The PP&S100 Project: Process Control as an Information System Instance

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Abstract *The Project PP&S100, Problem Posing & Solving, is part of a set of initiatives promoted by the General Directorate of the Italian Ministry of Education, Research and University, for supporting the many innovations that have recently affected curricula at the upper secondary level. Main goals of the project include strengthening computer science culture and enhancing its role as a scientific discipline; founding education processes on logics, mathematics and computer science weaved together to pursue an interdisciplinary scenario, building a culture of "problem posing and solving" by investing across a broad disciplinary group of subjects, ensuring growth of computer science based training of trainers and practicing activities within specific social networks and virtual learning environment to share learning materials, teaching supplies, mentoring and self-evaluation. This work presents a hierarchical conceptual model for "Computational Thinking" assumed by PP&S100, formalized according to the outcomes shown by information systems courses held at the Politecnico di Torino and validated using Process Control as an information system instance.*

Keywords: Problem Posing&Solving, Computer Science, Computational Thinking, Process Control, Collaborative Learning.

1. Introduction

The purpose of the project, which gathers among the primary proponents also the Italian Association for Automatic Computing (AICA), the National Research Center (CNR), the National Industrial Unions, the University of Turin

teaching plans in Maths with respect to the framework drawn by problem posing and solving. The Science Faculty of the University of Turin made a great experience in this field and, thanks to it, put in place a Moodle asset and a Maple suite for the project itself. Both of them, had been built tightly interlaced and were successfully used for several years in teaching Mathematics for all the students coming from the same Faculty, to whom a part of those attending other courses joined soon.

The whole infrastructure started first with a Moodle virtual learning environment, always available at the address http://minerva.i-learn.unito.it/. Then that Moodle platform grew integrating a Maple Suite, consisting of an advanced symbolic computing environment and MapleNet, supporting file distribution in such a way that interaction remains active even if Maple is not running locally on the computer. MapleTA added to soon, being a tool apt to develop tests and assignments, including definition of open mathematical questions and self-evaluations, and, in a while, MapleSIM followed, being useful to carry out virtual labs in Physics, Electronics, Mechanics, Thermodynamics and so forth. The whole system was able to sustain more than 150 teachers, which gave birth soon to a Community, taking advantage of the Moodle platform, which made a strong collaborative learning scenario possible, fully and constantly practiced.

An effective tutoring and coaching service was also established addressing teacher learning to pursue the constructivist approach [Brooks, & Brooks, 1999] in the classroom and to support products development to be shared on the Moodle platform. Since February 2013 more than 150 students communities grew in the project, where they could learn according to a multifaceted perspective: at school during their classes and in the labs, but also at home, by trying to solve problems together, understanding them first, according to the posing perspective, and choosing a suitable algorithm to carry out a possible solution, most of the times working inside the learning management platform as reported in [Zich et al].

A few classes – belonging to 10 high schools and 10 technical institutes, selected on a voluntary basis – are planned to start in the second project year (2013/2014). They are to provide for the breeding ground to put in place a proposal for a new discipline intended to deepen information and computer science: a first step towards the creation of a process able to deploy the same experience after the project ending. The discipline is being organized according to a framework articulated into two lab modules spread over two years of high school curricula.

Section 2 introduces emerging scenarios for computer science in the school, focusing on the layer abstract model assumed as a reference in the project. Section 3 describes the Computational Thinking Living Lab arguing on Process Control as an information system instance to validate the abstraction model, while Section 4 reports on concluding remarks and future work.

2. Learning Computer Science in Education: Emerging Scenarios

Inquiry based Science Education and Learning [Olson and Loucks-Horsley, 2011] can be considered as the result of different contributions given by several domains such as, among others, "constructivism" [Brooks and Brooks, 1999] [Marlowe and Page, 2005], "Bloom’s taxonomy of learning" [Forehand, 2005] and "multiple intelligences", without forgetting Paulo Freire’s “Pedagogy of the Oppressed” [Freire, 1993], where the terms “problem posing” occurred for the first time.

Problem posing and solving fits well the computer science discipline, which is able to give proper means, tools, methodologies and theories to describe real and conceptual phenomena. This is mainly because logics, formal languages and physical elementary devices are deeply rooted in the founding discipline principles.

A glance at the rest of the world [Peyton-Jones et al, 2011] shows that many other countries have expressed the same creative impetus that already hit England some years ago [Livingstone and Hope, 2011]. In fact, excitement around computing led UK to introduce this subject into schools curricula, making of that event an effective representative experience for all other countries. In particular, European countries [Gander et al, 2013], together with many others around the world, are now trying to collect information from UK, because they came to share what U.S.A. anticipated in their White Paper since 2005:

- a clear distinction between computer science as a discipline and rigorous computer applications or digital literacy should prevail
- recognize that all children and young students should learn information science in the same way they learn science or mathematics.
- be aware that growing demand for ICT professionals from the labor market reduces the potential supply of qualified teachers.

2.1 Computational Thinking

Computational Thinking (CT) is often elicited as a best practice of inquiry based science approaches, as defined by J. Wing: ”*Computational thinking is the reasoning processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent*” [Wing, 2008]. This definition can be assumed as a reference point with respect to the objectives pursued by the PP&S100 project, as the terms “formulating problems” and “formulating solutions” suggest.

The most important complex mechanism in CT is the abstraction process, which is used, well deepened and represented in Unified Modeling Language UML or Entity Relationship (ER) model, to define patterns, specializing entities or generalizing others, leaving from objects or other simpler entities (“generalization” abstraction and its converse, the so-called "specialization"). It is also used to capture essential common properties of a set of objects applying an abstraction procedure named "classification". Also an algorithm is usually given as an abstraction of a process having a determined objective, which operates executing a sequence of steps, working on a set of inputs to produce a corresponding set of outputs. A process itself can be considered an abstract data type representing a set of values and operations designed to manipulate those values, which are not visible from outside of that abstract data type representation. From that drawing comes out that efficient algorithms cannot be designed without using appropriate abstract data types to handle input data or internal temporary ones to be provided to the same process. Well depicted by both UML and ER models at least, abstraction gives analysts the power to deal with complexity scaling the representation of reality, leaving from the bit representation, as the lowest description level, up to the largest system you can find in realty. The hierarchical abstraction design follows a hierarchical sequence of layers, each one featuring its own specific abstraction level, thus recalling the communication domain where a layered architecture allows segmentation of services assigning specific functionalities to any layer to keep it disjointed from the adjacent ones. This enhances modularity, in fact when implementing or even changing functionalities, a specific layer is chosen to focus on, without affecting others, since adjacent interactions take place through specific inter-layer services. The loosely structured architecture of the Internet shows how effective and robust may be a well-formed abstraction. An example is provided by the TCP/IP layer, which, placed over the network and under the session layer has enabled a multitude of applications to proliferate at layers above, and a multitude of different platforms, media, and devices to operate at lower layers.

Fig. 1 depicts the model drawn to introduce the rationale of the computer science discipline to be developed in the project, fully adopting the “Inquiry based Science Education model” and its specialization represented by the “Computational Thinking” scenario. The most abstract modeling phase is placed at layer 4 (l4), the Problem Posing Layer, where the model is shaped through an inquiry-based process focusing on main questions linked to the problem to be understood. To give a flavor of that layer functionality, the Logical Framework Analysis [EU, 2004] has been recalled, to emphasize the fact that a collaborative interaction should also be taken into account and put in place among all the stakeholders involved in the problem.

Fig. 1 – CT and the Layer Abstraction Model

The next layer (l3) deals with the specification of the solution to be proposed for the problem posed at the previous one. Algorithms and data representation should be given there according to a formal abstract description, being they better shaped using specific environments, such as MAPLE/MAPLE SIM or

MATLAB/SIMULINK [Chonacky and Winch, 2005], LABVIEW [National Instruments, 28/8/2013] and UML [Wikipedia, 28/8/2013].

MAPLE, MATLAB and LABVIEW, together with their linked applications, may be considered as appropriate examples of Advanced Computation Environment (ACE) to specify mathematical models for complex phenomena. In parallel, for non-mathematical domains, in a complementary perspective with respect to ACE, the Unified Modeling Language [Unified Modeling Language, 28/8/2013] and IDEF (Icam DEFinition for Function Modeling, where ' ICAM' is an acronym for Integrated Computer Aided Manufacturing) [IDEF0, 28/8/2013], are also introduced. Thus a multi-faceted model description can be carried out, representing the same applications/phenomena by means of use-cases and activity diagrams to describe functionalities, class diagrams for static objects description, sequence diagrams for tracing object dynamic interactions and so forth. Both scenarios, mathematical and non-mathematical, are also able to sustain high-level simulations. In the most cases both environments can also translate given formal models descriptions into a first draft of the programming language description for the same systems/phenomena. These descriptions are handled at layer two (l2), where a more detailed picture can take care of the various aspects also linked to the hardware platform to be used subsequently at layer one (l1). At level two more precise simulations can also be planned, being given the infrastructure already traced in terms of operating systems, network features, file system and so forth, relying also on compilers (C, C++) or interpreters (Python, Scratch) to correctly implement the semantics of the language. To cite an example for all in terms of CASE tools, Visual Paradigm [Visual Paradigm, 28/8/2013], supporting also ER-Model based environments, and Eclipse [Eclipse Project, 28/8/2013] could be used as a specific reference. Hence, as shown by the experience already made at the Information Systems Course at Politecnico, conceptually showed in Fig. 1, Computational Thinking stems from both mathematical and engineering thinking. Unlike mathematics, where constraints take the shape of theorems, corollaries, assumptions, information systems are constrained by the physics of the underlying information-processing units and their related operating environment. This means that boundary conditions, failures, malicious agents, and unpredictability of the real world must also be taken into account, having in mind that, unlike other engineering disciplines like Mechanics or Constructions, Information Science — based on intangible artifacts like software, allows anyone to develop virtual worlds totally unconstrained by physical issues, in fact in cyberspace the only constraint to creativity may be given by imagination.

3. “Computational Thinking” Living Lab and the TestBed

This work deals with the development of a complete test-bed that aims at stating the feasibility of the learning process, based on previously exposed methodologies, when applied to a very simple but relevant context. The label assigned to this experience is “Living Lab”, focused on enhancing the relevance of computer science in the school as a means to represent realty with respect to both static and dynamic perspectives.

The Lab rationale has the following main points:

- check how learners can leverage learning approaches based on Problem Solving and Computational Thinking - being the latter a learning domain emerged recently and often considered in literature as a specialization of Problem Solving - when applied to scientific subjects in the secondary school to create a continuum from mathematics, to computer science, up to other "mathematics-based sciences".
- check how Simulation and Prototyping can act as "accelerators of understanding" of complex systems and physical phenomena.
- prepare a draft syllabus for the first module of Computer Science for the secondary schools, taking care of the features of the different specialization branches
- build an environment for trial studies around a "living-lab" framework, where basic elements are combined to develop prototypes, which span from simple process control systems together with their adjustment parameters, up to more complex systems like robots and organizations management networks.

The multi-disciplinary nature of the whole process is relevant for the objectives pursued by the project, since it encompasses perspectives linked to the "hardware" platform planning, together with a description of the system as a whole, traced at various abstraction levels. To validate what has been first modeled, several simulation phases are carried out, giving space to the following realization, which has to be made available at the final stage in terms of product or service.

To validate the abstraction model introduced in the project, a first example has been drawn using a heating system as an elementary process to which a regulation device should have been adopted. The reason for this choice relies on the easiness with which the system can be modeled and the wide number of applications available in different domains, ranging from home automation, industrial systems, chemical and rural plants, energy savings, and so forth.

3.1 The Driver

In order to make Computational Thinking well understood, and validate the abstraction model drafted above, a tangible and well-known ordinary living experience has been taken as an inspiring background. Since ancient times mankind has always tried to overcome any constraints imposed by the physical properties of being. Any natural phenomena has been analyzed and deepened with the aim of controlling its effects whether to get advantages, when positive, or to reduce its impact, in case of damage.

Hence, Controls and Regulators can be considered as ubiquitous and pervasive mechanisms, used to constraints economic systems behavior, when large-scale systems are considered, but also to control robots, or other smaller devices, when small-scale systems, even though complex, are examined. Controls and Regulators are also immediately perceived within people daily life, several examples do exist like heating and air conditioning systems, showers, and so forth. It is worth not forgetting that man lives because some physical features in its body, like blood pressure, heart beat rate, are regulated naturally, so that they are constrained within certain thresholds. Even when those features overcome those constraints, artificial devices, controllers or regulators, can be provided to force a correct behavior. An insulin pump device is a typical example where insulin levels corrections are executed to regulate glucose level in blood, when pancreas natural control system is not behaving normally. A picture showing what may happen without these controls is given by the consequences of a possible control failure: when blood glucose level is beneath its lower threshold, a loss of consciousness may occur, in contrast, when the level increases above the higher threshold, damage to liver, eyes, and kidneys may happen.

All the previous comments concern the definition of the possible main questions, related to the impact of a specific control device, to be placed mainly at the higher level (l4) of the layered model drawn in Fig. 1, corresponding to the “Problem-Posing” domain. The following layer (l3) is assigned to the “Problem Solving” domain, where a formal specification, representing the solution model, can grow, . While the third layer (l2) offers a translation of the formal specification into a descriptive programming language, layer l1 hosts an effective implementation on the basis of that language and a suitably chosen hardware platform. Hence, if the question “Why are we developing a control system” concerns the analysis of a specific problem, taking care of stakeholders, the impact of caused effects they should sustain, their influence on the domain, their interest to overcome the problem, and so forth, the question “What is a Control System?” should be placed at the second layer, since it concerns the solution to be realized to contrast the problem. Following the inquiry-based approach, it is expected that the next question should be “What is a System?”. Hence moving from it, the IDEF0 methodology is often suggested as a means to provide analysts with a suitable way to shape a graphical abstraction of what in nature, but also within organizations, can be perceived as a system, often understood simply through the analysis of its input and outputs. IDEF0 allows an extended representation of what is ordinarily named as a “block schema”, having the added value offered by three different sets of inputs, the first labeled as {constraints}, entering the box from above and representing the constraints the process has to respect, the other, labeled {resources}, from below, representing all the means used by the system/process when running, while {inputs} represent the set of information and/or raw material entering the process from the left side of the box. The picture is completed by an arrow coming out from the box, placed at the right side, labeled {outputs}, representing material and information processed and thus produced by the process. Always following an abstraction schema, a real

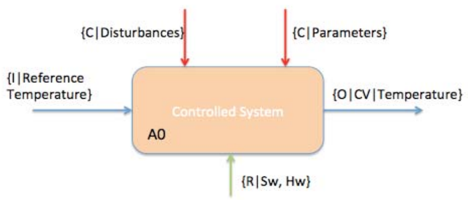

Fig. 2 - IDEF0 block to describe a Controlled System

controlled system can effectively be represented taking advantage of the same graphic representation, focusing on the conceptual model of a particular device, such as that one able to regulate the room temperature, which may be chosen as a first simple example to be dealt with the students.

Future developments will focus on the description of a MapleSim Diagram, choosing appropriate devices. UML diagrams will also be drawn to give an object paradigm perspective. Finally an Arduino platform will be used as a prototyping environment for the physical development.

4. Conclusions

PP&S100 aims at supporting the many innovations put in place by recent regulations adopted by the Ministry and affecting curricula at the upper secondary level of the national education system. One of the main objectives of the project deals with strengthening computer science culture and also enhancing its role as a scientific discipline. To this purpose a model is drawn in this work to shape the rationale of this discipline to be introduced at the secondary school, first cycle, fully adopting the “Inquiry based science education model”, rooted into the constructivist scenario and its specialization, represented also - among others - by the “Computational Thinking” approach. A hierarchical framework is defined using abstraction models shaped as an inquiry-based process and focusing on main questions linked to the problem to be posed and then described according to a “solution” perspective. A four-layer based hierarchy has been considered taking advantage of the project/product life cycle, which is usually founded on a process, which naturally evolves from the highest abstraction level (inception) up to a more practical (implementation and maintenance) phase, involving real world impact in terms of applied actions and sensed physical quantities. To enhance conceptual reading of functionalities provided by each hierarchical level, references to commercial available tools are also taken into account. To make “computational thinking” interpretation easier for large scale education and training systems, some catalyzers have been identified, which can suggest how enhancing and enabling interleaved disciplines domains, through ordinary problems faced by students and teachers in their daily experience.

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From career education to vocational education and training in digital era: exploiting Communities of Practice.

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Abstract. *The aim of this contribution is to sketch the possible role of the Communities of Practice (CoPs) in projecting in the digital dimension both the activities aimed at orienting towards a future professional life, and those aimed at Vocational Education and Training (VET). While the former are especially targeted at students just exiting from high school, the latter rather span an overall lifetime, including life-long learning, continuous in-service training and professional outplacement. Though the stakeholders participating the two processes might be different, the core underlying processes have much in common.*

Keywords: career education, vocational education and training, community of practice.

1. Introduction

The present economic and financial crisis that Europe and the whole world are experiencing has further underlined the need to devise new ways to fight unemployment and under-employment. In general, it is more and more necessary to avoid the waste of human skills and energy which very often characterizes the present labor market. This complex phenomenon must be approached from two opposite but somehow complementary sides. From the first one, youngsters approaching either university or their first employment should be guided to become aware of their full potential and real skills and abilities, and to choose the most appropriate career for their talent (career education). From the other side, Vocational Education and Training (VET) should efficiently support both continuous refresh of professional skills, and possible quick and satisfactory (for both the employer and the employee) outplacement. Traditional training courses, either organized in-house or by third-party, often reveal unsuccessful in effectively satisfying the anticipated needs. Most of all, a significant part of protocols, rules, strategies which are integral part of everyday tasks remains often hidden or badly underlined, so that the “official” training often fails in providing a ready-to-exploit expertise. To overcome this problem, the spread of digital resources may inspire new models and strategies. In particular, the flexible model of the Community of Practice (CoP) can be easily adapted to support both career education and VET. Lave and Wenger [Lave and Wenger, 1991] define a CoP as a group of people “who share an interest, a craft, and/or a profession”. The members share a common interest in a particular domain, and exchange practical experiences to increase knowledge and skills related to their field. In this way the members learn from each other, and also the group develops new potentialities and dynamics. In fact, a CoP can be realized in everyday life through direct contacts in a physical place, but also, thanks to the enabling technologies, at a distance through online discussion boards and newsgroups. Either a traditional forum may be configured as a basic example of CoP, or dedicated frameworks may be set up.

This paper aims to sketch a solution to make choices and provide services that promote entry into the labor market, acting as a first step in the design of a more comprehensive system that can trigger a permanent cycle of training and outplacement to allow all citizens to keep their skills up to date and adapt to rapidly changing work environments. The consequences of such a virtuous cycle in the long-term concern not only recent graduates looking for first occupation, but also people wishing to reposition themselves in the labor world and, ultimately, the companies that could encounter candidates more motivated and aware of the requirements for a successful working relationship.

2. CoPs history at a glance

The concept of Community of Practice was already around in social and educational sciences (e.g., see [Bourdieu, 1977] and [Vygotsky, 1978]), however its success and spreading of concrete implementations were spurred by the work of Lave and Wenger ([Lave and Wenger, 1991] [Lave, 1991]).

The core idea which aimed at changing the way people work and learn was just the discarding of the separation between work practice, mostly conservative and stable in time, and learning, which was in this way necessarily focused on the most static aspects. A large part of experiential knowledge, the so-called implicit knowledge gathered within an organization and while performing concrete tasks, was left out from training due to such separation. However, people actually work according to patterns and rules which are often different from manuals descriptions and from the "theoretical" descriptions of job tasks. The actual practice relies on often complementary as well as completely alternative strategies and rules. Nonetheless, organizations tend(ed) to rely on the "static" form of training to transmit work practice. The roots for this kind of behavior are mainly philosophical. A special value is assigned to "abstract knowledge", while the concrete practice details are considered as contingent, easily derived after the relevant abstractions, and therefore less essential.

It is interesting to notice that, actually, in the past of most cultures, learning and training were firmly based on the role of the artisan workshops, that were the privileged places for transmitting and preserving arts and crafts. Common practice and storytelling were the main instruments for the knowledge/skill transmission. Strangely enough, it was the industrial age that stated the prevalence of abstract knowledge over actual practice and established a separation between learning and working, as well as between *learners* and *workers*. The new theories claimed a return to the "ancient wisdom": appropriate practice is central to understanding roles and concrete practices related to a specific job, while abstractions detached from practice might obscure less trivial details of practice. Further, they assigned a central role to social exchange of experience and information. It is interesting to notice that such topic formerly focused on organizational learning [Brown and Duguid, 1991], at present deserves an increasingly significant role in learning in general. Theories by Vygotsky [Vygotsky, 1978] and by other researchers paved the way towards projecting the same ideas on education and learning, in the line of socio-constructivism. Learning is a social process happening within the zone of possible achievements of the student [De Marsico, Sterbini, and Temperini, 2013]. The core concept in the practice-based theory of learning devised by Lave and Wenger's [Lave and Wenger, 1991] is the "legitimate peripheral participation" (LPP) in "communities-of-practice."(CoP). In a CoP external observers may be allowed to watch without actively participating.The novices firstly access the community from the periphery; as they get experienced and gain reputation, they move towards full participation and membership. Therefore we can usually distinguish 1) a group of core experts, who achieved high reputation and reliability due to their experience and according to the assessment of their peers, 2) the major group of active participants, who participate to the exchange of information and experiences, and 3) the peripheral participants, who start as observes of the dynamics and contents of the CoP, and eventually and possibly level-up. Personal growth is also reflected by community growth: the community itself develops through different levels of interaction among the members, as well as different kinds of activities. Self-development originates by active participation to the community. As a matter of fact, the two central elements of the CoP approach are *situated learning* [Hummel, 1993] and *community reflection on practice*. Knowledge is acquired from and applied to everyday settings, and is discussed with peers and experts; this makes up a true social system [Wenger, 1998]. These concepts focus on learning, rather than teaching [Lave and Wenger, 1991], though not building an educational theory. Internet, with early forms of forums, and the modern Social Networks (SN), built upon Web2.0 dymanics, has technologically supported the exchange of not only personal data but also of working experience and learning difficulties on virtual communities. Dedicated software frameworks (e.g., ELGG - http://elgg.org) allow to set up CoPs, which have become one of the most appreciated forms of social learning [Blackmore, 2010]. Recent documents from projects in New Zealand also report the use of CoPs to implement career education networks. Their aim is to support an aware transition from school to work and/or further education [Vaugham and O'Neil, 2010].

We can say that learning is both the main activity and the core topic of the CoP strategies. Buysse, Sparkman and Wesley [Buysse, Sparkman, & Wesley, 2003] underline "the growing need to integrate educational research and practice" to connect what we know with what we do. However, shared lists of recommended practices often fail to promote the personal responsibility and exploration ability, pertaining to both educational researchers and teachers, and to parents and students. CoP practices should encourage and motivate every member of the educational community to analyze, constructively criticize, and effectively complement each other's experiences. Teachers should be encouraged in taking active part in research activities. To these aims, the authors consider CoPs a very promising tool, even compared with other proposed approaches to join research and practice, e.g., action research [Calhoun, 1994], or professional development schools. The core idea is breaking "the linear relationship through which information is handed down from those who discover professional knowledge to those who provide and receive educational services" [Buysse, Sparkman, & Wesley, 2003].

3. CoPs for career education

Currently the orientation towards a new job starts, at best, at the time of entering into the new organization ("staff orientation"). The orientation, which should begin in any case before the actual activity of the newly-hired, should provide the new employee with basic information about the organization, the position occupied and expectations linked to it by the company, and the overall community in which operations do occurr. However, a significant part of such information and related interactions should be anticipated at earlier phases prior to joining the labor world. In collaboration with universities and training centers, a first level of information should be provided before of the choice of university course or of applying for a future work, so to minimize the phenomenon of early school leavers, that often depends on incorrect assessment of commitment and perspectives. Moreover, additional information services should be provided in a later stage, before of the conclusion of the previous studies, so to support a more informed and convinced choice of both the completion of the educational/training path, and of the new career path.

Our proposal relies on a CoP-oriented approach to career education, which should include the development of an integrated IT platform and innovative services, able to support students during their academic career, from the decision about the most suitable course to enroll up, to the first contact with the labour world after graduation. In particular, it is important to model the processes that take the students from the moment they come out of high school and must choose the path best suited to their training and personal inclinations, and to follow them in their tracks involving either work or university or both. In fact, many universities are somehow equipped to respond to these needs, especially in promoting periodic meetings (possibly supported by technology) between students and companies and in presenting courses and routes.

These experiences provide obvious benefits, and also limitations. The meetings with the companies are particularly effective in connecting aspiring trainees with industrial stakeholders mainly interested in a temporary collaboration (the *stage*), which is part of the university curriculum, with a goal generally limited to short-term needs from both parties. In this perspective such meetings are mainly addressed to students at the end of their degree course. In addition, the cadence is mostly biannual, leaving many students run out of information when it would be needed. All this means that the target is mainly centered on the needs of the companies. On the other hand, existing career portals supports business contacts and the matching of supply and demand in the longer term, but the student is still a passive subject, and above all has very little information about the company's activity as a whole, which is often crucial to a satisfactory choice for both stakeholders.

In both cases, therefore, the companies' attention is particularly directed to illustrate the objectives of short or medium term. While this may be relatively satisfactory for a student looking for an internship, it shows serious limitations when the same student is looking for tools to get a better view on the development prospects of the companies (s)he made contact with, and on the fields in which the stage activity can possibly convey his/her professionalism, as well as on the possibility of conversion of skills acquired in different fields. Especially the current organization of the information is essentially static, and does not provide any form of customization. Moreover, as already pointed out above, students are not provided with any really interactive and informative communication tool with the labor world, nor with a support tool in the selection of training courses. Going even backwards, there is little or no concrete systematic information about careers and perspectives related to a given university course, so that the choice is often driven by friends, relatives, or even by vague as well as unfounded expectations. The result is a huge premature university death rate, with the related waste of resources and energies from both the student and the surrounding subjects.

This situation leads to one of the major ills recognized in the Italian education system: the distance between the world of production and the world of education. However, the current socio-economic situation highlights the need, even more than in the past, to support more effectively the match between supply and demand in the labor market. The solutions proposed to overcome the mentioned limitations include, for example, the provision of examples of company's work processes, so to allow application and testing of capabilities and inclinations of job applicants. For graduates, additional information and examples of the activities may be of help to focus talents and abilities, so to access career paths best suited to their preparation and most satisfactory against their expectations. Particularly valuable are the testimony of company employees who share their experiences, difficulties and satisfactions obtained in order to allow a comparison of experiences and a more conscious approach to the company. Question / answer forums and other means of communication between graduate and company should contribute to an open mechanism for the exchange of information and experiences, which can bring both the company and the graduate to take informed and effective decisions. In practice, we propose a first step in transforming the career education in a transversal tool, characterized by an ever-changing series of personalized services to facilitate the achievement of the objectives of education, training, empowerment, social inclusion and well-being of citizens.

To achieve the above objectives, guidance services should be seamlessly accessible, starting at as early a stage as possible in the university study career. This could avoid many failure-stories due to lack of awareness of the requirements and objectives of a study/training program. In this broader perspective, it is important also to provide a correct and clear information on the part of educational organizations, in synergy and collaboration with those alleged to counterparty possible future professional relationships.

In practice, we propose to implement a CoP, extended to both academy and companies, where the students enter in a “peripheral” observing role, but proceed along the path towards active participation, when they will be able in turn to give suggestions to younger newcomers.

This scenario requires a significant amount of energy and resources, and an effort to redesign at least part of the information architecture linked to the career education. On the other hand, the necessary actions might be framed in the context of the EU Horizon 2020 Strategy, with particular reference to the most recent document (June 2013) of the European Community that calls for action to solve the problems of youth unemployment (http://ec .europa.eu/europe2020/pdf/youth_en.pdf). These actions would also help to strengthen the links within the so-called "knowledge triangle" of research, education and innovation, which are the three main hubs around which the modern knowledge society should develop. This can only bring benefits to the same companies involved in terms of improved productivity and competitiveness. Good examples of the proposed approach come from abroad, e.g., the experience portal IGGY "Connecting and challenging the word's brightest young minds" developed by the University of Warwick under the auspices of the World Council for Gifted & Talented Children. Through the portal, the members access to a range of services including participation in discussions and debates on topics of interest with experts from worldwide, interaction with senior students from different universities, input from experts and professors, participation in projects and competitions, access to contents.

4. CoPs for VET: a concrete example

Digital support for VET is fundamental for workers, but it is of paramount importance for trainers. A main motivation for the European project Understand IT (http://aitel.hist.no/understandit/) was the documented need for supporting VET teachers, trainers and tutors in including ICT in their teaching activities, and in training their trainees in using similar tools for life-long learning. Despite the more and more advanced learning technologies, many teachers, most of all elder ones, are frightened or even disturbed by technology. The preceding project Vitae, whose results were exploited and refined in Understand IT, developed a set of net-based collaborative learning activities, using modern Web 2.0 tools. The resulting strategy aims at helping VET teachers to discover how to use these tools in their own practice. Communities of practice were encouraged in Understand IT, as a crucial mean to peer-assisted learning, together with mentoring, coaching and peer-to-peer activities.

The first concrete step of the project was the review of the actual situation of the national educational systems, national educational standards and curricula of participating countries (Denmark, Germany, Lithuania, Norway, Italy and Portugal). In practice, all countries are using virtual classes and learning platforms, but they still lack a systematic integration of ICT into the pedagogical activities, especially as for the use of Web 2.0 tools. There is a growing awareness of the crucial role of using Web in learning activities, but who, or what institutions in each country, should care about the training of involved teachers and trainers? In many settings resistance to change must be addressed, as the main challenge for educators is to give up control, and award learners new degrees of trust, exploiting peer-to-peer activities.

The results of the project were tried out by running courses in 4 languages in the participating countries. To this aim, it was not possible to overlook national situations and educational settings before proceeding to a joint planning towards the introduction of ICT in VET. In particular, before trying the introduction of a trans-national CoP. The project results especially emphasize the need for more independent learning, global and intellectual awareness, and proof of progress through the compilation of appropriate portfolios. In particular, it is often the case that learners are required to be able to use communication forums and assess the trustworthiness of online information in a critical way. On the other end, educators are more and more often required to train their students to use e-portfolios: these support evidence both of the learning advancement and of the teaching practice.

The powerful message sent by the learner centric model [Quintana, Carra Krajcik, and Elliot, 2001] can be enhanced by enriching the role of the teacher to include greater individual support and guidance for the learners. In addition, peer-mentoring and peer-coaching seem to be winning strategies, most of all when learners are teachers in their everyday life, as it was the case for the project experimental activity. However, coaching is an art, that implies carefully tuned presence/absence of the coach, to spur coachee's abilities regarding critical planning, and accurate evaluation of obstacles and of related overcoming activities. On the other hand, this model is somehow implicit in how CoP work [Wenger, 1998]. This was the main motivation spurring the establishing of a Learning Community of Practice (LCoP), to support participants' exchanges about their collaborative activities.

In addition to considerations regarding the search for effective *training-the-trainers* strategies, we also took into account the need for projecting national VET programs onto an European/international perspective. For the project this meant to cope with the language issues related to both the management and the interaction of several "local learning communities", based on the different languages of involved countries. Solutions were devised to allow interface localization, support to content translation and tagging (actually, these aspects are seldom addressed in existing CoPs), and channeling of the communication among local learning communities. Local peers could so have the possibility to add an international flavor to their achievements

We first run a pilot version of the VITAE course, and then experimented it with “real” teachers. The pilot version of the course was attended by members of the project (with other members running as observers). The course comprised several tasks, ranging from practice with Web 2.0 tools for doing and analyzing one's own teaching, to analysis of existing CoPs and social networks, to coaching and mutual coaching sessions with the course coordinator and with peers, to the final composition of a plan to experiment one's learning outcomes in her present teaching activity. Main outcomes of such trial were basically in the deeper appreciation of the amount of work the students are asked to perform, in order to timely deal with the assigned tasks, and in the knowledge about what parts of the course need localization and/or translation (and what of such parts are hardly tractable in such a sense). So we resolved to shorten the course (time is a premium for our prospective - working - students) and planned how to deal with localization/translation.

5. A possible implementation

Service Oriented Architecture (SOA) defines a logical model with distributed software modules offering services in a standardized manner. The application of this paradigm brings a series of advantages. Software as a Service allows the encapsulation of software components, isolating them so that only the layer relative to the actual service is exposed to the outside. This produces independence from the implementation and security of the internal system. The encapsulated application logic is completely decentralized and accessible over the Internet from different platforms, devices and programming languages, for full interoperability. Developing a set of components around a layer of existing software is simple and should not require changes in the original application code. The adoption of SOA paradigm allows for a gradual implementation, through the use of existing infrastructure and the simultaneous application of the latest technologies. Moreover, it allows to reduce the costs of training because it is based on a common set of shared services and activities.

The conceptual SOA framework is generally characterized by three specialized layers: a front-end layer (interface), a back-end layer (services logic), and a data persistence layer. Platform services would include: self-assessment of skills, knowledge and flaws; an information system available to companies to expose, in addition to research positions, the main strategic lines of development; a layered CoP where students and employees are able to obtain/offer training and guidance pathway identified. The different levels of information and interactive services require specialized modules, whose composition and structure, offered by a SOA framework, will be completely transparent to end users. First of all it will be necessary to define the different roles involved (student, educator, trainer, recruiter, etc.) as well as related services and levels of information relating to each. In addition to these roles, somehow "traditional", we propose to promote a concrete "coaching" activity by former students, eventually coming from the same educational setting, already currently employed by the companies involved, which can establish an interaction geared more to a peer-to-peer relationship, and then predictably more frank and open, with new aspirants. In addition, senior experts or teachers can also be consulted at all stages of the student's participation in the community. The set of planned activities takes the form of a CoP organized by areas, for roles and levels of detail, with extreme flexibility in switching between different informative areas. In addition, both the information and the actions of the parties may be subject to a process of "reputation gain" supported by a mechanism of peer-evaluation available to the community, so the information deemed most useful will be classified and stored for future research in a knowledge base. The latter is expected to grow in size over time, both in terms of depth (level of detail) and amplitude (variety of areas and topics) and representativeness. This may be achieved through appropriate participatory tools for tagging and annotation, so that the users themselves can actively contribute to information organization and to improve the community protocols. In addition, planning to exchange expertise and information within European Community, the platform might be opened to support automated or peer-mediated translation of contributions considered interesting. The overall architecture is sketched in Fig.1. For instance, company services may include publishing of various contents, e.g., job offers, as well as mentoring tools, e.g. editors to create guided tours of enterprise activities. Student services may include profile publishing, peer-coaching, and communication and cooperative working facilities. Expert services may essentially include facilities to mediate among stakeholders, or provide expert advice about specific questions.

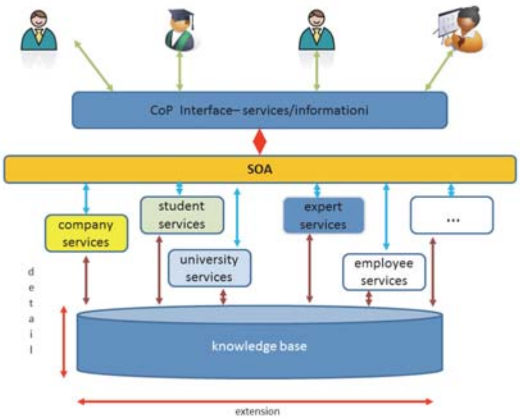

Fig. 1 – Proposed architecture

6. Conclusions

We sketched a possible architecture including the use of layered CoPs to handle both student orienting (career education) and VET for long-life learning and outplacement. The approach involves the active and stimulating participation of all stakeholders involved in the transition from school to labor world, and exploits the new possibilities offered by CoPs in the digital world.

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A Social Game-Based approach supporting Environmental Learning

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Abstract. *Environmental education is a priority at worldwide level. Thus, it is indispensable to change people ecological, economic and social perceptions by integrating the concept of sustainable development in their learning processes. In this paper we present and evaluate a game-based learning approach based on reputation, collaboration and competition aiming at promoting the waste disposal practice among the primary school children. The proposed game, named Pappi World, is a 3D Virtual World designed according to pedagogical theories concerning behavior and attitude changes.*

Keywords: game-based learning, social learning, virtual world.

1. Introduzione

Global environmental problems become increasingly pressing. To achieve the sustainable development it is necessary to change the ecological, economic and social attitudes and perceptions of people by integrating the concept of sustainable development in their educational process. Environmental education is linked to the acquisition of a responsible environmental behavior that goes beyond the mere knowledge. In fact, in addition to knowledge people has to develop attitudes and motivations towards correct behaviors. These activities are successful if they involve citizens from their early childhood.

In this paper we discuss the social aspects of a 3D game to support the learning of a correct behavior for the practice of recycling waste. The proposed game, named Pappi World, aims at supporting elementary school children in the learning of how to recycle waste. It proposes different learning approaches, such as: individual learning, in which students learn how to properly differentiate waste; social learning, based on the reputation of the participants. The game also supports collaborative and competitive learning mode. A preliminary evaluation of the students attitude and of their social interaction has also been performed.

This paper is organized as follows: Section 2 discusses related work, while Section 3 briefly introduces the game features, while Section 4 details the proposed learning approach. Section 5 describes a preliminary evaluation of a learning experience using Pappi World. Section 6 finally concludes by outlining the lines of future research.

2.Related Work

VR and 3D graphics have been largely adopted for e-learning (Monahan et al., 2008; De Lucia et al., 2009b). Barab et al. (2005) describe a learning and teaching project adopting a multiuser, virtual environment to propose to 9-12 children educational tasks. It combines strategies used in commercial gaming environments with lessons from educational research on learning and motivation.

An example of simulation-based learning game is Math-City, aiming at supporting the students in learning mathematical concepts (Polycarpou, Krausea, Rader, Kembel, Poupore & Chiu, 2010). The progress in mathematics is adopted by the students to grow their city. No social aspect is considered.

Wrzesien & Raya (2010) adopt a serious Virtual World for teaching children natural science and ecology. They follow both a collaborative and a competitive approaches, enabling the students to discover their potential and skills during the game and compare them with other players while competing, it also allows them to share and learn during the collaborative play.

3.The game

The game has been designed according to the guidelines specified by the Italian Environmental Education and Instruction Ministries, which include the understanding the concept of waste as a resource and the value of the differentiated collection, according to the practice of the three R’s (Reuse, Recovery and Recycling). In addition, the educative process should include laboratory activities, also in a edutainment modality. The laboratory, through experimentation, play and research activities provides new knowledge, creating the basis for reflection and exteriorization.

The aim of the game, funded by Campania Region (Italy), is to contribute to the sustainable development of the ideal sustainable world of the alien Pappi. This world is structured as a set of archipelagos, each one representing a school. Each island of the archipelago, representing a class, can be seen in detail. On an island there are several cities, representing the students' land. Finally, a city is an ad-hoc developed 3D world, shown in Fig. 1, which the students explore and where they learn the waste disposal practice. The city also offers a game room where the students can play individual game oriented toward the waste disposal learning.

4.The learning approach

According to the Tbilisi Declaration of 1977, environmental education was defined as formal and informal education, aiming at raising the awareness of people for ecological dynamics, their natural surroundings, environmental problems, and interdependencies with economic, social and cultural development. As a consequence, it is not enough to interact with learning contents to change the people behavior. People will behave correctly when they will change their attitudes, motivation, and values. (Smith & Ragan, 1999; Miller, 2005).

Fig.1 - Waste Collection

In the past, government organizations insisted on the knowledge of the problem (Dietz & Paul C. Stern, 2002), distributing informational materials. Concerning a correct practice of recycling, the subject of this article, they provided information on where, how and when to recycle (*Procedural knowledge*). Another type of knowledge is the knowledge of the Impact (*Impact Knowledge*), i.e. on the benefits of recycling of waste in terms of pollution reduction and energy conservation. A third type of knowledge is the *Normative Knowledge*. It represents the knowledge about the behavior of others. It has a strong impact on the attitude to properly recycle waste, basing on the awareness that relatives, friends and the whole community is dedicated with interest to this practice, and that each individual is judged by others and appreciated for its correct behavior. As shown by (Dietz & Paul C. Stern, 2002), this kind of knowledge has a strong impact on the changes in behavior and attitudes..

The game offers different learning approach, as described in the following.

3.1 Individual Learning

The individual learning activities proposed by Pappi World aim at promoting Procedural Knowledge (how to collect and differentiate waste). Each student owns a village, represented by the 3D world shown in Fig.1, and he/she has to collect the garbage, putting it in the appropriate bin. Garbage is randomly generated. The student can collect other waste by playing an individual game available in a game room, useful to collect extra waste recycling scores. These games are simply to use. The player can play with them until the needed quantity of material has been collected. They cannot freely be accessed, to avoid to distract the user from the game purposes.

3.2 Collaborative Learning

The students learn the relevance of a recycle policy by exploiting the collected garbage as a mechanism for growing their village. Indeed, they can convert the collected material in new houses and furniture for progressing their village. If they do not own the right quantity of a given material (plastic, paper, etc.), they can exchange it with other players. The material exchange interface is shown in Fig. 2. This practice enforces the idea that differentiating garbage is a useful practice for improving their village. Pappi World also add the "waste miles" concept, derived from "food miles" . Food miles is a term which refers to the distance food is transported from the time of its production until it reaches the consumer. Food miles are one factor used when assessing the environmental impact of food, including the impact on global warming. We introduce this concept also in the waste case, given a high value to exchanges of material between students that are closer.

3.3 Competitive Learning

A way to collect more garbage can be to go in the village of other students and take theirs. Competitive learning exists when one student achieves his goal and all other students fail to reach that goal (Johnson & Johnson,1991). Competitive learning have many criticisms, but if it is well designed can be very stimulating. In this game it is possible to take material from students of other classes, stimulating *intergroup competition* that can be seen as an appropriate competitive strategy since it maximizes the number of winners.

3.4 Reputation

The concept of reputation has a great relevance in the social dimension. In general, a reputation system makes evident the contribution of each member of a community, such as a class or a school. It is a mean for motivating participants, influencing their attitude and beliefs. To get the best results it is important that an individual can directly compare his or her behavior with the provided information (Dietz & Paul C. Stern, 2002). It is also worth making comparisons considering groups near to that person, such as the neighbors or the classmates, instead of the country or the city.

Pappi World adopts the following reputation mechanisms:

- *promoting class/school leader*, i.e., a student particularly motivated, that recycles diligently and encourages his/her classmate to recycle;

- disseminating data on community (class/school) recycling rates, such as the percentage of people that regularly recycle for each community;

- *city growing*, the representation of the village in the school island visually show the village level. In this way a visual feedback on the recycle level of each student of a class is provided, highlighting the most virtuous member of the class community.

Fig.2 - Material Exchange

3.5 The teacher role

The teacher acts as a facilitator of the game. He supervises the actions of each student and controls the class progresses. He reinforces the role of the class leader and stimulates the participation by public commenting on the game web site.

5. Preliminary evaluation

The participants in this study were 24 children between 9 to 10 years randomly selected from the primary school of the Town of Baronissi (Italy). They all attended the 5th grade and had the same learning objectives related to natural science and ecology.

Method

The aim of the evaluation was to assess the learner's attitude toward experiential learning with the Pappi World . In the experiment we considered the factors which promote the use of the system

Evaluation Organization

The study has been performed in one laboratory session (i.e., three supervisors for all the 24 participants). In the first step, a presentation of 10 minutes introduced to all the subjects the main features of Pappi World. The students played Pappi World for an hour. After playing, they answered the Student Post-Game Perception Questionnaire, reported in Table 1. A 7-points Likert scale anchored at 1 by Strongly Agree and at 7 by Strongly Disagree has been adopted.

Table 1. The Student Post-Game Perception Questionnaire.

ID	Question
Q1	The game environment was stimulating. (Environment)
Q2	When I made a mistake while playing, I was able to solve the problem easy and quickly. (Behavioral Control)
Q3	I quickly learnt to play the game (Learnability)
Q4	I'm satisfied with this game. (Satisfaction)
Q5	I will recommend the game to a friend.
Q6	I enjoyed the game. (Perceived Enjoyment)
Q7	I would like to use the game in the future. (Intention to use)
Q8	I was able to control the avatar and the events. (Control)
Q9	The avatar control distracted me from what I had to do. (Distraction)
Q10	It was easy to collect garbage. (Easy to use Perception)
Q11	I played without effort. (Mental effort)
Q12	I think I have learnt to make the waste separation better. (Perceived usefulness)

Q13	Material exchange was stimulating. (Collaboration,)
Q14	It was stimulating to collect the garbage in the city of the others. (Competition)
Q15	It is important for me to appear in the list of the most virtuous students that are an example of correct behavior. (Reputation)

The students involved were accustomed to answer questionnaires. Considering their young age open questions were avoided and the questionnaires have been designed to keep focused and straight forward, trying to avoid any confusion. In particular, we took into account the following factors derived from the TAM model (Davis,1989; Davis, Bagozzi, & Warshaw, 1989):

Perceived usefulness (question Q12), defined as “the degree to which a person believes that using a particular system would enhance his or her job performance”. In the learning context, the user believes that a system would yield positive benefits for learning.

Perceived ease of use (question Q10), “the degree to which a person believes that using a particular system would be free of effort”

Perceived enjoyment (question Q6), “the extent to which the activity of using the computer is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated” (Davis, Bagozzi, & Warshaw, 1992). .

We also included question Q1, which may have a significant influence on the determinants of attitude toward using the game.

When the student easily interacts with the environment and is able to manage problems without the need of an external help his avatar behaves as expected and moves in the virtual world according to his commands (question Q2). Learnability is an important quality of a game since low learnability gets the student to abandon the game (Q3). Question Q4 measures the overall satisfaction, while question Q5 considers if the user is satisfied with the game so as to recommend it to friends. Also Intention to use is a relevant aspect (Q7).

Since the game has been developed using a 3D Virtual World environment, aspects concerning the presence perception should be verified (Witmer and Singer, 1998; De Lucia et al., 2009b).

A high control on the environment and on the interaction contributes to get a high experience of presence (Q8). Distraction (Q9) is another factor that contributes to increase immersion and participation when is reduced. If the user does not control his avatar in a natural way the presence perception is reduced. Question Q10 is specific to assess the ease of the garbage collection feature of the game. It could happen that the game is easy to use in general, but the user could have some problems with its most relevant feature. Question Q11 collects the perception related to the mental effort of the user while playing. An excessive effort could discourage the use of the game.

Social aspects are considered in the following three questions: Question Q13 is related to the satisfaction concerning the material exchange feature (collaboration), while Question Q14 collects the perception related to the possibility of growing his own city by collecting the garbage of the other participants, competing with them to take their garbage. Finally, question Q15 collects the perception of the user of being appreciated by the community for his success.

Results

Fig.1 shows the boxplots representing the results of the user perception questionnaire in Table 1. All the participants considered PW stimulating (Q1). The games was perceived easy enough to be controlled (Q2): the positive scores are more than 70\%. It was also perceived to be easy to learn (Q3), with 100\% of positive answers. Participants were very satisfied (Q4), with 100\% of positive answers. 100\% of them would recommend the game to a friend (Q5); PW is considered very enjoyable (Q6) and 88\% of participants would like to use it in the future (Q7). The avatar control was not considered a distracting factor (Q9) and the garbage collection was perceived easy to perform (Q10). No particular mental effort was required (Q11), which were perceived instructive (Q12). The student perceptions related to the collaborative/competitive activities proposed by Pappi World are reported in Table 3. The judgments expressed were very positive.

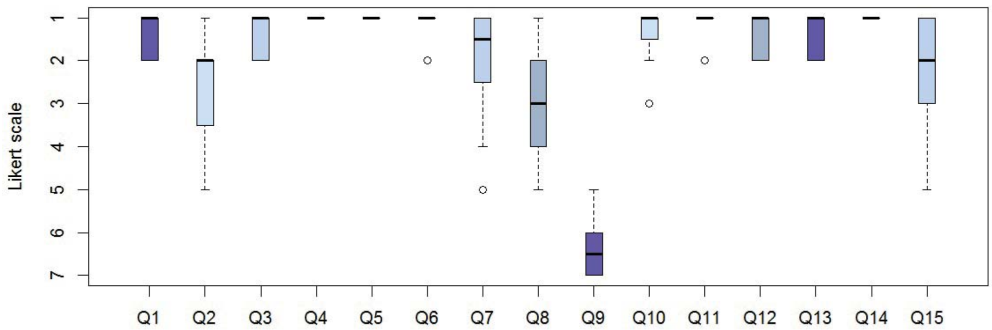

Fig.1 - Perception Results

Table 2. Social activity related results.

Question	% positive answer	Median
Q13	100	1
Q14	100	1
Q15	92	2

We also collected the data reported in Table 3 concerning the city level reached by the students.

Table 3. City evolution during the game..

μ	σ	$\tilde{x}$	min	max
2,37	0,76	2	1	4

This data confirm that the game is appropriate for three laboratory sessions of one hour. Indeed, after one hour, half of the students reached the second level of the game. Only one remained at level 1, while two of them reached level 4. Thus, one hour session is enough for exploiting the reputation approach, being the differences among the students visible. We also evaluate if the students really collected the garbage of the others. Indeed, they subjectively appreciate this aspect, but only if this had de facto happened during the game, it can be considered as an important mechanism. Table 4 reports the results concerning the competitive approach (take waste from the others) and the collaborative one (exchange of material). A greater number of visits has been performed w.r.t. exchanges. Thus, the first approach seems to be preferred.

Table 4. The collaborative approach data.

Collaborative approach	μ	**σ**	$\tilde{x}$	**min**	**max**
Neighbor visit	6	1,83	6	3	8
Waste exchange	3,70	1,4	4	2	6

6.Conclusion

This paper describes the social approach proposed by the game Pappi World and discusses a preliminary evaluation. The game follows pedagogical guidelines concerning the use of social features such as collaboration, competition, public scoring and reputation to induce the belief that waste can be a relevant resource. Each student becomes a member of a community where the recycling practice is diligently followed. The teacher has the role of an active mediator. We also collected the written comments of three teachers participating to the experience that expressed positive judgment towards the adoption of this game in a laboratory activity. In particular, they suggested to investigate how to present the game also to special needs children.

We plan to perform a deeper evaluation adopting the game in a longer education experience.

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