E-LEARNING, E-PRACTISING AND E-TUTORING: AN INTEGRATED APPROACH

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Abstract: In this paper is described a didactic methodology combining current e-learning methods and the support of Intelligent Agents technologies. The aim is to favor the synthesis among theoretical approach and based practical approach using the so-called Intelligent Agent, software that exploits the Artificial Intelligence and that operates as tutor, facilitating the consumers in the training operations. The paper illustrates how such new Intelligent Agent algorithm (IA) is used in the training of employees working in the transportation sector, thanks to the experience gained with the PARMENIDE project - Promoting Advanced Resources and Methodologies for New Teaching and Learning Solutions in Digital Education.

Keywords: Learning-by-doing, On-the-job Training, Intelligent Agents, Fuzzy Logic, Virtual Pedagogical Character, Virtual Tutor.

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Introduction

The PARMENIDE project is a two-year pilot project co-funded in the framework of the Leonardo da Vinci Programme, with the specific aim of addressing updated and effective training for technical staff employed in railway and airport sectors [PARMENIDE website]. The reasonable behind the project is represented by the limited resources in terms of teachers, spaces, but above all of the distant users' available time, the latter being far from the places of teaching, of student-workers and, particularly, of those workers that want to improve their knowledge or need to update their professional skills.

In this perspective PARMENIDE project, by promoting a new knowledge acquisition methodology in e-learning mode, aims at developing and spreading innovative learning opportunities for teachers and students, offering them the possibility to improve their respective qualifications. The trainers are involved in critically re-thinking their own way of training thanks to the use of IA and in order to collaborate to the re-definition of contents production modes, so that the learning methodology proposed turns out to be effective. The IA permit to harmonize theoretical with practical, experiential training on-the-job, following virtual *learning by doing*; students acquire practical skills, thanks to the experience coming from an educational use of devices, systems and equipments.

Compared to traditional multimedia learning systems, contents delivery becomes highly interactive and personalized, following individual paths considering the natural inclinations of students and respecting the different knowledge acquisition times, different from an individual to another one. Virtual tutors may use *Artificial Intelligence* methods to evaluate in depth the student's performances and reactions and adapt teaching to specific needs and environments as much as possible. They show the student how to accomplish a rather complex task, such as for example controlling an assembling process, using a mechanical circuit, repairing a system or specific machines; they take advantages from non verbal behavior in order to attract the student's attention on crucial moments of learning. Virtual tutors, thanks to their anthropomorphic features, make interaction between student and learning system more interactive, involving and effective, allowing improvement of contents use and considerably increasing the student's learning level through an active experiential participation.

Didactic Model

It is proved by practice that the blended solutions are most applicable when the training requires trainees to be aware of, understand, apply, evaluate, and synthesize like information in different situations.

Currently, the simulators are used for training in the sector of transport, for professional figures called to control the vector, for example pilots, ships and/or submarines captains, trains and high speed underground trains drivers, etc. On one hand, simulators are not very useful in order to make interventions in complex non-standard situations, on the other hand, they seldom allow a constant dialogue with the teacher/trainer who helps understanding the mistake one has made and how one must behave in order to avoid repeating it.

The analysis of training processes in the sector of transport, and in particular in the sector of air and railway transport, highlights a widespread use of driving simulators, but nothing seems to be available for simulation processes and the trainer's direct intervention for safety operators. The error margin of such operators must be equal to zero, and not always is the operator sure about what would happen in case of a mistake and of an intervention taking place while not following the procedures. In particular, the pedagogical methodology here proposed aims at favoring the difficult synthesis between theoretical approach and practical approach based upon strong experiential components (learning by doing), having IAs as its own basis.

Didactic methodology combing current e-learning methods with the support of Intelligent Agents technologies for the training is one of innovative elements of the project. The proposed methodology aims the provision of constant interaction with the teacher/trainer in a context of practical/virtual activities leading the student through learning by doing.

Intelligent Agents as virtual pedagogical characters

IAs are autonomous software systems realized with AI methods that can operate in the training environment as virtual tutors that adaptively assist users in the performance of the training tasks. They can intervene in case of suboptimal performance, demonstrate skills, provide explanations and answer to questions, and play the role of team members in multi-person tasks [Chen&Mizoguchi, 1999].

IAs, represented as virtual humans, take advantage from non-verbal behaviors, in order to capture the student's attention on the crucial moments of learning [Craig et al., 2003]. Thus, IAs become learning facilitators gifted with great reactive, intuitive and interpretative skills. Thanks to them, learning is based upon a knowledge transfer where the student is followed "step by step" by his own agent/trainer, enjoying a new learning methodology being highly experiential which allows real time testing of what has been learned and at the same time how to correct possible mistakes in the intervention.

The students/operators, thanks to these new learning paths, will be able to understand in real time the consequences of their own mistakes and acquire a capability of direct intervention in potentially unsafe situations being typical of the sector of transport.

Learning environment

The learning environment is structured in training area and communication area. The communication area consists of a set of instruments promoting collaborative and cooperative learning – forum, news section, web-conferencing facilities, virtual lab, calendar informing users/learners about the availability of new modules for the e-course and the pilot application in Italian and English. Users have been supported also by PARMENIDE course tutors who inform the users about the program of the course, collect requests on technical doubts/problems, update the NEWS section available in the PARMENIDE e-platform, promote the interaction among the users through the Web conferences, Forum, and etc.

The training area provides learning contents structured in modules and lessons and available through different formats promoting a personalized learning. Learners are able to act in a simulated hall of an airport or railway station, where each student plays the role of a public official responsible for managing fire emergencies.

The developed learning environment is aimed at training users on safety procedures to be used in crowded environments, such as airports and railway stations, affected by emergencies.

The accent is on the building a simulated learning environment, enhanced with an intelligent agent playing the role of virtual tutor, where the learner has to react to the event of a fire. This learning environment requires the student to carefully apply emergency plans, adjusting them to specific circumstances such as the location and magnitude of the fire, the location of emergency exits, the availability of fire extinguishers, etc., and therefore experimenting with several evacuation methods.

The 2D virtual hall is crowded with simulated people; each of these is controlled by a fuzzy logic system, emulating the behavior of a real person [Russell&Norvig, 1995]. The environment is able to respond to the user's inputs and within it the virtual tutor (the Intelligent Agent) verifies if emergency procedures and rules are respected and followed correctly by the learner. The initial conditions may be paracasual [Magoulas et al., 2001; Nedic et al., 2002].

The following inference engines based upon fuzzy logic were developed in the project framework:

- The first engine manages the settings of the learning scenario.
- The second inference engine controls the score process on the basis of the levels of the importance and the difficulty of the task, as well as of the fastness and correctness of the student's action/answer.
- The third manages the tutor's behavior as learner's supervisor and "advisor", using the fuzzy rules for evaluating the student's performance, in a way similar to what a real tutor would do.

Fuzzy logic, compared to other AI techniques, implies a reasoning style more similar to the way human beings usually think [Zadeh, 1965]: therefore it both enables teachers to provide more easily the set of rules which must be used by the Intelligent Agent for evaluating the student's performance, and experimenters to create a faithful simulation of the behavior of people in a crowded place [Klir&Folger, 1988].

The bi-dimensional realized scenario allows the student to make moves with a kind of pawn, which will represent him within the context of an evacuation, through a set of buttons and icons. The virtual agent (tutor), external to the bi-dimensional scenario, will evaluate the learner's behavior giving points to the different actions, according to the fuzzy rules. The tutor's "balanced" answer will be given at the end of each action.

The MATLAB's Fuzzy Logic Toolbox is used to implement the rules defined in the scenario. The rules are presented to the Fuzzy inference engine which provides to translate them in a mathematical way and generates automatically the code behind. Then the MATLAB code is compiled in C++ as Windows DLLs in order to be created a stand alone application. These DLLs are linked with the scenario interface to be created the entire application.

In summary, from instrumental point of view is proposed architecture matching a distance learning environment with an educational system based on IAs enabling individual learning and providing guidance and assistance to transport sector staff.

The Experimentation phase

The project experimentation phase involved a European target group set up by 49 users who tested the efficiency and effectiveness of the innovative methodology and project outcomes.

The testing phase of the learning pilot application, based on the innovatory methodology of IA, in specific segments of the transport sector and in particular in the air and rail ones, involved appropriately selected operators in the two sectors, in order to elaborate a methodology, from the point of view of both method and contents, using more specific supports, with the aim of improving the educational interventions in the vocational training domain.

The selection of the users was an important stage for the identification of those units which would take part to the experimentation phase for testing the efficacy and effectiveness of the application. The recruiting phase comprehended the research of users to be involved in the testing on the basis of specified set of criteria was a

fundamental component of the selection procedure. The users had to be European experts working in the transport sectors (railway and airport). They had to have:

- Competence in emergencies management and fire prevention;
- Knowledge of safety regulations in working environments;
- Computer skills;
- Proficiency in English language.

The experimentation activity comprehended the delivery of a pilot course to the target group, collecting data from questionnaires for evaluation of the platform, e-learning course and the pilot application, which users were required to fill in, and summarizing and evaluating of received data in order to verify the state of the project outcomes, defining which activities have been performed, and how their progress correspond to the expected results.

Fig. 1 – On line Course

The learning course and the pilot application are realized through the e-learning platform, inside the PARMENIDE Web Site, set up by e-course and pilot application both realized in Italian and English.

Fig. 2 – Audio Lessons

The on-line course (Fig.1), for the development of theoretical competences, consists of didactic environment hosting materials in several main macro-categories, including: video-lessons, didactic units, in-depth studies, slides and virtual lab - interactive and collaborative environment, aiming at the promotion of both synchronous and asynchronous communication among remote users and e-tutors, ensuring tracking and transparency.

Fig. 3 – Lecture notes

PARMENIDE e-course consists of different kinds of learning objects, which have been developed for the "Fire prevention, fire-fighting and emergencies management" course.

The fundamental learning objects are audio lessons (Fig.2) and lecture notes (Fig.3). Lessons are structured in three modules: Fire and prevention, Fire-fighting protection, and Procedure to adopt in case of fire. The timing of lessons is approximately 40 minutes each. They are lessons by teacher, recorded and divided following the topics, which can be listened and viewed "on demand". The sides, synchronized to the lessons, include the main concepts dealt with by the teacher, and help understanding them.

Didactic units are critical texts for in-depth study according the educational program, which supports an effective learning process. There is a possibility for on-line use by a platform as well as a possibility to print the texts for further off line readings. Students have a tutor, available on line, responsible for monitoring the training path during the whole testing phase.

The pilot application consists of two prototypes: the first one is addressed to employees working in the air transport sector, and the second one to those working in the rail transport sector.

The Pedagogical Agent, based on IA, evaluates the learner's behavior, assigning a score to the various actions and providing a "weighed" answer, at the end of each action. The Pilot Application, characterized by a strong experiential component, promotes and test the knowledge acquired during the on-line course (Fig. 4).

The screen is separated into different zones: 2D simulated environment (1) where user acts demonstrating obtained during the learning process experience and knowledge, external to the 2D environment zone for visualization of nonverbal behavior of the virtual tutor (2), acting as supervisor and evaluator of the student's behavior, zone for textual representation of the questions (3), and zone (4) for textual representation of the

agent's answers in the end of each action and corresponding feedback (comments, advices etc.). For each zone is assured audio support.

The target group of users was separated into 5 classes participated in the PARMENIDE experimentation. The duration of experimentation was two months. The users from all the classes attended at the seven virtual web-based meetings and thus they were able to exchange their experience, opinions, and attitudes as well as to ask some questions concerning the course, the pilot application, the learning process as whole with the project team members.

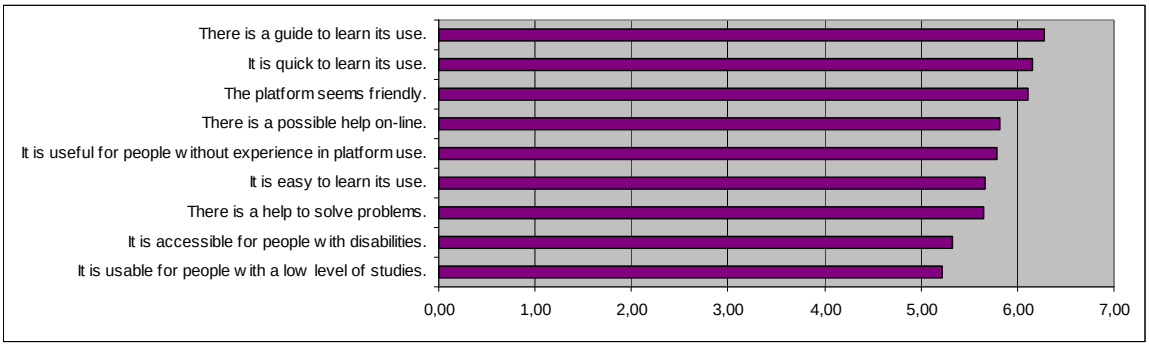
Fig. 4 – Pilot Application

The Evaluation

The final stage of the experimentation phase comprehended evaluation and synthesis of all the elements concerning the project realization.

In the end of the experimentation phase the users had been required to fill in questionnaires evaluating important characteristics of the e-platform, on-line course and pilot application with values from 1 to 7, considering 1 the lowest value and 7 the highest one.

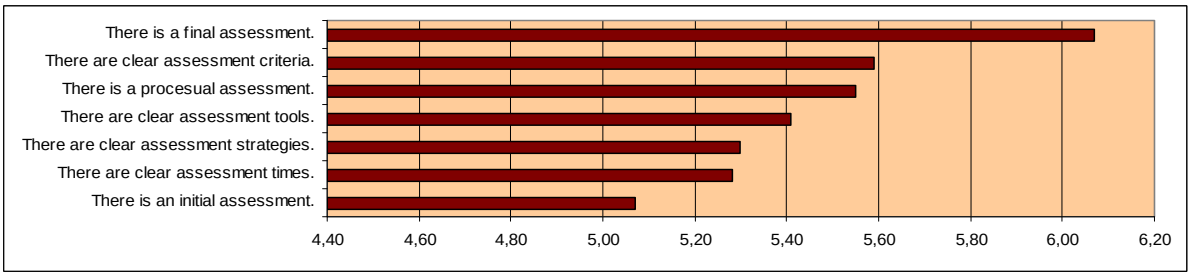
Concerning the e-platform the general average is quite high - 5.78. As we can observe in the Graphic 1, the lowest items are the usability for people with a low level of studies - 5.23, and the accessibility for people with disabilities - 5.33.



Graphic 1

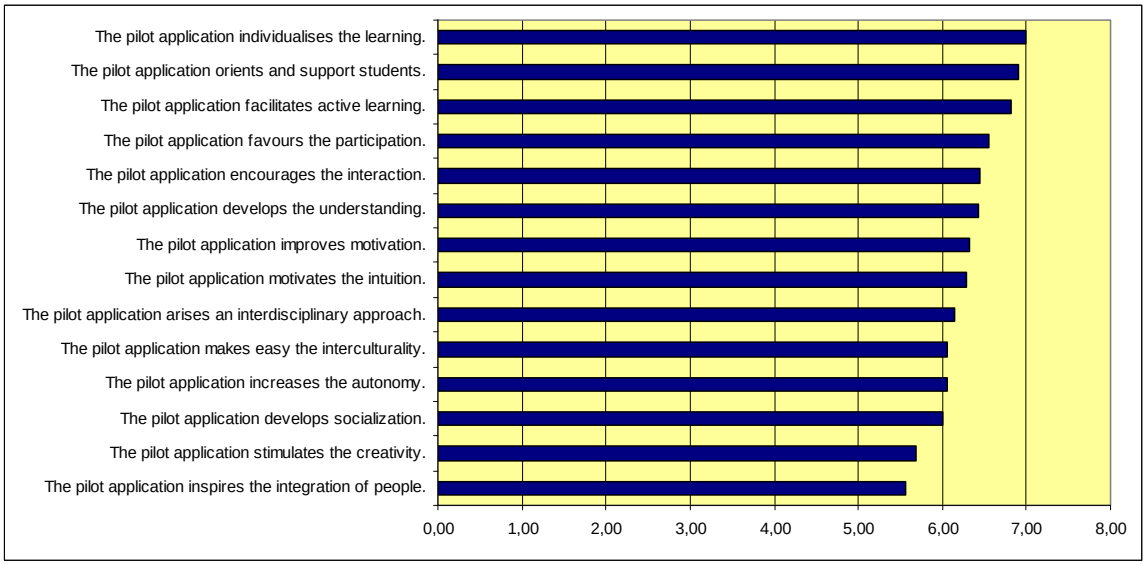
The results from evaluation of the e-learning course are given in Graphic 2. As we can observe general average is 5.47. The lowest items are the initial assessment - 5.07 and the assessment times - 5.28.

Here we have to explain that our aim from pedagogical point of view was to be assessed the behavior and knowledge level of learners exactly in situation where they are aware of the learning aims and objectives but the process of assessment is not fully transparent for them.



Graphic 2

As we can observe in the graphic 3, the general average for the pilot application is very high - 6.33. The lowest value is the integration of people - 5.57. The highest ones are the support to students - 6.90, and the individualization - 7.00.



Graphic 3

The questionnaires filled in by the users showed some weaknesses of the pilot course, which could be summarized as follows:

- Need of improvement of the didactic course complexity;
- Necessity of the development of more complex and interactive sets.

These suggestions depict the aspects for future improvement and we take as challenges in the real product development.

At the same time, the results of experimentation manifested the following strengths of the on-line course and the pilot application:

- From methodological point a view the course is innovative, useful and really formative;
- Method of IA is valid and innovative for learning and testing the theoretical course;
- Interaction with the IA favors the learning and the assessment;
- In respect to the evaluation of users' learning - to have immediate reports favors the users to use the application.

Conclusion

From the point of view of new methodological and instrumental approaches, the experimental learning methodology permits to:

- Finalize learning, issuing concrete opportunities for diversified learning situations;
- Activate a valuable psychological contract, granting a clear definition of internal and external roles, of relationship between roles and competence areas, practical organizational rules;
- Involve the trainee into learning, thanks to a gradual use of active didactic techniques, and of moments of actualization of personal life (trainers, on their part, will use the same innovative modes with final users, the operators in the sector of transport);
- Learn from practical experience through the reconstruction of dynamic didactic situations, recreating and allowing to relive actual experiences lived by participants;

- Learn as a research, stimulating continuous moments of discovery and having the goals of the intervention crystal clear in mind;
- Activate learning-extrinsic and -intrinsic motivations, appealing to the potential and latent levels every person owns.

The pervasive use of technologies in learning and training process bring us to re-think to the didactic methodology in an "ecological approach" which considers the user the focus of the learning process and not the technology.

Bibliography

[Chen&Mizoguchi, 1999] W. Chen, Mizoguchi R. Communication Content Ontology for Learner Model Agent in Multi-agent Architecture. In: Proceedings of the 7th International Conference on Computers in Education /ICCE99/, 1999.

[Craig et al., 2003] S.D. Craig, Gholson B., Driscoll D. Animated Pedagogical Agents in Multimedia Educational Environments: Effects of Agent Properties, Picture Features, and Redundancy. In: Journal of Educational Psychology, Vol. 94, pp. 95-102, 2003.

[Hayes-Roth, 1995] B. Hayes-Roth. An Architecture for Adaptive Intelligent Systems. In: Artificial Intelligence: Special Issue on Agents and Interactivity, Vol.72, pp. 329-365, 1995.

[Klir&Folger, 1988] G.J. Klir, Folger T.A. Fuzzy Sets. In: Uncertainty and Information. Prentice Hal, New Jersey, 1988.

[Magoulas et al., 2001] G.D. Magoulas, Papanikolaou, K.A., Grigoriadou, M. Neuro-fuzzy Synergism for Planning the Content in a Web-based Course. In: Journal Informatica, Vol. 25, 39-48, 2001

[Nedic et al., 2002] Z. Nedic, Nedic, V., Machotka, J. Intelligent Tutoring System for teaching 1st year engineering. In: World Transactions on Engineering and Technology Education, Vol.1, No.2, 2002.

[Russell&Norvig, 1995] S.J. Russell, Norvig P. Artificial Intelligence: A Modern Approach. In: NJ Englewood Cliffs. Prentice Hall, 1995.

[Zadeh, 1965] L.A. Zadeh. Fuzzy sets. In: Information Control, Vol. 8, pp. 338-353, 1965.

[PARMENIDE website] Promoting Advanced Resources and Methodologies for New Teaching and Learning Solutions in Digital Education. http://parmenide.unimarconi.it

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