# An Adaptive Personalized E-learning Model Based on Agent Technology

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*Abstract:* - Due to overall popularity of the Internet, E-learning has become a lot methods of learning in recent years. Through the Internet, learners can freely absorb new knowledge without the restriction of time and place. Based on individual difference of learner's abilities and preferred learning styles in hypermedia environment, the learning outcomes vary essentially. Meanwhile, with the development of E-learning technologies, learners can be provided more effective learning environment to optimize their learning. Adaptive E-learning systems are built to personalize and adapt E-learning content, pedagogical models, and interactions between participants in the environment to meet the individual needs and preferences of users if and when they arise. In our paper, we first explain the grid agent E-learning model, whose main actions including registry, directory and discovery. Through these actions, the manager's agent will find out the suitable learning services. Secondly, to implement the adaptability of the grid agent model, the method of Artificial Psychology and how to realize adaptive personalized E-learning by this method so that are the student's agent can employ the learning material matched to their own personality type are also emphasized. The experiment data also supported our assumption that the learners may perform better if they use our adaptive grid agent model.

*Key-Words:* - Personalization System; Adaptive System; E-learning; Grid Agent; Artificial Psychology

## 1 Introduction

With the development in communication and network technology in recent years, under the gradual improvement of network bandwidth and quality, the real-time transmission of high-quality video and audio becomes possible [1]. Therefore, the transmission of multimedia and relative network application technologies have gradually been developed and become popular, such as the technology of Distance Education, Video Conference and Video on Demand [2], etc. E-learning is an aspect of distant learning, where teaching materials are accessed through electronic media and where teachers and students can communicate electronically (email, chatrooms……).

There are many E-learning or E-education tools/platforms, such as SMART EDU [3], JADE [4] , etc. Usability is the vital role of E-learning and online game systems. But there are more works can be done [5]. Adaptive E-learning systems, deal with appropriate personalization and adaptation techniques (smart curriculum sequencing, navigation guidance, intelligent problem generation and analysis of solutions, adaptable interfaces, adaptive contents, etc.) in order to maximize the effectiveness of learning [6]. Adaptation system is the central component of any E-learning system and is responsible for tailoring learning materials or contents according to the learner's style, profile, interest, previous knowledge level, goal, pedagogical method etc. to provide highly personalized learning sessions. Customer preference and satisfaction are going to be more and more important to both E-learning and online game. Computer Science, together with Psychology and Education, has been trying to refine teaching computational tools towards individual-centered or personalized self-learning [4][5][7][8]. Every day, new approaches to the use of computer and education are bringing new perspectives to this area. The evolution of computer and education became computational teaching environments an excellent choice for distance learning, by bringing new vigor to this field of science.

E-learning projects must take into consideration that there are different classes of users. A simple result can be [9]: the non-cooperative, those who act in a passive way or even try to frustrate the program's objective; the cooperative, who follow orientations, but do not necessarily know where to go; and the pro-active students, who know very well their objective, and search for aid to relief the task burden. Obviously this method is too cursory, especially to arts E-learning and online games. Study about cognitive expansion of queries aims at the implementation of a knowledge-based query builder that allows complex query building in tight cooperation with the user. Due to the cognitive knowledge involved, these complex queries are expected to return more relevant results than traditional database queries or classifications [6][7]. Besides advanced techniques in personalization (preference modeling, etc.) research issues will have to focus on results from sociology and psychology to include implicit knowledge about human behavior and social expectations in the retrieval process.

The learner uses learning resources for the achievement of his educational goal. The E-learning environment can be considered as a virtual organization that supplies the learning resources. Its objective is to ensure a flexible, coordinated resource sharing among dynamic collection of learners and cooperative use of resources. Since the reusability, resource sharing and virtual organization are characteristics of a grid organization, the conceptual computer system ( E-learning environment) can have grid architecture [11]. The learning resources are presented as learning objects, since the grid organization bases on a homogeneous E-learning environment. The interface between the user and the conceptual computer system ensures the learner's access to the grid services, which implement a usage of available learning resources [12].

The teaching methodology employed in each case is different and there must have a clear concern by the technological environment on the profile of the user that will use the system [13]. In order to reach this goal, cognitive student's modeling is required, and it must make a clear specification of him or hers, including his or her psychology.

This paper presents a grid agent model based on artificial psychology to realize personalized E-learning. One main purpose of Artificial Psychology technologies is to imitate human psychology with computer, meanwhile, to provide some subjective evaluations for the objective things. This kind of research in e-learning is still at the beginning.

In this article, we first hope to expand on the current research issue in section 2 and E-learning indicators in section 3 , and then explain in section 4 the difference of E-learning and Distance Education, and in section 5 the relationship of Access Grid and Grid Computing. And explain in section 6 which model can resolve such kind of problems that we mentioned before, including three kinds of agents: student's agent, manager's agent and teacher's manager. Then to implement the adaptively of the Grid agent, in section 7, we describe how the grid agent is able to seek for the knowledge services according to the student's characteristics automatically and precisely. In section 8, the experiment data also supported our assumption that the learners may perform better if they can employ the learning material matched to their own personality type in the learning process. The conclusions are stated in Section 9.

## 2 Current Research Issue

While learner model plays an important role in the personalization of E-learning systems, it is seen as a part of the E-learning system in many applications [14]. The learner model and data contained can only be used within that particular system they belong to. Every personalized system uses its own learner model, and therefore, several models of the same user exist within different personalization systems [15]. This issue prevents the E-learning systems to provide better personalized support to meet the individual learning requirements for the following reasons:

- Each E-learning system implements a mechanism to gather individual learner's data to construct its learner model [16]. For example: Submission of a questionnaire for the first time the student logs onto the system to infer the learning style of the learner, keeping track of the learner's answers of test questions maintain and update a model for learner's prior domain knowledge. Since each E-learning system maintains its own learner model, this model is constructed from data gathered locally from the system, therefore, the system are not able to access or exchange useful information of the same learner gathered from other E-learning systems [17]. Thus, each system's learner model represents only a partially view of learners.
- The characteristics of learners modeled in the E-learning system evolve during the learning process [18]. For example, after browsing an education web page about earthquake, the knowledge state of the learner on earthquake changes and the model of learner knowledge need to be updated accordingly. Since each E-learning system maintains its own learner model, when a learner takes a learning activity in an E-Learning system, only the learner model of that system will be able to get updated while other system's model remain unchanged [19]. Thus, each system's learner model may represent an obsolete view of the learners.

To overcome these problems, our paper proposes a grid agent model technique for E-learning system.

## 3 E-learning Indicators

Defining, measuring and evaluating E-learning indicators was the essential research investigation realized.

We have defined the E-learning indicators as the important concepts and factors that are used to communicate information about the level of E-learning and their impact on learning as such that could be measured and described then in simpler terms and could be understood and used to make management decisions when planning E-learning strategy for an institution or University. In order to define and assess the E-learning indicators we have gathered the data for this research from interviews with E-learning specialists mentioned in the acknowledgment section and participants, focus group and a web based survey of academic staff and students.

What we have defined as E-learning indicators are: (1) learner education background, (2) computing skills level, (3) type of learners they are, (4) their learning style and intelligence, (5) obstacles they face in E-learning (E-learning barriers), (6) attention, (7) content( suitability, format preferences), (8) instructional design, (9) organizational specifics, (10) preferences of E-learning logistics, (11) preferences of E-learning design, (12) technical capabilities available to respondents, (13) collaboration, (14) accessibility available to respondents, (15) motivation, (16) attitudes and interest, (17) performance-self-efficacy( the learner sense their effectiveness in E-learning environment).

The E-learning indicators are assessed then measured and evaluated for the virtual learning environment Angel Learning Management System-ALMS. The analyses and specification of the E-learning indicators: (1) learner education background together with his cultural background is set as indicator since it is a direct factor that is associated and impacts E-learning [20]. According to, students today come from a variety of cultural backgrounds and educational experiences outside of the traditional classroom. How do students construct meaning from prior knowledge and new experiences? Based on this facts and interviews with E-learning specialist we have set it as important indicator [24]. (2) computing skills level of the learner is set as indicator since it directly influences the way E-learning because of the computing skills requirements. The indicator(3) type of learners they are depends primarily on the balance in the two dimensions of the learning style scale model formulated by [22]. The important of the type of learner (indicator 4) and their learning style is analyzed for both instructor and student. For instructors it is of important since it reflects the preferences of learning style to students. We advise to tend to use each learning style to teach also in a delivery type suited to other types of learners and turning to bring it closer and generalized to include all the types using visualization and verbal communications, as well as other communication tools. The indicator(5) obstacles they face in E-learning is set as important based on interviews and speaking with E-learning specialists. Indicator(6) attention is set as very import, attention cues when the learners begin to feel some mental workload. Indicator(7) E-learning content we consider as vehicle of the E-learning process and knowledge construction. The quality of the virtual learning environment is mainly depending on the quality of the presented E-learning content [23]. Indicator(8) instructional design has gained significant prominence in E-learning for a number of compelling reasons. One of them is the possibility for instructional design to systematically address the need for creating and evaluating students' learning experience as well as learning outcome. The other is instructional design can help faculty to focus on using the appropriate format and tools for the appropriate learning objectives [25]. Indicator (9) organizational specifics-every organization has its specific business processes that influences and impacts E-learning [26], (10) preferences of E-learning logistics-targeted at learners of different experience levels and organizational background, based on the ELA model-the European Logistics Association [27]. Indicator(11) preferences of E-learning design; Designing instruction needs to be flexible to address these differences [28]. The next indicator(12) technical capabilities available to respondents (13) collaboration; (14) accessibility available to respondents, are defined as important indicators in discussions with E-learning specialist and expert; (15) motivation, is essential to learning and performances, particularly in E-learning and performances, particularly in E-learning environments where learners must take an active role in their learning by being self directed. (16) attitudes and interest; A review of studies on attitudes toward learning and using information technology in education and using information technology in education has revealed that most studies have shown that students' attitudes toward technology are critical [29]. (17) performance: self-efficacy refers to people beliefs about their capabilities to perform a task successfully at designated levels [30].

## 4 E-learning and Distance Education

The development of current Distance Education System for E-learning can roughly be classified into 3 types as follows:

1. Multicast Teaching System:

This type of system is that the teacher and the students can be located in different places. By using network technology, the video/audio of the classroom teaching and multimedia teaching materials can be transmitted real-time to the remote side classrooms. Furthermore, it allows the two-way real-time communication between the teacher and the students in remote side classrooms.

2. Virtual Classroom Teaching System:

This type of system adopts one set of teaching management system to simulate the scenario of attending class in classroom(such as teacher's lecture, holding examination, specified assignment or questions answering, student proposed question or participating examination, etc.) Teacher and students can link to the teaching management system at any time through the Internet in front of computer for teaching or learning.

3. Video on Demand Teaching System:

This type of system adopts the technology of VOD(video on Demand). Students can obtain the learning teaching material through the Internet by using the computer or TV furnished with SetTop Box and to process distance learning in accordance with personal learning speed by controlling the broadcasting process.

The teaching mode combines Multicast and VOD teaching modes. Real-time video teaching is performed at fixed time but the rest of time is only web teaching. For instance, after the class, the video teaching course is produced as video stream file for broadcasting online for the convenience of learners who can not watch the real-time video teaching course.

## 5 Access Grid and Grid Computing

Access Grid is the technology developed by U.S. Argonne National Laboratory. It enables many people to process interactions and opinion exchanges through video and audio. At present, it has been used in many sites that need video such as training, teaching, conference and seminar, ect. The application software of Access Grid is called Access Grid Toolkits. This is a freeware that anybody can freely download from the Access Grid is called Access Grid Toolkit. This is a freeware that anybody can freely download from the Access Grid web site. On the web site, it also provides complete technical archives for giving necessary assistance to its users. Up to September 2003, the latest version of Access Grid Toolkit is Version 2.1.

Before Access Grid Toolkit Version 2.1, Access Grid is only a kind of video conference system. After Version 2.0, Access Grid has already tightly combined with Grid technology, therefore the grid middleware with grid technology, therefore the grid middleware globus toolkit needs to be installed before the installation of Access Grid Toolkit 2.0.

The middleware Globus will check thoroughly all the available resources in the grid when making a computing task, such as which hosts are available, how much processing capability is left, what the available data is in the database. Then, the tasks required by the users will allocate its resources and control its action by the system.

As AG(Access Grid) 2.0 has already tightly combined with grid so that all the functions of grid technology such as authentication, resource allocation, and remote data access and fault detection are the standard function of Access Grid; At the same time , XML web service is also the data transmitting method of Access Grid.

In Globus Toolkit 3.0, Web Service is already the standard architecture named OGSA(Open Grid Services Architecture). The web service based on OGSA is also named Grid Service.

## 6 The Architecture for Personalized Grid Agent e-Learning Model

The System established in this research will use the following architecture as Implementation:

1. The front end:

By using Access Grid technologies, the school can integrate their training courses and material into Grid environment which provides more fexible teaching mode.

It is necessary to set up a portal web site in the Access Grid System first, which not only provides services to the members of the Grid, but also acts as a teaching platform for the other academies through the internet.

Behind the portal web site, we will set up a video conference platform via Access Grid Toolkit.

In AG 2.0, Virtual Venue is the most important part. It is divided into three major parts, which are Venue server, Venue client and Venue Server Management Client. Their major function is to provide one collaborate place to all users.

The advantage of Virtual Venue is unlimited expansion; that is , if a new organization is to join the e-learning parade of Access Grid only if this new organization establishes its own Virtual Venue and establishes the inter-authentication relationship with other existing Virtual Venue, it can join the Access Grid and become one of the member.

Virtual Venue is a place where users collaborate so that we can establish one Data Grid Node in one Virtual Venue as the place for storing teaching resources. For the students who could not participate in the real-time courses, they can also watch them after the classes. Nevertheless, the files that record the video of the classes are usually so huge that they require high capacity of storage device such as Disk Array, NAS or SAN, Therefore, we can use Data Grid technology to substitute the above storage device. Establishment of Data Grid only uses the internal idle teaching or administration computer resources within the school. In this way, it is possible that the storage space obtained will not be less than that fo an expensive storage device. Data Grid environment consists of two important elements: GRIS(Grid Resource information Services) and MDS(Metacomputing Directory Services). GRIS provides an infrastructure for storing and managing the status and components around the whole Grid. MDS is based on LDAP(Lightweight Directory Access Protocol), which is used for storing and looking up data related to information on the Grid.

The Data Grid Architecture we adopt is separated into two parts. For the part inside the school we call it local Grid, which is formed by two nodes.

2. The Back end:

The system can not only be applied to the teaching on campus, but also provide other academies through the Internet to share its teaching material. Here we bring up an Internet virtual organization concept of partner Academy, which can be regarded as a Resources Receivers who can not only share the present sources on the Internet, but also act as a Resources Providers who provides resources. Each partner academy can provide different resources according to its specialty.

Based on the architecture of Data Grid, information placed in each local Grid should have its uniqueness and will not be repeated. For example, what is placed in school A will be mathematics and what is placed in school B will be teaching content of literature. In so doing, it will not result in waste of teaching resource investment.

Our project proposes a development and implementation of Distribute Intelligent Learning Environments, based on the approach of grid agent architecture towards Distance Education, for multiple domains.

Our architecture encompasses a grid agent environment composed of there kind of agents responsible for the system general control (student's agent), and a communication manager (manager's agent) and knowledge service (teacher's agent), where each agent may have its tasks specified according to its goal. A grid agent is any agent in the grid space. Each grid agent acts independently with other automatically find out each other on the grid and form one or many units called Grid unit which is similar to classroom. Grid member will self-organize into grid unit. Any grid agent will register with grid space manager to publish the service description of him and it can join or leave the grid unit at any time.

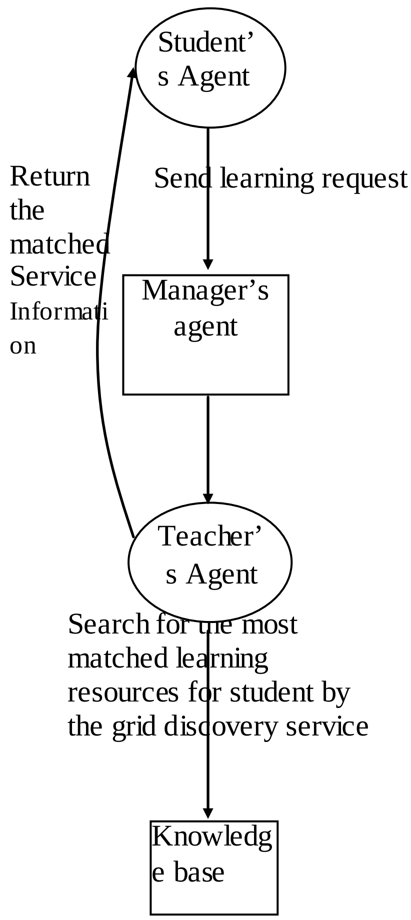


Fig 1 the Grid agent architecture

A grid member provides services that can be used by other grid members. A grid agent can contain behavior rules, and interacts with other grid agents using specialized communication language. Every grid unit has just one communication manager (see fig 1.).

All actions of student's data accessing are taken by the Student's agent, thus when a teacher agent is required to update the student's historic, this agent sends to the Student agent data to be updated, as well as any other change in the student's state of teaching. The tasks performed in teaching are decomposed and performed individually or in groups of agents. How the task will be decomposed is defined by the content of messages exchanged between agents. In our work, we aim at generates an educational course in accordance with understanding of a student. The teacher agent dispensable and the student model agent cares more about the experimental knowledge than traditional tools[31], and one additional work of the communication agent is cognitive query.

The knowledge base plays an important role in personalized e-learning systems. User psychology, a kind of implicit knowledge, is quantified in our work and a new adaptive model involving artificial psychology is presented in chapter 7. It communicates by exchanging information about the knowledge base of the whole system.

There are many services provided by the adaptive grid agent e-learning model, the main services are:

Agent registration service: it provides a mechanism to register services of various resources, including student, teacher and knowledge.

Agent directory service: it is used to publish the attributes of all grid agent services registered in the grid.

Agent discovery service: grid agent members to search for resources use the agent discovery service. The aim of the agent discovery service is to find out the best service even if the seekers just specify little parameters of interest. The discovery services first look up the directory service for a set of services that satisfy the requestor's need, then filters the set of services according to the criteria in the request.

An enquiry to a manager's agent will not only find the knowledge that the service request agent need but also the data processing techniques and the computing power to carry them out before sending to the service request agent the results.

The main actions involved in grid agent service discovery process are registry, directory and discovery. When any grid agent wants to enter in the grid unit, it must register its presence by publishing its services descriptions with the grid space manager. First, the service request agent (student's agent) needs a certain mount of descriptions to specify the services. And so, when any student's agent wants to search for learning service, it just needs to send asking signal with the request services descriptions to the manager and the manager will find out services by its descriptions, various grid service agents can be located. If the service request agent decides to access the service then it requires a set of information to ensure successful operation of the service.

Table 1 Average Table

| | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| hard-easy | 0.1 | 0.7 | 0.3 | 0.5 |
| advanced-primary | 0.3 | 0.5 | 0.8 | 0.2 |
| basal-prefessional | 0.5 | 0.6 | 0.8 | 0.9 |
| … | … | … | … | … |

Table 2 Numerical Representation

| | sample 1 | sample 2 | sample 3 | sample 4 | sample 5 |
|---|---|---|---|---|---|
| red | 55 | 108 | 234 | 199 | 23 |
| green | 123 | 111 | 67 | 9 | 100 |
| blue | 233 | 122 | 101 | 200 | 255 |
| lightness | 20 | 30 | 40 | 70 | 10 |
| cold or warm | 30 | 70 | 50 | 30 | 10 |

## 7 The process of Adaptive Service

To implement the adaptively of the grid agent, every grid agent should remember the evaluation of the former cases made by user, and analysis the evaluation to gain experience. Every grid agent has a repository to record the evaluation of former cases. The grid agent use Artificial Psychology (AP) to analysis the preference of user. We will illustrate this process in details as following. First, the grid agent collects the adjectives used by user to describe his or her requirements of the service, such as "advanced-primary", "hard-easy". However, not all the adjectives pairs are necessary; some adjective pairs have close correlation. So the representative pairs should be abstracted by factor analysis[32]. The repository will record the numeric evaluation value of every case corresponding to the adjective pair. Second, the user should fill a questionnaire to describe the service that he needs. At last, the grid agent will select the appropriate service according with the user's preference.

For example, a learner want to learn a computer course in the internet, firstly, there is a user preference value correspondence with the adjacent pair, and we call them average of the inquired samples, such as table 1. We can get the value like this, for instance, for advanced-primary, 0.1 represent lowest grade, 0.5 represent medium grade, 0.9 represent highest grade. Then we select red, green, blue, lightness, cold or warm as the items. We measure the colour value (0-255) by PHOTOSHOP; the value of lightness and the value (0-100) of cold or warm are obtained by the questionnaire. The result is given by table 2:

The corresponding reactor matrix:

$$X = \begin{bmatrix} 55 & 123 & 233 & 20 & 30 \\ 108 & 111 & 122 & 30 & 70 \\ 234 & 67 & 101 & 40 & 50 \\ 199 & 9 & 200 & 70 & 30 \\ 23 & 100 & 255 & 10 & 10 \end{bmatrix} \qquad (1)$$

With the help of Quantification Theory Ⅰ, each case can be written in the form of reactor matrix. According to the formula of Quantification Theory

$$\text{Ⅰ}: b = (X'X)^{-1}X'Y \qquad (2)$$

We obtain the quantification relationship of the adjective pairs and the case, with Y is a column vector and its value is the average of the previously evaluation corresponding to an adjective pair, like table 2. X is the reactor matrix. All values of b correspond with the adjective pairs are obtained. By replacing b with its expression, we can calculate the evaluation Y of case with the help of the predictive formula:

$$\hat{Y} = Xb \qquad (3)$$

The evaluations are stored in the grid agent's repository. When a service request agent begins its requesting, it will depend on its repository to decide its next behaviour, we understand easily why it is more and more accurate over time. The consequence is an improving self-organization process between all grid agents in the grid space.

A new grid agent does not have enough cases in its repository, but it can use the existing ones that have already been evaluated by the other grid members, it can use the knowledge transitorily, and then adjust the knowledge in its repository. When a service request agent asks for service, the preference will go along with the service request description, so that the service request agent can implement the adaptively of the grid agent in information retrieval.

Table 3 Task Performance in Traditional Model

| Personality type | *Reading time (Mins)* | Number of Correct answer |
|---|---|---|
| Pro-active | 6.5 | 15.01 |
| cooperative | 8.9 | 12.55 |
| Non-cooperative | 11.34 | 13.09 |

Table 4 Task Performance in Our Model

| Personality type | Reading time (Mins) | Number of Correct answer |
|---|---|---|
| Pro-active | 5.9 | 16.72 |
| cooperative | 8.1 | 14.41 |
| Non-cooperative | 10.09 | 13.32 |

## 8 The Experiment

An experiment was conducted to examine the relationship between learner's personality type and their preferred learning content structure. 30 participants took part in this experiment. They were all homogeneous in terms of their previous learning outcomes in other courses. Firstly, all the participants underwent the MBTI test [33] to identify their personality types, revealing 9 were non-cooperative, 13 were cooperative and 8 were pro-active. All the participants were undergraduate students (aged 18-25), who had enrolled in the Computer Science course. Whilst the validity of MBTI is still under the criticism from the psychometrics community, we simply choose this test as it has been widely used and extensively validated in the education domain. Table 3 and table 4 summarize the task performance of traditional e-learning model and our model respectively. Comparing the performance between the non-cooperative, the cooperative and the pro-active learners in traditional model, it seems that the pro-active learners read all the contents very quickly and they get best grades. The cooperative spend more read time than pro-active and few time than non-cooperative, but It probably led to a fewer number of correct answers. In contrast, the non-cooperative learners spent considerably more time on reading materials, so it would result in more correct answers than the cooperative learner.

We also analyzed the performance of our model in the same way as shown in Table 4. In this case, it appeared that the pro-active outperformed the cooperative and the cooperative outperformed the non-cooperative. This implies that when the pro-active and cooperative learners were being taught by our model, which seems to match with their personality type, they tend to adopt a holistic approach to the learning process. These results also supported our assumption that the learners may perform better if they can employ the learning material matched to their own personality type in the learning process.

## 9 Conclusion

E-learning in the present form is still in a static form and there are a lot of skeptics about its usefulness [34]. One reason for the skepticism probably lies in the fact that E-learning has not really revolutionized learning and teaching as promised. Far reaching, novel ways of teaching and learning, facilitated by ICT [35], remain still to be invented. In order to answer the question what makes a successful E-learning we took the approach with E-learning indicators. We have proposed, assessed measured and evaluated the E-learning indicators that we think communicate the information about the level of E-learning and their impact on learning as such that could be measured and described then in simpler terms.

E-learning is meant for learner communities [36], which may vary significantly in terms of accessibility, hardware and technical proficiency. Hence, Instructors must design the courses keeping in mind the learners' technical limitations so that they may use e-learning tools effectively [37].

Adaptation system is the central component of any e-learning system and is responsible for tailoring learning materials or contents according to the learners' style, profile, interest, previous knowledge level, goal, pedagogical method etc to provide highly personalized learning sessions[38].

In this paper, advanced adaptive personalized approach using grid agent and artificial psychology techniques is investigated. In the process of the model construction, we synthesize grid agent techniques and AP mathematics theories, and integrate them to form the Architecture for personalized e-learning System. From the two empirical analyses, we have identified that our adaptive e-learning model which matching learner's personality with the learning material designs outperforms than traditional model. From the perspective of all available evidence it points toward growing enrollments and provision albeit from a low staring point. We are in an opinion that the future quality development in E-learning has to be oriented at the learners needs and their specific situation that needs to be measured and evaluated using the E-learning indicators[39].

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