Management of Group Evolution Through Cooperative Work in E/M-learning Systems

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Abstract- **The current economic crisis require people to have several skills, such as becoming more and more capable of facing new tasks in distinct contexts and being productive members of teams. These features should be developed since the first school year and become fundamental targets in education system's renewal. To this purpose, the role of teachers in educating young students to work as teams is crucial and a great help comes from relatively low-cost technologies, appropriate devices, fast network access connections and powerful cooperative work tools at disposal. Advanced e/m-Learning environments and their services for remote group work, real-time or asynchronous, can help teachers to define groups, check their performance in a continuous way, and manage team evolution and membership over time. The problem faced here is from three interacting viewpoints: firstly, some factors are presented, related to education systems renewal in the direction of ICT and cooperative work; secondly, such considerations are used to define criteria for profile evaluation of both individuals and groups. Lastly, a framework is proposed for remote cooperative work management and optimization. In the considered scenario, the whole e/m-Learning system and its cooperative tools are accessed through heterogeneous devices and access network technologies. The system contains an adaptive testing component, for the continuous assessment of group activities and group evolution management, which makes use of the above mentioned profiles.**

Keywords- Education Systems; Remote Cooperative Work; Profiles; Heterogeneous Access Technologies; Group Evolution

I. INTRODUCTION

The role of teamwork has been strongly emphasized in several contexts [1, 2], for example a problem beyond an individual's capacity to face and solve; in fact, a strong and productive attitude towards teamwork is crucial, so are strong adaptability and flexibility. As a matter of fact, interactions with colleagues from other countries, groups and companies, as well as the fundamental interdisciplinary work, are factors of increasing importance. The ICT and the need to modernize some traditional jobs and create new application fields and market areas, in addition, require the above skills at least as a good theoretical and applied preparation.

In this context, e/m-Learning systems and their services for cooperative work must be properly exploited to teach ICTs, develop teamwork attitude and handle group management. Such systems have been promoted by several institutions and governments, for adapting education to the needs of knowledge economy. Their impact is increasingly strong, and they are crucial for fulfilling modern policies on schooling and higher education, as well as social inclusion, language learning, intercultural dialogue, as well as self-training and life-long training.

The primary and important advantage of such systems derives from the independence of end-users in space, and to customize information and learning paths to fit the specific needs of each student and follow his improvements step by step; this possibility makes the learning experience highly dependent upon the individual's objectives and performance [3, 4].

A serious issue to be faced in computer-based education is the cost of hardware and software, as well as adequate network access connections. The problem is still far from being solved, but the wide range of products put at disposal by consumer electronics includes relatively low-cost devices and network access connections. In the case considered, relative to on-line learning system design, no e/m-Learning system architecture could make sense without affordable devices and network connections. In this specific context, relatively low-cost devices and network access connections allow to use cooperative environments productively, especially in case of real-time cooperation.

This paper focuses on the design of an e/m-Learning system for cooperative work and management of group evolution over time. Several interdisciplinary aspects are faced: since evaluation of both individuals and groups must be made according to precise criteria, a preliminary discussion of pedagogical style is made about education system's renewal in the current labor market, in the direction of ICT and cooperative work; among the factors cited, early working experiences, self-motivation and stimuli from the labor market are fundamental. In the proposed approach, such factors contribute to define new, extended kinds of students' profiles, also based on the capacity to cooperate, and used to judge "good" team members as individuals and "good" teams. Such profiles are defined for both single students and groups.

Finally, an e/m-Learning architecture is presented for the selection and management of students in context of cooperative activities, real-time or asynchronous. The architecture contains a core adaptive testing component, for the continuous assessment of group activities and group evolution management; the adaptation of both learning and testing phases is based on the above mentioned profiles.

In the considered scenario, the whole e/m-Learning system is accessed through heterogeneous devices and access network technologies. As for such aspects, the architecture is defined on the basis of *functionalities* and *network access modalities*.

As for functionalities (Fig. 1), groups are meant to evolve over time and people having suitable skills must be traced, so as to optimize group work itself, as well as personal achievements.

In the proposed approach, the students' profiles are used to form suitable teams, which are meant to be refined during the whole learning process. In particular, adaptive testing [5, 6], widely used for the management of single students, is adopted for the periodic control of achievements or possible difficulties in the group or of single members.

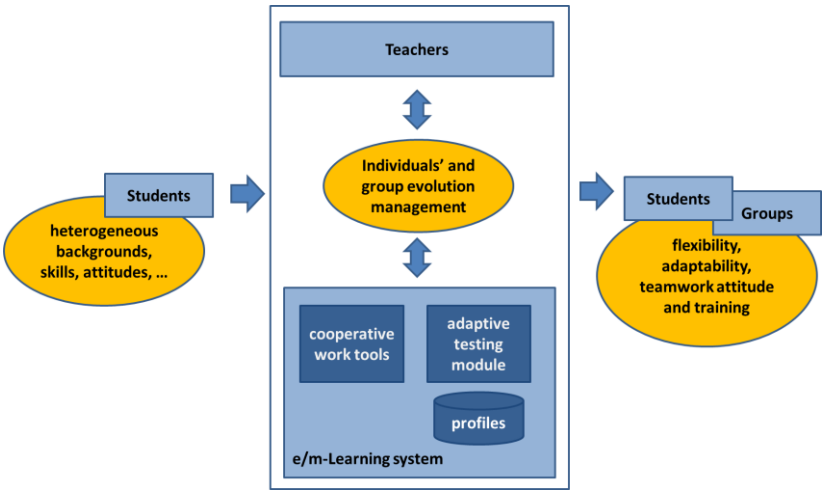

Fig. 1 Interaction among students, teachers and the e/m-Learning system: main goal of the work

As far as the network infrastructure is concerned (Fig. 2), the system can be accessed through heterogeneous network access technologies (cellular network, WiFi, DSL, wired/fiber) and devices (smartphones, tablets, laptops, desktops), each characterized by specific properties, in terms of speed and bandwidth supported. Tasks involving high bandwidth demanding contents, for instance, cannot be accomplished without an appropriate network technology. The proposed architecture takes such factors into account and schedules activities accordingly.

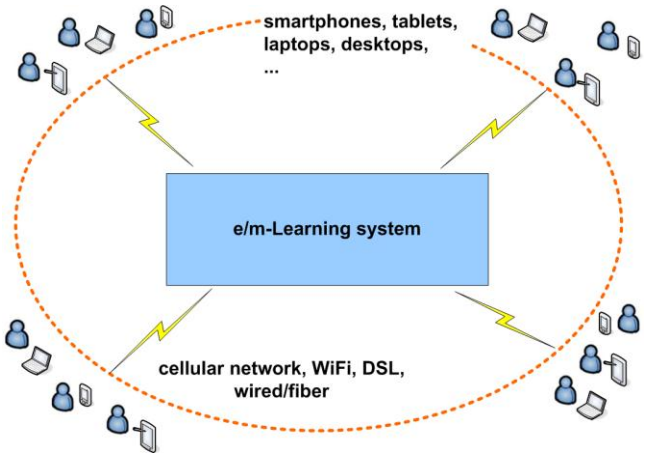

Fig. 2 Access to the system through heterogeneous network technologies and devices

Before detailing the list of contents, some comments must be made about the nature of this work. It must be noticed that the aim is to define methods for both individual and group evaluation, to be adopted in an e/m-Learning architecture proposal for cooperative work. Implementation is beyond the scope of this work. The interdisciplinary nature of this type of work must be properly underlined. As a matter of fact, ICT architectures for group evolution require criteria for evaluating both individuals and groups in their cooperative activity. Part of the discussion is consequently devoted to educational aspects, so as to identify and propose parameters to be used by the system. In this sense, this kind of proposal requires an interdisciplinary effort, partly addressed to educational issues. Traditional evaluation criteria, in particular, must be first discussed and revised in order to meet the modern work market requirements and this implies to discuss some factors of education systems renewal.

The paper is organized as follows: Section II contains a literature review about the proposed architecture and related factors discussed. Section III discusses education system's renewal, in a way oriented to the definition of students' profiles in cooperative activities. Section IV presents the considered scenario and, on the basis of the considerations in Section III, defines the adopted profiles; some aspects of adaptive testing are also defined. Section V proposes the main architecture and details its

main components, taking into account both functionalities of group evolution management and network access feasibility.

II. LITERATURE REVIEW

In the considered scenario and as mentioned above, a distinction must be made about educational methods and technological aspects, and the proposed architecture cannot set aside human factors in Information Technology [7]. A literature review must thus consider both aspects.

As far as methods are concerned, [7] is one of the first main contributions to the interdisciplinary discussion of personal, human and group aspects in the design of ICTs, as well as Computer Supported Cooperative Work (CSCW) design, languages and environments. In this context, the importance of human factors in ICTs evaluation was also underlined, as well as the importance to judge the individuals' support to the group activity in terms of innovation and participation. Several issues discussed in [7] are still present, and are here revisited according to the current labor market and its needs and role in education system's renewal. As widely emphasized in [8, 9], the role of investments in ICT adoption is fundamental to achieve or improve a competitive level in industry and lifestyle [10], and this kind of preparation must start from within education systems.

Another important and pioneering study about groups in ICT can be found in [11], in which groups are described as evolving structures, where individuals are assigned part-time roles in multiple projects. Groups themselves, especially if seen in an industry or organization perspective, can be temporary in terms of membership. The approach adopted in the present work refers to learning environments, where students can also belong to classes. The specific approach used takes into account that current education systems are presently considering the role of working experiences and stages seriously, so as to prepare the young to their future working life. To this purpose, at the school level as well as for adults, experiences in group evolution, turnover included, are fundamental.

Concerning technological issues, remote cooperative work will increasingly take place on platforms accessed through heterogeneous devices (more and more mobile ones) and using heterogeneous access connections, especially wireless ones. In this scenario, two aspects are particularly important: the application scaling and adaptation to distinct devices [12, 13], and the features of wireless communications [14-17].

In [12], several problems related to data format conversion to available devices are taken into account and a distinction is made between data transformation due to the type of device (Data Interpretation on the basis of device, easily made through XML conversions [13]) and data format optimization due to the type of network connection (Data Adaptation). The first case refers to the use of a format that both the front-end to the e/m-Learning system and the database components can understand. Data adaptation, instead, refers to a format scaling on the basis of the network access connection currently in use.

As for network aspects, [14] proposes an architecture for multi-access environments, i.e. environments where several network access technologies are at disposal and can be chosen, largely server-side and, according to the application and network load, by the user. The problem faced is to guarantee the same performance independently on the access used, particularly relevant in the heterogeneous environment considered.

The problem of application use and performance accessed through heterogeneous network technologies is widely studied. Paying special attention to cellular technologies due to their wide spread, [15] underlines the importance of supporting high data rates in mobile Internet access with particular reference to the Universal Mobile Telecommunications System (UMTS). LANs and wireless LANs performance are addressed, for instance, in [16, 17]; in particular, [16] takes into consideration the case of real-time applications, such as cooperative real-time work tools. The cooperative use of heterogeneous technologies to increase the network capacity and optimize the performance has been addressed in [18, 19] at different levels of the protocol pillar, showing the maximal achievable data rate from the joint use of different technologies.

III. SOME FACTORS OF EDUCATION SYSTEMS RENEWAL

In this section, some factors that could be taken into account in the modernization process of education systems are discussed. The aspects that can contribute to the judging of positive members of teams and productive teams will be used in profile definition.

The current social and economic crisis and the ICT revolution are transforming many aspects of our lives rapidly. Education systems are particularly involved, since they are required to evolve from at least two viewpoints. On the one hand, contents, technologies and methods are to be revised in depth. On the other hand, the impact of several external stimuli, such as market requirements, environmental changes, new technologies and the ever-growing need for a strong adaptability to different kinds of contexts and activities are leading educators to handle with a very strong generation gap. Education systems must take such factors into account, since they concern people's personal, cultural and professional growth. The idea, partially adopted by several institutions through stage experiences in the school years, is to enrich both methods and contents through human and external stimuli, in order to develop the search of new working and application areas and widen individual's studying and professional life. Some of such factors, presented in Fig. 3, are as follows: (i) the increasing importance of self-motivation and autonomy; (ii) attitude towards cooperation; (iii) macro working areas, such as tourism and the Cultural Heritage, whose

interdisciplinary nature and need of modernization in the ICT direction, always suggest and require interdisciplinary teamwork and can create new jobs and applications; (iv) early working experiences outside the school and stages; (v) the role of university spin-offs in higher education; and (vi) since people must be prepared to keep up to date during their whole working life, self-training and life-long training systems.

A. Role of Self-Motivation, Personal Initiative and Autonomy

The unemployment rate, the school's crisis and further grave economic factors make it difficult for young people to find a motivation to keep on studying or hope better times will come. The same applies to people in their mature age, who run the risk of losing their job or have already lost it, with deep personal and social consequences.

In this context, self-motivation [7-9] and the capability to keep up to date and find new perspectives become vital. As a matter of fact, people who are not sufficiently motivated run the risk of reduce their quality of study or work, surrender to unemployment, and develop grave mental and physical diseases [10, 11].

Although the problem is much more complex to discuss and explain, those people who are able or helped by the social environment, other people, friends, teachers, etc. to reach a high grade of self-esteem and self-motivation are likely not to be overwhelmed by external factors, forces and situations.

This kind of aptitude is quite precious and determinant when facing the labor market or trying to handle with it. In particular, this kind of people have generally personal initiative and capacity to face new challenges and, what's more, to develop new initiatives and be both mature and positive.

This aptitude is partially innate, but can also be strengthened by the environment, classmates, teachers, colleagues, etc.

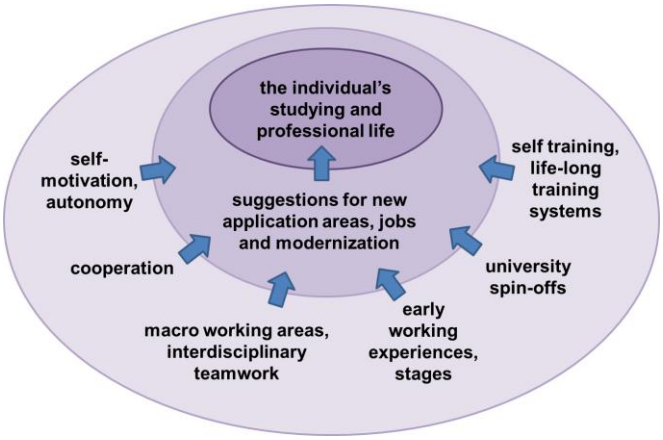

Fig. 3 Inputs to the education system reform and professional life evolution

B. Cooperation in Education and Professional Life

Many fields, especially the scientific and technical ones, have always provided students with a serious theoretical and applied preparation, so as to help them to face the work market properly, keep constantly up to date, master and/or develop autonomously new technologies in rapid evolution. This kind of approach has been successful for a long period; a serious preparation in the field of engineering, for instance, could guarantee the best and most serious students a good job.

The current situation, however, requires students to strengthen cooperation skills, be ready to work in unfamiliar environments, and reuse and widen one's skills and knowledge.

Moreover, the increasing interaction among technologies, different research and application fields, as well as modernization needs of public services have given rise to new interests and professions, where a high grade of cooperation is crucial.

In particular, students and people in general ought to be made aware that an effective interaction and productive cooperation between ICT and traditional fields is bound to help them to find or keep a job and to reuse and widen their skills and knowledge. As a matter of fact, this approach can help to foster the continuous breakthrough and renewal of the whole system. A cyclic process is thus formed, in which schools, universities and firms require and support the interaction between ICT and current application fields and jobs. This leads to new, advanced and modernized professions, which contribute to the processes themselves and make the procedure cycle.

C. Macro Working Areas, Interdisciplinary Teamwork and Modernization of Contents

The rapid ICT evolution and the consequent, strong interaction among technologies, existing professions and advanced applications have given rise to new jobs, study and application fields, where interdisciplinary knowledge and ICT skills play a

fundamental role.

All the stimuli coming from distinct macro application and working areas, such as public services, smart cities, telemedicine, the Cultural Heritage, tourism, farming, public administration, education, banking and their evolution are to be analyzed in depth. As a matter of fact, their needs already and will indicate in which directions professional skills are to be developed.

People (students, teachers, workers, employers, etc.) must understand that an effective interaction and productive cooperation between ICTs and such macro areas will produce and increase employment.

Schools, universities and firms must take advantage of professional stimuli deriving from macro working, both for students' and workers' benefit and their own. In particular, macro working areas can indicate subjects to face, new technologies to understand and adopt, and directions for further work and autonomous study.

D. Early Working Experiences and Stages

Several institutions and research centers, among which experiences of [12, 13], are stressing the importance of a proper practical training among youth and information properly organized in order to help people to find stages and job opportunities during and after their years at school or university.

In particular, the present situation suggests to renew a cooperative education model, where face to face or computer-based lessons or lectures are constantly associated to work experiences. In this way, schools, universities, firms and students find the way to keep in touch and interact in a productive way.

This kind of experiences play another fundamental role, i.e. they lead different people to work together, despite the differences; in addition, student can highly benefit and learn from distinct way of thinking and approaches. In this way, the young are naturally brought from the classroom environment to a real working place and also trained to cooperative work.

E. University Spin-Offs

Other important initiatives that can guide students towards the labor market are research and university spin-offs, include the MIT experience and several others worldwide.

University spin-offs put technologies, spaces and resources at the students' and their professors' disposal, in order to transform prototypes deriving from research projects into patents or copyrighted products. In more detail, in corporate law, a university spin-off is a capital company that transforms an idea or prototype born in the context of technological research into a corporate production. If not properly ruled or handled with, spin-offs can give raise to conflict of interests between academic research and commercial production. However, considering the serious lack of funding that many universities are undergoing in this period and the applicative nature of some faculties, a productive interaction between research and industry can only be welcomed.

Most naturally, such interaction must be fruitful for both research perspectives and business. Furthermore, in case activities born from initial spin-offs maintain their applied research nature, they can also become powerful glue between universities and industries, thus leading to innovation. The left part of Fig. 4 describes the interaction that can take place between universities and industrial partners, which, from within the university, leads to a spin-off. This process leads to the situation depicted in the right side of Fig. 4, where the spin-off activity evolves and brings new ideas, projects and further cooperation with both the university and industrial partners, whose mutual interaction is enriched.

As far as young people are concerned, they can find appropriate research and working suggestions from the industrial world and, at the same time, be helped to develop their ideas and begin to run their own future activity.

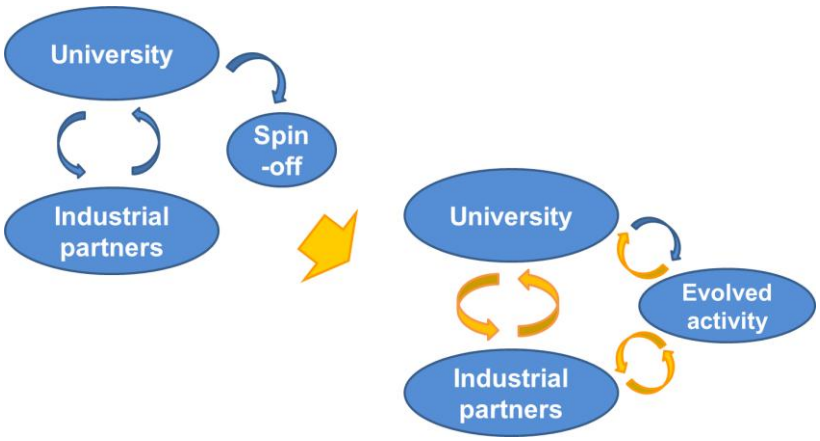

Fig. 4 Spin-offs as potential long-term glue between university and industry

F. Life-Long Training Systems

New jobs are continuously arising from the ICT field and requirements of global economy, some traditional jobs are disappearing almost suddenly, are to disappear soon or are becoming deeply different. In consequence, people must keep constantly up to date and middle-aged people, who run the risk to lose their jobs, must be prepared to keep learning and keeping up to date.

E/m-Learning techniques and the cloud can be applied to achieve both continuous training and human resources reconversion. For this purpose, and strongly recommended by the EU as well as several international governments, self-training and life-long training are becoming an increasingly compelling requirement.

While large companies are able to afford high-quality on-site trainings, small/medium companies may have great difficulties. In order to face this grave situation and, at least, reduce costs, e/m-Learning and assessment techniques are being adopted and guiding workers in their training paths. The same applies to individuals who want to keep up to date or try to find new working and application areas. In this context, the cloud is increasingly being used to share useful contents and benefit from advanced and more performing cooperative work services at lower prices or with no charge.

IV. PROFILES AND ADAPTIVE TESTING: DEFINITION AND APPLICATION TO THE CONSIDERED SCENARIO

As depicted in Fig. 1, the main goal of the proposed approach is to support teachers and students in the development of a strong teamwork attitude and appropriate skills in ICT-based cooperative work. In consequence, both students as individuals and groups must be properly assessed and followed over time, on the basis of technical and knowledge improvements, capability to support the group properly and evolution as a team. In more detail, profiles are defined for single students and groups and so are assessment phases.

The following subsections respectively discuss: (IV.A) how individual and group profiles can be defined; (IV.B) generalities about adaptive testing and adaptive testing applied to both individuals and teams, and are introductory to the main architecture.

A. Definition of Profiles in Teamwork

The factors that contribute to the definition of a “good” group member and of a “good” team are multifaceted and not easy to define. In a productive team, for instance, group members should be cohesive in accomplishing the goal, and everyone should be (or become) able to demonstrate understanding and comprehension of expectations and goals. Social skills should be stimulated, including listening, sharing, accepting ideas and differences, etc.; members, in addition, should assess their efforts as a group as well as personal achievements.

Beyond traditional aspects of personal and group achievements, such as learning levels, background, attitudes, school capabilities, results as a group and cohesion, some factors described in section II can be adopted and applied to the definition of social factors and response to external stimuli, such as the capability to meet the needs of the current work market and other external stimuli.

In the context of teamwork, for instance, factors that should contribute to individual profiles are previous workgroup behaviors, motivation, capability of integration, will to cooperate and to put personal skills and experiences at disposal of the group, as well as will to achieve personal improvements. As for teams, strong attention should be paid to cohesion and capability to organize and divide work properly, also on the basis of personal capabilities, attitudes and skills, as well as possible problem that can occur along the way, such as personal problems and consequent need to substitute members, partially or totally.

Several factors that should contribute to education system renewal were discussed, integrated with schooling traditional capabilities and applied to the definition of both individual and team profiles.

As shown in Table 1, all such factors can be referred for individuals or teams and divided into three main groups: attitudes, social capabilities and response to external stimuli.

TABLE 1 CONSIDERED FACTORS FOR INDIVIDUAL AND TEAM PROFILES

Target profile	**Factors**		
	Attitudes	**Social capabilities**	**Response to external stimuli**
Individual	learning levels, background, interdisciplinary work, use of self-training systems	self-motivation, initiative, will to achieve personal improvements, previous workgroup behaviors, capability of integration and cooperation, will to put personal skills at disposal of the group	early working experiences and stages, ideas deriving from macro working areas and interdisciplinary fields
Team	group work proceeds, interdisciplinary work, use of self-training systems	initiative, will to achieve team improvements, previous workgroup behavior, capability of integration and cooperation,	ideas deriving from macro working areas and interdisciplinary fields

		interdisciplinary work, division of tasks	

In particular, among attitudes of individuals, the factors can be learning levels, capability to perform interdisciplinary work, habit to use self-training systems; among social capabilities, the factors are self-motivation, initiative, previous workgroup behaviors, and others reported in Table 1; and response to external stimuli can be expertise deriving from early working experiences, capability to find stimuli from modern working areas and interdisciplinary fields. As for teams, attitudes can be workgroup proceeds, use of self-training systems for group advances and updates, interdisciplinary work; social capabilities can be initiative, will to achieve improvements as a team, previous workgroup behavior with the same staff, capability of integration and cooperation with new members or facing new problems, interdisciplinary work, division of tasks. Response to external stimuli as a team can be ideas deriving from macro working areas and interdisciplinary fields.

B. Adaptive Testing: Generalities and Use in Individuals' and Team Assessment

Adaptive testing can be defined as tailoring the difficulty or contents of the next question/problem/etc. presented on the basis of the learner's response(s). The underlying rationale is that this approach gives adequate information about the current level of the examinee's ability and can feed a dynamic process of adaptation of both learning contents and materials.

The use of adaptive testing allows to follow the complete cycle of learning, from the studying material to the evaluation of levels of comprehension. In addition, it feeds back this information to the system, so that the learning and assessment processes can be tailored to the students' specific needs and situations and the effectiveness is consequently increased.

Several examples of e/m-learning today are often associated to information repositories or web-based distribution, but the true realization of their potentiality is also related to the exploitation of the range of capabilities offered by technologies – one of the most obvious ones being the provision of assessment and instructional contents adaptable to the learners' needs and desires. The goal is to deliver the right content to the right person at the proper time and in the most appropriate way.

In the proposed approach, when adaptive testing is applied to a group work environment, its role is threefold: (i) it is used for the very first selection of group members; (ii) it is regularly used for controlling each participant's learning level and integration with the team, on the basis of the criteria defined for individual profiles; (iii) it is regularly used for testing the group's achievements and cohesion, according to the criteria defined for team profiles.

In more detail, as sketched in Fig. 5, when students first access the system (1), they are not divided into groups yet. In this phase, they can naturally have heterogeneous backgrounds, skills, attitudes and no training to work in teams. On the basis of preliminary assessment phases and individual profiles, teachers decide the teams to form (2-5).

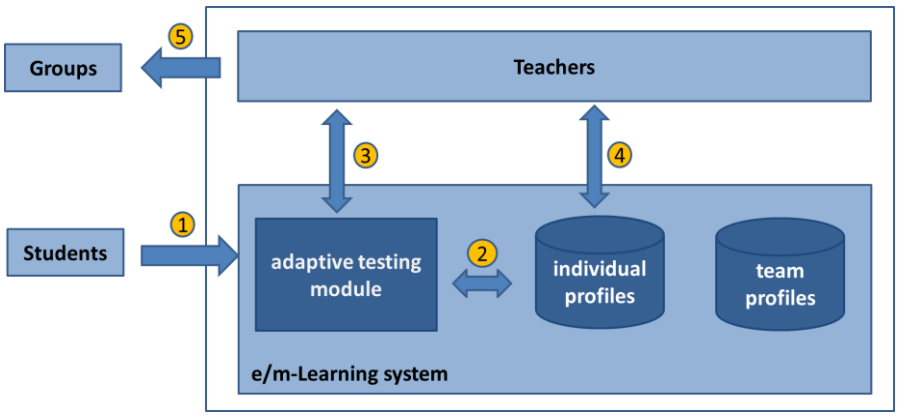

Fig. 5 Adaptive testing in team constitution

As outlined in Fig. 6, a continuous activity of learning, interaction and cooperation is then carried out by individuals and teams by accessing the activities block (1, 2), as well as a continuous assessment of development results (3, 4). In this way, educators are provided with very detailed and personalized information about single students and the groups and, if needed, are alerted about possible problems to solve. On the basis of such data, individual profiles and team profiles are updated and group evolution followed. In more detail, teachers can take part to activities (5) and are involved in activities scheduling and group evolution control (6). In particular, if a group or an individual have difficulties or, on the contrary, the activities are too easy, teachers can reschedule tasks or modify group membership.

V. PROPOSED ARCHITECTURE

This section presents the proposed architecture for selection and management over time of participants to cooperative e/m-learning activities, for both individuals and groups.

In the following, for the sake of simplicity, every interaction between students and the system seems to be direct; on the contrary, every step is meant to be supervised by teachers, through an appropriate interaction teachers-system.

Three main aspects were taken into account. The first refers to network and software optimization; on the one hand, reliable real-time intra-group communications must be guaranteed. On the other hand, each task uses applications characterized by suitable platform requirements. In order to achieve a full cooperation within each group, applications are adapted and scaled to all the members' devices and access technologies [14, 15].

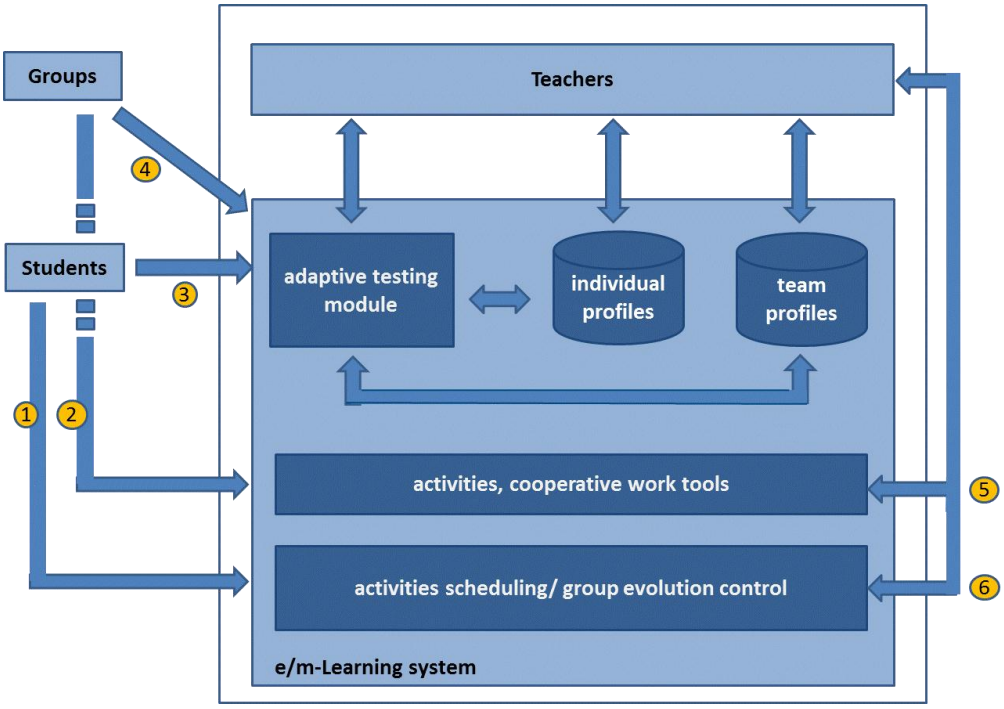

Fig. 6 Overall progress of the system

The second problem concerns educational aspects; as anticipated in previous sections, groups and activities must be defined and managed properly over time. In particular, in the proposed architecture, two aspects are the basis of groups' management. Firstly, groups are selected on the basis of the students' skills and attitude towards teamwork, in order to offer challenging and stimulating workgroup experiences. Secondly, expertise and capability to cooperate are constantly kept under control, so that over time, groups and their evolution are adapted to the skills detected among participants and their actual advances. In this way, both individual and team profiles become dynamic and are updated along the way, more frequently than it usually happens.

The last aspect considered refers to turnover management; in case some students change group membership, working continuity and quality must be guaranteed. This is achieved by comparing the people's and groups' curricula mentioned above. When students change group, details stored about their background can guide teachers to define a proper turnover.

In order to meet such requirements, the proposed architecture carries out the following tasks:

1. adaptive offer of activities: tasks are tailored to the users' needs, profiles and group requirements;
2. group first definition: individuals are assigned to a group on the basis of their schooling and social skills;
3. group evolution: groups are adapted over time on the basis of both individuals' and groups' advances or difficulties.

The architecture comprehends: (i) an external layer for user-system communication and application scaling; (ii) a decision system that performs testing phases and allows to manage profiles, individuals and groups over time; (iii) a database storing testing and learning material, profiles and groups as well as their evolution.

The main contribution of the proposed approach is that both individuals and groups are managed in a dynamic, self-adaptive way. As a matter of fact, people's interests and actual expertise are constantly evaluated and used to optimize their work, and so are the groups' achievements. In this way, the system performs a self-adaptation over-time, tailoring groups and their evolution to the capabilities of participants.

A. Use of Profiles and Main Architecture

The desired system functionalities were enumerated. Such requirements were analyzed in order to identify the main components needed.

The first version of the main architecture is depicted in Fig. 7 and includes the three layers sketched above and here better defined as User-System Interface, Dynamic Self Adaptable Learning Engine and Database Module. The User-System Interface is accessed by both individuals and groups and, for the sake of clarity, is divided accordingly to Fig. 7.

When the user (as an individual) accesses the system (top part of Fig. 7), he is identified by means of a userId; his profile, also identified by the same parameter, is retrieved from the individual profiles database. In the same way, the user's device is identified, in order to tailor the access to services to a proper format (smartphone, tablet, laptop, etc.).

In this first phase (adaptive offer of activities, corresponding to requirement 1), the user's past experiences, stored in the profiles DB, are forwarded to the Dynamic Self-Adaptable Learning Engine, in particular to the Data Analysis Module. Such data are thus processed, so that the Decision Module offer of activities to the skills, interests and needs are detected.

The role of such suggestions is twofold; on the one hand, it mainly refers to new capabilities that should be acquired; on the other hand, it can also refer to previous issues that need to be deepened, on the basis of companions available, tasks not accomplished yet, etc. Data about such phase are used to update the profiles DB.

Once the user sent the acknowledge parameter, the phase of group definition (requirement 2) begins, carried out by the Decision Module: the user's level of expertise in the activity and teamwork initial attitude or past experiences are retrieved from the individual profiles DB; the user is consequently inserted into a group of an appropriate level, updating the teams DB in consequence. Information about group membership is also sent to all the users involved.

The phase of group evolution (requirement 3) follows, orchestrated by the Data Analysis and Decision Modules: while the tasked are carried on, the user's ability evolves. The working progress parameter is accordingly forwarded to the system and analyzed, so that updated learning levels can be assigned and stored in the profiles DB.

Once the work is in progress, the groups access the system (Fig. 7 on the left) and undergo working and testing phases; team profiles are consequently updated and decisions about group membership (for individuals) and group evolution (for teams) are made. The relative database is also modified in consequence and decisions about group adaptation submitted. Users who are rapidly improving their level, for instance, can be offered to face tasks and join groups of a higher level or groups that need new skills can achieve further members.

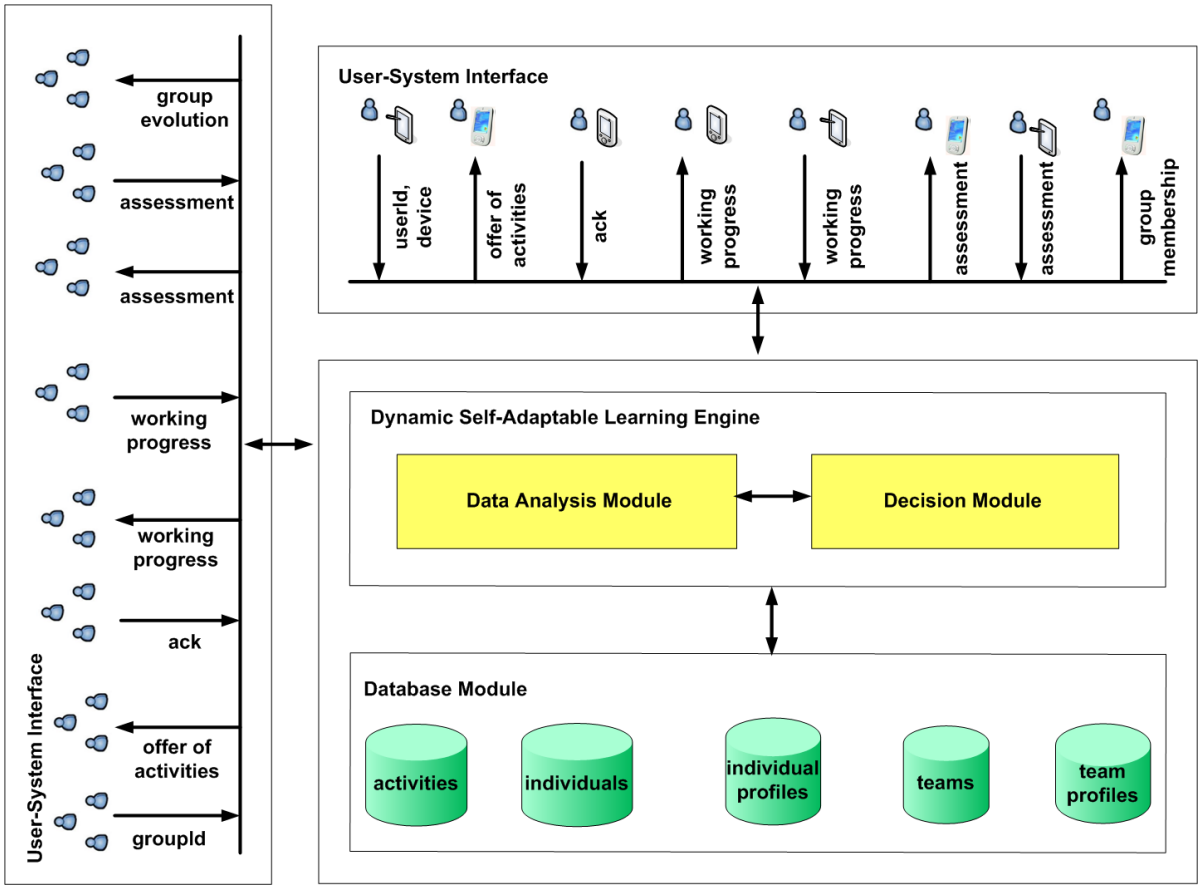

Fig. 7 Main Architecture

The proposed architecture is represented in more detail in Fig. 8. The User-System Interface and the Dynamic Learning Engine have both been expanded. The components and their interactions are as follows.

1) User-System Interface;

As far as users (as individuals or members of a group) connect to the system by means of heterogeneous devices and access technologies, the User-System Interface acquires information and forwards it to the system after a format conversion, if required by the user's device. Such interface is also in charge of returning activities, group definitions, working progress and group updates in a format that the users' different devices are capable to understand. It can happen that, during a cooperative work session, several members use different devices, so adaptation must be carried out at individuals' level.

More precisely, the User-System Interface must carry out the following tasks:

1. receive the user's data and forward them to the Dynamic Learning System;
2. receive the answers from such system and send back the results;
3. transform all the requests and answers on the basis of the user's device (smartphone, tablet, laptop, etc.);
4. more generally, make the user and the system communicate on the basis of the user's device;
5. adapt data to the user's device and access technology, so as to meet the users' and the group requirements and optimize the overall process.

When systems of any kind are accessed through heterogeneous devices and connections, this kind of data management must always be faced and handled.

It should be noted in particular that task 3 concerns the management of queries and data with respect to the user's device, and is accomplished by the Query Module.

Task 4 concerns data optimization on the basis of network access technology and is fulfilled by the Data Adaptation Module.

In more detail, the problem of converting data on the basis of available devices has not been mentioned yet, but in terms of data format, two different - even not independent - operations must be distinguished, data transformation due to the type of device (data interpretation on the basis of device), and data format optimization due to the type of network connection (Data Adaptation).

As for data interpretation, the system must communicate on the basis of the user's device, thus the user's data must be converted into a format that both the front-end of the system and the database can understand.

This process will last the whole lifespan of the learning activity and can easily be done by means of XML conversions. As a matter of fact, this is a straightforward, general and effective way for exchanging data between heterogeneous environments.

As far as the Data Adaptation Module is concerned, information is adapted to available technologies (smartphones, tablets, laptops, etc.).

2) The Dynamic Self-Adaptable Learning Engine;

The expanded version of the Dynamic Learning System includes three components, which are divided into sub modules:

- the already mentioned Data Analysis Module, composed by the *Profiles Evaluation* module and the *Expertise Evaluation* module;
- the already mentioned Decision Module, which includes the *Offer of New Activities* module and the *Groups Management* module;
- a further component: *Download/Upgrade Module*.

All such modules interact so as to guide the whole process. In particular, once the user's profile has been retrieved on the basis of his UserId, a first profile evaluation is performed in order to identify the user's needs, skills and attitudes, as an individual and as a member of a group.

According to this analysis, the Offer of New Activities module searches the activities DB, defines the offer and forwards it to the user. If the user chooses to join an activity that requires a specific software program, such application is downloaded from the DB through the Download/Upgrade Module; the same applies to upgrades of activities in progress.

Once the user has sent his acknowledge, his profile in the corresponding subject is analyzed by the Profile Evaluation module and sent to the Groups Management module.

This component receives many profiles for each activity, defines the groups on the basis of similar skills and forwards memberships to the users.

During the whole process, the working progress parameter is analyzed by the Expertise Evaluation module, which forwards it to the Profiles Evaluation module and to the Groups Management one. In this way, the users' profiles are updated and groups can be dynamically rearranged.

B. Network Infrastructure and Main Architecture Expanded

The considered scenario also takes into consideration the access to the system (Fig. 2): users access group work services through heterogeneous network technologies (cellular network, WiFi, DSL, wired/fiber) and devices (smartphones, tablets, laptops, desktops). Different technical features and possibilities, thus, cohabit [16-21]; it must be noticed that several activities, such as high bandwidth demanding ones, can only be performed through appropriate network technologies and devices. People's achievements and group evolution, thus, also depend on the individuals' access techniques. Consequences of this problem on teamwork are also discussed.

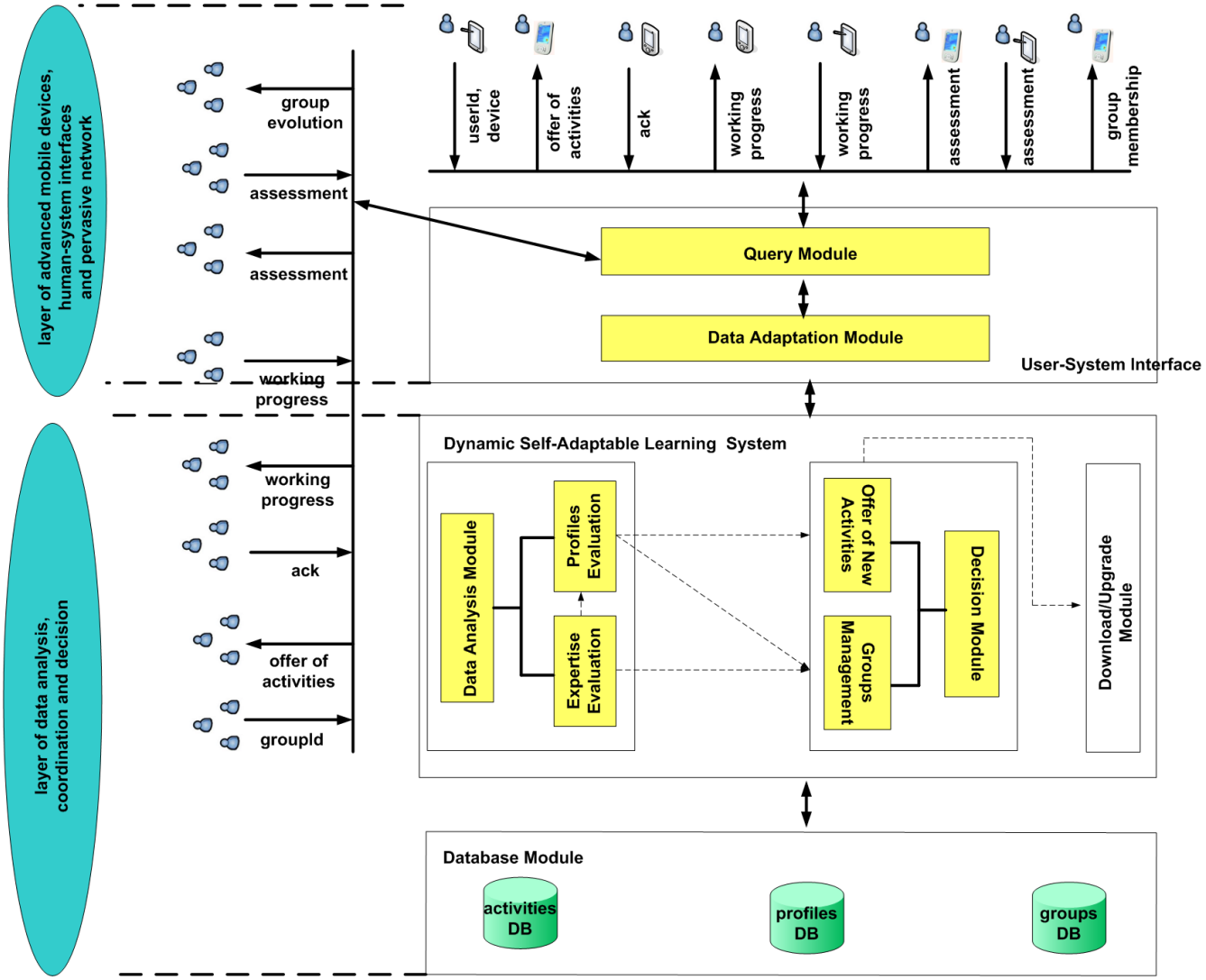

Fig. 8 Expanded Main Architecture

Communication technologies are at last ripe enough to guarantee good quality m-learning services running on affordable electronic devices. The new concept of m-learning is, in fact, based on the availability of contents through mobile access with different devices, based on heterogeneous technologies and in ubiquitous contexts.

This leads to new challenging issues, aiming at extending and increasing the flexibility offered by web systems on mobile devices.

In addition, since different physical and logical abilities require different features, several technologies, methods, and interfaces can potentially be integrated into the device. In particular, in order to support the foreseen cooperative mobile environment, the network infrastructure is assumed to satisfy the following requirements.

- In case the device supports multiple access technologies, the most suitable one is automatically selected for a given activity in a specific context. Depending on the environment and during the whole learning session, a dynamic adaptation to the to the most convenient access method is also carried out.

- Awareness of the surrounding environment and of the users' current status is needed, in order to (a) adapt learning contents automatically to both the bandwidth and the system data rate; (b) take into account the users' preferences and device capabilities so as to profile and adapt the contents in an understandable format for users and devices.
- The lesson contents should be scaled to the device and technology features.
- The infrastructure should be able to support the user's ability to switch among different electronic devices (such as notebook, tablets, smartphones) with different capabilities (such as screen size, multimedia support, bandwidth), and to use different connection types and networks (cellular network, WiFi, DSL, wired/fiber).
- The m-learning activities must be reusable on different devices or software platforms (such as Windows, iOS, Android), hence users' interfaces have to be adaptive and re-configurable depending on the their profiles and lessons requirements.
- Heterogeneous technologies have to cooperate in a transparent manner to the users, to allow seamless indoor-outdoor operations.
- The heterogeneous network ought to allow peer to peer communication between educators and students, and among students.

In the near future, the characteristics mentioned above should be supported on platforms that make use of social networks principles, so as to disseminate knowledge as well as entertainment.

VI. CONCLUSION AND FUTURE WORK

In this paper, an architecture was proposed for a cooperative e/m-Learning system and the management of groups and group membership over time. A discussion about related work was carried out in Section II and further reading is addressed in [22-30]. The proposal required some related interdisciplinary steps. The first was a discussion, carried out in Section III, about the criteria that should guide education systems renewal, taking into account new market requirements, such as adaptability and capability to cooperate. These factors led to the second step (Section IV), i.e. the definition of evaluation profiles for both groups and individuals, in order be adopted by an adaptive testing core component of the system for managing group work and group evolution. The idea is to tailor working and assessment phases to specific needs of both individuals and groups and also to compose homogeneous groups on the basis of individuals' skills and groups' needs.

As long as a user's ability evolves, for instance, he is assigned to groups of different expertise or to further activities.

The last step (Section V) was the definition of the architecture and its modules, whose distinct roles and interactions were described in detail. Three layers were highlighted; the first is a user-system interface that allows every kind of mobile device to interact with the system. The second layer is the learning system properly defined, containing the decision module and further components for data analysis. The last layer is the database layer, describing activities, profiles and the dynamics of groups.

Future work will be devoted to a better specification of decision processes and selection on the basis of skills, attitudes to work in groups and willingness to try new activities. In the same way, the information schema will be better defined.

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