience, which will start by the entering to the system and will end by the achievement of the defined goal or goals. For that reason, the identification and optimization of the characteristics of the seeker’s interaction with the system is crucial. There are three actors of the system with whom the seeker interacts directly. Two of them are agents, the Student Agent (SA) and Pedagogical Agent (PA) and the third one is the Marketplace’s frontend interface. At this part of the thesis we are going to describe and analyse the details of every case of interaction. Additionally, we will refer to the different types of pedagogical agents that can be created. Every type refers to a different student personality thus there are different aspects concerning the interaction.

#### 4.1. The Student Agent’s Interaction with the Student

The student agent is the actor of the system that generally serves the knowledge seeker. This actor can be considered from the one hand, the student’s representative to the marketplace and on the other hand, the marketplace’s representative to the student. In other words, the SA is the link among the student and the system. When we refer to “the system” we mean the services provided by the marketplace in total. From the student’s perspective, the received services are a result of many different agents’ operation and collaboration. However, the
knowledge seeker is not interacting with the course assembly agent, the searchbot agent or others but instead, the SA gathers the results of all these agent’s operations and presents it in many different forms to the knowledge seeker. Conversely, the SA is gathering and presenting to the system and the system’s agents, all the relevant information from the student. Conclusively, we can describe the SA as the agent assigned to the student immediately when he or she enters the system. Its responsibility lays in transferring or assigning tasks to the other agents that are integrated to the system.

In this section we will focus on the tasks that involve SA and student interaction. To begin with, the student will have to enter all the relevant background info that will lead to his or her profile delineation. All the student’s relevant experience, activities and individual competences, will contribute to the generation of a student model. The student agent, via student modelling techniques, will exploit this model’s attributes in order to construct the tutoring process. As it is mentioned in the Ontology Agent’s part, the goal is for an ontology language to be created. This ontology will be used as the digital course’s unique identity and tool for resource detection regularization and application. The acceptance of the query is another very important type of knowledge seeker and student agent interaction process. The query acceptance is a challenging process, since the potential student will have to provide all the required information for the query to become unambiguous and precise. The information provided at this point will also be used in the ontology language generation and the construction of the course’s identity. The next part of the interaction refers to the negotiating phase, the student’s preferences and the contracting phase. During the profile delineation process and the query submission, the student will also enter information relevant to the amount-range of money that he or she is willing to spend for the course in order for the agents to provide affordable solutions. The student agent will arrange the negotiation process to be done by the course assembly agent (CAA) and will monitor the process. When this process comes to an end, there will be a number of candidate-solutions (including PAs and pedagogical resources formulating a course) presented to the student (by the SA) among which the student will choose the most convenient. Alternatively, he or she will be able to configure the parameters even further in order for new solutions to be generated. The selection of the most convenient and complete solution will lead the student and the SA to the contracting phase, where the marketplace’s rules and regulations will be decided and signed and all the rights will be reserved according to certain protocols. The last part of interaction between the SA and the student is the feedback collection for evaluation purposes. The feedback can be expressed in several ways, for instance by special forms to be filled, rating or plain text. This feedback will be transferred to the evaluation agent for further exploitation.
4.2. The Pedagogical Agent’s Interaction with the Student

The student interacts with the pedagogical agent (PA) during the instructional phase. As long as this phase is in progress, no other agents involve. However, the evaluation agent is collecting important data concerning the tutoring progress and the student agent is making sure that the resources are all available and the contracted tutoring plan is followed accurately but these operations do not involve student interaction.

In order to understand the way that the PA operates and interacts with the student-knowledge seeker, it is needed to make some assumptions. We presume that the PA belongs to a specific kind and has certain attributes. Due to the development of the interface technology and our need to introduce it to education through the Digital Knowledge Marketplace for Education, we can now refer to a sophisticated Pedagogical Agent whose target and reason of existence is to benefit the student’s motivation and learning (Yanghee Kim, 2015). Since the system we are describing is a computer program that aims to support the tutoring process and achieve an even more positive outcome, we have to take care of the social presence that needs to be perceived especially by young learners. For that reason, we will make use of an anthropomorphized Pedagogical Agent in our model that will give to the process a more social and natural sense. This is because people tend to unconsciously apply similar social rules to computers and expect similar confrontation as they do to humans.

The human instructional roles (and their characteristics) that we need to incorporate in the PAs of the digital marketplace are the following. First is the expert’s role which holds expert knowledge and is able to provide useful feedback in order to guide and correct the learner. Second is the tutor’s profile, which can support a dialogue with the knowledge seeker and emphasize on any inaccurate or misunderstood parts in order to support deeper reasoning and understanding. Thirdly we have to incorporate the mentor’s role that will be as close as possible to the attributes of the ideal human instructor who combines both professionalism or expertise and real caring for the learner. Lastly, we need to include the companion-learner’s attributes that will motivate the student and also familiarize him or her with the system even further. This type will show the characteristics of a peer student, a collaborator, a competitor or even a troublemaker if that fits to the student’s profile. Conclusively, it is important to keep in mind two crucial issues when we refer to the Pedagogical Agent’s design principles, the agent’s instructional role and the agent’s personal attributes. We analyzed the first issue already with the reference to the four types of instructional roles. The second issue has to do with attributes that will help the learner perceive the instructional process in a way that fits to his or her character and will contribute to the optimization of the tutoring result, which is the
transmission of knowledge of course. These attributes refer to the agent’s gender, ethnicity, personality etc. (Yanghee Kim, 2015)

Mark Elsom-Cook identifies six student models or, in other words, six different interaction categories that can be followed according to the character and needs of the knowledge seeker (Mark Elsom-Cook, 1993). These are the following:

- Corrective, where the goal is to locate the student’s misunderstanding or the difference between the student’s perception and the correct situation and fix it.
- Elaborative, where the system aims to fill empty areas with accurate knowledge or extend the student’s knowledge where needed.
- Strategic, where the system aims to alter the followed tutoring strategy constantly in order to maximize the positive effects. This tactic, of course, needs to have information about past results of the same student in relation to different strategies followed. In other words student’s past record is needed.
- Diagnostic, where the actual state of the student’s profile is analyzed. All of the methods related to the digital marketplace are diagnostic.
- Predictive, where the system is aiming to estimate the situation of the student after the interaction or the tutoring. The digital marketplace is supporting this predictive strategy through the IF-THEN technique.
- Evaluative, where the system’s goal is to assess the effectiveness of the student and the tutoring process. The digital marketplace is also supporting this strategy through the operations of the evaluation agent.

Beishuizen and colleagues (2001) have come to a conclusion that when students and teachers were asked to identify the “good instructor’s” characteristics, they both distinguished two main categories of evaluation. First category is to evaluate the instructor in terms of expertise and second to evaluate the instructor in terms of personality and behaviour. For that reason and based on the (Amy L. Baylor, ph. d, Yanghee Kim, ph. d. 2005) research, we will distinguish and analyze three types of possible Pedagogical Agent for our system. The expert will appear to have advanced knowledge on a specific domain. The motivator will encourage the learner verbally. Lastly, the mentor will include attributes from both of the other types (Amy L. Baylor, ph. d, Yanghee Kim, ph. d. 2005). Every type of PA will be retrieved and used according to the unique characteristics of the knowledge seeker (student model), as they are collected and analyzed by the Student Agent and the Course Assembly Agent.

The analysis is going to be based on the three types of PAs (expert, motivator and mentor) that were incorporated into the web-based research application, MIMIC
MIMIC facilitates students in learning the basics of instructional planning. This web application was developed in terms of functionality according to factors regarding learner and agent control (Baylor, 2001). Technically, it is comprised of a series of HTML forms within which the user interacts with the agents, programmed by Visual Basic Scripts. The core of the application’s processing is done with server-side scripting, implemented with Cold Fusion. CFML (Cold Fusion Markup Language) is used to process all submitted forms, provide database interactivity, and allow the MIMIC environment to be set to variable configurations. The aspects that were interesting to analyze and configure in every agent type were five. Initially it was the image, which is the main thing that can influence the student’s perception. Animation is the second aspect and it includes movements of the head the face or the body. Animation is used to boost the student’s motive and understanding. The third aspect refers to the emotion of the digital Pedagogical Agent, which is very important in order to navigate the student’s perception. Another mode of communication that has to be taken into consideration is the voice. The voice is related to the behaviour, the attitude and of course the language of communication. In addition, it can also be considered a very good way to reinforce social presence. The last aspect and the most important is the script for every type of PA or in other words the scenario that will characterize the content of the communication-dialogue according to each PA’s nature. The scripts have to be developed based on the behaviour of human tutors of each kind. The aspects will be linked to every different type of agent’s profile as follows.

4.2.1. Pedagogical Agent as an Expert

This type of Pedagogical Agent refers to an experienced professional whose profile exudes confidence and stability in performance. For that reason the design will be based on a middle aged and therefore mature man who will have a small range of movements and expressions. The speech will be formal and serious and thus reliable. The Expert Pedagogical Agent will not be affected by the knowledge seekers emotions and will not use emotions to achieve the goals but will only provide accurate and valid information to this end.

4.2.2. Pedagogical Agent as a Motivator

For the delineation of this type of PA, we have to understand the way the learner perceives the course and the PA. Our target here is the agent’s efficacy optimization
for a specific part of audience. According to Bandura, attribute similarity between the learner and social model significantly affects the learner’s self-efficacy belief (Bandura, 1997). In other words, a tutor-agent that looks same age as the learner can bring better results. For that reason, this type of agent will be designed based on a young man’s model (early twenty’s), wearing casual clothes exuding the perception of a peer learner. As far as the agents character and verbal attributes are concerned, constant encouragement will be promoted through an enthusiastic as well as energetic voice. To this end the agent’s movements will be animated to be very expressive with the ultimate purpose to affect the student’s motive. Conclusively, the PA as a Motivator will not be presented as an expert but mostly as a partner promoting persistence to achieve the goal. Additionally, a peer like agent can be cooperative, confused, happy but also indignant sometimes.

4.2.3. Pedagogical Agent as a Mentor

Our last type of PA will not be limited to providing information and expertise. The goal here is to guide the learner through the resources in order to bridge the gap between his or her initial stage and the desired skill level that needs to be achieved. In other words, having met all the prerequisites, to make use of the provided pedagogical resources and follow the tutoring process so that the post condition stage is reached. It is preferred for the mentor to be guiding and coaching the learner without being authoritarian (however, experience and knowledge have to be clearly perceived by the learner). Additionally, collaboration between the learner and the Mentor PA will be promoted. Thus, the agent as mentor should demonstrate competence to the learner while simultaneously developing a social relationship to motivate the learner (Baylor, 2000). To this end, the image will be less formal than the expert’s but definitely older than the motivator’s. The designed movements and expressions will be exactly like the motivator’s, accompanied by a friendly and approachable voice but more confident and professional. In general, the mentor’s script will have characteristics from both the expert and the motivator and will aim to give out the impression of something in between.

4.3. Evaluating the Pedagogical Agent

At this point the means of the Pedagogical Agent’s performance evaluation will be cited and analyzed. These evaluation methods will lead to the discovery of the potential for improvement for the PA. Additionally, the quality issue for the provided
services will be addressed as well as the maintenance of the desired performance level will be ensured.

4.3.1. Methods to Evaluate the Pedagogical Agent

In the chapter 3 where the Digital Market Model for Education was described, we made a reference to the Evaluation Agent (EA) and its functionalities. Nevertheless, it is worthy to analyze the evaluation strategies in a separate chapter, since EA is mainly collecting the data rather than processing it to reach to valuable conclusions.

To begin with, it will be helpful to keep in mind that the knowledge seeker will follow a certain tutoring procedure. The resources will be presented in a certain sequence and every step-resource will require the existence of prerequisites. Also, after the completion of every step-resource of the tutoring phase, certain post-conditions will be met. All these resource attributes have to be presented and investigated before the usage of the actual material. The extend that every different resource’s post-conditions are met, is a valuable indicator for the evaluation of the resource and the tutoring method in respect to it. For that reason, the post-conditions will be checked through questionnaires presented to the student (that will be analyzed later), tests that will take place during the phase to measure student’s performance, or feedback from later results will be used. The last case refers to the situation according to which the tutoring process goes on to more sophisticated types of resources whose prerequisites involve knowledge from previous ones and feedback or results can be used.

There are many different factors that we can refer to when measuring and evaluating the performance of a tutoring process. The elements that take part in this procedure are Pedagogical Agents and Pedagogical Resources. The time needed (and spent) is one of the factors. It is important for the estimated time to be precise and any extra time used can lead to lower evaluation depending on the situation. The cost of the resources is definitely one important measure and will be a subject of evaluation since the value for money philosophy is our guide. Additionally, the amount of needed material and the number of resources matters for our report (of course this does not mean that the less the better). A crucial measure is the student’s performance (as mentioned already). The performance is inextricably related with the value of the PA and the tutoring material. Tests, qualifications and progress reports will provide to us all the needed information for the value estimation. Last but maybe the most important indicator for the evaluation process is the knowledge seeker’s opinion and impression about the course and the total experience. Questionnaires will be prepared and conducted for that purpose.
Through their content, information related to the level of satisfaction as well as the student’s engagement level will be extracted. Also, the Pedagogical Agent’s (and the whole procedure’s) impact to the learner will be questioned and used for evaluation.

In particular, one aspect of this model’s intellectual contribution is estimated to be the gradual improvement of the resource models and the Pedagogical Agents that will handle the tutoring processes. This goal will be achieved through the Resource Classifier’s operation that is explained in part 3.1.7. Besides that, statistical methods and machine learning techniques will be used to evaluate the procedure-course and facilitate the scheduling, since the fuzzy plan operators will continuously improve through learning (Beverly Park Woolf et al., 2002).

4.4. The Marketplace’s Interaction with the Student

The Digital Marketplace’s interface is the only part of the system that interacts with the knowledge seeker from the first moment of his or her entry to it, until the end of the whole tutoring process. The Marketplace is interacting with the learner mainly through the agents and the instructional resources. In general, a user friendly and convenient digital environment will guarantee a stable and smooth interaction and learner’s experience. Additionally, it is important to mention all the contracting methods and regulations that the system will provide to the user in order to obtain honesty and smooth operation among agents, students and tutors. Conclusively, the marketplace will ensure that the phase alternation, the availability of resources and the agent performance are operating as desired.

5. Expected Performance of the Resulting System

In order to address the performance of the resulting system, it would be unavoidable to be based on some estimation, since the digital marketplace for education is not under construction. However, the point of reference for our estimations will be the technologies that will be used to enable every phase’s operation. Additionally, it is clear by now that the time variable (independent variable) will influence significantly the performance (dependent variable) of certain phases and operations.
5.1. The student registry and query refinement phase

Since this phase consists of 2 smaller phases, whose performance characteristics are different, it would be wise to analyse them separately.

5.1.1. The student’s registration

The delineation of the student’s profile will be conducted by making use of questionnaires, tests and student modelling techniques. As explained in chapter 3.3.1 the domain specific information and the domain independent information will be gathered and processed. If we would like to picture this phase’s performance on a two-dimensional chart (performance, time), we would start from a high level of performance, since the technologies that we have access to allow us to produce a trustworthy student model. Subsequently, due to the improvement of the student modelling techniques over time and the exploitation of Big Data in a constantly increasing rate, we would display a slow but steady rise until we reach to a consistent flow. The consistent flow will be reached at the time that we will decide that the student model does not need to be more efficient in order for the student to be capable to actively influence the tutoring process and not become a passive observer of automated processes. Additionally, by that time many student types will have been processed and the process will take less time to be completed.

![Graph](image)

*Figure 8 phase's 1.1. performance*
5.1.2. The query refinement

The refinement of the query starts at this phase. The CAA and the OA are defining the student’s goals and are using information from the student’s profile (student model) and the query (ontology identity) in order to build the ontology language based on certain key words (the process is described in chapter 3.1.10). Information retrieval techniques will be used by the ontology agent who will access existing repositories that are assigned to the system. To picture the performance of this operation graphically, we have to assume that the available repositories to access are fixed. However, the number of accessible repositories that will be our source of information will change over time (our hope is to increase). For that reason it would be helpful to picture the behaviour of our chart during a change (increase) of a third variable (the repository number).

![Figure 9 phase's 1.2. performance](image)

As explained in chapters 3.1.10.1 and 3.1.10.2 the availability of accessible repositories is not the only variable that influences the performance of the resulting system. In fact, the accessibility to bigger amount of information only provides us with a reliable basis to start with. The processes that take place after that are also influencing the performance of our system. With the techniques analyzed in the abovementioned chapters, we are trying to encounter the various challenges. However, this part of the system is constantly developing and is directly affected by the progress of data science and information technology in general. When we succeed in perfectly defining theoretically the “similar to” concepts’ relation, this
would mean a boost to the performance of this phase of our system and a huge progress for Artificial Intelligence.

### 5.2. The resource gathering and course planning phase

The generation of the course is taking place during this phase. Since the course planning part is making use of IF-THEN techniques related to the resource prerequisites and postconditions (and its performance can be considered stable), the graphical representation of the performance as far as the whole phase is concerned, will be based on the part that is related to the resource gathering. This operation is the continuation of the query’s refinement process and is directly related with it. As explained in chapter 3.1.10 the resources will be followed by a description which will reveal their ontological identity and other attributes like cost, time for completion, effectiveness, evaluation results and others. According to this information the relevant resources will be selected and extracted from the available repositories/databases and the most suitable to formulate a course will be selected. This selection will be improving and becoming more and more sophisticated through the exploitation of the feedback, the information gathered during the evaluation phase and of course through the improvement of the query refinement phase (which is not taken into consideration for the diagram). The performance representation will reveal a steady grow in the beginning as the number of processed queries increases and a rapid grow as the time goes because of the evaluation systems’ development. Of course in the end a consistent flow will be reached.

![Figure 10 phase’s 2. performance](image-url)
5.3. The tutoring and monitoring phase

This phase consists of two parts. The monitoring part is following a certain strategy. Specific information has to be extracted like time, scores and general feedback through questionnaires. Thus, its performance can be considered consistently satisfactory or at least adjustable. Therefore, our interest will lie on the tutoring part of this phase. From the analysis that is presented at *chapters 4 and 5* and the phase’s description presented at *chapter 3*, we can derive that the tutoring process is dependent on two factors mainly. On the one hand the resource effectiveness and accuracy and on the other hand the pedagogical agent’s efficacy, in relation to the price. The resources can be considered responsibility of other agents (CAA, OA etc.) that appear in the previous phases and their performance can be followed on *figures 8 and 9*. The pedagogical agent’s (as a tutor) performance is very much related to the analysis and description of the different PA types presented at *chapter 4*. As far as the type of the PA, that has to be used, is concerned the information that will lead to that decision will be extracted from the student’s characteristics delineated at *phase 1*.

Conclusively, we have two indicators that influence the performance of this phase. One is the PA’s type decision related to the 1st phase’s performance (*Figure 8*) and the second is the PA’s evaluation of performance described at *chapter 4*, according to which the system is improving steadily over time through indicators like time, cost, grades, feedback etc. Having that in mind, we cannot present the performance diagram of this part else wise rather than linearly with a slow but steady increase over time until the point that the desired rate will be obtained and followed.

*Figure 11 phase’s 3. Performance*
6. Conclusions and Future Research

In relation to the research questions addressed in this assignment, we observed that the Digital Marketplace for Education is a model that reflects not only big interest but also great concerns. Our goal is to manufacture a digital university, based on agent technology, which will be able to provide high quality training and tutoring in a wide range of possible topics and queries. On a theoretical basis the goal seems feasible. However, on a practical basis it would be wise to highlight the difficulties and the challenges that will rise during certain operations of the resulting system. Throughout this assignment, the categorization of the system’s procedures into three phases has been very helpful in order to organize our thoughts and be able to analyze the flow and the processing of the information. The same tactic will be followed also in this chapter in order to point out the challenging parts that demonstrate high risk.

The student registry phase is characterized, among others, by the application of student modelling techniques for the delineation of the student’s profile. This operation will be the basis for almost every other task that will take place in the system and also will be a precondition in order to achieve high quality results. Our goal here is to design a marketplace for education that will be able to adjust its operations and behaviour according to different learner characters. Every character’s state and cognitive attributes will be processed by the system and stored for future use (Mark Elsom-Cook, 1993). These student models that will be created are considered the first big challenge of this idea and should be a subject of deep research and planning. Information about this system’s description in relation to exploitation of existing student modelling methods, will lead to the construction of a technique that will fit perfectly to our needs and objectives. The problems that exist here and require attention and further analysis result from the difficulty to model the emotional factors of the student’s attributes meaning the motivation or the desire to achieve his or her goals (Mark Elsom-Cook, 1993). These factors play a significant role when the tutoring process is undertaken by a human instructor. It is true that the utilization of modern techniques and trends like “big data” or “internet of things” could allow us to build very accurate student models. Many companies already exploit these technologies successfully to build customer models. However, are we sure that taking the absolute control of the decisions and methods to be used is the best way to treat a student? According to Self J. A. these problems do exist but they are not as difficult as we think to overcome (Self, 1990). The solution lays in understanding exactly what it is that we need to achieve. Student modelling is not about trying to build the exact cognitive model of a student. If that was our need we would have to solve all the problems related to cognitive science (Mark Elsom-Cook,
In our case, the real need is to take advantage of student modelling techniques, only to the necessary detail level that is required in order to enable the crucial teaching decisions to be taken. For example, if the Pedagogical Agent has only two ways of action, then the model should be capable to provide enough accuracy only for this decision to be taken (Mark Elsom-Cook, 1993). In addition, our need is not to build a powerful system that will be in the position to infer every detail or piece of information that is needed. We are aiming to build the program in such a way that the student can choose and control the information that has to be provided in order to receive the desired services. By the knowledge seeker encouraged to collaborate actively on building the model it is believed that we will maximize the value of the educational process (Mark Elsom-Cook, 1993).

The query refinement and the resource gathering phases are both characterized by the ontology language that leads to the formation of the ontology identity. The operations that take place at this point will lead to the construction of a complete course that will answer accurately to the knowledge seeker’s query and will provide relevant and efficient guidance for it. This is the reason why this part ranks among the most challenging parts of the system which require attention and research. By making use of ontology matching we are aiming to filter the resources which we can access and extract those relevant to our query that can provide us with the desired training. To succeed in that we need to enter existing taxonomies and repositories of data and match the ontology identity that we generated for the query with the ontology identity that already exists to the description of the available resources. In order to achieve accurate matching of resources the Ontology Agent has to be programmed to take specific actions. The width and complexity of the scope of the information that the Digital Knowledge Marketplace for Education will process is forcing us to try to make use of existing taxonomies and ontology lists instead of trying to build new ones of our own (Natalya F. Noy and Deborah L. McGuinness).

What we are interested in is to build an identity that will allow us to be precise when we need to. This will happen through the OA’s operations that will combine existing ontologies and extract the corresponding information whose level of detail will be totally dependent on the query’s complexity. Our estimation is that the utilization of existing taxonomies and databases to answer an educational query will be very challenging, but feasible. An important issue that exists here is to evaluate somehow the course that will be generated and ensure that it will be effective before it is taught (Peter Cassin et al., 2003). This task is very difficult to perform because an educational course is always subjective. An idea would be to run the ontology extraction process (analyzed in chapter 3.1.10.1.) many times, in order to observe the outcome (data included in the course and data excluded from it). This will reflect the consistency of the process (Peter Cassin et al., 2003). In general, the extractor requires a lot of research in order to operate as needed.
The reason that the term “Marketplace” is included in the title of our system is the involvement of monetary units in its operations. The pricing system and the way this issue will be addressed by the Digital Marketplace for Education should be considered a subject of serious research and analysis. On the one hand money increases the system’s quality, accuracy, reliability. Additionally the field becomes more attractive to potential investors. On the other hand the complexity increases and the regulations of the market have to be carefully defined. Although knowledge is relatively static by itself, it becomes very dynamic when we are talking about knowledge services. The idea here is to create reputation mechanisms and dynamic pricing algorithms in order to control the continuous variation of Pedagogical Agent and Pedagogical Resource prices. These variations have to be directly related to effectiveness and evaluation (Hai Zhuge & Weiyu Guo, 2007, 1837).

The tutoring and monitoring phase contains the system’s practical value and provided services. On the one hand we have the pedagogical or educational part which satisfies the student’s demand. On the other hand we have the monitoring and evaluation process which ensures the system’s sustainability and quality. The tutoring process is represented by the pedagogical agent. The analysis of the PA led us to the conclusion that different “characters” of agents should exist in order to cover the pluralism of student profiles and maximize the model’s efficiency. Concerning the evaluating mechanisms described, reliability, transparency and integrity have to be ensured. The fact that the evaluation process is directly related with the monetary value of the resources, the tutors or the courses, forces us to address this operation very carefully. Our goal is for a reliable grid of rules and regulations to be built. Automated processes during the evaluation will ensure honesty among the users. Additionally, automated operations and transparency have to be promoted during the contracting phase.

The final part that has to be considered and included in the part of the conclusions and future research is the testing part. The challenges that we are currently facing concern the following factors. Firstly, the amount of information and resources that the system and the agents will have the ability to access has to be tested. Secondly, the simultaneous interaction of many users through the system forces us to address the stability issue. And thirdly, the reliability of the tutoring material or the communicated information puts security and transparency into consideration. The needs of the model require for a large-scale testbed to be developed through several web related sites and different user profiles (different types of learners and possible tutors). Additionally, the testbed should be able to support different types of multimedia services as well as provide access to the needed sources of information. Agent technology should be supported and security has to be considered.
Conclusively, we have by now realized that we are not far from achieving our goal. That is to abolish the borders in education and help the knowledge seeker to obtain the maximum benefit from the existence of the millions of digital educational resources. However, there are still steps to be taken and research to be conducted. If something is for certain, that would be the interest of individuals and organizations or universities to reach to a solution. And this is not because we are talking about a good investment or a new form of marketplace that can be rewarding for some people. It is because education is what survives when what has been learned has been forgotten (B.F. Skinner).
7. References


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