

# Bio-Inspired E-Learning Systems – A Simulation Case: English Language Teaching

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## 1. Introduction

The objectives of using new computing techniques in e-learning systems are defined by the necessity of teaching according to the individual needs of the students, to whom education should provide different e-contents, pedagogical paths and interaction manners.

As nowadays e-learning systems are too rigid, there have been numerous attempts to develop really adaptable e-learning systems (Paramythis & Loidl-Reisinger, 2004) (Brusilovsky & Nijhavan, 2002). This implies hard work and teams formed of specialists from diverse fields: instructional, computer science, teaching area experts and important financial and time resources. The main factor that affects the functionality of e-learning systems is the human being, an instable factor, and, therefore the instructional objectives depend on an instable and unpredictable factor.

As a result, an e-learning system has to be prepared to deal with any learning situation. Building an e-learning system efficient for any learning context is possible only on the condition of using new computing techniques. In the field of online instruction, the part called machine's intelligence has a primordial role. The machine's intelligence derived from sophisticated software programme having the following features: adaptability, flexibility, reactivity, autonomy, collaboration and reasoning capacity.

Intelligent Tutoring System and Adaptive Hypermedia System are the main types of e-learning systems that provide instruction according to the parameters of the instructional process. These parameters characterize the actors of the instructional process and the environment and are included in the components of an e-learning system: expert model, learner model, instructional model and interface model (Phobun & Vicheanpanya, 2010)

An adaptive system is a system that changes its behaviour according to the environment's changes in order to reach certain goals. An intelligent e-learning system is an adaptive, complex system. The complexity of the system is due to the different interactions between its component parts and to the nature of these interactions: human-machine, human-human via machine and machine-machine. To confer the system self-learning capacity, the usage of artificial intelligence is imperative.

In (Ruiz et al., 2008), the authors present two types of e-learning systems which adapt taking into account the learning styles of the learners:

"1. Systems that use learning styles to guide the design of the educational contents. These systems are based on offering the users the type of materials that are preferred by individuals classified in their specific learning style.

2. Systems that use learning styles to guide the adaptation of the structure of the contents to the mental processes of each individual (particular styles of thinking, perceiving or remembering) that falls in a certain category.”

The adaptation property of the e-learning systems presented in (Ruiz et al., 2008) is reached using a set of rules or using objects with a certain format adequate for each instructional situation.

Learner's classification, considering his/her individual learning style is used in the software system for online learning proposed in (Moise, 2007), called iLearning. The system is based on shaping a course by means of conceptual maps. Each node of the conceptual maps contains pedagogical resources in different formats and structures according to the learning styles of each student. The implementation of an iLearning system on a computer is realised using intelligent agents technology.

The system described in (Tzouveli et al., 2008) offers a flexible solution capable to adapt to learners' preferences using e-questionnaires to establish automatically learners' profile.

The problems of adaptation and flexibility of the e-learning systems are difficult, as the main actors are complex and unpredictable. In order to solve such problems, the researchers ask for new computing techniques.

Bio-computing techniques simulate biological mechanisms and are used in solving the most difficult problems. The purpose of this chapter is to present e-learning systems architectures based on new computing techniques, namely neural networks and swarm intelligence techniques.

Artificial neural networks techniques are inspired by the activity of the human brain and swarm intelligence techniques are inspired by insects' behaviour. The authors selected these artificial life techniques in order to solve the problems related to collective and individual intelligences, collective and individual behaviours, collective and individual knowledge. The expected results are: a higher level of students participation in the instructional process, a better internalisation of rules and contents, more numerous and diverse types of interaction, a higher level of motivation and self-esteem. The expected results respond to cognitive, psychological and instructional demands.

## **2. Theoretical background**

In this section, there are presented two bio-inspired techniques, namely neural networks and swarm intelligence, techniques that may be successfully used in designing adaptable e-learning systems.

Bio-inspired techniques, unlike conventional intelligent techniques, use algorithms that enable them to learn by themselves, without further human intervention.

### **2.1 Neural networks**

Neural networks are structures inspired from neuron circuits of the nervous systems and they are composed of interconnected computing units. Each neuron sends and receives impulses from other neurons and these changes are modelled as data changes. The main element of a neural network is the artificial neuron. Some indexes of neural networks development are the following: Warren McCulloch and Walter Pitts proposed the model in 1943 and it has still remained the fundamental unit of most of the neural networks. (McCulloch and Pitts, 1943) In 1958, Frank Rosenblatt added the learning abilities and developed the model of perceptron. (Rosenblatt, 1958) In 1986, David Rumelhart, Geoffrey

Hinton and Ronald Williams defined a training algorithm for neural networks. (Rumelhart, Hinton, Williams, 1985) The diagram of a neuron with  $d$  inputs and one output is presented in figure 1.

The main elements of a neural network that affects the functionality of the network are: the structure, the learning technique and the transfer function that reflects the way how the input is transferred to the output.

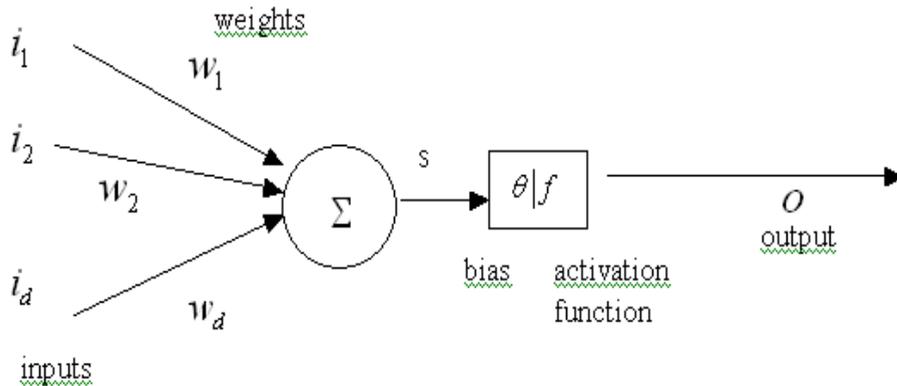


Fig. 1. Neuron with  $d$  inputs and one output.

Each input has associated a synaptic weight, noted with  $w$ . This weight determines the effect of a certain input on the activation level of the neuron. The balanced sum of the inputs  $\sum_{j=1}^d w_j i_j$  (called net input) defines the activation of the neuron. The net input value is based on all input connections.

The net input can be calculated using the euclidian distance:  $\sqrt{\sum_{j=1}^d (w_j - i_j)^2}$

The function  $f$  represents the activation (or transfer) function and  $\theta$  represents the bias. The output ( $o$ ) is calculated using the following formula.

$$o = f\left(\sum_{j=1}^d i_j w_j - \theta\right) \tag{1}$$

The most used forms of the activation function are presented in the formulas 2-6.

- step function

$$f(s) = \begin{cases} 0, & s \leq 0 \\ 1, & s > 0 \end{cases} \tag{2}$$

- signum function (used by Warren McCulloch and Walter Pitts)

$$f(s) = \begin{cases} -1, & s \leq 0 \\ 1, & s > 0 \end{cases} \quad (3)$$

- linear function

$$f(s) = s \quad (4)$$

- sigmoid function

$$f(s) = \frac{1}{1 + e^{-ks}}, k > 0 \quad (5)$$

- generalized sigmoid function

$$f(s) = \frac{1}{1 + a * e^{-bs}}, b > 0 \quad (6)$$

There are two fundamental structures for the neural networks: the feedforward neural network and the neural network with reaction. In the model proposed by Moise (Moise, 2010), it is used a feedforward neural network with a topology on levels, according to the geometrical positions of the neural units (figure 2).

The model of a feedforward neural network with one input layer (with  $d$  units), one hidden layer (with  $p$  units), one output layer (with  $n$  units) and a linear activation function is described in formulas 7-8 (figura 2).

$$\begin{aligned} z_1 &= f(\text{net}_1 - \theta_1) = f\left(\sum_{j=1}^d w_{1j} * i_j - \theta_1\right) = \\ &= w_{11} * i_1 + \dots + w_{1d} * i_d - \theta_1 \\ &\dots \end{aligned} \quad (7)$$

$$\begin{aligned} z_p &= f(\text{net}_p - \theta_p) = f\left(\sum_{j=1}^d w_{pj} * i_j - \theta_p\right) = \\ &= w_{p1} * i_1 + \dots + w_{pd} * i_d - \theta_p \end{aligned}$$

$$\begin{aligned} o_1 &= f'(\text{net}'_1 - \theta'_1) = f'\left(\sum_{j=1}^r v_{1j} * z_j - \theta'_1\right) = \\ &= v_{11} * z_1 + \dots + v_{1p} * z_p - \theta'_1 \\ &\dots \end{aligned} \quad (8)$$

$$\begin{aligned} o_r &= f'(\text{net}'_r - \theta'_r) = f'\left(\sum_{j=1}^r v_{rj} * z_j - \theta'_r\right) = \\ &= v_{r1} * z_1 + \dots + v_{rp} * z_p - \theta'_r \end{aligned}$$

In the formulas 7-8, we considered that  $f(\text{net}) = f'(\text{net}) = \text{net}$ .

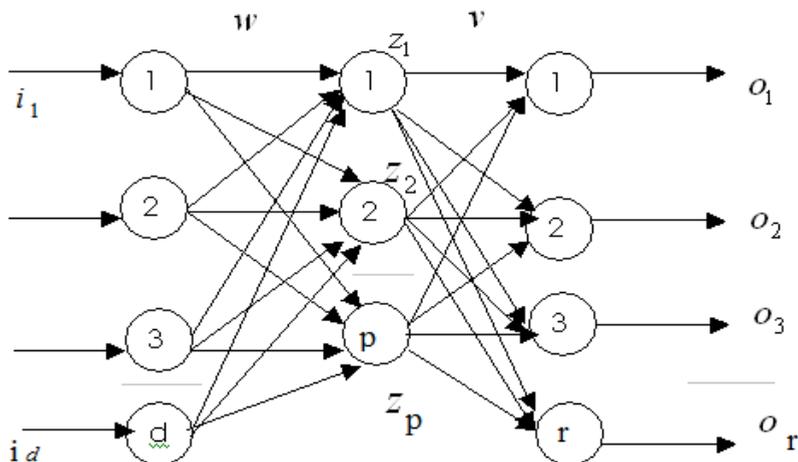


Fig. 2. The Architecture of a neural network to adaptable e-learning system.

The positive weights determine the excitatory connections and the negative weights determine the inhibitory connections. The weights 0 denote the absence of connection between two neurons. The higher the absolute value of the weights ( $w_{j,i}$ ) is, the stronger the influence of the neuron  $i$  on the neuron  $j$  is stronger.

The neural networks are information processing adaptive systems. The most important quality of a neural network is its learning capacity. According to the received information, learning can be supervised or unsupervised. The supervised learning uses a training dataset, pairs of inputs and correct outputs. The algorithm used in the model of the e-learning system is the backpropagation algorithm and it works as follows: it computes the error as the difference between the desired output and the current output. The error is delivered back to the input of the neural network (Freeman, J. A., Skapura, 1991).

The performance function can be as in formula 9.

$$\sum_{j=1}^r (d_j^{(m)} - o_j^{(m)})^2 \text{ or } \sum_{l=1}^e \sum_{j=1}^r (d_j^{(m)} - o_j^{(m)})^2 \tag{9}$$

Where  $e$  represents the number of pairs (inputs, desired outputs), which form the training set.

The learning process of the neural network consists of two phases: one phase of learning and one phase of testing.

More details about the theory of a neural network can be found in (Freeman, J. A., Skapura, 1991).

The weights' set that minimizes the error is the solution to the problem. Training of the neural network can be realized till the error decreases to an acceptable value or till reaches a maxim predefined epochs.

## 2.2 Swarm intelligence

It is known that classic optimization algorithms do not offer an efficient manner of solving involved large scale combinatorial and highly non-linear problems. The main characteristics of these classic algorithms are that they are characterized by an accentuated inflexibility concerning the need to adapt the algorithm to the proposed problem (Chan & Tiwari, 2007). So a set of assumptions is made and their truthfulness is not always easy to prove and it can easily affect the quality of the returned solution.

In this context, the development of nature-inspired algorithms is well motivated and it proposes a new perspective in solving these categories of problems by providing in most cases a better solution comparative to the classical optimization algorithms.

A branch of these nature-inspired algorithms is known as Swarm Intelligence and includes algorithms as Particle Swarm Optimization, Ant Colony Optimization, Artificial Bee Colony, and so one.

Swarm Intelligence was defined in 1989 by Gerardi Beni and Jing Wang as the collective behaviour of decentralized and self-organized systems. Swarm Intelligence Systems are composed of a population consisting in simple agents that interact locally with one another and with the environment by following simple rules (Chan & Tiwari, 2007). The agents' behaviour is defined by a certain degree of randomness and their social interactions are inspired by nature. Swarm Intelligence techniques are based on applying behavioural response to the environmental state, which serves as a work state memory and do not depend on specific agents.

In 1994 Mark Millonas mentioned the five basic principles of swarm intelligence (Stanarevic & Bacanin, 2011):

- The proximity's principle - each individual is able to memorize space and time computations;
- The quality's principle - each individual is able to respond to the quality of the environmental factors;
- The diverse response's principle - each individual "should not commit its activities along excessively narrow channels".
- The stability's principle - the changes considering the individuals behaviour should not be influenced by the environment changes;
- The adaptability's principle - individuals behaviour can be changed when it's worth his computational price.

*General Assignment Problem* is represented by the necessity of assigning with a minimum cost a set of tasks to a set of agents with limited capacity. Each task can be assigned to single agents and uses certain of this agents' resource.

This study aims to propose a solution for a General Assignment Problem using a Swarm Intelligence technique, represented by *Artificial Bee Colony* algorithm.

Artificial Bee Colony represents a Swarm Intelligence technique that tries to model the natural behaviour of real honey bees in food foraging. By performing the waggle dance during the food procuring the bees can successfully share information about the direction

and the distance of food and also about the amount of nectar available at the indicated location (Chan & Tiwari, 2007).

The studies considering bee compoment shows that the waggle dance contains a series of information about the food source: the direction of the bees' body indicates the direction of the food in relation to the sun, the waggles intensity is proportional to the distance to the food location and the dance length indicates the amount of nectar available at the food source.

In 1996 Yonezawa and Kikuchi developed an algorithm after closely observing the foraging behavior of honey bees and indicated the importance of group intelligence (Yonezawa & Kikuchi, 1996). The proposed algorithm highlights the fact that the results obtained by simulating an artificial systems including two bees are superior to the results obtained by simulating an artificial systems including a single honey bee.

In 2005 Karaboga proposed a new perspective by simulating the foraging behaviour for solving multi-dimensional and multi-model optimization problems, called Artificial Bee Colony (Karaboga, 2005).

The artificial bee population consists of three groups of bees (Chan & Tiwari, 2007):

- Employed bees - they are assigned to a specific food location; when the amount of nectar on this area goes to zero, they become scouts;
- Onlookers - considering the waggle dance performed by the employed bees, they choose one of the food locations described by this dance; the probability of choosing a location increase proportionally with the amount of nectar available there;
- Scouts - they navigate through the search area without any assistance in order to find new food locations.

The ABC algorithm is based on representing the possible solution to the optimization problem as the position of the food source, while the amount of food corresponds to the solution quality. In these conditions, the number of the employed bees or onlookers bees is equal to the number of solutions in the population.

The main steps of this algorithm are (Stanarevic & Bacanin, 2011):

- Send the employed bees into the search space and determine the nectar amounts available;
- Calculate the probability values of the preferred sources for the onlooker bees
- Stop the searching process on the location abandoned by bees;
- Randomly send the scoots into the search area in order to find new food sources;
- Memorize the location of the best food sources find so far.

The Artificial Bee Colony algorithm used in General Assignment Problem is presented in schema from figure 3.

The variables used in problem codification are:

- EmployedBeeNumber = the initial number of employed bees;
- OnlookesBeesNumber = the initial number of employed bees;
- MaximimIterationNumber = the maximum accepted iteration number;
- fit<sub>i</sub> = the fitness value corresponding to the i bee;
- EmplBee<sub>i</sub> = Employed Bee number i;
- OnlkBee<sub>i</sub> = Onlooker Bee number i;
- i\_Neighbour = neighbor corresponding to the I bee;
- pi = the probability of the Onlooker bee to choose the location of the EmplBee<sub>i</sub>
- SN = Scout Number

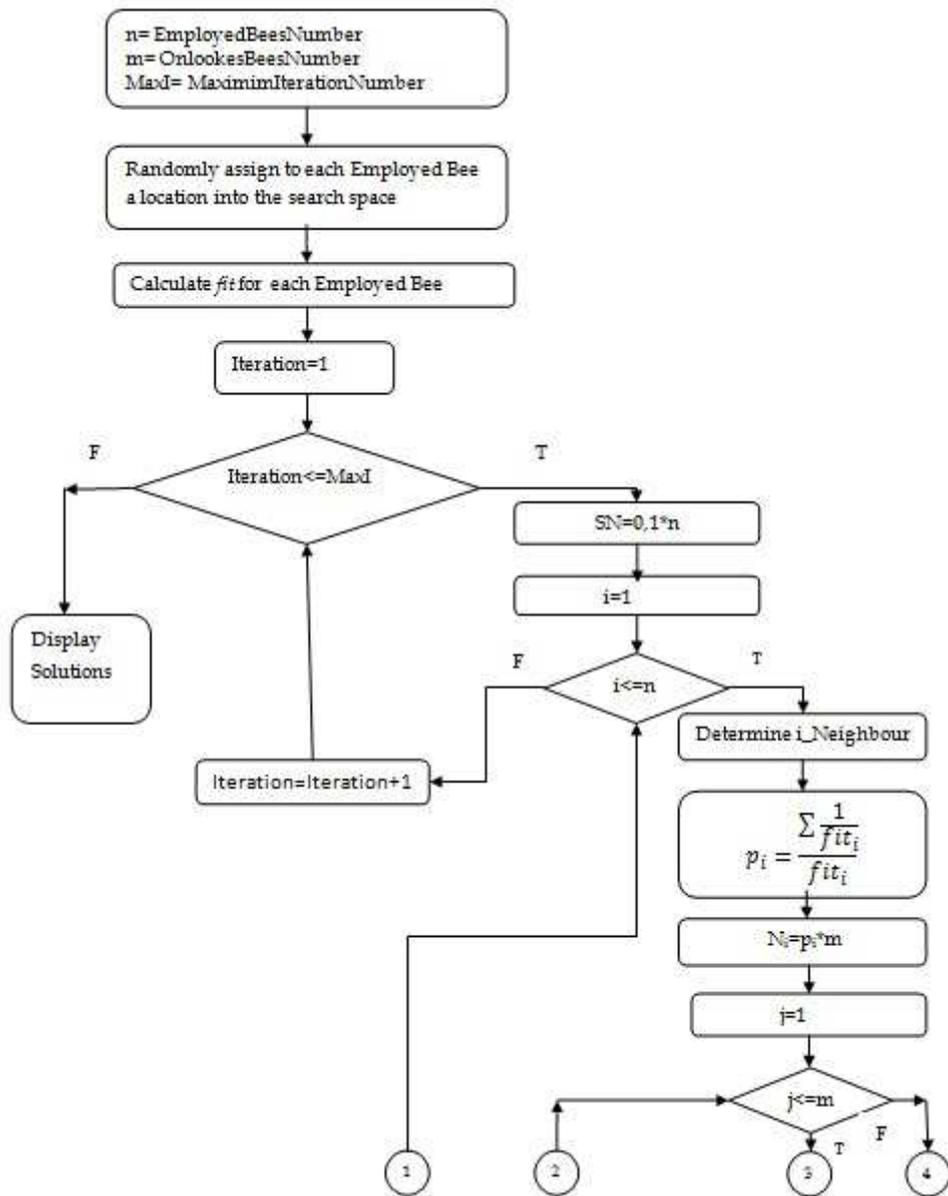


Fig. 3. (Continued)

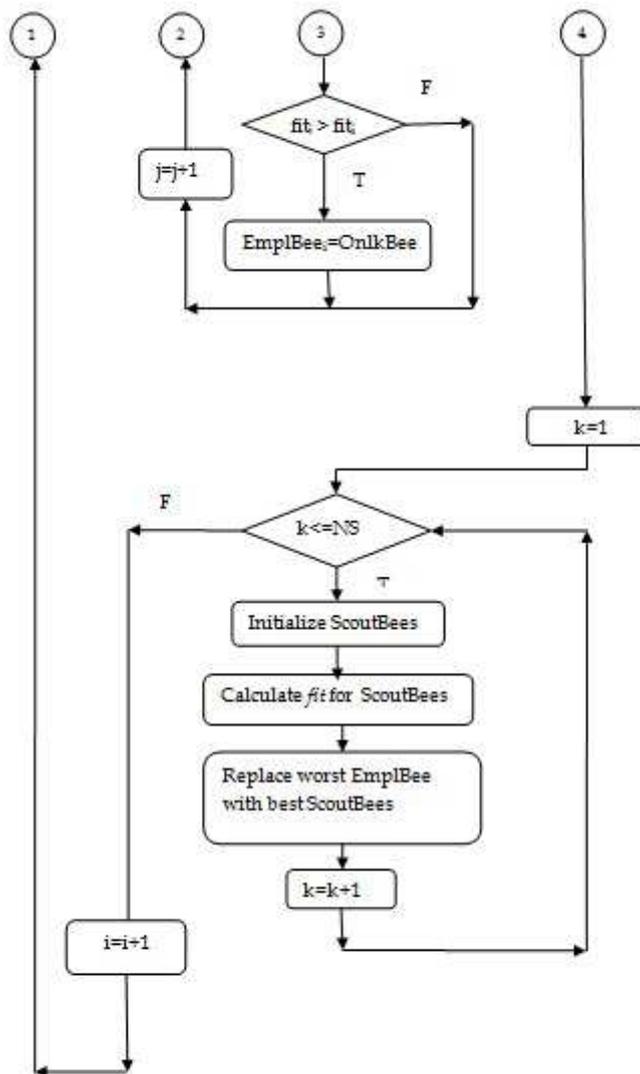


Fig. 3. The Schema of the Artificial Bee Colony Algorithm.

The authors consider that the problems related to the learning process are difficult problems, non-determinist, so, in this chapter there is presented an approach based on neural networks and swarm intelligence in order to model the learning process into an adaptable and flexible e-learning system.

### 3. Neural networks and swarm intelligence based e-learning systems

Mota (Mota, 2008) uses the neural networks to design two types of adaptability in an e-learning system: adaptive presentation and adaptive navigation. (<http://paginas.fe.up.pt/>)

~prodei/DSIE08/papers/35.pdf) The student model is defined considering Kolb learning styles inventory: Reflector, Theorist, Pragmatist and Activist student. The adaptation strategy uses SCORM 1.3 learning objects. The architecture proposed by Mota in (Mota, 2008) contains a Multilayer Perceptron trained with back propagation learning algorithm. The neural network is integrated in an intelligent unit, called CeLIP - Cesae eLearning Intelligent Player. Learners will have associated suitable learning objects according to their learning styles, user preferences and performance.

In (Seridi-Bouchelaghem, Sari, Sellami, 2005), there are used two neural networks: the former to select the appropriate basic units ("a basic unit is a multi-media document having intrinsically a teaching quality, i.e. which can be used within the framework of the knowledge transmission") for the learner and the latter neural network is used when the learners do not pass the post-test and select base units having reinforcing roles.

An Artificial Neural Net model is used in (Seridi, H., Sari T., Sellami, M., 2006) in order to select in an adaptive way the learning basic unit. Viewing the problem of adaptive course generation upon learners' profiles as a classification problem, the authors propose two neural networks:

The former neural network is used to select the adequate learning material in the first stage of learning and has the following properties:

- each neuron in the output layer is assigned to a learning material, referred as a basic unit in (Seridi, H., Sari T., Sellami, M., 2006);
- each neuron in the input layer represents the concepts related to the learning goal of the course;
- the hidden layer is used to computation and the number of neurons of the hidden layer is modified manually in the training stage.

The latter neural network is used in the reinforcement stage in the cases in which learners do not pass the test after the concepts training:

- The input of this network represents a grade of concepts' understanding by the learners;
- The output layer is defined by the basic units having the reinforcing role.

The algorithm used for neural network's training is backpropagation.

The system proposed initially in the paper (Moise, 2010) and further extended in this chapter uses a conceptual map based representation of an electronic course, the ABC algorithm to initial assign Learning Units (containing different teaching models for the same concepts, theory etc.) and a neural network based intelligent engine to adjust the unfolding of the learning-teaching process to the learner's needs.

An electronic course can be modelled using a conceptual map with  $k$  nodes (figure 4) (Moise, Dumitrescu, 2003; Moise, Ionita, 2008)

Each node has associated more learning units (for a node  $i$ , we note the number of pedagogical resources with  $nLU_i$ ). The maxim number of combination is  $\prod_{i=1}^k nLU_i$ , so the teaching models are less than  $\prod_{i=1}^k nLU_i$ . A learning unit (LU) consists in pedagogical resources and a teaching model. So, a node can be taught in different way using different learning units.

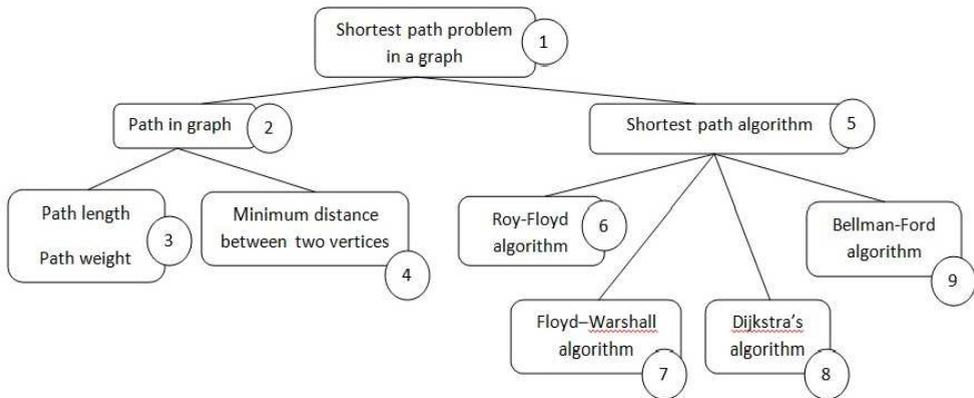


Fig. 4. Conceptual Map of an Electrical Course.

The problem of a right association between learners and learning units is solved in two phases:

1. Initial assignment between learners and LU using ABC algorithm;
2. Adaptation of the pedagogical path to each learner, by using neural network.

Phase 1

General Assignment Problem is represented by the necessity of assigning with a minimum cost a set of tasks to a set of agents with limited capacity. Each task can be assigned to single agents and uses certain of this agents' resource.

These types of problems are common for the computer and communications area, vehicle routing, group technology, scheduling, etc.

This study aims to propose a solution for a General Assignment Problem using a Swarm Intelligence technique, represented by Artificial Bee Colony.

The proposed problem can be described as follows: a set of learners  $\{L_1, L_2, \dots, L_n\}$  subscribe to attend a series of e-learning courses. In order to obtain information about the student's experience, about his learning skills and his preferences, an e-questionnaire is completed at the moment of the platform registration. Taking into account this information a learners' profile is associated to each candidate. On the e-learning platform there are a set of Learning Units for each e-course  $\{LU_1, LU_2, \dots, LU_k\}$  and the purpose is to assign each student to a proper Learning Unit in order to maximize students' performance.

The bees will represent the Learning Units and the constraints associated regard the number of students that can simultaneously access a specific LU and the fact that one student can only access a single Learning Unit at the time.

The search space is represented by the learners. When a learner has assigned a Learning Unit, a fitness function is calculated considering the learners' profile and the Learning Unit characteristics and the value of this fitness function needs to be maximized. Learners' profile is defined using the instruction context (Moise, 2007):

- Mental context (MC) includes: general abilities and knowledge, the intelligence of the student, mental structure and the capacity of the learner to learn, understand and practice the material.
- Social context (SC) includes the familiar context, familiar stress, friends view.

- Technological context (TC) refers to course structure, format, informational technology, technological equipment.
- Knowledge context (KC) refers on previous knowledge, past experience related on the topic presented in course.
- Emotional context (EC) refers to the motivation, interest and goals of the students.
- Classroom context (CC) includes teaching methods, the structure of students (age, gender, ethnical structure, etc.)

The fitness function can be established defining for each parameter of instruction context a values scale. An example of the fitness function is presented in formula 10.

$$f_{ij} = \frac{E\_Q_{ij} + E_{ij}}{O_j} \quad (10)$$

Where  $E\_Q_{ij}$  represents a value that indicates the level of knowledge that the learner  $i$  has in the Learning Unit  $j$  area,  $E_{ij}$  represents the student's experience in that area and  $O_j$  represents the occupancy degree of the considered learning unit.

#### Phase 2

The implementation of the adaptability property of the system is realised using a neural network, which has the goal to provide for each learner the proper teaching model. The neural network is trained, therefore an input vector involves a certain output. We define a value for acceptable error and we note it with  $\varepsilon$ .

We choose the structure of the neural network consisting of an input layer, a hidden layer and output layer and the standard connection (all neighbour layers are connected) (schema from figure 2). The input layer has a number of units equal with the number of inputs. The input vector is defined by values which state the instruction context (MC, SC, TC, KC, CC, EC) (Moise, 2007)

Each context factor is defined by a set of parameters. Generalizing, the input vector is defined as in 11.

$$\begin{pmatrix} mc_1, mc_2, \dots, sc_1, sc_2, \dots, tc_1, tc_2, \dots, \\ kc_1, kc_2, \dots, ec_1, ec_2, \dots, cc_1, cc_2, \dots \end{pmatrix} \quad (11)$$

MC	SC	TC
KC	EC	CC

The output layer has more units (corresponding to the teaching models which conduct to maximal performance). The desired goal is to associate to each instruction context the proper model teaching. The number of units from the hidden layer can be chosen using a heuristic method or one can adjust it during the folding of the teaching process in order to increase the complexity of the network.

For instance, if we consider a neural network with  $d$  inputs and  $r$  outputs, we can select  $\sqrt{d * r}$  hidden units.

The neural network has to resolve the following problem: the association of an instruction context sacred to a learner with a teaching model obtained through the composition of the teaching models of each node from the conceptual map. Often, the architecture of the neural network remains fix and the values of weights are changed.

Schema of using the neural network in the instructional adaptive system is presented in figure 5. We suppose that there are four teaching models (TM).

$$\begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} \text{ - TM no.1} \quad \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix} \text{ - TM no. 2} \quad \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix} \text{ -TM no. 3} \quad \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix} \text{ - TM no. 4}$$

The inputs have the following forms:

$$\begin{pmatrix} i_1 \\ i_2 \\ \dots \\ i_d \end{pmatrix}, \text{ where } i_k \in \{0,1\} . \text{ For instance } \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \text{ represents the visual learning style, } \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \text{ auditory}$$

learning style,  $\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$  kinesthetic learning style,

The training set contains  $p$  pairs  $\{knowninput,desiredoutput\}$ , hereupon we add perturbed inputs.

$$H = \left\{ \left( \begin{pmatrix} 1 \\ 0 \\ 0 \\ \dots \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} \right), \left( \begin{pmatrix} 0 \\ 1 \\ 0 \\ \dots \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix} \right), \left( \begin{pmatrix} 0 \\ 0 \\ 1 \\ \dots \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix} \right), \dots, \left( \begin{pmatrix} 0 \\ 0 \\ 0 \\ \dots \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix} \right) \right\}$$

The error associated to the training set computed according to the formula 12.

$$E = \frac{1}{2} \sum_{i=1}^4 (t_i - o_i)^2 \tag{12}$$

where  $o_i$  is the current output and  $t_i$  is the desired output

The output of the neural network is computed as in formula 13.

$$o_1 = f \left( \sum_{i=0}^3 v_{i1} * z_i \right), \tag{13}$$

where  $z_i = f \left( \sum_{j=0}^d w_{j1} * x_j \right)$  for  $i = 1,2,3$  and  $z_0 = -1$

$x_0 = -1$  and  $x_j$  are binary vectors

If  $d = 3$ , then the number of the hidden units is 3.

In order to adjust the weights, we use the backpropagation algorithm to train neural network presented in figure 5.

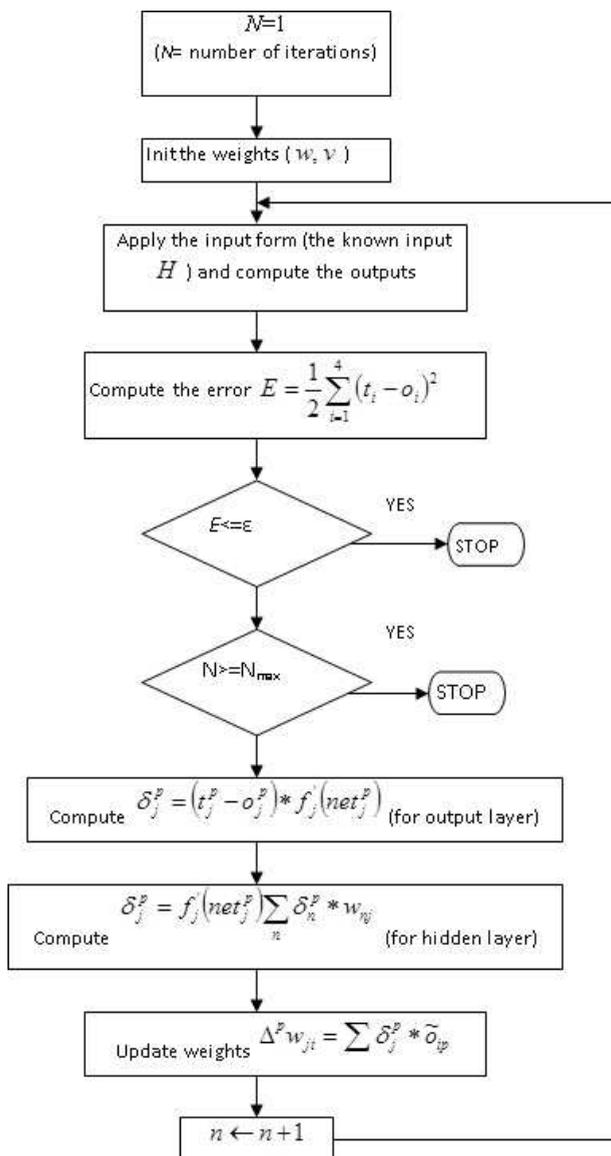


Fig. 5. The Backpropagation Algorithm.

#### 4. Use of new computing techniques in learning English as a foreign language

Learning is an inner capacity of the living beings, which, due to new computing techniques, namely bio-computing ones, has transgressed ontological borders and has become a capacity of artificial intelligence systems as well. In acquiring a foreign/second

language (L2), learning “can be broadly defined as the internalization of rules and formulas which are then used to communicate in the L2.” (Ellis, 1996) In this sense, language learning is considered synonymous with language acquisition. However, Krashen (Krashen, 1981) makes a clear distinction between the two terms, referring to learning as a process of developing conscious or metalingual knowledge through formal study, whereas acquisition implies spontaneous rule internalization, similar with “picking up”. New technologies should take into consideration both capacities, as natural, spontaneous acquisition and formal study alike are essential in one’s personal development of communicative skills.

When defining second language acquisition (SLA), Rod Ellis makes no distinction between learning and acquisition, in that he refers to SLA as “subconscious or conscious processes by which a language, other than the mother tongue, is learned in a natural or a tutored setting. It covers the development of phonology, lexis, grammar, and pragmatic knowledge.” (Ellis, 1996) The traditional study of foreign languages was limited mostly to the internalization of morphosyntactic rules and vocabulary in a rather decontextualised, memory-based manner. Technology development, and as a result, permanent access to up-to-date information, as well as intercultural direct contacts established in an increasingly globalized work and education market, have facilitated and changed the way a foreign language is perceived and learned. There is an astonishing number of youngsters and grown-ups in nowadays society who, according to Krashen terminology, acquire or “pick up” rather than learn a second language, without any tutoring, textbooks or methodologies, forced by new social and work market conditions.

The present analysis will focus on learning English as a tutored, formal activity within the Practical Course classes of the Romanian-English Specialization (day classes and Distance Education forms), functioning within the Petroleum-Gas University of Ploiești. Practical Course of English is an obligatory subject and it is allocated 4 hours (in the 1st year) and 3 hours per week, respectively (in the 2nd and the 3rd years) throughout the 3-year curricula of this specialization.

The authors aim at highlighting the advantages of using e-learning within foreign language classes, both in Distance Education and day classes, and the changes that the use of e-learning triggers in the process of SLA. Aspects to be discussed in this respect are: the new roles of the participants in education, types of interaction, e-course generation and navigation, use of technology in ELT (namely ProLang phonetic laboratory, as interactive equipment available within University of Ploiești).

The authors consider learning a collaborative accomplishment of an individual’s, in that he/she receives language inputs, practices and internalizes them in order to finally produce and transmit language outputs in the form of oral or written communication. The traditional emitter of the language inputs used to be the teacher, so formal study was a face-to-face collaboration of students and their teacher, supported or mediated by different types of educational material. Besides Teacher-Student and/or Student-Student interaction, in the last decades, there have manifested new types of interaction, namely Student-Machine, Teacher-Machine and Machine-Machine. The increasing implementation and use of artificial life techniques allow a shift in the perception of computers, from mere equipment to valuable partners and participants in education, language learning included.

Learning by means of electronic devices has already proven its advantages, when used in the process of SLA: endless opportunities for up-to-date information and immediate access to primary and secondary sources (books, textbooks, dictionaries, encyclopaedias etc),

exploring both virtual and real linguistic contexts otherwise unavailable in the class, receiving foreign language inputs from native speakers, with different accents, rhythms or register styles, the possibility of synchronous and asynchronous communication with students' peers or teachers, a reduced level of anxiety for less confident students, flexible and adaptive contents custom-made for students' individual pace, needs and personal learning styles, the possibility of immediate evaluation of their performance, developing computing skills of both students and teachers, a higher level of motivation and involvement, as students make use in their education of familiar facilities: e-mail, Internet navigation, forums and other types of group works, Internet Relay Chat, learning media such as texts, graphics, stills, animated images, real-life or education-targeted film etc.

As a result, the foreign language teacher stops being the only provider of accurate language or the primary source of comprehensible linguistic items in terms of pronunciation, vocabulary, morphology, syntax or pragmatics. Students and teacher alike take new roles within e-learning based activities, different from traditional education. Although the teacher continues to be the organizer, tutor, controller and assessor of the learning process, his or her magister position is not as obvious as in the traditional, face to face education. Students feel more independent, relaxed and confident in what seems to be a learner-driven lesson, within which the teacher behaves more like a silent observer and assessor or like an equal participant in group activities. Computer techniques mediation allows varied interaction, which, according to Julien Edge, presents several advantages in foreign language teaching and learning: "a change of interaction brings a change of focus of attention, which helps keep people interested; in pairs and groups, there is opportunity for more individuals to use the language; students perform differently away from the pressure of teacher and whole-class attention; students learn to be more self-reliant"(Edge, 1993). This medium will also enable students to repeat a word, stop, go forwards and backwards in the course at an individual pace, without disturbing the rest of the class.

If advantages of using new technology and computing techniques are not to be questioned and discussed any further, these complex, adaptive and flexible systems of e-learning pose various challenges as well. Besides the financial issue and the computer literacy required, a major challenge is that of e-course generation. First, an electronic practical course of English is to meet the demands of any course, in that it should observe the syllabus of the subject, establish realistic objectives and appropriate teaching strategies, choose contents and support materials that appeal to students' areas of interest and consider their level, establish and announce the modality and frequency of evaluation. In the case discussed, most of the 1st year university students at the Romanian-English specialization are intermediate and upper-intermediate (8 years of English, on average), their major issues being grammar and reluctance to speak in front of the class. Evaluation consists of three tests per semester, in which both receptive and productive skills are being assessed.

Considering the fact that the 1<sup>st</sup> year students form a heterogeneous group, in terms of linguistic competence and computer literacy, an e-course of English should be organized in coherent, still flexible and adaptive modules, with user-friendly layout and tools, and nodes that associate various pedagogical resources. A focus on functions (introducing oneself, inviting, asking for information, apologizing and so forth) and themes (Family, Travelling, Education, Hobbies) would be useful in organizing and ordering contents, as it provides a natural context for vocabulary acquisition and grammar rules internalization.

Each unit is to offer visual and audio support, to consider the four basic skills and to be learner-oriented, in that the student may have the possibility to choose tools and different

levels of language (Phonetics, Vocabulary, Morphology and Syntax) depending on his/ her individual needs and knowledge. In terms of Swarm Intelligence technique, students become decentralized and self-organized agents that interact with one another and the teacher, respectively, and with the multimedia environment in order to solve multi-levelled problems. Still, there will be common objectives and a unique evaluation at the end of each unit.

Learning a foreign language resembles neural activity as well, in that it implies the existence of linguistic inputs and outputs. Rod Ellis defines input as “the language to which the learner is exposed to. It can be spoken or written” and it “serves as the data which the learner must use to determine the rules of the target language” (Ellis, 1996) Depending on students’ background, knowledge and communication skills, as well as on the appropriateness of the e-course organization of contents, input may be comprehensible or incomprehensible, case in which the course should be adjusted. In 1983, Krashen and Terrell formulated the input hypothesis, which states the following: “in order for acquirers to progress to the next stage in the acquisition of the target language, they need to understand input language that includes a structure that is part of the next stage.” Krashen synthesizes this with the formula “ $I + 1$ ”, where “ $I$ ” represents the input, and “ $I + 1$ ” – the input that contains structure slightly above the current level of the learner. The output is the language produced by the learner, both in its spoken and written form, and, depending on the student’s actual progress and level of rules internalization, the output may be in its turn comprehensible or incomprehensible to the others. In the latter situation, he/she should return to the linguistic level or the thematic unit of the course that posed the problem, or, if there are more students in this situation, the e-course should be readjusted.

In current foreign language teaching and learning, the most common and popular technology continues to be audio devices, as they are affordable and require no particular educational environment. Video devices prove also useful in SLA, as they support the development of the receptive skills, by adding to sound images which provide natural and synaesthetic communication contexts, thus facilitating acquisition. Dictionaries and online encyclopaedias are currently available on mobile telephones that tend to become an integrated part not only of a student’s everyday life but also of his/her formal education. Multimedia computers, either as stand-alones or within networks, combine the above-mentioned advantages of technology in a compact form and at increasingly accessible price. A complex, interactive equipment is currently used within Practical Course classes at Petroleum-Gas University, namely ProLang laboratory. The model PL 28 consists of 28 students units, fixed on furniture, 28 student headsets with microphones, 1 console and 1 headset with microphone for the teacher, 1 ProLang software and 1 mounting kit. The teacher console is commanded by a microcomputer that incorporates microphone mixers and internal amplifiers, and allows students simultaneous individual activity, as well as independently working of 4 groups. Student units dispose of a “rising hand” button that may improve T-S interaction and eliminate some students’ reluctance of speaking in front of the class. The equipment allows varied, simultaneous activities: listening, conversation, repetition, group discussion and simultaneous translation, fact that keeps the learner’s interest and attention throughout the class, by making him/her an active participant in foreign language learning. ProLang provides also tools for recording and archiving, which allows self-evaluation and progress tracking. As foreign language teachers are currently making use of different materials in order to meet the 1st year students’ individual needs,

the design of an adaptive, flexible, new computing techniques-based e-course would ease both teaching and learning in that it might resolve the challenge of working with extremely heterogeneous groups, in terms of communication skills, learning styles, aptitudes and background.

Simulation case: English Language Teaching

Target group: the 1<sup>st</sup> year students (a group of 28 students).

5 teaching methods:

1. Listening;
2. Conversation;
3. Repetition;
4. Group Discussion;
5. Simultaneous translation.

Instruction context:

1. students' background (knowledge context);
2. knowledge skills (mental context);
3. communication skills (mental context);
4. teaching method (classroom context);
5. ProLang lab (technological context).

Learning units are grouped according to levels of language:

1. Phonetics;
2. Vocabulary;
3. Morphology;
4. Syntax.

The steps needed to design the e-learning system are:

- i. There is built the Conceptual Map of the Practical English Course (Figure 6).
- ii. Students attend an e-Questionnaires to establish the instruction context.

Each variable of the instruction context receives a value (numerical or Boolean).

1. Students' background receives one of the values: intermediate (0) and upper-intermediate (1).
  2. Knowledge skills receive one of the values: absence (0) and existence (1).
  3. Communication skills receive one of the values: absence (0) and existence (1).
  4. Teaching method receive one of the values: Listening (1), Conversation (2), Repetition (3), Group Discussion (4), Simultaneous translation (5).
  5. ProLang lab one of the values: absence (0) and existence (1).
- iii. There is realised an initial assignment between learners and LU using ABC algorithm. The fitness function is established experimentally. The occupancy degree of each learning unit is 28. The fitness function can have a mathematical form or can be as a set of rule of form presented in 14.

$$\begin{array}{l}
 \text{If (condition)} \\
 \text{Then (consequent)} \\
 \text{Else (alternative)} \\
 \text{End If}
 \end{array}
 \tag{14}$$

- iv. Adaptation of the pedagogical path to each learner using neural network.

The neural network is built according the model presented above and in paper from the reference (Moise, 2010).

The neural network resolves the problem of the association of an instruction context (each student is described according to the instruction context) to a learning unit.

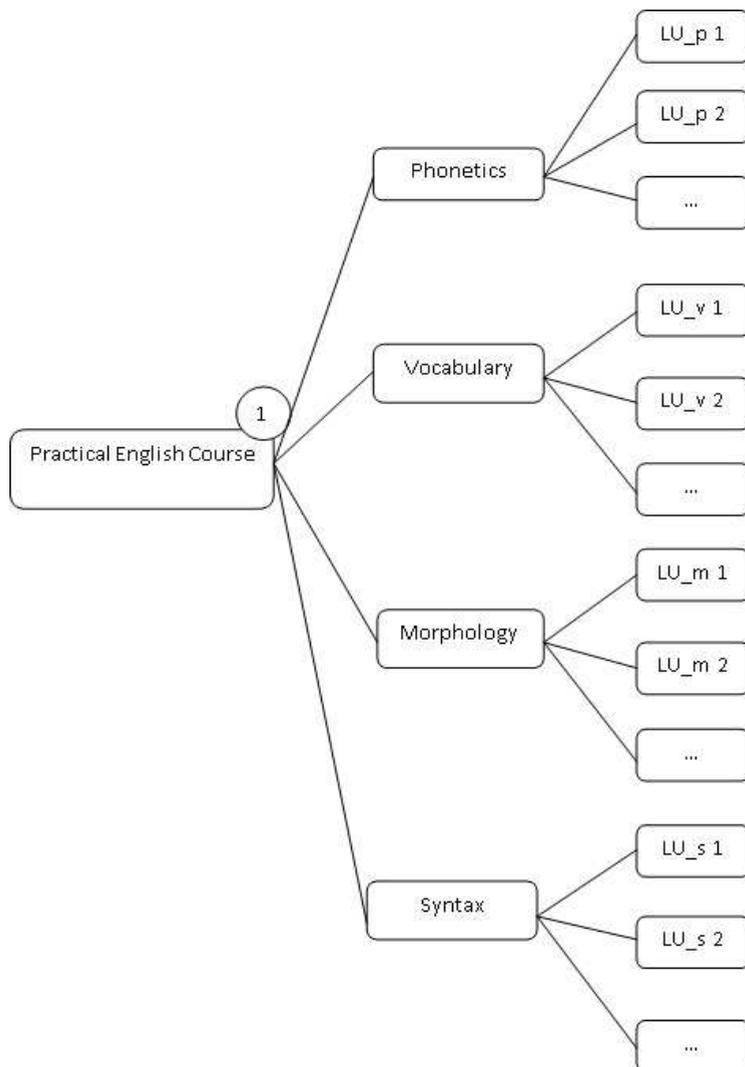


Fig. 6. Conceptual Map of Practical English Course.

## 5. Conclusion

The proposed e-learning system is avant-garde in the purpose of the e-learning system development trends. The tendency is to replace human teacher, so there are necessary sophisticated techniques to obtain good performance in the conditions of a learner control or machine control in the e-learning system. The techniques are inspired from the living world and have been successfully applied in different types of systems, including e-learning systems. Starting from the theoretical background of the e-learning processes, namely instructional systems, communications and computers theories, the approaches presented in

this chapter are relatively new and difficult to implement. As main drawbacks, we mention: heterogeneous teams of experts (IT and specialization experts), initial long time and high costs for developing such systems, lack of computer literacy for some of the students and teachers involved.

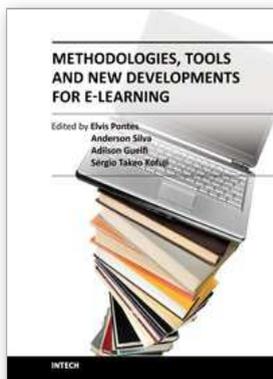
The authors consider this chapter as a possible start point for interested teams of e-learning systems developers, in that future preoccupation in this area is to find IT experts willing to implement these techniques in valuable systems.

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## **Methodologies, Tools and New Developments for E-Learning**

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With the resources provided by communication technologies, E-learning has been employed in multiple universities, as well as in wide range of training centers and schools. This book presents a structured collection of chapters, dealing with the subject and stressing the importance of E-learning. It shows the evolution of E-learning, with discussion about tools, methodologies, improvements and new possibilities for long-distance learning. The book is divided into three sections and their respective chapters refer to three macro areas. The first section of the book covers methodologies and tools applied for E-learning, considering collaborative methodologies and specific environments. The second section is about E-learning assessment, highlighting studies about E-learning features and evaluations for different methodologies. The last section deals with the new developments in E-learning, emphasizing subjects like knowledge building in virtual environments, new proposals for architectures in tutoring systems, and case studies.

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