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Preface

Education is the cornerstone of any society, and it serves as one of the foundations for many of its social values and characteristics. Knowledge societies offer significant opportunities for novel ICT tools and applications, especially in the fields of education and learning. In such a context, the role of intelligent systems, rooted in artificial intelligence, has become increasingly relevant to the field of technology-enhanced learning (TEL). New intelligent solutions can be stand-alone or interconnected to others. They can target not only cognitive processes but they can also take care of motivational factors. Furthermore, more recently, makerspaces have emerged as environments for learning, increasing the offer of formal and informal learning opportunities, also for "fragile users," as, for example, children, elderly people, people with special needs.

The 7th edition of this conference expands the topics of the previous editions in order to provide its participants with an open forum for discussing intelligent systems for TEL, their roots in novel learning theories, empirical methodologies for their design or evaluation, stand-alone solutions or Web-based ones, and makerspace opportunities, also fostering entrepreneurship and increasing business start-up ideas. The conference intends to bring together researchers, educators, and developers from industry to discuss the latest scientific research, technical advances, and methodologies.

This volume presents all papers that were accepted at MIS4TEL 2017. All underwent a peer-review selection: Each paper was assessed by three different reviewers, from an international panel composed of about 50 members of 11 countries. The program of MIS4TEL counted 15 contributions from diverse countries, such as Brazil, Colombia, Italy, Mexico, Portugal, Romania, and Spain. The quality of papers was on average good, with an acceptance rate of approximately 70%.

This conference has grown across years in quality and visibility at the international level. As we like writing every year, that would not have been possible without the interest of MIS4TEL authors in the conference as well as the help of the Program Committee who assisted the editors in the review process for giving constructive feedback to all authors. Therefore, we would like to thank, once more, all the contributing authors, reviewers, and sponsors (IBM, Indra and IEEE SMC

Spain), as well as the Organizing Committee for their hard and highly valuable work. The work of all such people crucially contributed to the success of MIS4TEL'17 and to shape the future and practice of TEL research.

Pierpaolo Vittorini
Rosella Gennari
Tania Di Mascio
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Organisation of MIS4TEL 2017

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Artificial Intelligent Technologies and Algorithms for TEL

A Fuzzy-Based Multi-agent Model for Group Formation in Collaborative Learning Environments

Sebastián Torres, Oscar M. Salazar, and Demetrio A. Ovalle(✉)

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Abstract. Group formation is one of the key stages in a Computer Supported Collaborative Learning (CSCL) process since each organized group should be composed of adequate individuals that perform good interaction and contribute to the group's goals. Team members use their capabilities and strengths always in order to achieve satisfactory learning results from efficient collaborative work. The aim of this paper is to propose a fuzzy-based Multi-Agent Model for group formation based on nine roles defined by Belbin typology using the strengths and ideal responsibilities for each team member role. To better balance different working groups based on existing roles we use a fuzzy logic approach that allows classifying the role performance of each individual into the group. In order to validate the proposed model a prototype was built and tested through a case study. Results obtained demonstrate the effectiveness of this approach to group formation stage for CSCL environments, which constitutes an attempt to improve learning processes.

Keywords: Computer Supported Collaborative Learning · Adaptive Virtual Courses · Fuzzy logic · Belbin's team roles · Group formation

1 Introduction

Computer Supported Collaborative Learning (CSCL) is a computational approach allowing students –being organized into groups– to work together for a common goal and discuss from different points of view always seeking to improve learning processes. The CSCL process includes different stages such as group formation, teamwork task planning, learning resource assignment, group work assessment, task evaluation, among others [1, 2]. Group formation is one of the key stages in a CSCL process since each organized group should be composed of adequate individuals that perform good interaction and contribute to the group's goals using their capabilities and strengths always in order to achieve satisfactory learning results from efficient collaborative work [3].

Depending on their competencies and strengths, each member of the group assumes one or more roles. Belbin [4] defines nine roles in a team which represent the preferred ways in which team members interact, behave, and contribute to achieve teamwork goals, as follows: (1) Resource Investigator: Being good communicative and

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enthusiastic this role develops contacts who can help the advancement of the project. (2) Team Worker: Being good cooperative and perceptive this role averts friction and promotes harmony in the teamwork, (3) Coordinator: Being a good team leader this role clarifies goals, promotes decision-making and delegates tasks well, (4) Shaper: Being challenging and thrives on pressure this role drives and encourages to overcome obstacles, (5) Implementer: Being disciplined and efficient this role turns ideas into practical actions, (6) Completer-Finisher: Being meticulous and conscientious this role seeks errors and omissions. In addition, this role delivers work on time, (7) Plant: Being creative and imaginative this role is able to solve difficult problems, (8) Specialist: Being self-starting and dedicated this role can provide knowledge and skills but in his own style, (9) Monitor-Evaluator: Being strategic and discerning this role sees and evaluates options producing judgements as much accurate as possible.

Despite the collaborative learning methodology has many advantages however, there are still drawbacks in the formed groups because most of the time the members of these groups have similar roles or roles that can create conflicts with others. In this case, teamwork becomes inadequate and inefficient. The main problem is that after performing the group formation stage many of the formed groups are unbalanced considering the roles of individuals thus resulting in inadequate interaction and poor efficiency in collaborative work.

In order to face this problem, we propose a model based on the integration of two main approaches: fuzzy logic and multi-agent systems [5–7], applied on Adaptive Virtual Courses (AVC) [8, 9]. We use a fuzzy logic approach [10] into the agents to better balance different groups based on existing roles under Belbin typology [4] since it allows classifying the role performance of each individual into the formed group. In this way, formed work groups will be further balanced.

The rest of the paper is organized as follows: Sect. 2 shows some related works according to the proposed model. Section 3 presents the proposed model and then Sect. 4 exhibits the prototype implementation, and validation. Finally, Sect. 5 presents conclusions and future work.

2 Related Works

This section presents some related works with the research field, and compares them in order to identify their strengths and weaknesses.

Hübscher [11] presents a model for the assignment of students to working groups using general and context-specific criteria. Such assignment is carried out by the use of the heuristic Tabu search algorithm. The considered students' preferences describe: (1) the interest of a student X for sharing group or not with a student Y, (2) the interest of a student X for belonging to a specific group, or (3) custom skills defined by the teacher using a specific user interface. The results show that the model helps to find groups more balanced and adjusted to the criteria or preferences defined by the teacher. However, there are several difficulties since not only the preferences to be considered must be expressed mathematically but also it is complex to detect them in pedagogical terms.

Srba and Bielikova [12] describe a novel method for group formation based on a group technology approach, which considers feedback on students' collaboration to improve group formations. The implementation of the method is carried out from the integration with the platform PopCorm, which provides students in the created groups with a set of real-time collaboration tools. The results of this research work allow concluding that the incorporation of the feedback from students' collaboration allows reaching a better quality in the collaborative learning. Brilhante and Nardini [13] cope with the problem of the group formation considering common interests and inter-group relations through the proposal of the framework GROUPFINDER. This approach provides a new mechanism of group recommendation, which considers a relevant item for suggesting group of friends that share the same interest for the topic. The proposed case study seeks to determine the best group of companions based on items of common interest with whom to visit an attraction or travel to a tourist destination.

Lescano et al. [14] propose a genetic algorithm for the automatic generation of groups considering the learning styles of each one of its members. Historical data about performance of groups was used to create association rules, which are used in the fitness function. The algorithm designs different alternatives of grouping considering the learning styles of the students under the restriction of producing groups of balanced size. The proposed algorithm was analyzed with different sizes of groups given to the teacher. Through experimentation, it can see what type of configuration achieves to be more appropriate. Although this approach produces good results, it was not used the concept of the role played by the members which produces different group formations.

Previous works allow demonstrating great strengths that help to clarify the developments that have taken place within this research field. However, these works also exhibit weaknesses that need to be faced in order to improve the group formation. The majority of revisited works consider group formation based on their members' intrinsic features such as learning styles, ages or topics of interest. However, these works do not consider the role that each of the students can play within the formed working group. This approach allows groups to be transformed into really working teams with well-defined roles, which represents an attempt to improve their working and learning performance.

3 Model Proposed

The proposed model was developed following the Prometheus methodology alignments for Multi-Agent systems design. The Prometheus methodology proposes, as mentioned above, the following three phases: System Specification, Architecture Design and Detailed Design. The System Specification involves the definition of the following elements: goals, scenarios, roles, actions and perceptions. The main objective of the proposed system is to form role-balanced working groups. To achieve this, the following sub-goals have to be achieved: know the profile of each student, obtain feedback from the formed groups and ensure that the working groups are role-balanced.

In order to achieve the proposed sub-goals, the following scenarios are defined: (1) Fill out of the student profile, (2) Group formation, (3) Group readjustment, and (4) Role performance assessment. Thus, the five main roles of the system are: (1) Group formation, (2) Profile filler, (3) Watching, (4) Assessment and, (5) Data analyst. Finally, the most relevant actions and perceptions that the system exhibits are: Form groups (perc1), Fill profile (perc2), Established groups (act1) and Saved Profile (act2).

The design phase of the Prometheus methodology defines the system overview (see Fig. 1) where agents interact not only with the databases –that store information of the system entities– but also with other agents through communication protocols. It is important to highlight that for this system each defined role in the previous phase became a system agent, in other words, the agent-role cardinality is one to one. The databases defined for the system are the following: (1) students, (2) profiles, (3) working groups, and (4) group assessment.

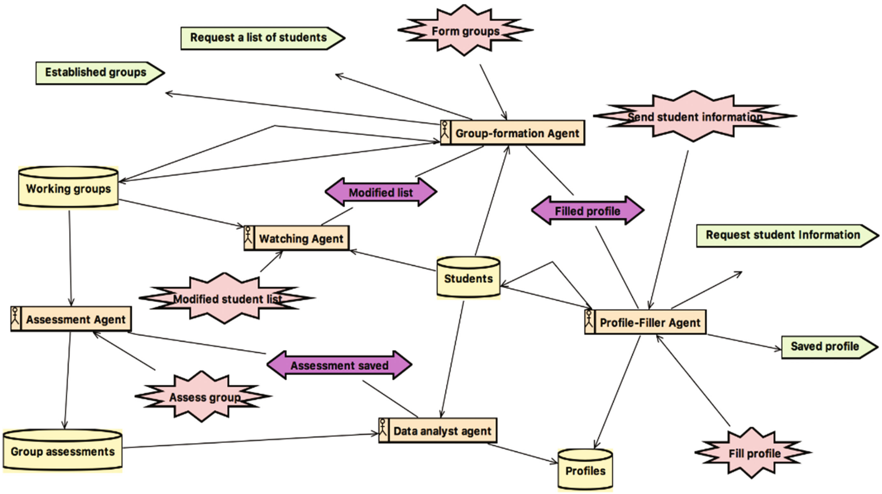

Fig. 1. Multi-agent system overview

Figure 2 presents the flow diagram concerning the group formation mechanism used by the group-formation agent during the system execution. It is important to highlight that in order to keep all the groups in balance the inference mechanism of the group-formation agent exchanges those students between working groups having the same role (i.e. making a vertical movement of students in the group matrix). This action decreases the overall score difference between groups and so they become balanced.

Profile-Filler Agent Based on Fuzzy Logic

In order to establish the student's performance level regarding Belbin's nine different roles that the student can assume within its working group, the profile-filler Agent uses a form with which he obtains the student's specific information. In addition, this agent makes use of a fuzzy logic module, described in the next section – which helps him to transform student responses that characterize each of the nine Belbin's team roles into performance level fuzzy values.

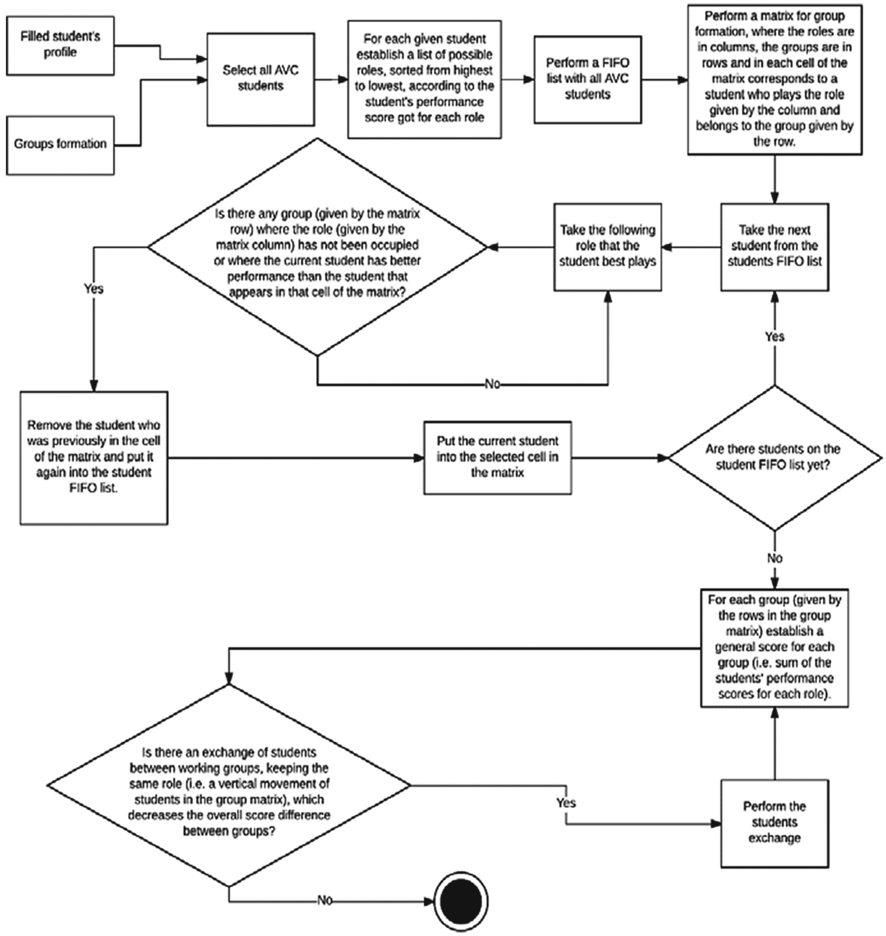

Fig. 2. Main capacity flow diagram concerning the group-formation agent

4 Model Implementation and Validation

In order to simulate the AVC platform as an external system, a Web service was developed, in which the fuzzy-based MAS can consult available courses, students list and the students' basic information. This Web service was implemented as a REST API using the Rails framework and the Ruby programming language. The implementation of the fuzzy-based MAS was performed under the JADE platform [6]. The fuzzy logic module was developed using Java's JFuzzyLogic library [10]. The system DB is managed through the MySQL DB manager system.

By now, three of the five agents proposed in the Fuzzy-based MAS Model were implemented as follows: group-formation agent, profile-filler agent, and watching agent. In this way, the first three scenarios proposed above are achieved. Table 1 shows a partial view of the answers given by the student #1 to the questionnaire requested by the profile-filler agent to know the student's performance for nine Belbin's team roles [4] as follows: Resource Investigator, Team Worker, Coordinator, Shaper, Implementer, Completer-Finisher, Plant, Specialist, and Monitor-Evaluator.

Table 1. Filled partial questionnaire of student #1 concerning nine Belbin roles

Question (Score varying from 0: "not good" to 5: "very good")	Score
How good are you to communicate with other people?	Moderate
How much extroverted are you?	Bad
How much motivation do you have working on a collaborative project?	Very good
How much cooperative are you?	Moderate
How much insightful are you?	Good
How much diplomat are you?	Bad
How disciplined are you with your academic tasks?	Moderate
How good are you as leader by working on a collaborative project?	Good
How good are you to make effective decisions?	Good
How good are you to face challenges?	Very good
How much perfectionist are you in your tasks?	Very bad

Table 1 shows the partial questionnaire got by the student #1 that corresponds to a defined fuzzy input variable (Plant role). In addition, for each possible role a fuzzy output variable was defined. Besides, for all input and output fuzzy variables some fuzzy sets (i.e. very bad, bad, moderate, good and very good) were established like those shown in Fig. 3 corresponding to the Plant role.

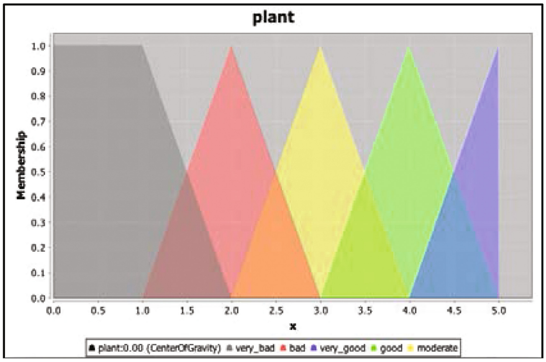

Fig. 3. Fuzzy sets for Plant role variable

We defined nine blocks, corresponding to nine Belbin's roles having each one three inference rules such as for example "**RULE 6:** IF creative IS bad OR problem_solving IS bad THEN plant IS bad". For each role, the input fuzzy variables are addressed to an output fuzzy variable. For example, the fuzzy inference rules block corresponding to the Plant role is presented below. It is important to remain that the Plant role is characterized by being creative and imaginative and so this role is able to solve difficult problems.

Table 2 shows the students classification of a AVC in four of the nine Belbin roles. Table 3 shows the formed groups of the AVC using the classification offered by Table 2. We can see that in the formed groups each student is playing his/her best role, for example, student #10 has a score "very good" for the role Plant. On the other hand, the student #5 has a score of "very good" in coordinator.

Table 2. Scores obtained by 12 students for selected Belbin's roles

Students id	Plant role	Coordinator role	Monitor role	Implementer role
#1	Bad	Good	Bad	Bad
#2	Moderate	Moderate	Good	Moderate
#3	Moderate	Moderate	Moderate	Good
#4	Bad	Very bad	Bad	Good
#5	Good	Very good	Very bad	Bad
#6	Very bad	Moderate	Very good	Very bad
#7	Bad	Good	Good	Moderate
#8	Very bad	Bad	Very bad	Good
#9	Very good	Good	Moderate	Bad
#10	Very good	Good	Bad	Good
#11	Moderate	Bad	Good	Bad
#12	Very good	Good	Moderate	Good

Table 3. Formed working groups obtained after executing Fuzzy-based MAS

Formed working groups					
Group id	Plant	Coordinator	Monitor	Implementer	General score
Group 0	#10	#5	#2	#3	18
Group 1	#9	#1	#6	#4	18
Group 2	#12	#7	#11	#8	17

We can see that in the "general score" column (see Table 3 at right), the scores after performing the defuzzification stage appear very balanced (i.e. having just one point of difference among them).

It should be noted that a student may not play his/her best role when that role is already occupied with students having a high score. In this case the Fuzzy MAS through group-formation agent looks for such a student plays his next best role. Also, the group-formation agent while forming groups is capable of replacing a student previously assigned to a group if he finds another student with a better score in the role played. Finally, the system always seeks that the conformed groups are balanced according to the general score obtained by each group through the exchange of students who play the same role in different groups.

5 Conclusions and Future Work

From the case studies previously considered we can conclude that students can play their best roles within the formed groups according to their performance. In fact, the balanced group algorithm performed by group-formation agent allows having groups of similar performance where each student can offer their best abilities and skills according to the role-played. With respect to the fuzzy logic approach, the rules contemplated in the profile-filler agent allow a good classification of the strengths and weaknesses associated with each role. Results obtained demonstrate the effectiveness of integrating fuzzy-based approach with MAS to group formation, which constitutes an attempt to improve learning processes in CSCL environments. As future work we intend to implement the two remaining agents of the system namely assessment agent and data-analysis agent. Finally, we will attempt to migrate the profile-filler functionality to mobile devices.

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Using Large Margin Nearest Neighbor Regression Algorithm to Predict Student Grades Based on Social Media Traces

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Abstract. Predicting students' performance is a popular objective of learning analytics, aimed at identifying indicators for learning success. Various data mining approaches have been applied for this purpose on student data collected from learning management systems or intelligent tutoring systems. However, the emerging social media-based learning environments have been less explored so far. Hence, in this paper we present an approach for predicting students' performance based on their contributions on wiki, blog and microblogging tool. An innovative algorithm (Large Margin Nearest Neighbor Regression) is applied, and comparisons with other algorithms are conducted. Very good correlation coefficients are obtained, outperforming commonly used regression algorithms. Overall, results indicate that students' active participation on social media tools is a good predictor of learning performance.

Keywords: Educational data mining · Performance prediction · Large Margin Nearest Neighbor Regression · Social learning environment · Social media

1 Introduction

Learning analytics is a growing field of research which deals with collecting and analyzing student data in order to understand and improve the learning process and the learning environments [4]. Prediction of student performance is one of the most popular goals, which aims to estimate future learning outcomes and identify indicators for learning success [10]. The predictive information can be used by the instructor to monitor learning progress and provide personalized feedback and interventions, especially for students at-risk, who are in need of more assistance [14]. Prediction results could also be employed in a formative assessment tool or simply to increase students' awareness [10, 14].

The goal of performance prediction is to develop a model which can infer students' outcome (i.e., the *predicted variable*, generally in the form of grades or scores) from a

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combination of various indicators (i.e., *predictor variables*) from the educational dataset [1]. A large variety of indicators can be used, such as: number of content pages viewed per student, number of threads started per student, number of messages read on forum per student, number of assignments submitted per student, students' tags of learning resources, etc. [2]. These depend also on the particular learning environments in which the study takes place (e.g., Learning Management Systems, Intelligent Tutoring Systems, Massive Open Online Courses) which influence the type and amount of data collected.

As far as computational techniques are involved, a wide variety of methods have been applied so far for predicting students' performance, such as linear regression [9], decision trees [13], neural networks [11], Bayesian networks [3], or genetic algorithms [14].

In the current paper, we investigate the less explored context of social learning environments; more specifically, an innovative algorithm, called Large Margin Nearest Neighbor Regression (LMNNR) is applied in order to predict academic performance based on students' activity on social media tools (blog, wiki, microblogging tool). The novelty of our approach consists in the successful application of the algorithm in the educational domain, on students' social media traces. The context of study and data collection are described in the next section. The Large Margin Nearest Neighbor Regression algorithm is briefly presented in Sect. 3. The analysis results are reported and discussed in Sect. 4. Some conclusions and future research directions are outlined in Sect. 5.

2 Educational Dataset

Data was collected during a Web Applications Design course, taking place at the University of Craiova, Romania, in 2015/2016 winter semester. A social learning environment called eMUSE [8] was used to implement a project-based learning scenario. 75 undergraduate students worked in groups of 3–4 peers in order to develop a relatively complex web application; they used three social media tools (Blogger, Twitter, Mediawiki) to communicate and collaborate for the project activities. The learner tracking mechanism provided by eMUSE collected students' actions on the social media tools: blog posts and comments, tweets, wiki page revisions and file uploads. Based on these actions, a set of 14 numeric features were computed for each student:

- *NO_BLOG_POSTS* (the number of blog posts)
- *NO_BLOG_COM* (the number of blog comments)
- *AVG_BLOG_POST_LENGTH* (the average length of a blog post)
- *AVG_BLOG_COM_LENGTH* (the average length of a blog comment)
- *NO_ACTIVE_DAYS_BLOG* (the number of days in which a student was active on the blog, i.e., wrote a post or a comment)
- *NO_ACTIVE_DAYS_BLOG_POST* (the number of days in which a student wrote a post on the blog)
- *NO_ACTIVE_DAYS_BLOG_COM* (the number of days in which a student wrote a comment on the blog)
- *NO_TWEETS* (the number of tweets)

- *NO_ACTIVE_DAYS_TWITTER* (the number of days in which a student was active on Twitter, i.e., posted at least one tweet)
- *NO_WIKI_REV* (the number of wiki page revisions)
- *NO_WIKI_FILES* (the number of files uploaded on the wiki)
- *NO_ACTIVE_DAYS_WIKI* (the number of days in which a student was active on the wiki, i.e., revised a page or uploaded a file)
- *NO_ACTIVE_DAYS_WIKI_REV* (the number of days in which a student revised a wiki page)
- *NO_ACTIVE_DAYS_WIKI_FILES* (the number of days in which a student uploaded a file on the wiki)

In addition, the final project grade obtained by the student (on a 1 to 10 scale) was included as predicted variable. The algorithm used to analyze this dataset is briefly described in the next section.

3 The Large Margin Nearest Neighbor Regression Algorithm

In a classification context, support vector machines rely on the idea of finding a large margin between classes by solving an optimization problem. This idea was used in conjunction with the k-Nearest Neighbor method [12] to change the distance metric of the kNN space by using a matrix:

$$d_M(\mathbf{x}_i, \mathbf{x}_j) = \left(\mathbf{x}_i - \mathbf{x}_j\right)^T \mathbf{M} \left(\mathbf{x}_i - \mathbf{x}_j\right). \quad (1)$$

This method was further developed for regression purposes, resulting in an original algorithm, *Large Margin Nearest Neighbor Regression* (LMNNR) [6, 7], briefly described as follows.

For simplicity, it assumes that $\mathbf{M}$ is a diagonal matrix, and in this case the weights of the neighbors are:

$$w_{d_M}(\mathbf{x}, \mathbf{x}') = \frac{1}{d_M(\mathbf{x}, \mathbf{x}')} = \frac{1}{\sum_{i=1}^{n} m_{ii} \cdot \left(x_i - x'_i\right)^2}. \quad (2)$$

These weights can also be interpreted as the coefficients that stretch or shrink the axes of the input space according to the importance of the attributes.

Equation 2 involves a single, global matrix $\mathbf{M}$ for all the instances. However, it is possible to have different distance metrics for different instances or groups of instances. The LMNNR algorithm allows the use of *prototypes*, which are special locations in the input space of the problem. Each prototype P has its own $\mathbf{M}^P$ matrix. When computing the distance weight to a new point, an instance will use the weights of its nearest prototype, i.e., m_{ii}^P instead of m_{ii} in Eq. (2).

Finding the appropriate matrices is achieved by solving an optimization problem. In a simplified formulation, the objective function F, which is to be minimized, takes into account two criteria F_1 and F_2, defined below, with equal weights.

In order to briefly explain the expressions of these functions, let us make the following notations: $d_{ij} = d_M(\mathbf{x}_i, \mathbf{x}_j)$, $d_{ik} = d_M(\mathbf{x}_i, \mathbf{x}_k)$, $g_{ij} = |f(\mathbf{x}_i) - f(\mathbf{x}_j)|$ and $g_{ik} = |f(\mathbf{x}_i) - f(\mathbf{x}_k)|$, where d_M means the weighted square distance function using the weights one searches for.

Then, the first criterion is:

$$F_1 = \sum_{i=1}^{n} \sum_{j \in N(i)} d_{ij} \cdot (1 - g_{ij}), \tag{3}$$

where $N(i)$ is the set of the nearest k neighbors of instance i, e.g., 3. This criterion reflects the fact that the nearest neighbors of i should have similar values to the one of i, and more distant ones should have different values.

The second criterion is expressed as follows:

$$F_2 = \sum_{i=1}^{n} \sum_{j \in N(i)} \sum_{l \in N(i)} \max\left(1 + d_{ij} \cdot (1 - g_{ij}) - d_{ik} \cdot (1 - g_{il}), 0\right). \tag{4}$$

The distance to the neighbors with close values (the positive term) is minimized, while simultaneously trying to maximize the distance to the neighbors with distant values (the negative term). An arbitrary margin of at least 1 should be present between an instance with a close value and another with a distant value.

4 Results and Discussion

Even if the grades are integers, there is a definite order between their numeric values. Also, subtle differences in student evaluation may sometimes occur, which cannot be taken into account in a classification problem with discrete, unrelated values. Therefore, we considered that this problem is a suitable one to be addressed by means of regression algorithms.

4.1 Performance of Classic Regression Algorithms

In order to assess the performance of the LMNNR algorithm, a comparison with the algorithms implemented in *Weka* [5] was attempted.

As mentioned in Sect. 2, the original dataset has 14 attributes and a numerical class that represents the project grade. First, different *Weka* algorithms that belong to different classification/regression paradigms, were applied, e.g., k-nearest neighbors, neural networks, decision trees, support vector machines. The correlation coefficient was used as a performance measure. The best results obtained by different algorithms for 10-fold cross-validation were:

- *Random Forest* with 100 trees: $r = 0.6795$;
- *k-Nearest Neighbors*, with k obtained by cross-validation and inverse-distance weighting of the neighbors: $r = 0.569$.

In order to improve on these results, feature selection was also attempted. By taking into account the indications of the *ReliefF* algorithm, only 5 attributes were selected: *AVG_BLOG_POST_LENGTH, AVG_BLOG_COM_LENGTH, NO_ACTIVE_DAYS_BLOG_POST, NO_ACTIVE_DAYS_TWITTER,* and *NO_ACTIVE_DAYS_WIKI.*

Under these circumstances, the same regression algorithms in *Weka* performed the best, however with similar results as before:

- Random Forest: $r = 0.6887$;
- k-Nearest Neighbors: $r = 0.5535$.

One can notice that the random forest algorithm achieved slightly better results, while k-nearest neighbor achieved slightly worse ones.

Because the grades are natural numbers, it is also possible to treat them as distinct values, and transform the problem into a classification problem, instead of a regression one. However, the results were not promising; in this case, the random forest algorithm only achieved a 44% success rate in correctly classifying the instances, also in a 10-fold cross-validation scenario.

4.2 Performance of the LMNNR Algorithm

Next, we turned our attention to the evaluation of the original LMNNR algorithm for the given problem. The first attempt was to assess the influence of the feature selection on its performance. The comparison was made for the simplest parameter settings of the algorithm, with 1 prototype and 3 classification neighbors:

- *LMNNR* with feature selection: $r = 0.818721$;
- *LMNNR* without feature selection: $r = 0.826438$.

There is no significant difference between these values, and there is even a slight increase of correlation when the full set of attributes is used. This can be explained by the nature of the algorithm, which implicitly searches for the importance of the input attributes. Therefore, there is no need to manually reduce the number of attributes; on the contrary, it seems that the algorithm is able to use the additional information better than other regression algorithms.

One can immediately notice that the overall results are far better than those obtained with the well-established methods implemented in *Weka*, with a 20% increase in the quality of the results.

Table 1 presents the performance of the algorithm when the number of classification neighbors (i.e., the number of close instances that are actually used to compute the weighted output) and the number of prototypes vary. It must be mentioned that the algorithm also has an additional parameter, the number of optimization neighbors which are used to solve the optimization problem defined by Eqs. 3 and 4. However, from previous studies, it was found that a value of 3 is sufficient in most cases, while higher values only increase the computation time without providing better results.

Table 1. Performance of the LMNNR algorithm for different parameter values

Number of neighbors	Number of prototypes	Correlation coefficient *r*
3	1	0.826438
3	2	0.821534
3	3	0.822922
5	1	0.800335
5	2	0.818194
5	3	0.814019

By observing the results in Table 1, one can notice that the best combination of parameter values is also the simplest one: 1 prototype and 3 neighbors. The configuration with one prototype can be viewed as a particular case of the configuration with two or more prototypes, in which all the prototypes have the same location and weights. However, from the practical point of view, when there are more prototypes, the search is actually performed in a much larger space, and this can affect the result quality in a negative way.

This also confirms the general empirical finding that simpler models usually tend to generalize better than complex ones. In our case, the generalization capability was the only criterion used in the analysis.

Figure 1 displays a comparison between the test results and the desired outputs. The scale of the chart is the [0, 1] interval because all the data is normalized attribute-wise, before applying the algorithm. One should notice the fact that these data are obtained on the combined test bins in the 10-fold cross-validation. Since it is an instance-based method, the results of LMNNR on data that belongs to the training set are always perfect.

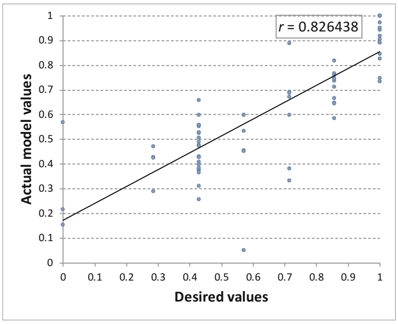

Fig. 1. Comparison between the predictions of the model and the expected data

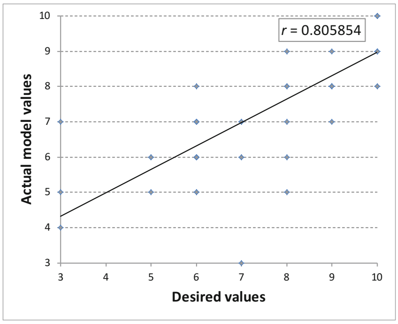

Fig. 2. Comparison between the predictions of the model and the expected data transformed into integer grades

While the chart in Fig. 1 displays a comparison between normalized output data, Fig. 2 displays a comparison between output data rounded to the nearest integer grade. The grades in the dataset are between 3 and 10, where 10 is the best grade.

Because of the rounding, one can see that the correlation coefficient slightly decreases by roughly 2.5% to $r = 0.805854$. However, this chart can offer a better understanding of the results by translating them into their original domain.

Finally, Fig. 3 shows the errors of the model, as actual differences between the predicted and desired grade values. One can notice the shape of the graph, which looks like a skewed Gaussian distribution, which is mainly caused by the number of the training instances, which is not so large: there are only 75 instances in the dataset. More importantly, this analysis shows that 85% of predictions are within only 1 point of the actual grade. This emphasizes the fact that the model is capable of good approximation for our particular problem.

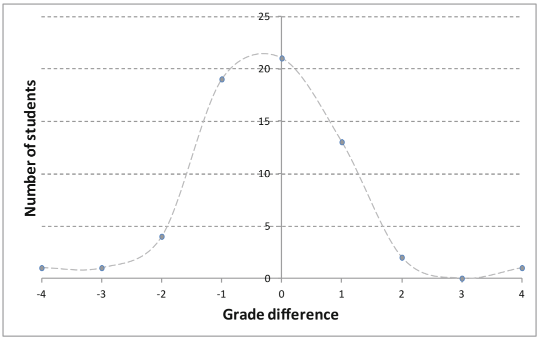

Fig. 3. The differences between the predictions of the model and the expected data transformed into integer grades

Regarding the larger differences, they are caused by the random splitting of the data into the training and testing sets of the cross-validation bins. As an instance-based method, the LMNNR algorithm cannot extrapolate to values outside the range of its training instances. For example, the small grades of 3 and 4 are rare in the dataset. If a training set contains only higher grades, and the small ones are only placed into the testing set, there is no way for the algorithm to compute proper predictions for them as a weighted sum of its training data.

5 Conclusions

The paper presented an approach for predicting students' performance based on their traces on social media tools (i.e., blog posts and comments, tweets, wiki page revisions and file uploads). An innovative algorithm, called Large Margin Nearest Neighbor Regression, was applied and its performance was assessed by means of comparisons with various algorithms implemented in *Weka*. Very good correlation coefficients were obtained (greater than 0.8), outperforming commonly used regression algorithms. Overall, results showed that students' active participation on social media tools was a good indicator of learning performance.

A potential limitation of the study is the relatively small number of students involved (75). Therefore, as future work, we plan to extend the analysis to a larger dataset, by including several cohorts of students. Investigating the algorithm performance on student data collected from different years and slightly different instructional scenarios is an interesting research direction; a more comprehensive perspective on academic performance predictors in a social learning environment could thus be obtained.

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Adaptive Agent-Based Environment Model to Enable the Teacher to Create an Adaptive Class

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Abstract. Learning management systems are used as a support tool in the process of knowledge sharing. Teachers add the material related to the domain of knowledge and also elaborate pedagogical mediation activities for the students. This process, in general, results in a learning environment that presents the same content for all participants, not taking into account the differences that exist between each of them, both in performance and behavior in the environment. The purpose of this work is to show an adaptive, agent-based environment model to enable the teacher to use some tools to create an adaptive class. In this model, resources and activities are made available to the participants in an individualized and adaptive way according to a previous configuration made by the teacher on the learning environment. The system was developed using Moodle to be used as a test bed case study and a basic calculus course was created to perform a practical evaluation test of the proposed model with real students as participants.

Keywords: Adaptivity · Tutoring · Learning management system

1 Introduction

With the expansion of distance education and internet, learning management systems (LMS) have become instruments that enable the production, management, and sharing of knowledge, as well as the availability of pedagogical mediation tools and resources, using cyberspace and allowing the interaction between the actors. However, the sharing and availability of resources occur in a limited way regarding the adaptivity that is the capacity of the environment to adapt automatically, according to the changes that take place in it.

According to [1], an adaptive digital system dynamically personalizes instruction using information collected during the course with the aim of improving or accelerate the student's performance gain. The main objective of adaptive systems is to recognize

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how the student is going on through the course, if s/he understands the content or not and, in regard of this, try to help the student providing a content that better suits to him/her, evaluating her/him again or giving a hint that helps him/her to achieve the goals of the course. Also, the levels of difficulty of the content can help students to feel more confident or frustrated depending on his/her own levels of prior knowledge. A student that has to solve a problem that is too easy for him/her can be unmotivated or bored about the topic, and another student that has more difficult to solve the same problem can be frustrated. As the education has a high cost for having a teacher for each student, it is not easy to have personalization in learning [2].

If there is not any adaptivity in the course, all the students see the same content and execute the same activities. Based on the premise that each student is an independent and different human being, adaptivity is the property of the environment that allows each user to have access to a personalized learning [1]. In comparison to traditional methods, adaptive learning systems (ALS) have better results in efficiency and effectivity for students' learning. In addition, a recent study concluded that some adaptive systems were nearly as effective as one-on-one human tutoring" [3].

The motivation regarding ALS comes from their characteristic of giving to the student the possibility of learning above its ability level and needs, showing a challenge rather than discouraging him/her. Furthermore, some ALS take into account the learning style of the student, if s/he prefers text or audio, or video, or an online book. By doing this, the drop-out rates can reduce, the effectiveness in learning can increase, and there are larger results in learning achievements [2].

In order to evaluate the relevance of the research, a review of the literature was carried out in an integrative way. Among the works analyzed, [4] talks about user satisfaction in interactive systems, concluding that "The success of an interactive system, such as the web and its applications, is determined by the satisfaction of users". In addition, for the author, "The content and structure of the material available on the web influence directly the user experience and must be adapted to the needs and characteristics of the user". These statements are in line with the research of [5], whose the results showed that student satisfaction is related to the flexibility of the course. Thus, researches in adaptive learning environments are relevant and can improve the learning experience of students, which are the most of users of learning environments.

According to the integrative literature review, it can be verified that the researches in adaptivity and LMS are most directed to adapt the environment according to the preferences and learning styles of the students. Considering this context, the aim of this work is to present the development and implementation of a model of an ALS that takes into account the student's performance, applied in the LMS, allowing teachers to have access to an adaptive system which they can configure with their own pedagogical model, for any class they have in the LMS. The adaptive system model was created based on the intelligent tutoring system (ITS) classic model [6].

2 Agents' Model

This model is an extended version of an adaptive learning environment model developed and presented in a previous research work. The model from which this research starts [7] is based on the classic model of ITS, and have the following elements: Pedagogical Model; Control; Student Model and; Domain Base (Fig. 1). The Pedagogical Model is defined by the teacher who creates the activities to be performed by the student, defining the flow between them. The Student's Model is represented by the information of his profile, his interactions with the environment and the results of the evaluations. The Domain Base contains the content of the course, provided by the teacher, as well as the environment information, stored in the database. The Control, of which the agents are a part, consists of the process through which the agents access the database obtaining what is necessary to be able to execute its instructions.

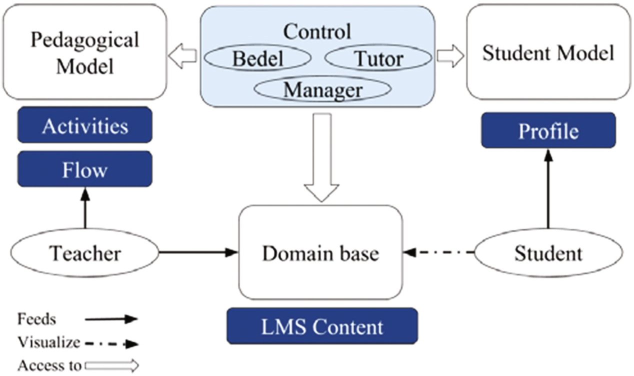

Fig. 1. Updated system model. Source: Prepared by the author (2016)

In order to evaluate the model, a prototype was constructed using the LMS Moodle. This choice is due to the fact that this is a flexible and open source tool, which offers facilities for development. The creation of a Tutor block to the LMS Moodle was carried out to be used for the configuration of the agents of the system. Blocks in Moodle are tools that can be developed as plugins to add any new feature to the Moodle LMS. Through this tool, the teacher implements the instructional design of the course by establishing all the possible flows, and configuring the agent, informing the level of difficulty of the contents and the relations between the several itens of the learning materials.

Among the elements of the model of intelligent tutors, the pedagogical model is a main piece in the development of the ALS. The teacher provides the contents and course activities to the learning environment and sets up all possible precedence flows between them. After that, the agents can execute theirs plans and perform the pedagogical model designed by the teacher, according to the student's interaction with the environment.

Once the teacher has been provided all the learning material and has the Tutor block in the Moodle activated, s/he can access this block and can set the order of precedence of the materials and their levels of difficulty (basic, intermediate, advanced or general). The level called general refers to the material that will be shown to all students alike. And the other three levels of learning material can be shown to the student depending on his/her performance.

The teacher, additionally, has to choose both the initial resource and activity so that the agents can obtain the first performance information of the students. According to the result of this first activity, the agent can set up the initial profile of the student according to which the student will fit into the next topic and starts the adaptative mode to show the contents and activities to the students.

One characteristic of this model is that the teacher has complete freedom to choose previously the contents that will be part of the adaptive process and the ones that he will leave as fixed content in the class. The system was designed to accommodate multiple classes of students from each course, in the LMS.

Besides the agents Bedel and Tutor, this extended version of the first model is adapted to give an additional agent performing the role Manager agent in the agents' model. This agent takes care of creating the Bedel and Tutor agents each time a class is setted up to be adaptive or a student is inserted into an adaptive class, respectively. For each class of the LMS courses, there is an instance of the Bedel agent and, for each student, there is an instance of the Tutor agent. There is just only one instance of Manager agent for the entire system. This extension of the original model is created to support a more robust adaptative learning environment which can lead with multiple different courses and multiple student classes of each course.

The Manager agent stays alert to verify if any class has been created in the LMS or if some student has been inserted into any class to instantiate the agents needed. As the LMS works with data that is updated constantly, the Manager agent controls all this information for the system, being running asynchronously all the time that the system is operating.

3 System Workflow

The agent manager creates its artifact and starts to work continuously. This agent checks if there are some adaptive classes of students, without a Bedel agent instantiated for them. If they exist, it instantiates new Bedel agents to attend these classes. The agent manager additionally checks if there are new students in some adaptive classes who do not have the Tutor agent instantiated for them, if they exist, the Manager instantiates the missing Tutor agents.

The Bedel is the agent which performs the adaptivity in the student class. This agent provides different levels of content to the student in each topic of the course, taking into account the grades they had in the activities of evaluation and their average. The Bedel agent continuously verifies if there are new results of some activity evaluation available in his student class data base. If so, it takes the evaluated student id, the id of the activity that generated this evaluation and the grade of the student in this activity, and verifies if the activity was already processed for the calculation of the student profile. If the activity was not processed, the Bedel calculates in which profile the student fits (basic, medium, advanced) depending on the grade s/he had. If the student has a grade less than 2.5, the Bedel agent provides additional content related to the same topic and updates the related activity in order to let the student to answer the topic again. The historic of the student is still available to be accessed by the agents to a better analysis of the situation of the student performance in the course. If the student has more than 2.5, the Bedel agent provides the next content to the student. After that, the Bedel sends a message for the Tutor agent which sends a message to the student explaining about his/her performance and telling what to do to continue with the content. To provide activities and new or review content to the student, the Bedel agent consults the table in the system database that stores the information about the tree of pre-requirements of the content. The teacher adds this information, previously, when configuring the tutor block in the space of the class in the environment.

The Tutor agent performs interactions with the student. This agent receives messages from the Bedel and sends messages of information and encouragement or congratulations for the student. This agent keeps waiting for messages from the Bedel agents. When receives some message, he verifies the grade that his/her student had in the last activity and verifies if the activity is the last of the course. If this is the case, the Tutor agent sends a message to the student to congratulate him/her for having finished the course and waits for new messages from Bedel agents. The Tutor agent can receive messages from different Bedel agents. If the evaluated activity is not the last one, the Tutor agent verifies if the student had a grade higher than 2.5 and if s/he have done another activity before. If so, the agent verifies his/her profile and if the student has a better average or not, in comparison with his/her previous grades, after that, the Tutor agent sends a message of encouragement or congratulations, depending on the student performance. If the student had grade lower than 2.5 s/he can not go to the next contents. In this case, the agent verifies if the student has difficulties in this specific activity by checking if s/he had done the same activity before and have got a grade lower than 2.5

If this is the first time that the student had made the activity, the Tutor agent sends a message to him/her to inform that he provided to him some optional review content material and that a new updated activity were also provided to be answered again. If it is the second time that the student made the activity the Tutor just sends a message to the student to suggest the revision of the additional contents that were provided for him/her the first time the activity was answered. If the student still not being able to have a grade higher than 2.5 to continue with the new topics, the Tutor agent verifies the level of the activity provided to the student and provides to him/her a new lower level activity. Therefore, the student has the possibility to answer a new exercise easier than s/he was trying before, since even having a good performance in the previous topic, in the current content s/he can have more difficulty. The values defined in this system used by the agent to decide if a student could advance or not in the course were chosen by common sense, to accomplish the experimental course, to evaluate the proposed model. However, in a more realistic situation, these criteria should be defined by the teacher, when s/he configures the pedagogical model of the course using an appropriate tool to be implemented in the future.

4 Implementation

The implementation of the prototype used to evaluate this model was made using the LMS Moodle. This learning environment, even though is not an adaptive environment in itself, offers some useful resources and tools that easily can be integrated into an ITS, resulting in an intelligent learning. One of the most important characteristics of agents is their ability to adapt to environment changes. This feature was explored for this implementation, because of the constant change of the student's data in the system. The agents have the capability to provide the resources and activities to the students according to their performance, and also to update the availability of these resources constantly, each time a new activity is answered by the students.

The adaptation of the system occurs through the diverse responses of the agents to the changes of the environment, which are observed through the updates in the database. These responses are provided by the agents after executing their proper plans, working according to the information received. The agent code was developed using the Jason development platform, interpreter of the AgentSpeak language, which is an open source, agent-oriented programming language distributed under the GNU LGPL (GNU Lesser General Public License) and implemented in Java [8].

For the execution of the task to configure the agents by the teacher, a special Moodle block was developed, using PHP, according to the block creation steps recommendation available in the Moodle.org website. The name given to this block is Tutor because it is used by the teacher to configure the Bedel agent. According to this configuration, the virtual environment can present an adaptive behavior and the student can receive messages from a special Moodle user previously registered as Tutor Agent. All instances of the Tutor agents use this Moodle user's profile to send the messages and show the student's follow-up during the course.

To configure the Tutor block, the teacher must add this block to the class space of the course. Further, the teacher needs to provide all the content that can be used by the students during the course, and then configure the behavior of the agents for that course. First, the difficulty levels of all course resources and activities are defined and, after that, the first resource and first activity of the course must be setted up.

The last part of the Tutor block configuration is the selection of the prerequisites for each one of the contents that belong to the adaptive part of the course in that class. For each resource and activity the other resources and activities available in the class will be presented, with multiple choice option, to select one or more prerequisites and thus generating a Dependency Graph. This resource is used so that the teacher can visualize all possibilities of dependency flows between the activities of the course. The agents also use this flows graph to configure the interface of the learning environment to the student, according to the activities performed by him/her and the results obtained in these activities. The edition of the dependency graph is allowed during the course, but the teacher should previously prepare the pedagogical model, and the possible paths that can be followed by the students, and set up the prerequisites using the Tutor block.

The Bedel agents are also configured through this block, however, they do not use any user of the LMS. All the work of Bedel agents is done directly in the system's database. Bedel agents are responsible for the adaptive behavior of the virtual environment by setting up the appropriate information in the Moodle database tables. In order to make the resources and activities available to students, two resources were used in this version of Moodle. The first one is the Moodle resource called Groups, and the second one is the Restricted Access, which enables a resource or activity to be shown to the students who obey the configured restriction. The defined restriction is to be member of a specific group. Each resource and activity is directly related to a group.

The Bedel agent calculates the profile of the student who has been evaluated and, with this profile, he knows the level to which this student belongs. According to this information, the agent defines how the next content has to be shown to the student. Bedel checks if there is already another student who has the same profile for this same content and, if not, creates the group with the name Adaptation, followed by the letter that represents the basic, intermediate or advanced level and the id of the resource or activity that will be related to that group. After that, it inserts the student into the group. Once the student is in the group s/he starts to view the restricted content for that group. The Bedel calculates the profile every time he needs to provide new contents to the students, that is, whenever there is a student with a new evaluation. The agent checks if the group needed for setting up the student view of the environment exist. In this case, the agent adds the student to the appropriate group, if it does not exist, it creates a new group and adds the student in it.

The 2.9.1 version of Moodle stores all the information of the environment in 328 tables of the database. Some additional tables have been added to support the system: Tutor _student _evaluated: stores the data which the agents need to know the students' performance history; Tutor_bedel_course: stores the information of the classes in which the Tutor block was activated; Tutor_tutor_student: stores the information of the students who belong to one or more adaptive classes; Tutor_rec_act _profile: stores the profile information (Basic, Medium, Advanced, General) of each of the resources and activities reported by the teacher; Tutor_dependency: stores the information about the configuration of prerequisites and dependencies. The agents Manager, Bedel and Tutor use the information stored in these tables to execute their plans in order to make the Moodle LMS an adaptive environment.

5 Final Remarks

In addition to the development and implementation of the adaptive system model, the operation of the system was tested with a class with university level students, using the contents of a basic calculus course as a field study.

This test was performed to verify the proper operation of the system in a real scenario. The preliminary results prove that the system works as expected and the students received the content adaptively. The test had eight volunteer participants who complete all the topics of the course. For each topic the students were evaluated and the material was showed for them taken into account their performance in the previous content. The students passed from basic to intermediate or advanced and vice versa, depending on the grades they had on each evaluation. The Bedel agent organized the material for each student independently and the Tutor agent sent the messages according to the student profile in the moment.

For this work an adaptive learning environment model previously developed [6] was taken as a basis. Improvements on the original model was made to get the adaptivity in the learning environment independently if several students are engaged in different courses and each course has several student classes.

Experimental results confirmed that the presented model enables teachers to provide the content and learning activities of the course in an environment that adapts to students' performance. The system, which is inserted into the Moodle LMS, contains a configuration block that is simple to use and configure by the teacher.

Thus, the most relevant contribution of this work is the insertion of intelligent and adaptive tools in LMS of common use, so that teachers can, in a personalized way, reach students with different levels of knowledge and skills. Delivering more advanced tasks to better performing students, enabling more efficient learning, and maintaining a basic level for the general learning of course content.

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Answer Identification Model for Methodological Question in Student Texts

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Abstract. Writing research findings turns out to be hard work. For college students, the complexity is increased by the lack of experience in writing scientific texts. Defining the general objective allows students to set forward the way for the development of the thesis. One of the three questions suggested by the authors of methodology books; "What will you do?", serves as a guide for the objective formulation. In this work we developed an Answer Identification Model to approach such question, employing a Language Model and an Answer Scanning Method. This model can be used to identify answers to open questions that seek to reveal specific content. We are reporting initial results of the analysis of a test collection in Computer and Information Technologies.

Keywords: Objective research writing · Research methodology · Student writing assessment

1 Introduction

Academic programs or courses in educational institutions often conclude requiring students to elaborate a thesis or research report. However, students often find this writing assignment quite challenging, since they sometimes have to adhere to certain guidelines. In addition, the documents must show an internal structure that includes the problem statement, objective, hypothesis, justification, methodology, results and conclusions [1]. Normally the first draft written by student exhibits deficiencies, e.g. bad orthography, poor lexical features, opacity of statements, and low support of ideas. Also, the documents are poor in structure.

A study related to student's perception of difficulties when writing the discussion section of thesis [2], pointed out about the uncertainty of students about the content that should include the discussion section and how it has to be organized. This result was surprising to supervisors, considering the time and feedback that students received.

Using a learning approach [3], a method was developed to identify the thesis and conclusion statements in student essays to provide a rapid feedback to students. In contrast, our work assumes that each element is embodied in the document and we are focusing on the task of analyzing the structure that must contain a general objective of a thesis. The documents that we analyze correspond to thesis of graduate and

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undergraduate students with the aim of assessing later on student texts at early stages of development.

Defining the general objective allows students to set forward the way for the development of the thesis. Three methodological questions [4] suggested by the authors of methodology books serve as a guide for the objective elaboration: What will you do? (1Q), What is the purpose of doing it? (2Q), and How are you going to do it? (3Q). This paper focuses on the identification of the answer to 1Q. For example, from the objective:

> *Generate a support tool for the study of algebra at the bachelor level, through a computer system that manages learning objects with IEEE-LOM associated with various topics of algebra.*

We can identify the text segment "Generate a support tool" as the answer of 1Q question, that indicates the "object/product to be achieved", i.e. the "support tool". Notice that the answer contains words that differ for distinct objectives, as well as of varied lengths. Moreover, the answer is not bounded to specific data, i.e. does not correspond to factual data (e.g., named entities). Our main contributions are: (1) Developing an Answer Identification Model to approach the question What will you do?, employing a Language Model and an Answer Scanning method; (2) Initial results of the analysis of a test collection.

2 Related Work

Scientific paper evaluation is a complex task, requiring that the reviewers provide a judgment based on their experience and domain knowledge. From a computational approach, we seek to capture the knowledge latent in the corpus using techniques of natural language processing.

Structured movements on articles abstracts were analyzed with the goal of identifying the background, purpose, method, result, and conclusions of a research paper [5], by training a Markov model. Then, collocations were automatically extracted to find phrases that represent rhetorical moves (such as "paper address"), being labeled with the type of movement. The accuracy result of structured movements was 0.80. This work inspired us to implement a method that includes movements to identify elements required in an objective, since the answer to the question 1Q does not appear necessarily at the start of the objective.

The identification of the elements of a scientific paper has been also addressed by applying approaches of cohesion devices. In a recent study [6], a method was proposed to identify six discourse elements in student essays: introduction, prompt, thesis, main idea, supporting idea, and conclusion. First, identity chains were created by extracting all nouns/entities from POS/NE tags, and then the third person pronoun was identified, assembling so the chains. They also created lexical chains, which refer to relations between text by using lexical repetition, synonymy, or near synonymy, computing the word relationships with the Word2Vec toolkit. Local and global chains in sentences were also calculated. Similar to this work, our method aims to identify patterns of grammatical pairs of class and token appearing in the objective, locally close together.

Identifying sentences that do not fit into the scientific writing genre was studied in [7]. Some addressed features were a formal notation, extensive mathematical expressions, terminology of the discipline, citations, section headers, references to other elements of a paper, lists and enumerations, and bibliography elements used in the papers. This study describes the situation where many researchers seek to publish the results of research projects in English. However, not all researchers were native speakers, being categorized as English Language Learners (ELL). The corpus used consists of extracts of 4,000 published articles, mainly in physics and mathematics. The problem we seek to solve is similar but in other context, since students are required to complete a document (thesis) with a technical language and rules.

We found a method to evaluate and qualify short answers to questions previously established [8]. The method is entitled as graph-based cohesion technique, which initially agglomerates the closest answers, and generates a representative cluster of each answer. During graph generation, each answer was tagged with part-of-speech (POS). Similarly, our method tries to identify patterns through the use of language models. One difference of our method is that we only have one question and many possible answers, and the main idea is generate a model of all answers for question 1Q.

The reviewed works show the results achieved by researchers trying to enhance student writing using different techniques. Most of these studies aimed to identify characteristic elements of essays, including the determination of sections that integrate an essay. Our work attempts to contribute by evaluating the structure and content of a general objective, analyzing the answer to the reflection question that the student processes when drafting its objective, being an open content answer.

3 Data Description

A collection of objectives was extracted from ColTyPi[1], a theses corpus of Graduate: Master (MA) and Doctoral (PhD) degree; and Undergraduate level that includes: Bachelor (BA) and Advanced College-level Technician (TSU) level. The corpus is in Spanish and the domain is computer and information technologies. Each item in ColTyPi is a document that had been evaluated at some point by a reviewing committee.

For the experiments, a task of annotating 300 objectives was conducted, where four annotators with experience in reviewing research proposals (academic instructors) were selected, from three different universities to have high coverage and variety in criteria. For this work, we provided a guide to the annotators, with steps for the task, including the elements that authors of research methodology books suggest for formulating an objective. Each annotator marked the part of the text corresponding to each of the answers to the methodological questions (1Q, 2Q and 3Q), if the annotator does not identify any of the answers, the label “Not Found” is assigned. For example, if 1Q

[1] http://coltypi.org/.

answer was not identified in the general objective by the annotator, then 1Q answer would be tagged as NF[2].

Four annotators coincided in 123 answers, i.e. they marked the segments of the same length, or variable length but that kept the main idea in the marked text. Three annotators agreed in 109 segments, two in 63 texts and there were 5 segments with no coincidence. The Fleiss Kappa level for 1Q question, of four annotators, was 0.629 corresponding to Substantial agreement with P level-value less than 0.0001.

For experiments, we considered four and three coincidences of annotators (232) for 1Q. The training and test sets were built at random with 188 elements and 44 elements, respectively. The first test group, called Positive-Test, contains answers to question 1Q. A second test group (Negative-Test 1) includes answers for 2Q and 3Q. It is important to remark that these answers are part of the same element (general objective) containing the 1Q answer. In contrast to the second group, we add a Negative-Test 2 group with 2Q and 3Q elements that are not part of the same objective, i.e. 44 elements were randomly selected of the remaining corpus, including the two and null coincidence among annotators. The purpose of the evaluation with the second set of negatives was to observe whether the generated model was sensitive to answers that were not part of the same objective. With the trained model, we plan to evaluate objectives that not in the training set.

4 Model Overview

Our proposed model has two main components as depicted in Fig. 1. The first, the language model, captures features of each element of the training corpus (sentences). Through a cross-validation, lower and upper thresholds were obtained to differentiate objectives containing the 1Q answer. The second component, Answer Identification Scanning (AIS), analyzes new objectives formulated by students. The candidate text segment selected by AIS is classified using the thresholds determined by the first component.

AIS component executes a scanning of the objective in search of the answer to the question 1Q. If the objective contains the answer, the model will generate favorable feedback for the student, otherwise he would be asked to rewrite the objective. The student feedback provides tips and examples of objectives taken from the corpus.

The input to the Language Model was preprocessed generating sentences with token+grammatical category (using Freeling tool), with the goal of considering the syntactical role of each token. For each component of the evaluation, results with test groups are provided.

[2] An online tool was provided to annotators for the task.

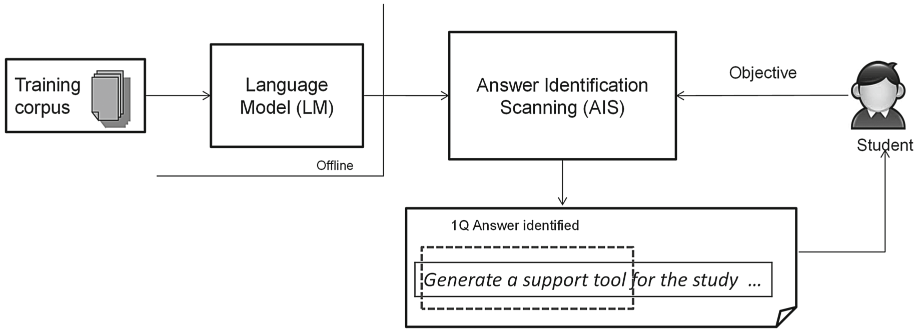

Fig. 1. Answer identification model

5 Language Model

To build the language model, the "SRI Language Modeling Toolkit[3]" was employed, with a Laplace Smoothing method. The training set was used to build the model. An example of 1Q answer input used to generate the model is:

Develop/VB a/DT system/NN capable/JJ of/IN performing/VBG the/DT tasks/NNS inventory/NN control/VB management/NN and/CC bug/NN reports/NNS[4]

After training the model, we defined an acceptance range to assess the three test groups. A 10-fold-cross-validation on the training set was performed to obtain the minimum and maximum value. For each fold, a minimum and a maximum were obtained, and then the averages of all minimum and all maximum values were computed. The idea was to establish an acceptance range in a perplexity scale, being: Minimum = 3 and Maximum = 13. The perplexity value indicates how similar the assessed text is to the language model. A low value indicates greater proximity of the evaluated text, i.e. the text shares similar characteristics to those used to trained the model.

Table 1. Language model evaluation results

Class/Measures	Evaluation: Positive-Negative 1		Evaluation: Positive-Negative 2	
	Positive	Negative	Positive	Negative
Positive	35	9	38	6
Negative	14	30	11	33
Accuracy	0.73		0.80	
Precision	0.79		0.86	
Recall	0.71		0.77	

[3] http://www.speech.sri.com/projects/srilm/.

[4] The example has been translated to English from the original in Spanish for easy reading.

To build the language model, we used an "ngram" command and configured Laplace Smoothing to avoid zero probabilities with terms out of vocabulary.

The first evaluation was performed considering the Positive-Test and Negative-Test 1 groups. The second evaluation was done with Positive-Test and Negative-Test 2 groups. Each element of the test group was evaluated in the language model and subsequently classified according to the range of perplexity previously established (see Table 1).

After evaluating the elements of Negative 2 group, we can observe in Table 1 an improvement of accuracy, precision and recall. As expected, the cause of this behavior is the thematic proximity between the elements of Negative 1 with Positive group (both elements are part of the same objective). However, 1Q answers can be distinguished from 2Q and 3Q answers. The prediction results of Positive-Negative 2 test could be the closest scene when the student evaluates his objective, since his draft would be different thematically, and likely to have deficiencies.

6 AIS: Answer Identification Scanning

The second component (AIS) is a scrollable window positioned at the beginning of the objective, and then the window moves to the right one place (i.e. considering Token (T) +grammar category (GC)). The value of perplexity is calculated at the beginning and at each step to the right of the window, and checking whether is within the range set by the first component (LM). The search for a candidate segment to answer 1Q stops when the window reaches a value within the established range. Below, the diagram shows the scrollable window to set the initial evaluation of perplexity and the movements to the right (see Fig. 2).

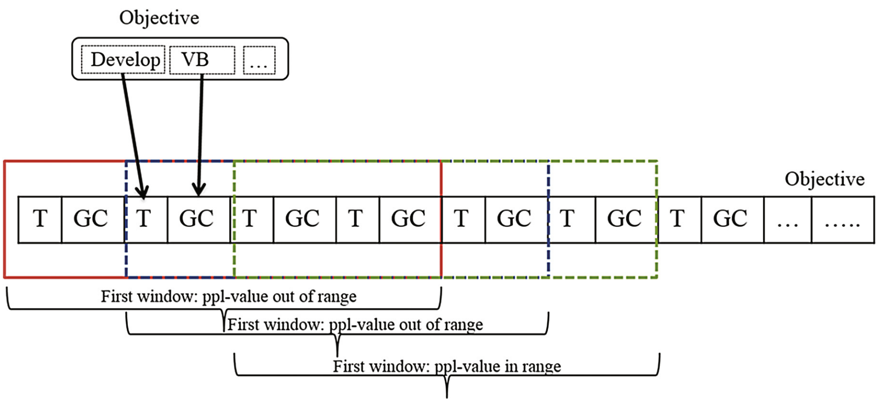

Fig. 2. Scrollable Window

The red line represents the initial window, then the window is moved to the right (dashed blue line) and finally the window reaches a value of perplexity in the range (dashed green line). The size of the first window (size 8) was established after reviewing the corpus of objectives and identifies the minimum of tokens used by students to express the answer of question 1Q. Also we considered two other window sizes (10 and 12) to compare results of accuracy, recall and precision and choose the window with best results.

The method of scrollable window stops when finding a text segment with perplexity value within the range (Min = 3 and Max = 13). In Fig. 1, we can notice that the method stops on the text segment enclosed in the green window, indicating that the method has found a candidate segment to provide an answer to the question 1Q. After experimentation of the scrollable window method, the size 10 was better than the windows of size 8 and 12.

After selecting the text segment candidate for 1Q answer, we added a window adjustment, experimenting with the expansion (increasing the window size) and the shrinkage (reducing the size of the window), with the goal of improving the accuracy and recall measures. The idea behind the expansion and the shrinkage occurs under the premise that the window established at first considers the presence of answer to 1Q question, in the best cases. We seek to soften the selected window for cases where the answer to the 1Q question could be overlapping other windows. After experimentation, the shrink adjustment improves the results (AIS+Shrink). In next section, we present the evaluation of AIS methods and shrinkage

Evaluation

The evaluation was performed considering the Positive-Test (first group) and Negative-Test 2 (second group). The first group contains answers to question 1Q, so for this evaluation we considered the complete objective. The purpose of evaluating the overall objective is that the scrollable window method identifies the candidate text segment as the answer of question 1Q. Also for the second group the complete objective was considered. Table 2 shows the results of experimentation with AIS and AIS+Shrink. Besides, the following table shows the results obtained with different window sizes (8, 10 and 12).

Table 2. Results for Answer Identification Scanning (AIS)

Methods	Window size	Precision	Recall	Accuracy
AIS	8	0.586	0.772	0.613
AIS+Shrink	8	0.632	0.704	0.647
AIS	10	0.785	0.909	0.829
AIS+Shrink	**10**	**0.803**	**0.931**	**0.853**
AIS	12	0.524	0.727	0.534
AIS+Shrink	12	0.555	0.681	0.568

Above, we can observe that the window of size 10 reached better results compared with the windows of size 8 and 12. The combination of AIS+Shrink obtained an accuracy value of 0.85 and a recall of 0.931.

In addition to the measures of accuracy, recall and precision, the level of agreement among annotators and the results obtained by AIS+Shrink(10) method was computed.

The goal to obtain Cohen kappa level was to verify whether the candidate segment to answer 1Q identified by our method is in agreement with annotators, taken as a ground truth. The Kappa value obtained was of 0.73 corresponding to the level “Good”. This result provides an acceptable result for the efficacy reached by the AIS+Shrink combination method, validating the computed range (Min and Max).

7 Conclusions

Assessing the objectives in a scientific document is a complex task for computers, and sometimes even for humans. Moreover, the subjectivity of the annotator complicates further the task. Our main research contribution is that the application of language models and an innovative method of scrollable window can identify the answer to one methodological question. This model can be used to identify answers to open questions that seek to demonstrate specific content, i.e., the answer is not unique, and with a recognizable structure.

To improve the performance of language model, we will increase the number of elements in the sub-collection, to reach a finer range and capture a wider variety of objectives. In future work, we plan to move to tackle the remaining methodological questions (2Q and 3Q), that present a more elaborated structure and demand a different approach. We also foresee a pilot test with students, already including evaluation of the three answers with their corresponding feedback.

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The Design of a Smart Tray with Its Canteen Users: A Formative Study

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Abstract. The ability of taking responsible decisions concerning eating depends on the eating context. This paper considers users of university canteen environments. It outlines the GAPH project and system for informing canteen users about their eating choices, and the effects of choices on their diet. The main component of the system is a tangible solution: the smart GAPH tray. The paper presents the design approach for rapidly deploying tray prototypes, and for assessing them in their natural context. It focuses on the most recent study concerning end users' interaction with the GAPH tray, and reflects over its results also in terms of the chosen design approach for tangibles for novel contexts.

Keywords: Methodologies for the design of accessible and usable TEL systems · Internet of things solutions for TEL · AI technologies and tools for TEL

1 Introduction

Nutrition experts and organisations, such as the World Health Organisation, design and update healthy nutrition guidelines that can help people in taking decisions concerning their eating, and avoiding eating disorders or diseases [21]. However, responsible decisions can be taken only according to the eating context and information available therein. Decisions concerning nutritional control during cooking and ingredient purchase are important for a healthy eating in home contexts. The Interaction Design (ID) and decision-making literatures have so far focussed on supporting them, e.g., [9]. Those decisions are however not in control of canteen users. Anyhow, these have to take two decisions that affect their healthy eating, and specifically their healthy daily diet: their choice of canteen dishes; the amount of food intake.

The Gamified Probes for Health (GAPH) project is an exploration of how ID can support canteen users' healthy eating: specifically, GAPH aims at supporting healthy canteen users in taking informed eating decisions for their daily diet. One of its goals is to inform canteen users about their canteen meal choices and the

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effects of choices on their daily diet, with the long-term aim of raising awareness and self reflection concerning canteen eating habits. In order to tackle its goal, GAPH is developing an information system with different but integrated ID solutions. One is a tangible ID solution, namely, the smart *GAPH tray*, which mainly tackles the aforementioned goal of informing user's canteen meal choices and their effects on the user's daily diet. This paper focuses on the smart GAPH tray for canteens.

The GAPH tray is developed with a participatory approach [5,10], which proceeds through alternative design solutions and studies with end-users: these are continuously involved in informing critical design decisions over time [2,7]. The paper gives a compact account of related work, and of the GAPH context. Then the paper outlines the design process of the GAPH tray, and comes to the study with end users concerning the latest GAPH tray prototype. This was organised so as to rapidly gather data about specific design choices. Related considerations are put forward in the conclusions to the paper.

2 Related Work

After an initial pilot literature review, two researchers run a systematic literature review [16]. Researchers classified the retrieved interactive solutions into: (C1) interactive solutions for mobile devices or computers, e.g., the commercial MyNetDiary [15]; (C2) interactive smart environments for eating, with embedded electronics, such as smart balances, e.g., [4]; (C3) interactive solutions for specific users. Due to space constraints, only the last category is expanded.

Several interactive solutions, mainly web-based, are meant for specific users. Of relevance for this paper is the smart tray by Kim et al. for patients of hospitals, advanced in [13]. Kim and co-authors proposed the prototype of a smart tray for hospital patients. Patients select dishes from a predefined list via a smartphone, and the tray weights dishes. Then patients have to *watch the smartphone* to have feedback about calories and sodium values in their meal and their eating pace. According to evaluation results, not all participants observed their intakes of sodium and calories on the smartphone while eating; all participants tended to consult them after eating, only.

Other relevant solutions are for youths, gamified for engaging them into healthy nutrition habits. In its most general and recent acceptation, gamification means properly using game-based elements (e.g., progression bars, rewards), in a non-game context, in order to positively engage people [19].

In the health-nutrition context, gamified ID solutions are mainly for mobile or computer devices. An exception is Gululu, a cloud-based drinking driller: the bottle embeds sensors that track the amount of water intakes and a small-size screen displays results through animated characters; families can set and monitor the daily water intakes through a mobile app [11]. Another interactive, augmented-reality solution is FoodWorks, which explicitly rewards children according to their adherence to healthy nutrition habits [8]. However, it has still to be evaluated whether gamified ID solutions engage users into healthy nutrition habits, in the long term.

3 GAPH Design Goal and Requirements

3.1 GAPH Main Users and Design Goal

GAPH main users are healthy canteen users, mainly eating at university canteens: university students; academic staff members. The goal of the GAPH project, explored in this paper, is informing its users about their canteen meal choices and their effects on their daily diet.

3.2 Context of Use and Design Requirements

The *context of use* of GAPH was initially investigated with: (1) a literature review (see above); (2) repeated observations of the canteen eating context in the geographical area of GAPH; (3) short contextual interviews with seven canteen users; several rounds of inquiries with three nutrition experts in the country where GAPH will be used. Requirements were formulated in light of the context of use analysis results. The main requirements are reported below, *in italics*, in line with [17].

In the geographical area of GAPH, canteen meals consist of *four dishes*: a first dish, a second dish, a side dish, a fruit dish.

Canteen meals follow the nutrition guidelines of the Italian Society of Human Nutrition (SINU), and dietary reference values for healthy individuals [12] (*req1*). Such values are used for computing Diet Needs (DN's), and concerning a healthy person's: (1) global energy needs per day, in Kcal; (2) nutrition needs per day, namely, needs of carbohydrates (CHO), fats, proteins, in Kcal.

Canteen users have neither such knowledge, nor information about their canteen meal Kcal contribution—globally, per nutrient. Thereby their choice of canteen dishes may easily yield to Kcal unbalances, globally or per nutrient, with respect to their DN's. Briefly, canteen users should be *informed about the balance* between their DN's and Kcal contributions of their canteen meals, both globally and per nutrient (*req2*).

Meals in canteens are socialisation opportunities; during canteen meals, people communicate face to face. GAPH should be simple to use and *simple and unobtrusive* with respect to the socialisation function of canteen meals, especially the need for communicating face-to-face. GAPH could thus follow the technology paradigm of persuasive or ubiquitous computing [20]: technology should be embedded and perceived "natural" in its context of use, so that people use technology enhanced solutions without being absorbed by them (*req3*).

4 GAPH Design Choices

The GAPH tray was developed through a design process that stepped through firstly alternative design mockups and then interactive prototypes, implementing few critical functionalities (a.k.a., *vertical* prototypes, in the sense of [17]). They were all assessed with interaction design experts and their users in small-scale studies, so as to rapidly gather usability data and disclose unforeseen design spaces [3]. Specifically, several design alternatives for the GAPH tray were developed by starting from the above requirements. The majority were abandoned in light of results of small-scale studies. The remaining ones were realised as vertical prototypes, again assessed within small-scale studies with canteen users.

The remainder of this section describes the latest vertical prototype, evaluated in the large-scale study that is reported in this paper. See Fig. 1.

Fig. 1. The progression bar of the GAPH tray prototype

Interaction. The GAPH tray prototype was developed as a flat layer fitting into canteen trays in line with the above requirements: (*req1*), (*req2*), (*req3*).

As for (*req1*), The GAPH tray is divided into one area per dish of the local canteen meal. As for (*req2*), the GAPH tray identifies a user via his or her university card, placed on a slot of the GAPH tray. The user identification is required to retrieve relevant data for computing his or her nutrition balance. A *progression bar* is attached to the GAPH tray: the bar displays the nutrition balance feedback concerning the balance between the user's DN's and Kcal contributions of canteen dishes, both globally and per nutrient. The bar uses color codes and iconic faces to show the user if there is balance (then green is lighted up in the bar) or not (if the Kcal contribution is low then blue is lighted up in the bar, and if the Kcal contribution is high then also red is lighted up). Users can actively explore the Kcal contribution of each dish anytime they wish (globally, per nutrient): by pressing the green-LED button nearby a dish, the progression bar updates its balance feedback in relation to the dish.

All the GAPH tray was realised so as to make the inquiry about the nutrition balance as simple and unobtrusive as possible (*req3*). In particular, according to results of the study [13], people would not watch nutrition information on a mobile app while eating, thus the GAPH tray itself could display such information and avoid the need of an external device while eating. The nutrition balance feedback is given by the progression bar of the tray, and not via an external device. Anytime users wish, they can inquiry about their nutrition balance and trigger the progression bar by pressing the green-LED buttons.

Architecture. The tray embeds a Raspberry PI version 2, running Python version 2.7, for triggering the progression bar feedback in a smart manner. The tray takes the weight of dishes via its balances, as well as their weights through an external videocamera. Photos of dishes are sent by the GAPH server to an image recognition system; once dishes are recognised against the predefined list of daily canteen dishes, the server computes Kcal contributions of dishes and the user's DN's, and it returns information to the tray for the progression bar (see Fig. 2). The evaluation and usage of the prototype with canteen users of different ages is reported in the following.

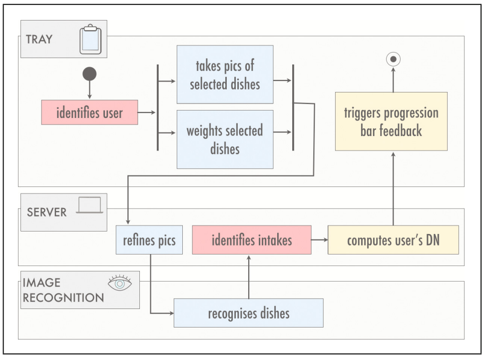

Fig. 2. The GAPH main architecture

5 Field Study for Rapid Design Decisions with End Users

5.1 Goal, Setting and Participants

The evaluation focussed on the progression bar of the vertical prototype of the GAPH tray, and on the following questions: Would the progression bar feedback be understandable? Would the GAPH tray be overall usable, or what would be usability issues? Would users change anything in the design of the prototype?

The study was run at the local university canteen. It used photos of dishes so as to rapidly engage as many users as possible with a single tray, like in [6].

Participants were 45 canteen users of two different age ranges: 25 *younger* users, all university students (18–29 years old, with mean age $M = 22.64$ and standard deviation $SD = 3.25$), and 20 *older* users (30–50 years old, with mean age $M = 38$ and standard deviation $SD = 7.9$), all academic staff members. All participants were volunteers. Two evaluators were present, as well as a technician for potential technology issues. An evaluator acted as *moderator*: he managed the interaction with participants. The other evaluator acted as *recorder*: she was a passive observer and kept track of data.

Participants were given different photos for the 4 typical canteen meals: 4 first dishes; 4 second dishes; 4 side dishes; 4 fruit dishes. Balances were not used and weights were set according to typical canteen portions. In this setting, it was impossible to control all factors, and to personalise the progression bar feedback; the reference DN's were of an 18 year old, average male user. Participants were informed about it.

The evaluation was thus divided into two sessions. In the *first session*, participants were asked to guess and pick up 1 first dish, 1 second dish, 1 side dish and 1 piece of fruit for a balanced meal in terms of Kcal contributions (globally, per nutrient). Participants then received the progression bar feedback about their meal. In the *second session*, participants could explore Kcal contributions of specific dishes by interacting with LED buttons.

5.2 Data Collection

The moderator probed participants in both sessions in relation to the study research questions, while the recorder registered answers or relevant behaviours.

Understandability was assessed by considering whether participants correctly answered two groups of questions concerning the progression bar feedback: (Group-1) Is your meal balanced? What makes you think so? (Group-2) What does the feedback tell you now? Group-1 questions were posed at the end of the first session, and the Group-2 question during the second session.

Usability issues and users' ideas were instead tracked in free-text format by the recorder, which run a short debriefing about them with the moderator after each usage session [1].

5.3 Results

Answers to the Group-1 and Group-2 questions were independently classified by the two evaluators as correct (1) or wrong (0). Then evaluators compared their classifications and reached a common decision. Understandability in relation to the Group-1 questions was 89%, and to the Group-2 question was 93%, with 95%-CI [73%, 94%] and CI [79%, 97%], respectively, calculated with the Adjusted-Wald method [18].

Moreover, the two evaluators considered the reported issues and ideas. Data were independently ranked by relevance (major, minor) by the evaluators and then compared. Younger users, all university students, seem to have found the interaction with the tray not sufficiently playful for them. For instance, a younger user was reported saying: "I would expect to have a more lively and fun feedback, say, blinking red colours, when my meal is unbalanced, and to receive a reward when the meal is balanced". Major issues with the granularity and the blue of the scale were also reported, independently of the age range. All users seemed to appreciate the usage of iconic faces in the progression bar feedback. An older user suggested that the GAPH tray have faces also for Kcal nutrition components, because "faces help me more quickly grab if I am ok or not than color codes do". Finally, an older user reported to appreciate the Kcal split per nutrient because of health-related issues with carbohydrates.

6 Discussion and Conclusions

This paper presented the main ID component of the GAPH information system: the smart GAPH tray for canteen users. It explains how the design process was rooted in the local context, which motivated why the GAPH tray should be quickly understandable and unobtrusive with respect to the socialisation function of canteen meals. The paper shows how the design process of the tray evolved from its requirements, via alternative design solutions (mockups and vertical prototypes) and studies, with end users using tray prototypes in their context.

The paper focussed on a field study with a vertical prototype of the GAPH tray. The study enabled researchers to rapidly collect data with a single tray prototype, and in relation to the understandability of the progression bar feedback of the tray, usability issues as well as unexpected design possibilities.

The analysis results show that the information delivered through the progression bar was generally understood by canteen users: the lower bounds of the CIs for correct answers to the understandability questions were all above 73%. However, by inspecting the emerged usability issues, it seems that the simple design of the progression bar is not sufficiently engaging for younger users: its design was not sufficiently playful for younger participants, who were all university students. Such result is hardly surprising in light of the available literature [14]. However, the usage of the prototype in the study also suggested what younger canteen users would expect to find in terms of playful features, e.g., rewards when their meals are balanced. Therefore, in the next vertical prototype of the GAPH tray, related playful design choices will be implemented and assessed with younger canteen users, together with the other relevant components of the GAPH information system, e.g., an app for showing users their canteen eating history so as to raise awareness and trigger reflections about it.

Overall, in spite of its limits, the study, run with a single GAPH tray prototype, allowed researchers to rapidly collect interesting data concerning the GAPH tray design. In terms of general research findings, the results of this paper corroborate existing findings that support the chosen design approach for tangibles for novel contexts, e.g. [2]. This advocates the need of evolving design over time, through the continuous end users' involvement in using mockup solutions or interactive prototypes. In case of the GAPH tray, its prototypes were vertical and rapid to design, as well as economic. Such design choices make it easy to abandon design decisions in case of critical usability issues, and to rapidly adapt the prototypes according to the discovered design possibilities.

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Methodologies for the Design, Personalisation, User Modelling and Adaptation in TEL

Assessing the Role of Computer Simulation in Chemistry Learning

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Abstract. Simulation and Computation make a versatile teaching strategy, and may be an important way to motivate students and lecturers to achieve meaningful learning. Indeed, this work refers to a study whose main objective is to set the influence that a teaching approach based on the use of computer simulation would have on students' learning, compared to the one in use today. This work involved the participation of two classes of 11th grade at a Secondary School in Lisbon, Portugal, where the main goal is to teach a specific topic to an untried student's group. With regard to the simulation environment, it will be grounded on a Proof Theoretical approach to Knowledge Representation and Reasoning, which caters for the handling of incomplete, unknown or even self-contradictory information or knowledge.

Keywords: Computer simulation · Chemistry learning · Teaching strategies · Secondary education · Logic programming · Knowledge representation and reasoning

1 Introduction

In the last decades a great effort has been made to equip schools with computational resources and Internet access, in order to enable the use of new teaching and learning strategies, namely through the use of simulation techniques. In fact, these resources are available on the Web for free, an in the most diverse forms. Therefore, one is faced to a simple exercise of common sense in the prospect of its use in teaching, either to evaluate if simulations should be used only to illustrate a particular subject and/or to motivate the students or, on the contrary, if it has an educational potential that should not be depreciated.

Computer simulation stands for a multimedia resource, i.e., a computer controlled combination of at least one type of static media (e.g., text, graphic, photograph), plus a

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minimum type of dynamic media (e.g., video, animation, audio). The term multimedia refers to digital technologies that allow for creating, manipulating, store and search for contents, prevailing the use of senses such as sight, hearing or touching [1, 2].

An interaction's measure with the mainstream media in terms of human perception was set at 55%, 38% and 7%, respectively for visual, vocal, and textual media. However, when combined, the percentage of efficiency increases significantly [1, 2]. In this way, since multimedia contents stimulate more than one sense, these resources increase the capacity of processing and storage information. Indeed, this assertion is supported by diverse beliefs on multimedia learning such as Sweller's cognitive theory [3, 4], Schnotz and Bannert's integrated model of text and picture comprehension [5], or Mayer's theory of multimedia learning [6, 7]. In particular, Mayer assumes that verbal and pictorial explanations are processed in different cognitive subsystems (a dual channels assumption), which result in the construction of different mental models [7]. Verbal selection processes lead to a propositional text base and verbal organisation processes result in a text based mental model. Pictorial selection processes lead to an image base, and the respective organisation processes result in a picture based mental model. The verbal organisation processes take place in the verbal part of working memory, while the pictorial organisation processes occur in the pictorial one. The elements (and relations) of the text-based model are mapped on elements (and relations) of the picture model, and vice versa [7].

Computer simulation entails an interactive environment with characteristics that are similar to real life events, and may be classified into two distinct groups, namely operational and conceptual ones. The former one is mainly aimed at teaching procedural skills. Usually include two realistic interfaces, the working and the answering ones, which are particularly useful in situations where the use of the existing equipment is dangerous or expensive. The conceptual simulations focus is on a learning process of specific principles or procedures from different domains, and on problem solving heuristics, i.e., are designed to build mental models on a specific domain [8].

Really, in the last decades several studies have been carried out to evaluate the effectiveness of computer simulation in the teaching/learning process [9–13], i.e., there are authors that point out the advantage of providing students with new and more effective teaching methodologies [11, 13].

This paper involves four sections. In the former one a brief introduction to the problem is made. Then different methodologies for problem solving in this area are presented. In the third section some results are presented and discussed. Finally, in the last section the most relevant conclusions are described and future work is outlined.

2 Knowledge Representation and Reasoning

Many approaches to knowledge representation have been proposed using the Logic Programming (LP) epitome, namely in the area of Model Theory [14, 15], and Proof Theory [16, 17]. In the present work the Proof Theoretical approach in terms of an extension to the LP language is followed, where a logic program is a finite set of clauses, given in the form:

$$
\begin{aligned}
&\{\\
&\quad \neg\, p \leftarrow not\ p, not\ exception_p\\
&\quad p \leftarrow p_1, \cdots, p_n, not\ q_1, \cdots, not\ q_m\\
&\quad ?\,(p_1, \cdots, p_n, not\ q_1, \cdots, not\ q_m)\ \ (n, m \geq 0)\\
&\quad exception_{p_1}\\
&\quad \ldots\\
&\quad exception_{p_j}\ \ (0 \leq j \leq k),\quad being\ k\ and\ integer\\
&\}::\ scoring_{value}
\end{aligned}
$$

where the first clause stand for predicate's closure, "," denotes "*logical and*", while "*?*" is a domain atom denoting falsity. The p_i, q_j, and p are classical ground literals, i.e., either positive atoms or atoms preceded by the classical negation sign ¬ [16]. Indeed, ¬ stands for a strong declaration that speaks for itself, and *not* denotes *negation-by-failure*, or in other words, a flop in proving a given statement, once it was not declared explicitly. Under symbols' theory, every program is associated with a set of abducibles [14, 15], given here in the form of exceptions to the extensions of the predicates that make the program, i.e., clauses of the form:

$$exception_{p_1}, \ldots, exception_{p_j} (0 \leq j \leq k)$$

which stand for data, information or knowledge that cannot be ruled out. On the other hand, clauses of the type:

$$?\left(p_1, \ldots, p_n, not\, q_1, \ldots, not\, q_m\right)(n, m \geq 0)$$

also termed invariants or restrictions, allows one to set the context under which the universe of discourse has to be understood. The term $scoring_{value}$ denotes the relative weight of the extension of a specific *predicate* with respect to the extensions of peers ones that make the inclusive or global program.

3 Methods

This section depicted, succinctly, the cohort characterization, lesson plans and support materials used at the experimental group. Moreover, it is presented the test applied to assess the students' learning.

3.1 Participants

A total of 55 students aging between 16 and 17 years old, attending for the first time the 11th grade of Sciences and Technology area, were enrolled in this study. The experimental group was formed by 23 students (8 female and 15 male) and the control one involved 22 students (14 female and 8 male).

3.2 Lesson Plans

The main objective of this procedure was to determine the influence that a strategy based on the use of computer simulation would have on students' learning, compared to the resources usually used for teaching the same content. In the experimental group a computer simulation was used and in the control one a traditional methodology was followed, being the lesson plans presented below.

- **Duration:** 90 min.
- **Summary:** Chemical reaction, stoichiometry, reactants, products and leftovers.
- **Objectives:**
  - Identify the limiting reagent;
  - Identify the excess reagent;
  - Characterize a complete chemical reaction;
  - Characterize an incomplete chemical reaction; and
  - Understand the stoichiometry of a chemical reaction.
- **Resources:**
  Experimental Group:
  - PowerPoint presentation; and
  - Computer simulation [16, 18].

  Control Group:
  - Blackboard presentation; and
  - Image projection.
- **Strategies:**
  Experimental Group:
  - Using the PowerPoint presentation, the teacher defines the relevant concepts (e.g., chemical reaction, stoichiometry, reactants, products, limiting reagent and excess reagent); and
  - Following the instructions, the students explore the computer simulation.

  Control Group:
  - Using the blackboard and image handling material, the teacher defines the relevant items (e.g., chemical reaction, stoichiometry, reactants, products, limiting reagent and excess reagent); and
  - The students try to get an answer to the problems presented to them, using the traditional methodologies for problem solving.
- **Assessment:** An individual test was applied.

3.3 Teacher Support Materials

The strategy followed by the teacher in the experimental group was based on the use of computer simulation, having into account the *Reactants, Products,* and *Leftovers* [16, 18]. This simulation explains the perceptions of limiting and excess reagent's models. In the initial approach the students may choose the ingredients of a sandwich, showing which ones are in excess (Fig. 1a). In the second one they may choose one of three possible chemical reactions, as well as the amount of each reagent, identifying its excess if it exists (Fig. 1b). Finally, a didactic game is proposed where the students earn points when they give the right answer (Fig. 1c). The whole process is now depicted in the form:

- **Making sandwiches** (Fig. 1a)**:** We are faced to an analogy, i.e., it is our intention to disclose the manner or form in which a chemical reaction develops, and wherein the reagents are replaced by bread, cheese and ham. These reagents may occur in excess or be limiting.
- **Chemical reactions** (Fig. 1b)**:** An extract of the logic programs used in the simulation process (where some of the reagents are in excess or are limiting), and given in terms of the Logic Programming Language PROLOG, may be seen as follows:

```
1. Initial state:
     :- op(900,xfx,'==>').
     :- dynamic mol/1.
     :- dynamic consume/1, produce/1.
     molH2(3). molO2(4).
     [2 molH2 (H2), 1 molO2 (O2)] ==> [consume (2 molH2
     (H2)), consume(1 molO2 (O2)), produce(2 molH2O
     (H2O))].
     ...
2. Final State:
     ...
     molH2(1). molO2(3).  molH2O(2).
     ...
```

- **Playing a game** (Fig. 1c)**:** An extract of the logic programs used in the simulation process and given in terms of the Logic Programming Language PROLOG, may take the form:

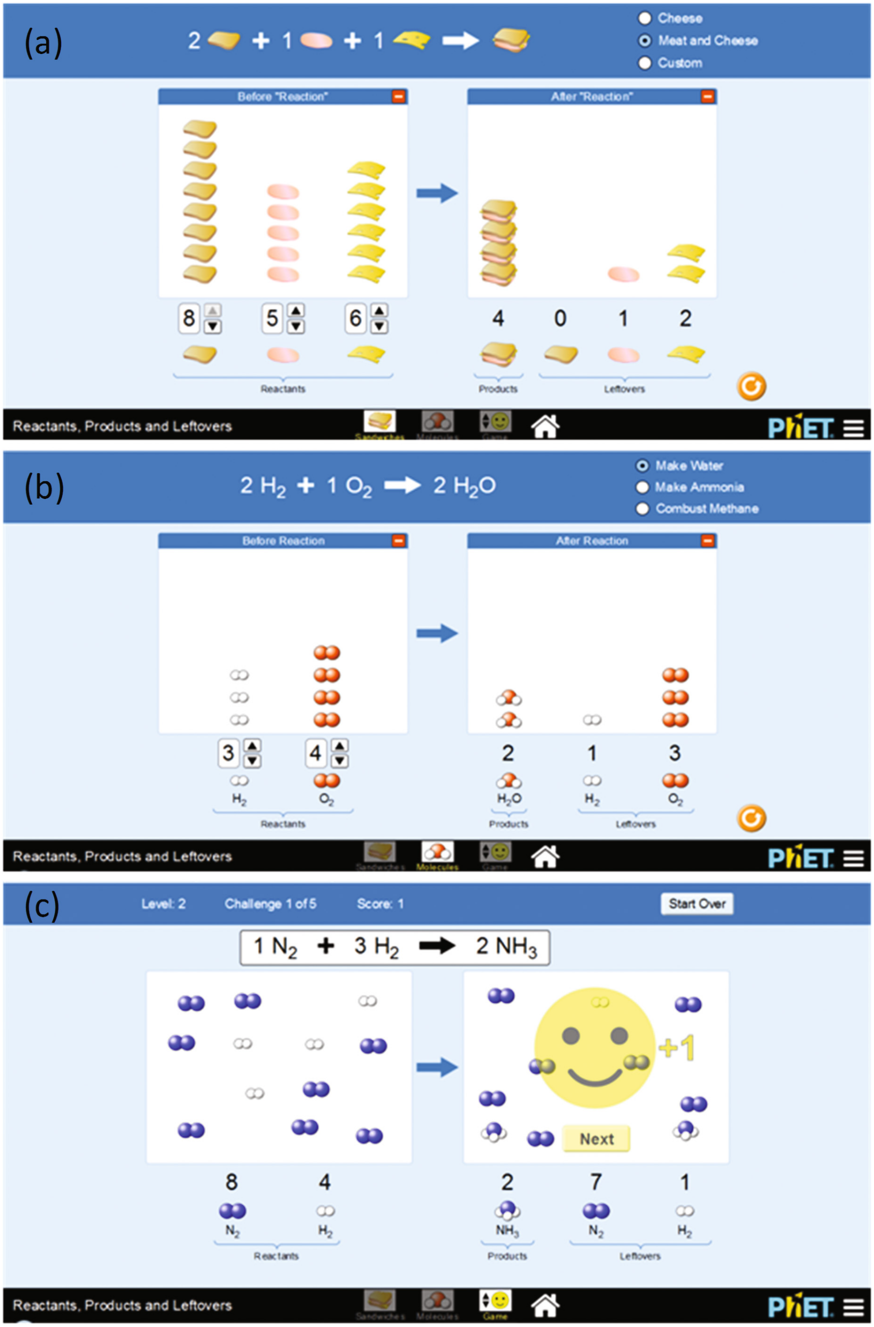

Fig. 1. A screenshot of the possible simulation's alternatives. Make sandwiches (a), chemical reactions (b), and play a game (c).

```
1. Initial state:
    :- op(900,xfx,'==>').
    :- dynamic mol/1.
    :- dynamic consume/1, produce/1.
    mol_N2(8).   mol_H2(4).
    [1 mol_N2 (N_2), 3 mol_H2 (H_2)] ==> [consume(1 mol_N2
    (N_2)), consume(3 mol_H2 (H_2)), produce(2 mol_NH3
    (NH_3))].
    ...
2. Final State
    ...
    mol_N2(7).   mol_H2(1).   mol_NH3(2).
    ...
```

where the chemical reactions are given as productions of the form *Condition==>Action.*

The logic programs referred to above stand for a type of rational agent, a *Belief-Desire-Intention* (*BDI*) one, denoting a software model that is an example of a *reasoning architecture* in which the elements are able to learn, socialize (i.e., work as a group), feel fear or hate, with the potential to abstract to other scenarios [19].

3.4 Students' Learning Assessment

In order to assess the students' learning, a test was applied to both groups, at the end of the lesson. The questions included in the test were:

Consider the chemical equation 3 A + 4 B $\rightarrow$ 2 C + 3 D. For each question tick the correct answer:

1- When 6 mol of *A* react with 9 mol of *B*, one may have:
☐ *A* is the excess reagent ☐ *B* is the excess reagent ☐ No reagents are in excess

2- When 5 mol of *A* react with 7 mol of *B*, at the end of reaction are present:
☐ *C* and *D* ☐ *C*, *D* and *A* ☐ *C*, *D* and *B*

3- When 0.5 mol of *A* react with 2 mol of *B*, one may have:
☐ *A* is the limiting reagent ☐ *B* is the limiting reagent ☐ No reagents are limiting

4- To obtain 4 mol of *C* it is necessary to handle:
☐ 6 mol of *A* and 8 mol of *B* ☐ 6 mol of *A* and 4 mol of *B*
☐ 3 mol of *A* and 4 mol of *B*

5- When 2 mol of *A* react with 3 mol of *B* are produced:
☐ 2 mol of *C* and 3 mol of *D* ☐ 2 mol of *C* and 1,33 mol of *D*
☐ 1,33 mol of *C* and 2 mol of *D*

4 Results and Discussion

In order to analyze the results obtained in the test by the students of both groups (i.e., the experimental and the control ones) a graph was constructed and is presented in Fig. 2. The analysis of this figure shows that the percentage of correct answers to questions 1, 2 and 3 is higher in the control group, namely 95.5%, 77.3% and 95.5%, against 91.3%, 60.9% and 65.2% for the experimental one. Conversely, regarding the questions 4 and 5, it was in the experimental group that the percentage of correct answers was higher (100% versus 77.3% and 81.8%). In order to evaluate the statistical significance of the data obtained for both groups a t-test was carried out. The t-test revealed significant differences in the answers to questions 2, 3, 4 and 5 (sig. (2-tailed) < 0.05). An interpretation of these results necessarily implies an individual analysis of each question. In fact, questions 1, 2 and 3 refer to the stoichiometric relationship between the reagents and the identification of their limiting/excess quantities. The students can solve these kind of situations by analogy, taken into account the examples presented by the teacher, in terms of a relationship with other parts or quantities. Questions 4 and 5, in turn, require the prediction of the quantities of products based on the initial quantities of the reagents or vice versa. If a computer simulation is used as strategy in the experimental group, the students mentally make the prediction of the quantity of products formed or the amount of reagents required, through the visualization of images, without calculations. This fact can justify the 100% of correct answers to these questions by the students of the experimental group.

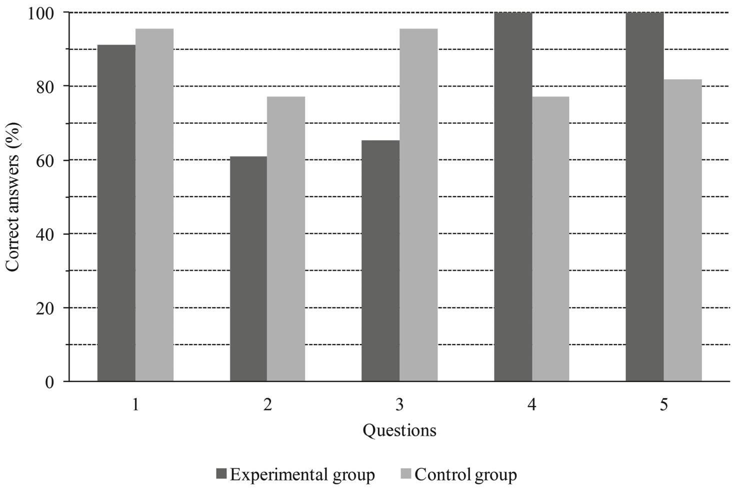

Fig. 2. Percentage of correct answers obtained in the test.

The overall analysis of the results seems to show that the two methodologies complement each other. In fact, it is important to recognize the limiting reagent by calculations associated with stoichiometry of the reaction, which was achieved with the traditional methodology. However, the skills acquired by students of the experimental group through the use of computer simulation are also important, allowing a better understanding of the composition of the reaction system.

Despite some studies that point to the advantage of providing students with new and more effective teaching methodologies [11, 13], the results obtained show that the traditional one and the one based on the use of computer simulation complement each other. In fact, the results shown are in agreement with some published studies in which the advantages and limitations of the use of computer simulation are mentioned. Jimoyiannis and Komis state that computer simulation may be used as a complementary instructional tool, in order to help students confront their cognitive constraints and develop functional understanding of physics [10]. Ruttens et al. analysed the effects of computer simulations in educational science and refer that reviewed literature provides robust evidence that computer simulation can enhance traditional instruction [12].

5 Conclusions

The results of this study revealed that the traditional methodology (oral explanation on the blackboard, with concrete examples and mathematical calculations) and the methodology based on the use of computer simulation are equally important. The former methodology develops skills related to the resolution of exercises through the use of relationships with other parts or quantities, i.e., rules, while the second is more effective when a more complex reasoning approach is needed. Multimedia tools, in particular computer simulation, can be used as a helpful instrument to capture students' attention, and to exemplify abstract scientific concepts. However, there are other strategies that must also be considered. For example the summary of contents using the blackboard, the resolution of exercises/problems and the execution of experimental activities are strategies that also lead to positive results. These aspects of the problem will be object of future consideration. Furthermore, the strategy based on the use of computer simulation will be extended to include other topics like chemical equilibrium and acid-base reactions, just to name a few. In order to support and validate the study findings the cohort should also be increased as well as the number of questions included in the learning assessment test.

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Literature-Based Analysis of the Potentials and the Limitations of Using Simulation in Nursing Education

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Abstract. "Simulation," in terms of its application in nursing education, is the imitation and replication of some of, or nearly all, the fundamental aspects of a clinical situation to strengthen comprehension and teach best practices.

An extensive review of literature was performed in order to understand what are the potentials and the limitations of using simulation in nursing education.

Likely, the benefits of using simulation will depend on the educational objectives: simulation can be used not only by nursing students to gain clinical competences in a safe learning environment, but also by experienced professionals to get expertise in facing unpredictable, rare, or risky real-life situations.

Because of the evident advantages in terms of cost, risk, and benefits, the use of simulation in nursing education is ineludible, and its implementation in curricular programs is recommended.

Keywords: Nursing education · Simulation · High fidelity simulation · Learning

1 Introduction

From Sairey Gamp's—the incompetent, untrained, dissolute, sloppy, and generally drunk nurse—was depiction in Charles Dickens' Martin Chuzzlewit (1843–1844) to today, the nursing profession has evolved through a journey that has made it essential in health care systems worldwide. Nowadays, nurses are the largest part of the professional staff in acute care hospitals, and the quality of the nursing influences, directly and indirectly, patients' health [1]. The high proficiency of nurses achieved in recent years allows effective clinical management of patients in many hospital settings. For example, in intensive care units, daily nursing vigilance, combined with the use of sophisticated computer systems for continuous monitoring of vital signs, often prevents unpredictable

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and undesirable events for patients [2, 3]. In the fields of anesthesia [4] and ultrasound [5], there is also evidence that advanced nursing skills result in high-quality outcomes. Because of the changing health needs of populations worldwide, nursing activities are in great demand not only in the traditional settings, such as hospitals or long-term care facilities, but also in primary and home care [6], with plans to develop very innovative roles for nurses that should be complementary to the general practitioners' activities [7].

In many countries, the nursing education has reached the highest academic levels, up to PhD, significantly contributing to the scientific and technological development in the health sciences fields [8]. Until recently, the teaching of clinical skills occurred mainly at the patient's bedside, but this "apprenticeship model" [9] is not always ideal because it in general only allows students to observe the skills performed by professionals. Fortunately, over the past 20 years, teaching methods have changed, leading to the development of clinical-skills laboratories (CSLs) in the fields of medical and nursing education [10], mainly based on simulation techniques. The first CSL was established in Maastricht, the Netherlands, at Limburg University in 1976 [11], and at present, many nursing courses around the world use CSLs as a teaching tool [12]. Traditional simulation in the form of static manikins, partial task-trainers, and role-playing is defined as "low fidelity" because it does not reproduce authentic scenarios and allows the acquisition of skills and knowledge related only to specific areas, such as hygiene, elimination needs (urinary catheters), nutrition (nasogastric tubes), mobilization, peripheral vein cannulation, oxygenation therapy, injections, and wound care [13].

"Simulation training" may be viewed as a continuum from low to high fidelity, and this literature review was performed to better understand what are its potentials and limitations in nursing education.

2 Methods

Extensive literature research was conducted on PubMed and Scopus throughout February 2017, using the following keywords: "nurs*," "simulation," "simulator," "training," "high fidelity," "technologies," and "learning." To identify potentially relevant papers published until today, an additional search was conducted on textbooks.

All studies that matched with the scope of this paper were carefully reviewed by its authors, and their synthesis is the result of the following shared analysis.

3 Results

The results of this analysis can be divided in two sections that reassume, respectively, the evolution of simulation models, and the technological-enhanced simulation.

3.1 Evolution of Simulation Models

Simulation is used in many contexts, such as in safety engineering [14], aviation [15], management of nuclear installations [16], military flight [17], other industrial areas [18], and video games. In most of these cases, it is used as a stronghold for the education and training of professions and as a method for performance evaluation.

In 1929, the best-known early flight simulator, the Link Trainer, was developed by Ed Link, and during World War II, Link received a plethora of orders for his basic trainer, the "Blue Box." The military used his simulators to teach wartime instrument flying, aerial gunnery, bombing, navigation, automatic piloting, and radar operation to half a million airmen [19]. The military was a major impetus in the transfer of modeling and simulation technologies to medicine [20, 21], and until the 1990s, it still accounted for 80% of all modeling and simulation work [22]. However, by the mid-1990s, the gaming industry surpassed the military as the driving force in the development of high-resolution graphics [22, 23] used in simulators.

Modern medical simulation recognizes some essential antecedents in flight simulation, resuscitation, and plastics, as well as in innovations in computer sciences, that simplified and accelerated the mathematical description of human physiology and pharmacology, and the design of virtual worlds [24].

Several simulation models are available in the medical field, from "ex vivo" models and live tissues to high-fidelity simulation (HFS). Excluding "ex vivo" models and live tissues, which are generally used for surgery training, and cadavers (reminiscent of old medical anatomy courses), medical simulation can be divided into five categories: verbal, standardized patients (SPs), part-task trainers, computer patient, and electronic patient [22, 25].

Verbal simulation is simply role-playing. This method can also be used in high-fidelity simulation sessions where actual clinicians or students role-play "themselves" or change their roles [26]. Standardized patients can be actors or patients/actors and were first used in 1963 by a neurologist from the University of Southern California. This method can be used to educate and evaluate history-taking and physical examination skills, communication, and professionalism [27]. Part-task trainers may be simple anatomical models of body parts in their normal state or representing disease [22]. This simulation model is oriented particularly to the acquisition of technical, procedural, or psychomotor skills [13], such as cardiopulmonary resuscitation; incision and suturing; heart and lung sound-recognition; urinary catheterization; airway management; vascular access; lumbar puncture; and nasogastric tube insertion [28]. Computer patients are interactive and may be software-based or part of an Internet-based virtual world [22]. This model has grown with the development in computer science and can substitute the SPs in many areas at a reduced cost [29]. Electronic patient is the most complete type of simulation and can be either manikin-based or virtual reality-based, with sophisticated computer controls that can be manipulated to provide various physiological parameter outputs and integrated with replicas of clinical environments [29].

3.2 Technological-Enhanced Simulation

Since the Resusci-Anne manikin was invented in 1960, simulation technologies have noticeably evolved into computer-controlled patient simulators, which are currently the spearhead of existing simulation tools [22, 29]. These simulators are fully programmable, whole-body manikins and are often considered the only tools that allow the application of HFS techniques in the nursing field [30, 31], even if the concept of ‘‘fidelity’’ encompasses a number of different facets related to the simulation activity, including the characteristics of the simulator that mediate sensory impressions (visual, auditory, olfactory, and tactile/haptic) [32].

HFS techniques mimic essential aspects of a clinical situation in the three major dimensions of fidelity: physical (i.e., equipment and environment), psychological (i.e., the learner’s engagement in the experience with the simulation), and conceptual (i.e., the ability of the simulation activity to create connections between theoretical concepts and clinical-reasoning skills) [33]. Human simulators are the most realistic and interactive tools and offer the opportunity to experience many clinical situations, such as acute coronary syndrome, acute abdominal pain, acute respiratory distress, and sepsis with hemodynamic compromise [34]. For example, human simulators can provide prerecorded sounds and voices, allowing trainees to be aware of sudden patient deterioration and to perform appropriate clinical treatments while working successfully as a part of a team [32, 35]. “Teaching” or “learning” modalities can be used as a purpose for designing the simulation. The educator provides the student goals, methods, objectives, and outcomes through the “teaching” modality, while the “learning” modality, which is less used, refers to the processes by which the student develops skills, knowledge, and dispositions through a planned experience [36]. Algorithm-based, interactive scenarios are the core of HFS, and students are involved in a “real” patient situation in order to test and develop their nursing skills and engage their emotions [37].

One of the advantages that the HFS technique provides to nursing students is familiarity with sophisticated medical equipment and supplies in greater detail than other educational methods [31]. Hereby, they acquire competences to administer drugs and oxygen, manage mechanical ventilation, use AMBU, manage drainages, and place central venous catheters. Students also learn to use defibrillators, pace-makers, and infusion pumps; and monitor blood pressure, breath curve, hearth rate, body temperature, O2 saturation, and electrocardiography, as computerized monitors show realistic and dynamic clinical signs that can be recorded [29, 34, 35]. Furthermore, several clinical procedures may be carried out, such as the Sellick’s maneuver, bronchial aspiration, nasogastric tube placement, wound dressing, and male and female urinary catheterization [35].

4 Discussion

In the specific reference to health care, the main scope of simulation is “to replicate some of or nearly all the essential aspects of a clinical situation, so that the situation may be more readily understood and managed when it occurs for real in clinical practice” [38].

Among the simulation models, those based on high-fidelity patient simulators (technology-enhanced) are extremely realistic and sophisticated, with a high level of interactivity that should allow the learner to enhance his or her skills and knowledge to improve performance in professional contexts [39].

Two meta-analyses, published in 2011 and 2012 with 609 and 92 eligible studies, respectively, showed that the use of technology-enhanced simulation in the education of health care professionals is consistently associated with significant effects on learner-related outcomes compared to no intervention [40] and with small to moderate positive effects compared to other instructional simulation methods [41]. However, these studies suggested that strong instructional design, rather than simulation training per se, is at least partially responsible for the observed effects, and the benefits of simulation likely depend on educational objectives, as suggested by the larger effects observed for clinical skills [40, 41]. For these reasons, many institutions are increasingly interested in developing guidelines or regulations that support simulation as a partial substitute for traditional clinical training for undergraduate nursing students [42]. Hospitals have always been the traditional place for the practical training of nursing students, but the reshaping of hospitals, due to the development of technologies and the need for nurses to acquire familiarity with these new technologies, leads to the recommendation of simulation programs.

Simulation can be used not only by nursing students who need to achieve curricular competences in clinical practices, but also by experienced professionals (as part of their continuing education) who need to grow their expertise in order to effectively face unpredictable, rare, or risky real-life situations and who need to learn complex maneuvers that require a team effort [39]. There is much evidence that simulation is highly effective at improving skill performance in different fields of nursing, but the research results are poor when it comes to the effects of simulation on non-skill performance, including critical thinking and patient interaction [32, 40, 41]. This suggests that educators might use less-costly interventions (e.g., lectures or Web-based learning) for non-skill objectives and reserve simulation for later stages of instruction.

In addition to using simulation as a teaching strategy, many institutions have started to consider simulation as an evaluation or assessment method to measure nursing competences for licensure, certification, or performance appraisals [39], but more research is needed to provide valid and reliable instruments for this scope.

The use of simulation is expected to impact not only nursing students in terms of their satisfaction and their achievement of learning objectives but also patient outcomes, but in this field the research is still poor.

From an ethics point of view, the use of simulation in nursing education imposes some considerations, ranging from the need to provide students with a safe learning environment and patients with care in a competent way, to the question whether there is sufficient scientific evidence to make mandatory the integration of these models into the instructional curricula [39].

Starting a simulation program requires human, structural, and technological resources. It should consider the need for a qualified coordinator supported by technical personnel, which should also cover the maintenance of equipment and spare parts. Furthermore, time spent to develop scenarios and replicate simulation sessions, when they can be attended only by small groups at a time, must be considered as a cost [43]. In each case, the simulation training was costlier (financially or in terms of personnel) but also more effective than other instructional methods. However, future research should carefully document actual costs, including the costs of equipment, space, time, and salaries for development and maintenance, in addition to opportunity costs (e.g., what is replaced when simulation training is introduced).

5 Conclusion

Because of its evident advantages in terms of cost and risk benefits, the use of simulation in nursing education is ineludible, and its development into curricular programs is recommended. In fact, the development of technologies in the health care field has determined both the reshaping of hospitals, which have always been the traditional place for practical training of students, and the need for nurses to acquire familiarity with these new technologies.

Simulation-based nursing education does not substitute education involving real patients in genuine settings, but it prepares students for real patient contact, allowing them to improve their skills and professional performance and acquire knowledge, competencies, and skills in a controlled, safe, and forgiving environment.

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Use of Internet and Wellbeing: A Mixed-Device Survey

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Abstract. The debate on the effects of Internet for people's wellbeing is nowadays being paid more attention by the researchers in line with the worldwide constant increasing rates of Internet use. However, current data are contradictory and support opposite positions. We focused on the relation between Internet use and wellbeing for a sample of university Italian students ($n = 101$) involved in a mixed-device survey. They completed weekly, for five weeks, an on-line questionnaire measuring the amount of time spent virtually and non-virtually for different purposes (social, learning, and leisure Internet use, and social non-virtual use) and wellbeing in terms of emotions and life satisfaction. We analyzed the data with Generalized Linear Mixed Models (GLMM). The results indicated that the amount of time for virtual and non-virtual activities influenced differently emotions, but it was not related to life satisfaction. The findings are discussed taking into account their theoretical and applied relevance.

Keywords: Internet use · Wellbeing · Emotions · Life satisfaction

1 Introduction

Among the different potentialities allowed by information and communication technology (ICT), benefits for psychology are at least twofold, regarding both the socio-emotional and the cognitive domain. Concerning the socio-emotional level, ICT is currently assuming higher relevance for people in everyday life to create and maintain social relationships, but also for leisure purposes [10, 18]. As regards the cognitive level, ICT is a basic tool enabling people to seek information and learn new knowledge. Recently, an increasing number of studies has paid attention to the way in which the use of ICT can directly influence psychological processes, and in particular wellbeing [10, 18]. However, current data are contradictory and support opposite positions [10]. Therefore, we studied further whether and how the amount of time spent using the Internet is related to wellbeing.

We used a mixed-device survey, i.e. a survey that can be administered by common Internet browsers and is therefore deliverable by means of different devices, such as PC, laptops, tablets, mobile phones, etc. [26]. Currently, different technologies are increasingly being utilized to measure how individuals perceive, elaborate, and react in

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everyday life, also in relation to learning contexts [26]. Advantages in the use of self-report instruments presented online reside for example in the possibility to involve many people, also physically distant, in a short time, and in the fact that the outputs of the surveys can be immediately available.

1.1 Internet Use and Wellbeing

According to the augmentation hypothesis, spending time with a medium would have beneficial effects also on the use of other media, promoting people's wellbeing [10]. For example, chatting with friends through the Internet could help to improve also the quality of face-to-face social relationships with them. Indeed, different studies documented that technology use would positively influence wellbeing in light of its potential to create and support social relations [7, 9, 12]. On the contrary, the displacement hypothesis assumes that the time spent with a medium would substitute the time spent with others, influencing negatively wellbeing [10]. For example, chatting online would bring people to neglect relationships with people in real contexts and face-to-face interactions [13]. Moreover, in other cases no relations between Internet use and wellbeing were found [11].

Recently, a meta-analysis examining 40 studies with a total of more than 21,000 participants indicated that the effects of using the Internet on wellbeing are weak but detrimental [10]. In this meta-analysis, no moderating effects of factors such as type of Internet use, indicators of wellbeing, open-ended questions versus Likert scales for measuring the quality of Internet use, age, and gender emerged [10]. However, the author underlined the need to be cautious on the results of this meta-analysis, given specific limitations of the researches on this issue [10]. For example, the existence of different definitions of the same construct, i.e. wellbeing, led to different ways of operationalizing it in different studies, making it difficult to compare their results; there is a lack of researches examining moderating factors, including also the purposes for which time is spent on the Internet; moreover, only a few studies used longitudinal designs considering micro-analytically changes in wellbeing.

Concerning in particular the definition of wellbeing, in the psychological literature this construct is generally operationalized in terms of affective reactions and life satisfaction, reflecting two aspects, state emotions on the one hand and more durable evaluations on one's own life on the other hand [8]. However, examining the relation between Internet use and wellbeing, some authors did not distinguish between these two components [9, 10, 13], while others distinguished between them but, specifically for affective reactions, they focused on the sole happiness [18] or rather on symptoms related to mental health such as depression or stress [7].

1.2 The Present Study

Our aim was to investigate whether and how the differential use of Internet influences wellbeing. We distinguished three types of Internet uses, namely social Internet use (e.g., chatting with known or unknown people), learning Internet use (e.g., seeking information related to studying or working activities), and leisure Internet use (e.g., playing games) [10, 14]. Given that interpersonal communication is one of the main purposes for which the Internet is used [10], we also checked whether possible differences in wellbeing depended from the fact that people are actually socializing with others or from the fact that they are simply using the Internet for communicating. Therefore, we examined also the relation between face-to-face communication and wellbeing. In the four cases, we asked participants to report their perception on the amount of time (number of hours) differently spent on a weekly base for a period of five weeks. Wellbeing was operationalized as life satisfaction and emotional reactions [8] in terms of a wide range of emotions, measured again on a weekly basis for five weeks.

We formulated the following research questions:

1. How do people spend their time surfing the Internet?
2. Does using the Internet influence wellbeing?
3. Is such influence related to the purposes for which the Internet is used? In other terms, does using the Internet for different purposes influence differently wellbeing?
4. Is such influence related to specific characteristics of virtual compared to non-virtual contexts? In other terms, does communicating with others influence differently wellbeing whether it happens in a virtual context compared to a non-virtual context?

2 Method

2.1 Participants

The participants were 101 undergraduate students ($M = 20.61$ years, $SD = 3.01$; 85% female) at the University of Verona, in Northern Italy. They took part to a larger micro-longitudinal study for which a mixed-device survey administered for a period of five weeks had been planned [6, 17, 23]. The data analyzed for the present work were collected during the spring of 2016. Students' participation was voluntary, and all the students signed an informed consent form. The research was approved by the ethic committee of the Department of Human Sciences, University of Verona (protocol number: 61174).

2.2 Material and Procedure

The data were gathered through a questionnaire administered with mixed devices. It was presented at the end of each of the five weeks of the larger study. It included measures of type of Internet use, emotions, and life satisfaction. The participants received an e-mail message the day before the last day of each week, in which they were reminded to answer to the online questionnaire the day after. The mixed-device survey was administered using the Apsym-Survey Software, ApSS [17]. ApSS is a customization of the LimeSurvey open-source project [24] that allows to create powerful online question and answer surveys that can work for a few or many simultaneous participants, close or far away, by means of a common Internet browser.

2.2.1 Virtual and Non-virtual use of Weekly Time

We assessed the amount of time spent each week for Internet use (virtual use) for different purposes, namely social, learning, and leisure Internet use [14]. We asked to the participants to indicate the number of hours spent during the week surfing the Internet for social use, i.e. communicating with other people chatting or messaging through Facebook, WhatsApp, Skype, e-mails, etc. (*Referring to the last week, how much time have you spent chatting or messaging with other people through Facebook, WhatsApp, Skype, e-mails, etc.?*); for learning use, i.e. to gather information for activities relating to studying or working (*Referring to the last week, how much time have you spent surfing the Internet for study or work reasons?*); and for leisure use, i.e. for entertainment (*Referring to the last week, how much time have you spent surfing the Internet for entertainment?*). In addition, we assessed the amount of time spent each week for real social relationships (non-virtual use). We asked to the participants to indicate the number of hours spent during the week communicating face-to-face with other people (*Referring to the last week, how much time have you spent chatting with other people face-to-face?*).

2.2.2 Weekly Emotions

We used the Achievement Emotions Adjective List, AEAL [5, 19–22] to assess the intensity of emotions felt during each week. The questionnaire includes 30 adjectives related to five positive and five negative emotions (enjoyment, pride, hope, relief, relaxation, anxiety, anger, shame, boredom, and hopelessness). Participants rated each item on a 7-point Likert scale (1 = *not at all,* 7 = *very much*), referring to how much they had felt each emotion during the previous week.

2.2.3 Life Satisfaction

We utilized the 5-item (e.g., *In most ways, my life is close to my ideal*) Satisfaction with Life Scale, SWLS [8]. Participants rated each item on a 7-point Likert scale (1 = *strongly disagree,* 7 = *strongly agree*), at the end of each week.

2.3 Analysis Procedure

We used Generalized Linear Mixed Models (GLMM). We utilized the lmer/glmer functions in the lme4 package [1] of the R-software environment for statistical computing and graphics [e.g., 2–4]. We performed Mixed Model ANOVA Tables via likelihood ratio tests (afex package) [25]. We reported effect sizes in terms of conditional R^2 (R^2_c; MuMInpackage) [16]. We utilized Gaussian family and identity link-function, after verifying the normality of the data distribution. We used Bonferroni correction for post-hoc tests (lsmeans package) [15]. Participants was the random effect. We reported means and standard deviations of the measured variables in Table 1.

3 Results and Discussion

3.1 Virtual Use of Time

We conducted a GLMM to explore how the participants spent their time surfing the Internet (research question 1). We considered type of Internet use (social, learning, leisure) as the fixed effect, and hours for each type of use as the rating dependent variables. There was a significant effect of type of Internet use, $X^2(2, N = 101) = 510.470$, $p < .001$. Post-hoc tests indicated that the participants declared that they had spent more hours for social than for leisure purposes, $t = 14.850$, $p < .001$, and for leisure than for learning purposes, $t = 7.322$, $p < .001$ (Table 1).

Table 1. Means (*M*) and standard deviations (*SD*) for virtual and non-virtual use of time, life satisfaction, and positive and negative emotions ($N = 101$).

Use of time and life satisfaction	*M* (*SD*)	Positive emotions	*M* (*SD*)	Negative emotions	*M* (*SD*)
Social Internet use	23.40 (21.73)	Enjoyment	4.33 (1.16)	Anxiety	3.17 (1.22)
Learning Internet use	8.42 (13.96)	Pride	3.86 (1.30)	Anger	3.55 (0.67)
Leisure Internet use	13.37 (16.05)	Hope	3.97 (1.19)	Shame	3.58 (0.61)
Social non-virtual use	25.24 (23.20)	Relief	3.46 (1.25)	Boredom	3.35 (0.58)
Life satisfaction	4.22 (1.32)	Relaxation	4.02 (1.17)	Hopelessness	2.65 (1.16)

3.2 Virtual and Non-virtual Use of Time and Emotions

To test whether the amount of time that the participants declared they had spent for virtual and non-virtual use influenced emotions (research questions 2–4), we conducted ten GLMM with social Internet use, learning Internet use, leisure Internet use, and social non-virtual use as fixed effects, and emotion as rating dependent variables, separately for each emotion (Table 2). For each significant effect, we also reported the estimates (*Est.*) of the fixed-effects parameters from the fitted models (Table 2). Estimates with a positive sign indicated that the relation between the independent variable and the dependent variable was directly proportional, while estimates with a negative sign that it was inversely proportional.

For positive emotions, these analyses revealed significant effects of leisure Internet use and social non-virtual use for enjoyment ($R^2_c = .60$); leisure Internet use and social non-virtual use for pride ($R^2_c = .63$); leisure Internet use for hope ($R^2_c = .57$); leisure Internet use and social non-virtual use for relief ($R^2_c = .47$). For negative emotions, there were significant effects of learning Internet use and leisure Internet use for anger ($R^2_c = .54$); learning Internet use and leisure Internet use for shame ($R^2_c = .53$); leisure

Internet use and social non-virtual use for boredom (R_c^2 = .66); and social non-virtual use for hopelessness (R_c^2 = .54). On the whole, examining the estimates, we found that learning Internet use was positively associated with anger and shame; that leisure Internet use was negatively associated with enjoyment, pride, hope, relief, anger, shame, and boredom; and that social non-virtual use was positively associated with enjoyment, pride, relief, and boredom, and negatively associated with hopelessness (Table 2).

Table 2. Chi square tests (X^2), degrees of freedom (*df),* sample size (*N*), level of significance (*p*), estimates of effect size (*Est.*), and conditional R^2 (R_c^2) for GLMM. We reported only significant effects.

Emotion	Use	X^2(*df, N*)	*p*	*Est.*
Enjoyment	Leisure Internet use	3.294 (1, 101)	.050	–0.751
	Social non-virtual use	12.837 (1, 101)	<.001	0.991
Pride	Leisure Internet use	10.339 (1, 101)	.001	–0.142
	Social non-virtual use	16.200 (1, 101)	<.001	0.119
Hope	Leisure Internet use	6.921 (1, 101)	.008	–0.114
Relief	Leisure Internet use	5.474 (1, 101)	.019	–0.115
	Social non-virtual use	3.623 (1, 101)	.050	0.061
Anger	Learning Internet use	4.455 (1, 101)	.034	0.071
	Leisure Internet use	5.869 (1, 101)	.015	–0.061
Shame	Learning Internet use	4.086 (1, 101)	043	0.635
	Leisure Internet use	3.813 (1, 101)	.050	–0.455
Boredom	Leisure Internet use	6.049 (1, 101)	.013	–0.046
	Social non-virtual use	5.528 (1, 101)	.018	0.030
Hopelessness	Social non-virtual use	6.057 (1, 101)	.013	–0.073

In brief, the amount of time using Internet for different purposes influenced emotions differently. Surfing the Internet for social purposes did not have any effect on emotions. Surfing the Internet for learning purposes had negative consequences, i.e. with a higher amount of time associated with increases in anger and shame. Surfing the Internet for leisure purposes had effects in terms of diminishment of the intensity of a large range of emotions, i.e. enjoyment, pride, hope, relief, anger, shame, and boredom. Finally, a higher amount of time spent for social purposes in real contexts was associated with increases in enjoyment, pride, relief, and boredom, and decreases in hopelessness.

3.3 Virtual and Non-virtual Use of Time and Life Satisfaction

To examine whether the amount of time that the participants declared they had spent for virtual and non-virtual use influenced life satisfaction (research questions 2–4), we conducted a GLMM with social Internet use, learning Internet use, leisure Internet use, and social non-virtual use as fixed effects, and life satisfaction as the rating dependent variable. No significant effect emerged, indicating that the amount of time spent for virtual and non-virtual purposes was not related to life satisfaction.

4 Conclusions

In light of the widespread diffusion of the Internet, we focused on the relation between Internet use and wellbeing [10, 18]. The uniqueness of this work resides in three aspects, i.e. operationalizing wellbeing in terms of a wide range of state emotions beyond considering life satisfaction; focusing on the role of different types of Internet use; and studying this issue with a micro-longitudinal design.

Our findings indicated that the participants declared that they had used the Internet more frequently to socialize rather than to be entertained or learn, and more frequently to be entertained rather than to learn. In addition, the amount of time spent weekly to use the Internet had a differential impact on wellbeing depending on the type of use, but only considering emotions and not life satisfaction, for which no differences emerged. Surfing the Internet for social purposes did not yield any uniform effect on emotions. Surfing the Internet for learning purposes had detrimental effects in terms of increases in anger and shame. Interestingly, surfing the Internet for leisure purposes had a kind of deactivating effect, with decreases in a wide range of emotions, i.e. enjoyment, pride, hope, relief, anger, shame, and boredom. Moreover, we found that the relation between socializing and emotions depended from the way used to communicate, virtual or real, with mainly positive consequences associated to an increasing amount of time spent for socializing in real contexts (i.e. there were increases in enjoyment, pride, relief, and boredom, and decreases in hopelessness), but no association between emotions and time spent for socializing in virtual contexts. On the whole, our data suggest that nor the augmentation neither the displacement hypothesis [10] can fully explain the effects of Internet use on wellbeing.

This study suffers from limitations such as the absence of assessment of the characteristics of the used device, e.g. the place in which it is utilized or the persons with whom the time is spent, and the fact that our sample was homogeneous (i.e. it involved only university students, and it was not balanced for gender). We underline also that the relation between Internet usage and wellbeing is complex, and our data did not allow to examine fully issues concerning the causality of the links between the two constructs. Notwithstanding the need of future studies to generalize the present findings with different samples, our results have clear implications for people's health, underlying the relevance of investigating different aspects of wellbeing to understand the complex patterns of relations between the use of new technologies and psychological processes. Finally, it is worth noting that we used an online survey as a way to learn about psychological constructs characterizing people. One of the potentiality of this use is the development of instruments that could be self-administered to learn more about one's own psychological functioning.

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TEL Methodologies in Health Education. Effectiveness of a Group Educational Intervention in Patients with T2DM

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Abstract. Diabetes mellitus (DM) is an important problem for public health. This is because it affects a large portion of our society and the prevention, control and treatment of the disease and its complications have a significant impact on socioeconomics. Chronic care is one of the current challenges that the National Health System is faced with; eighty percent of primary care patients and sixty percent of those admitted to the hospital suffer from a chronic disease. In our study, we performed a quasi-experiment in a simple random sample of 30 patients with type 2 diabetes mellitus (T2DM), in order to test the effectiveness of using ICT in an educational intervention group of patients with T2DM, developed over 7 participatory sessions. A literary search has been conducted using important databases: PubMed, Embase Elsevier, CINAHL, in the specialized registers of the Cochrane Group Practice and Organization of Effective Care (Cochrane Effective Practice and Organization of Group Care), as well as various scientific search engines, such as Dialnet.

Keywords: Diabetes mellitus · Chronic diseases · Telemedicine · Primary care · mHealth · Self-care · Glucose monitoring

1 Introduction

Technological development has enabled us to apply Information and Communication Technologies (ICT) in the area of Health, providing tools that are necessary for adherence to the treatment of diseases [2]. Technological advances can be used in prevention,

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with their application we can significantly reduce the demand for health care and improve the health of citizens [1].

ICT are “technical tools that are used to create, store, retrieve and transmit information quickly and in large quantities”, strengthening, helping and improving the current health care model; health professionals use ICT to ensure support, coverage and continuity of care, improving communication processes and adapting available health resources to existing demands [3].

Diabetes mellitus is a chronic metabolic disease, with high morbidity and mortality. Its prevalence is 10–15% in Spain, being one of the most important cardiovascular risk factors. The incidence of T2DM is 3–4%, reaching 16% in people over 65 years of age. Prevalence rates have increased alarmingly in young people, during the last 10 to 20 years, overweight and obesity being one of the main causes [4].

Health professionals have opted for ICT due to the benefits they can bring to the health system and the patients, providing us with instruments such as digital clinical history, teleservice and telecare, also used to improve communication processes and knowledge management and research. All this convinces them that ICT will contribute to generating higher levels of health, well-being and economic improvement [5].

The treatment of T2DM is based on diet, exercise, diabetes education and pharmacological treatment [6]. Teaching a person with diabetes about their disease is fundamental, in this way they will be able to take responsibility for their illness and enjoy greater independence [4]. Therefore, the educational intervention group has been conducted using ICT for its advantages of improving glycemic control, weight and exercise. In addition, it delays the need of insulin treatments [5], less personnel is required and more time is saved. Interactive games favor social experiences [6] and at the same time they teach about diabetes and self-care processes [7].

Objective: To maintain maximum autonomy and improve the quality of life using ICT and online tools during the different sessions of the group educational intervention. Aiming to lower the levels of glycosylated hemoglobin (Hba1c) in patients within 3 months by increasing their knowledge about T2DM, so that it results in a drop of (Hba1c) below 7% in 80% of participants.

Hypothesis: The use of ICT in a group educational intervention is effective in patients with T2DM, improves their knowledge of the disease and maintains HbA1c below 7%.

2 Material and Method

Quasi-experimental pre-post test in a simple random sample of 30 patients with T2DM, which uses a pre-post test to evaluate the effectiveness of ICT before and after the group educational intervention. A group educational intervention has been developed over 7 participatory sessions, each one lasting 60 min. It was carried out after a bibliographic search in relevant databases.

Study Population/Inclusion Criteria: Diabetic patients aged 12 to 16 years old who meet diagnostic criteria T2DM in the Health Area of Salamanca:

- Glucose random at or above 200 mg/dl, usual signs and symptoms of diabetes (polydipsia, polyuria, polyphagia and weight loss).
- Basal plasma glycemia equal to or greater than 126 mg/dl on two or more occasions.
- Glycemia at two hours of oral overload with 75 g of glucose equal to or greater than 200 mg/dl on two or more occasions.
- Diagnosis of previous diabetes: there is some reference to the diagnosis, control or treatment of diabetes in the Clinical History.
- Have a computer or mobile with an Internet connection to participate in the educational sessions.

Exclusion Criteria:

- Patients with a sensory, psychological or physical deficit that prevents them from following the dynamics of the sessions, the use of ICT and marked controls.
- Patients who have received Group Health Education in previous 2 years.
- Patients monitored at another level of care.
- Do not have a computer or mobile with an Internet connection.

Withdrawal Criteria: Patients who are admitted to hospital or have deceased, as well as those that move out to a place outside of the area of intervention.

Variables of Study:

- Socio-demographic variables (age, sex, academic studies)
- Time of evolution of T2DM
- Type of treatment
- Complications related to DM
- Anthropometric measurements (BMI = Weight (Kg)/Size m2)
- HbA1c
- Degree of knowledge of the disease using a questionnaire developed by Hess and Davis of the University of Michigan (USA) [8].

The questionnaire consists of 38 questions covering five areas of theoretical knowledge about T2DM: basic questions (1–6 and 35–38), blood glucose (7–16), insulin administration (17–21), hydrates (22–26 and 28) and food exchange (27 and 29–34). Patients should indicate the correct answer to each question with (X). The overall reliability of the questionnaire is 0.89, with questions of equal difficulty.

To determine the degree of association between the study variables, considering that they are nominal, the chosen statistical method is the Chi-Square test for two independent groups, with a statistical significance level of $p < 0.05$ and 95% reliability using the statistical software SPSS version 2.3.

Basal records are compared before and three months after the education-al intervention to investigate the degree of knowledge. To determine the effectiveness of metabolic control in patients, dichotomous classification was used according to the Professional Practice Committee 2016 of the American Diabetes Association and trichotomy to find out about the patients' knowledge of T2DM [8], being as follows:

– **HbA1c:** <7%: good control; ≥7%: poor control.
– **A systolic:** <130 mmHg: good control; ≥130 mmHg: poor control.
– **HDL-cholesterol:** >35 mg/dl mmHg: good control; ≤35 mg/dl mmHg: poor control.
– **IMC:** decreases 1 point: good control; decreases below 1 point or does not decrease: poor control.
– **Knowledge about Type 2 DM:** ≥30 points: high knowledge; 20–29 points: moderate knowledge; <20 points: low knowledge.

3 Phases of the Group Educational Intervention Using ICT

3.1 Recruitment of Participants

Participants were recruited through the Medora software that is used in the Health Centers of Castile and León, and permission was requested from the Ethical Committee of Primary Care of the Health Area of Salamanca. Once the commitment of confidentiality was signed, the register of patients between 12–16 years old who have T2DM was searched and the patient's telephone number was obtained through their digital clinical history and they were invited to participate in the study.

3.2 Individual Basal Visit

Duration of 10–15 min, at the Health Center. At the visit the patient was informed about what group educational intervention consists of. Patients were asked to provide their e-mail address in order to send them the schedule of the sessions, interactive infographics and digital brochures. The T2DM Knowledge Test was done at the visit, in Google Drive query. To notify the patients of each of the sessions, their email address was added to a group created in the Remind APP (Fig. 2), containing the name of the project. In this way the patient received a reminder on their phone before each session.

3.3 Development of Group Sessions

Seven sessions were conducted, each guaranteed a systematized, programmed and valuable educational approach that would help these patients self-control their disease, improving the quality of their lives and reducing the use of health resources that are often required by this pathology.

3.4 Post-intervention Individual Visit

Patients were individually appointed for a visit at the Health Center through the Remind APP, 3 months after completing the intervention in order to obtain analytical information and check Hba1c, HDL-cholesterol, blood pressure and calculate the patient's BMI.

3.5 Evaluation of the Intervention

The results of the test on theoretical knowledge of T2DM pre and post intervention were analyzed, in order to see if there is a significant difference in its results. Also, find out the patients' degree of satisfaction through a questionnaire that was given in the last session. The information collected in the different sessions and the values for hba1c, BMI, systolic BP and HDL, were also analyzed 3 months after the intervention, in order to evaluate the effectiveness of the intervention.

4 Development of the Sessions Using ICT

Session 1: Introduction and basic knowledge. Pre-Test is performed on Google Drive to evaluate previous knowledge of T2DM (http://bit.ly/2kMI77X). Viewing videos like ¿Qué es la diabetes? (What is diabetes?) and watching an interactive tutorial produced by the American Diabetes Association which is used to test the knowledge acquired (http://bit.ly/2kXO2cc) and ¿Qué pasa en la diabetes tipo 2? (What happens with diabetes type 2?) (http://bit.ly/2loIclg).

Session 2: Alcohol and tobacco. Develop and disseminate an interactive infographic about alcohol (http://bit.ly/2kMBQZQ) and tobacco (http://bit.ly/2k8zanf).

Session 3: Food and diet for rations. Interactive presentation on the topic (http://bit.ly/2lt61nQ). Visualization and reading the online book of recipes based on the Plate Method (http://bit.ly/1lkery3). Online interactive game to make a healthy dish (http://bit.ly/1A2HWuy).

Session 4: Physical exercise and sport. Viewing educational videos. Digital brochure about physical exercise in T2DM (http://bit.ly/2loLy7M).

Session 5: Self-analysis and pharmacological treatment. Visualization of videos and learning about glycemic control applications (http://bit.ly/2kwFqIW) such as Sanofi diabetes Manager IOS Itunes (Fig. 1). A blood glucose monitoring device connects to iPhone and iPod Touch and works in conjunction with a diabetes management App. After blood glucose testing with the device, results will automatically be uploaded on the App. People with diabetes can then manage, analyze and send test results by email to their healthcare professional -including blood glucose, carbohydrate intake and insulin dosage-.

Session 6: Acute Complications in Diabetes. Digital brochure of acute complications in patients with T2DM (http://bit.ly/2lvJ8kx).

Session 7: Evaluation. Google Drive knowledge test on T2DM (http://bit.ly/2kMI77X) and a Google Drive survey for satisfaction level (http://bit.ly/2kXQn72).

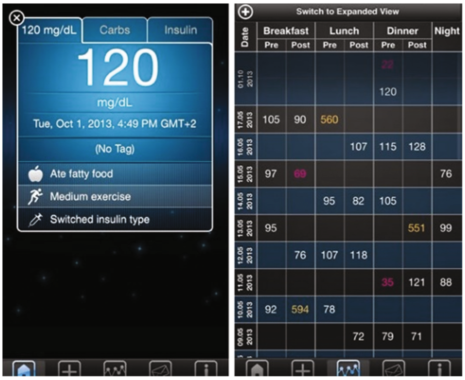

Fig. 1. Sanofi diabetes manager APP

Fig. 2. Remind APP

5 Results

During the evaluation period for the use of ICT in patients with T2DM, a total of 30 patients were studied, 60% (n = 18) men and 40% (n = 12) women. The mean age was 15 ± 1 years old. The mean progress of DM was 3 ± 1 years. 75% had no complications, 10% macrovascular, 10% microvascular and 5% both. The mean value of glycosylated hemoglobin (HA1c) at the start of the study was 8.2 ± 1.3 and at the end was 6.3 ± 1.2.

At the beginning of the intervention using ICT, 10% of the patients had normal weight, 30% overweight and 60% obesity. At the end, a BMI decrease of 3% was observed. The mean abdominal circumference at the beginning of the educational intervention using ICT was 115 ± 11.9 cm in men and 100 ± 10.1 in women and at the end of the intervention 97 ± 12.2 cm in men and 87 ± 8, with a decrease between 12 and 15.6%.

Regarding T2DM knowledge, the mean number of correct answers in the Pre-test questionnaire, completed on Google Drive before the group intervention, was 18.36 ± 4.7 and after the educational intervention with ICT, the mean was of 90 ± 1.8 successes, acquiring in 90% of the participants a high level of knowledge (score ≥ 30). Mobile applications enabled 98% of patients to have a better track of their diabetes, making control easier for them and their medical professionals, both doctors and nurses.

Using ICT and online tools, we obtained that 93% of the participants after the group educational intervention had a glycosylated hemoglobin (Hba1c) below 7%, 90% maintained a systolic BP < 130 mmHg after 3 months and 92% had HDL > 35 mg/dl, decreasing by a point in their BMI by 78% in these 3 months.

There were no significant differences in the variable gender ($p = 0.01$), nevertheless, there are significant differences in the variables age ($p = 0.001$) and time of disease evolution ($p = 0.03$) in the effectiveness of educational intervention using ICT.

6 Conclusions

ICT are becoming instruments that act as a source of information, a means of interpersonal communication and collaborative work in the exchange of information and ideas, a medium for expression and creation, a cognitive tool and information processor, an interactive resource for learning, simulates and motivates through multimedia didactic materials. All this shows that ICT are an instrument that can change our lifestyle, creating new training settings and improving our health.

The group educational intervention using ICT improves the level of knowledge of the disease, diet, exercise, adherence to treatment and better metabolic control, representing a 90% higher level of knowledge in all areas. ICT allow the maintenance of maximum autonomy and improve the quality of life, increasing knowledge about T2DM, and helping 93% of participants to achieve glycosylated hemoglobin (Hba1c) levels below 7%.

Group dynamics and ICT favor changes in the patient's attitude in 98%. Mobile applications allow better registration of diabetes control, making it easy for 98% of patients to record data, eliminating the need for notebooks that are often forgotten at home when taking measurements on the street or when going to the doctor. [9] The patient's participation in sending the recorded data to their digital clinical history helps control their disease.

Future Research: Use of ICT to improve adherence to treatment in patients with chronic diseases.

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Psychology of Programming: The Role of Creativity, Empathy and Systemizing

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Abstract. In this paper, we started to analyse the impact of individual cognitive processes on early programming learning and performances. In particular, we focused our attention on *divergent thinking*, *creative personality* and *brain type*, analysed within the theoretical framework of the *Empathizing-Systemizing* (**E-S**) *Theory*. We involved a sample of students in the first year of a bachelor curriculum in Applied Mathematics at the University of Verona. We used this sample to analyse the relations between cognitive styles and programming attitudes and performances. We also explored sex differences, concerning both the level of each measure and these relations.

Keywords: Programming · Cognitive processes · Teaching methodology

1 Introduction

Computer science skills are central in European education trends. Nowadays, most of the college curricula include programs devoted to informatics. The importance of informatics and, more generally, of the computational thinking in school education has been emphasized in a number of works [9,17]. Nevertheless, in primary and secondary school (with the exclusion of some technical schools), informatics plays a minor role in the curricula. So, it is not surprising that first year university students of non vocational curricula encounter difficulties in learning to program at the college level and performances in this activity turn out in general not satisfactory.

Some previous investigations show that alternative educational paradigms, such us the *eXtreme Appreticeship* (XA) [11–13], can improve students' training and performance. Non traditional methods such as XA accompany the cognitive advancement of students in programming learning, taking into account personal

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learning tendencies by reducing the "burden" of the traditional frontal lessons. Basing teaching methods on students' previous and individual attitudes, we aim to explore in a deeper way the mechanisms underlying the programming activity, taking into account also a psychological perspective. We claim this could be a good way to understand this process, and consequently plan adequate teaching activities which consider also individual differences. The importance of motivational and affective aspects has been highlighted in the context of learning how to program in [5], suggesting that research on cognitive processes involved in this challenging task must be deeply analysed. Considering affective aspects, few empirical studies are available: for instance, emotions are related to the quality of a product, in participatory game design with primary school children [7].

Also enhancing creativity could have an important role to improve learning how to program, given the need to use inductive reasoning, and exploring the predicting role of creativity in programming can also suggest some teaching strategies.

This study is an initial step of an action-research which aims to understand some psychological antecedents – cognitive and affective – of the performance of learning how to program. In this way, we tried to understand how to improve the efficiency of teaching methods, in order to refine and model students' computational attitude. We analyse the impact of individual cognitive process on programming learning and performances. In particular, we focused our attention on three aspects: *divergent thinking*, *creative personality* and *brain type*, analyzed considering the cognitive style, within the theoretical framework of the *Empathizing-Systemizing* (**E-S**) *Theory* [1].

Empathizing-Systemizing Theory and programming aptitude. The *E-S Theory* suggests that people can be classified on the basis of two cognitive styles: *empathizing*, which is connected with the comprehension of the emotional states of other individuals, and *systemizing*, which allows individuals to predict systems' behaviour on the basis of the knowledge of the underlying rules. The *E-S Theory* assumes that a high level of Squotient, SQ should be connected to a good performance in the domains in which this skill is important, such as scientific disciplines, whereas a high level of EQ should be more necessary in other domains in which the comprehension of other people is important, for instance for humanities and social sciences [14]. The difference between an individual's empathizing and systemizing scores has been proposed to lead to different "brain types" [8]. The *E-S theory* proposes that the difference between empathizing (E) and systemizing (S) categorises the individual "brain type" as ***Type S***, when SQ is higher than EQ, ***Type E***, when EQ is higher than SQ, and ***Type B***, when EQ and SQ are balanced.

The link between brain type and programming aptitude has been stated by [18], and recently resumed by [5]. These authors found controversial results, making unclear whether it is true that – as "folk" psychology suggests – a high level of SQ is related to good performance in programming. While Wray found a positive relation between SQ and a test for programming ability, and a negative relation between this same test and EQ, Coles and Phalp found no correlations between brain type (*S-type vs. E-Type*) and programming performance, even if the brain type was related with the choice of the degree subject.

Creativity and programming aptitude. A second individual aspect considered in this research concerns creativity and divergent thinking. Zapata-Ros in [19] proposed divergent thinking and creativity as important computational thinking components, among others such as bottom-up analysis, top-down analysis, heuristics, problem solving, abstract thinking, recursion, iteration, successive approximation methods (trial and error), collaborative methods, patterns, synectics and meta-cognition. The model of Williams [16] constituted the theoretical framework; according to this model, it is possible to identify four typical characteristics of creative personality:

1. willingness to risk-taking, that is, the tendency to act under non-structured conditions and defend one's own ideas;
2. imagination, considered as the ability to visualize and build mental images;
3. curiosity, in terms of the ability to investigate elements and ideas, finding new connections which are not always direct and obvious; lastly,
4. preference for complexity, in terms of the tendency to look for new alternatives and solutions to problems, to restore order out of chaos.

Inductive reasoning could be a fundamental step in the programming activity. Several studies suggested that creativity and divergent thinking are related to inductive reasoning [15], and creativity and divergent thinking, which are characterised by the use of imagination and by the generation of new ideas, are essential to hypothesis testing.

Aims of the study. We analysed the relations between cognitive styles (specifically SQ and EQ), divergent thinking, creative personality and performance in early programming learning. We also explored sex differences, both for each measure and in these relations. We focused on the first two months of the activities where students learn the basics of programming with `Python`.

2 Method

Participants and teaching method. We considered a course of *"Computer Programming with Laboratory"* which is a compulsory course in the first year for a bachelor curriculum in Applied Mathematics at the University of Verona. We focused on the very first period of didactic activity when students tackle with basics of programming. We applied the XA teaching methodology [13] in an adapted form, inspired to some experiences of a Bozen University team [6,10–12]. In the "theoretical" activities the principles of programming were introduced and discussed. In practical activity students solved exercises with the constant help and support of the assistants. Moreover, special sessions were organized in order to recover basic computational skills.

A total of 33 university students (20 males and 13 females; $M = 20$ years, range = 19–29 years) participated, coming from a variety of socio-economic and educational backgrounds.

Measurement instruments and procedure. Participants were administered a written battery of questionnaires at the beginning of the class in two sessions. They participated on a voluntary basis and were assured about anonymity and that their answers would not have influenced course evaluations. In the first session they completed a demographics questionnaire and the measures on divergent thinking and creative personality. In the second session they answered two measures on brain type. To assess creativity we used the Italian version of a standardized test named *Test of Divergent Thinking and Creative Personality* [16]. This test assesses two different aspects: divergent thinking and creative personality.

Divergent Thinking. This part is formed by 12 frames containing incomplete graphic stimuli shown to the participants who were asked to draw a picture (in 20 min). The following four scores were utilized as indicators of creative performance: fluency, flexibility, originality and elaboration. A fifth score related to the assignment of a title to the work done, and it regarded lexical skills and the attribution of creative meaning. Two independent judges coded the protocols, with scores ranging from 0 to 12 for fluency, from 0 to 11 for flexibility, from 12 to 36 for originality, and from 0 to 36 for elaboration and title.

Creative Personality. A second part of the test assesses creative personality with 50 items comprising four dimensions, with 13 items for risk-taking (i.e. "I want to be sure to win when I try a new game"), 13 items for complexity (i.e. "I don't like programming what to do"), 12 items for curiosity (i.e. "I like to try many new things"), and 12 items for imagination (i.e. "I like to imagine something I want to know or want to do"). Participants were asked to answer on a 4-point Likert-type scale (1 = almost always true and 4 = almost always false).

A second measure, **Brain Type**, was used to classify participants on the basis of their scores along two dimensions: empathizing (E) and systemizing (S). We used an adapted translation of the short version of the *Empathy Quotient* (EQ-Short) and the *Systemizing Quotient* (SQ-Short) elaborated by [14], including 20 items for the EQ, 20 for the SQ and 20 fillers. Responses were given on the basis of agreement on a 4-point Likert scale and scores can range from 0 to 40 for each scale. Finally, the last assessment concerned students' **Performance in Programming**. Students had to take a written test made up of two parts: the "theoretical" one (TH) consisted of a few questions about the knowledge of basic concepts about programming; in the "practical" part (PR) the students had to solve exercises of increasing difficulty about programming competences and problem solving skills: problem and algorithm understanding and coding. Class performance was operationalized in terms of the score, standardized to be in the interval from 0 to 1, obtained in the two different parts.

3 Results

Descriptive statistics in the study variables, separately for male and female students, are shown in Table 1. The independent sample t-test was used to assess sex differences in the mean level of each measure. No significant difference was found between the level of SQ, divergent thinking, creative personality and performance in programming task. The only difference that emerged related to the EQ, with female students showing a higher level than male students, $t(31) = 2.007$, $p = .027$[1], Cohen's $d = .49$, which describes a medium effect size. This result seems in line with previous studies [1,2], which show that women have higher EQ than men.

Table 1. Mean values (standard deviation in brackets), for each measure.

	M		F		p-value
EQ test	17.4	(4.2)	21.1	(6.9)	.027
SQ test	20.6	(6.9)	19.9	(5.1)	.764
Divergent thinking	116.7	(39.7)	129.2	(24.2)	.319
Creative personality	66.2	(11.2)	64.7	(14.4)	.737
TH score	.78	(0.15)	.81	(0.18)	.647
PR score	.54	(0.27)	.57	(0.29)	.740

M = male students, F = female students

EQ, SQ and performance in programming. To test the relation between brain type and programming performance, an independent sample t-test was run comparing the performance, in terms of both theoretical score (TH) and programming score (PR), of the two groups of participants (*Type S vs. Type E*). No difference in performance was found. To deepen this result, we decided to verify whether male and female students differed in some ways, and we discovered that the same level of SQ was found for the two sub-groups of female participants (female students: SQ for brain *Type S* = 20.8; SQ for brain *Type E* = 20.3), while for the two sub-groups of male students this difference in SQ was significant (male students: SQ for brain *Type S* = 14.4; SQ for brain *Type E* = 25.9; $t(16) = 5.48$, $p < .001$). This result suggests that female students, at least in our sample, showed similar level of *SQ* independently from the brain type, whereas male students seemed to be more differentiated in the same measure (SQ) depending on brain type.

Given this first result, we decided to explore the pattern of relations among all the variables, also dividing by sex. Pearson's correlations were computed between the observed variables (see Table 2, for the whole sample, Table 3 for the two sub-samples of male and female students).

[1] A one-tail test was performed, in line with the literature that suggests a higher empathy for females.

Table 2. Pearson's correlation coefficients for all the measures

	1	2	3	4	5	6
1. EQ test	–	0.12	0.15	0.43*	0.18	0.23
2. SQ test		–	0.05	0.24	–0.08	0.14
3. Divergent thinking			–	0.10	0.13	0.13
4. Creative personality				–	0.37*	0.46**
5. TH score					–	0.67***
6. PR score						–

*$p < .05$, ** $p < .01$, ***$p < .001$

Table 3. Pearson's correlation coefficients for all the measures by gender

3a – Males	1	2	3	4	5	6
1. EQ test	–	−0.14	0.13	0.26	0.04	0.31
2. SQ test		–	0.13	−0.02	−0.30	−0.10
3. Divergent thinking			–	0.08	−0.03	0.05
4. Creative personality				–	0.40	0.33
5. TH score					–	0.72***
6. PR score						–
3b – Females	1	2	3	4	5	6
1. EQ test	–	0.58*	0.07	0.67*	0.24	0.15
2. SQ test		–	−0.20	0.70**	0.33	0.65*
3. Divergent thinking			–	0.20	0.42	0.32
4. Creative personality				–	0.37	0.63*
5. TH score					–	0.60*
6. PR score						–

*$p < .05$, ** $p < .01$, ***$p < .001$

No significant correlations were found between programming performance (TH and PR) and EQ or SQ. Considering separately female and male students, an interesting significant positive correlation emerged between SQ and programming score, $r = .65, p < .05$. This means that the higher the SQ, the higher the performance in the programming task. No correlation was found for the theoretical part. EQ didn't correlate neither with the theoretical part nor with the programming part, even if, for female students, a negative correlation with SQ was found.

Creativity and performance in programming. A second step of the analysis concerned the relations between divergent thinking, creativity and performance in programming. Table 2 shows that only creative personality seems to be positively related with performance in programming. In fact, Pearson's correlation coefficient is .37 ($p < .05$) for theoretical score and .46 ($p < .01$) for programming score. Higher values in the test of creative personality were connected with higher scores both in theoretical and programming scores, with a larger effect for the programming score.

Table 3 shows what happens considering separately male and female students. It is possible to note that the Pearson's correlation coefficient between creative personality and performance in the programming task was high and significant for the female students, $r = .63, p < .05$, while it was not significantly different from zero for the male students. This result suggests that creativity personality is related with programming performance for women but not for men. It is also interesting to note that for women there was a high correlation between creative personality and SQ, $r = .70, p < .01$. This means that, for the female sample, SQ, creative personality and performance in the programming part are all directly connected.

4 Discussion and Conclusion

The aim of this study was to explore some cognitive antecedents of programming skills, in particular brain type, which refers to the dominance of empathizing or systemizing modes of thought, and creativity, here described considering the two components of divergent thinking and creative personality. This is a work in progress: in fact, up to now, only 33 students could be considered which completed all the battery of questionnaires. Notwithstanding, we get some evidences about correlations between cognitive styles and programming attitude. In particular, a positive correlation was found for female students between the SQ and the test connecting with the practical activity: it seems that women with high level of SQ perform better than women with low level of SQ in the activity more connected with programming. No correlation was found for male students. This result should be more deeply analysed, in the light of contradictory results on this topic that can be found in literature [5]. Furthermore, the study suggests the important role of creative personality, mainly for the programming activity, both for male and female students. Creativity is an aspect that can also be stimulated in order to solve problems [3,4], and this possibility could be used also to enhance performance in programming. If this link between creativity and programming skills will be confirmed, it would suggest that creativity should be encouraged, using specific techniques, to ensure requirements for a good performance in programming. We planned to extend our study to a larger sample: we are collecting more data, in order to confirm measured correlations and possibly discover other correlations. Finally, we think that it should be interesting to apply the same study (with larger sample size) in different universities and countries.

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Analysis Learning Styles Though Attentiveness

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Abstract. Attention is one of the most widely misused and overgeneralized constructs found in the educational, learning, instructional, and psychological sciences. It would be convenient for teachers if they could grasp the attentiveness states of learners in their classes precisely so that they could try to improve the way to deliver the course material in a manner that could attract more learners. When students are doing learning activities using the news technologies is very hard for the teacher detected if each student her/his level of attentiveness. Furthermore, different student learn in different ways, each one preferring a different learning style. This paper presents an experience using different learning styles with a system that monitoring attention, with the aim of providing a non-intrusive and non-invasive way, reliable and easy tool that can be used freely in schools, without changing or interfering with the established working routines. Specifically, we look at desk students in learning activities, in which the student spends long time interacting with the computer.

Keywords: Learning style · Attention · Behavior biometrics · Technologies in learning · Ambient intelligent system

1 Introduction

Learning activities can occur in class in an on-line context, which is usually used to practices online teaching exercises. Basically, they all refer to learning processes that use information and communication technology to facilitate synchronous as well as asynchronous learning and teaching activities.

Learning theories provide insights into the very complex processes and factors that influence learning and give precious information to be used in designing instruction that will produce optimum results. The learning models are designed in order to supply to the students with practice, evaluation and improvement procedures which will adjust the model [1].

Many contemporary educators argue the value of a constructivist approach to teaching. One of the central arguments for the use of Web-based resources in the classroom

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is that it gives learners access to information resources in ways that allow them to search for relevant data, synthesize that information, and draw their own conclusions.

The teaching process first requires that the instructor creates a pedagogical design of the objectives and determines the content to be taught. Second, a pre-assessment is used to determine learning abilities. Third, pedagogical procedures are used when teaching is initiated. Finally, assessment is applied to determine what learners have achieved, and, according to the assessment results, instructors should use feedback to determine the cause of ineffective instruction [2, 3].

Furthermore, for various reasons, students may not be predisposed to learning. In this sense, and in bigger classes, it is important that the teacher has instruments to point out potential distractions (namely in what concerns the applications being used by the students) that may indicate a lack of predisposition to learning.

Another important aspect is the type of exercises that is given by the teacher. Some students may prefer exercises with visual context and other exercises only with text contents. For this reason it's important have the background behavior learning style of the class and each student.

The goal of this paper is to propose an ambient intelligent (AmI) system, directed at the teacher that indicates the level of attention of the students in the class when it requires the use of the computer connected to the Internet. This AmI system captures, measures, and supervises the interaction of each student with the computer (or laptop) and indicates the level of attention of students in the activities proposed by the teacher. When the teacher has big class, he/she can visualize in real time the level of engagement of the students in the proposed activities and act accordingly when necessary. Thence it was applied in four different lesson in the same class with the same subject. The purpose was verified the learning style which had better results in attention level.

This paper is organized as follows. In the next Section the related work with learning styles and AmI system where scientific literature is reviewed. Section 3 contains the study outline, and Sect. 4 presented the results. In Sect. 5 discussion and some conclusions of this work are presented.

2 Related Work

It is crucial to improve the learning process and to mitigate problems that might occur in an environment with learning technologies. To explain how learning is processed it is possible to use the learning cycle shown in Fig. 1. The learning cycle has five steps: Engagement, Exploration, Explanation, Elaboration, and Evaluation [4].

The first step of the learning cycle is the engagement step where the student's attention is focused on the subject. In this step prior knowledge is explained and the student is reminded about topics that she/he should already be familiar with. The evaluation of this step consists in pre-assessing the prior knowledge of the subject.

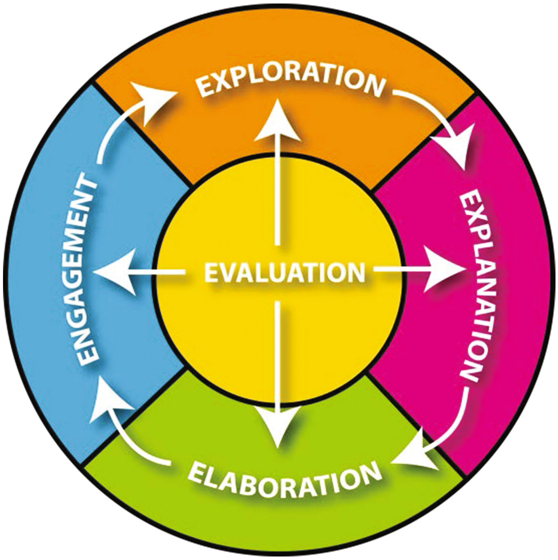

Fig. 1. Learning cycle [4].

The second step, the exploration step, has students gathering information that they can use to solve the problem that was proposed. The evaluation of the exploration step is carried out through the evaluation of the gathering information process.

In the explanation step the students use the gathered information to solve the problem and report what they have done and also try to work out the answer to the presented problem. The evaluation of explanation focuses on how well the students are using the gathered information and what new ideas they have come up with.

The elaboration step is where the student has new information that extends what they have been learning. Also, in this stage students are solving problems that require the knowledge acquired during the learning process in order to solve them. The evaluation of the elaboration step usually is the test at the end of the subject, which measures how well students understood what they have learned.

Based on Kolb framework it's necessary that student stay engaged in the subject in order to improve all the step of the framework. Another aspect that is necessary to be consider is that the degree of the learner's attention affects learning results, where the lack of attention can define the success of a student and in learning activities. So the level of attention is very important in order to perform a task in an efficient and adequate way [5].

2.1 Learning Styles

In order to maximize the learning is also important to consider the concept of learning styles. A learning style is the method that allows an individual to learn best. Different people learn in different ways, each one preferring a different learning style.

Learning style not only specifies how a student learns and likes to learn, but it can also help a teacher to adapt to individual students, so that they might learn successfully. When the teacher's methodologies do not support a specific learning style, the student will find it more difficult to learn and acquire knowledge. Everyone has a mix of learning styles, but some people may find that they have a dominant style of learning. Others may find that they have different learning styles in different circumstances.

Learning styles can be defined as cognitive, affective, and physiological features that serve as relatively stable indicators of how learners perceive interaction and respond to their learning environments [6].

There are several models developed by several authors that try to represent the way people learn [7]. Previous research suggests that, in the context of learning activities, different learning styles can influence learning performance [8, 9]. Learning styles are considered one of the more important factors influencing learning [10].

Some researchers have argued that learning style is also a suitable indicator of potential learning success because it provides information about individual differences in learning preferences and information-processing [4, 8].

However the field of learning styles is a very controversial field, because there are some authors that consider that scientific support for learning styles theories is lacking [11].

2.2 AmI System

When students are doing learning activities using new technologies and connect to the Internet, it is extremely important that the teacher has feedback from the students' work in order to detect potential learning problems at an early stage so he can choose the appropriate teaching methods.

The learning is improved if the teacher has a system that can detect and classify the learning preferences of students and provide advice from potential learning problems at an early stage in order to choose the most appropriate teaching methods.

For this reason we propose a AmI system that uses the information of a software that run in a parallel and transparent process, while student conscientiously interacts with the system and takes his/her decisions and actions.

This work was detail in [12], but briefly the devices in which students work have software that generates raw data, which store the raw data locally until it is synchronized with the web server in the cloud. After the raw data was stored in a data store engine, the analytic layer provides powerful tools for performing analytics and analyses in real-time, where the system calculates, at regular intervals, an estimation of the general level of performance and attention of each student, based on work-related tasks defined by the teacher. In the classification layer the indicators are interpreted. Based on data from the attentiveness indicators and building the meta-data that will support decision-making. When the system has a sufficiently large dataset that allows making classifications with precision, it will classify the inputs received into different attention levels in real-time, creating each student learning profile. With these results it is possible to obtain a profile of the learning style. Finally, the actual students' attention information is displayed in the visualization layer, and can be used to personalize instruction according to the specific student, enabling the teacher to act differently with different students, and also to act differently with the same student, according to his/her past and present level of attention.

3 Study Outline

The present work adds a new feature to this previously existing framework, by providing the learning styles theory, where the applications of different type of exercises obtained different results of level of attentiveness. It constitutes a much more precise and reliable mechanism for attention monitoring, while maintaining all the advantages of the existing system: nonintrusive, lightweight, and transparent.

3.1 Methodology

This work was applied on a vocational course while performing an activity based on Adobe Photoshop at the high school of Caldas das Taipas, Guimarães, Portugal. We want to determine how the class reacts during the lessons and the effect on mouse and keyboard dynamics, and attention level.

For this purpose one group of 22 (9 girls and 13 boys) students were selected to participate in this experience. Their average age is 17.6 years old (SD = 1.4 years). The experiment was applied in four different lessons, where they have access to an individual computer and 100 min to complete the task. Students received, at the beginning of the lessons, all necessary data with the goals of the task.

To quantify attentiveness the following methodology was followed. Apart from capturing the interaction of the students with the computer, the monitoring system also registers the applications with which students are interacting. Attention is calculated at regular intervals, as configured by the teacher (e.g. five minutes). The teacher may also want to assess, in real-time or a posteriori, the evolution of attention of the whole class.

In order to determine the learning style of each student, four different exercises were applied in four different days where the room had similar conditions in terms of lightning, temperature and humidity. The exercises applied were the following: on the first day a video exercise without audio; on the second day, an exercise only with images; on third day, an exercise only with text; and on the fourth day an exercise only with audio. In the end of each class, the exercise was saved in order to be assessed by the teacher.

3.2 Features Extraction

The process of feature extraction starts with the acquisition of interaction events, which is carried out by a specifically developed application that is installed in each of the computers, laptops or tablets. The first stage in the life cycle of the proposed system takes place in the data generating devices, which was designed and implemented using a logger application.

The data collected by the logger application characterizing the students' interaction patterns is aggregated in a server to which the logger application connects after the student logs in. The privacy of the students is ensured, since the necessary data that is collected in the registration process are an ID that does not identify the student, password, and gender. Furthermore, the privacy issues of the system are assured, since the teacher will only have access to the final results on the level of attention.

The Mouse and Keyboard Sensing layers are responsible for capturing information describing the behavioral patterns of the students while interacting with the peripherals [5].

4 Results

During the lessons the monitoring system was used to assess the interaction of the students with the computer and to quantify their level of attentiveness as well.

On each lesson the level of attention of each student was quantified. However, at the beginning it is necessary that the teacher define the task-related applications that the students will use during the class. For that he/she uses a graphical interface to set rules such as “starts with Photoshop” or “Contains the word Photoshop” which are then translated to regular expressions that are used by the algorithm to determine which applications are and are not work-related [12]. In this sense it is necessary to measure the amount of time in each interval, which the student spent interacting with task-related applications. By default, applications that are not considered task-related are marked as “others” and count negatively towards the quantification of attention. The teacher may also determine the regular intervals at which attention is calculated.

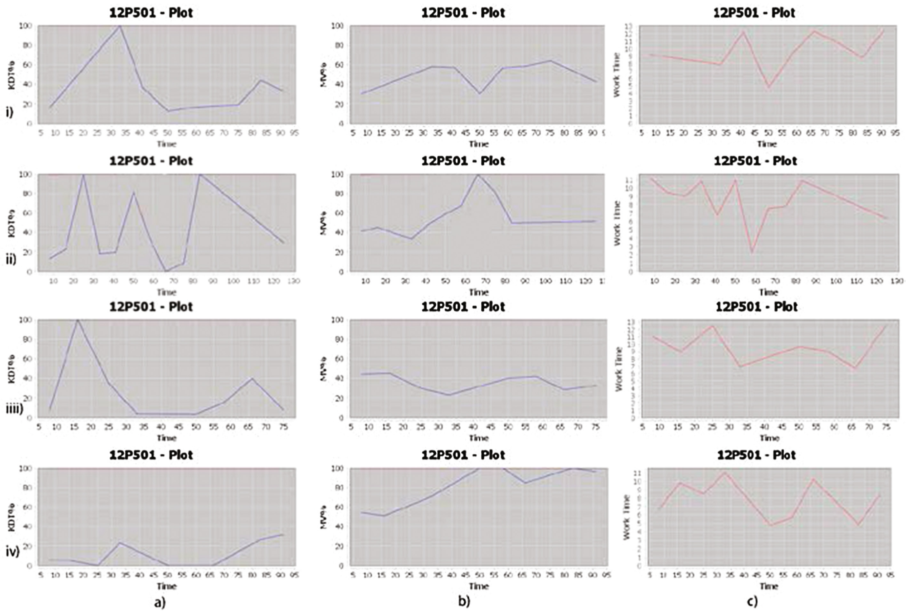

Fig. 2. Detail of evaluation of keyboard (a); mouse (b) and attention (c) for a specific students in the four different lessons.

Figure 2 shows the output of the evaluation of keyboard ((a) KDT, the number of time that keys are press), mouse ((b) MV, the velocity of the mouse movement), and attention ((c) worked task-related) of a specific student in the four different lessons.

The first lesson (i) was a video exercise without audio; the second lesson (ii) was an exercise only with images; the third lesson (iii) was an exercise only with text; and the fourth lesson was an exercise only with audio.

In each of these lessons it's analyzed: the interactivity with the keyboard, by measuring the keys press during the lesson; the movement of the mouse, measuring the mouse velocity; and the level of attention, which is measuring with the work task-related.

This is an example of a student, but the teacher had access to all students and the global of the class, which allows the teacher to assess the temporal evolution of attention. These results consider the entire length of a class and give the percentage of time spent in task-related or other applications, for each student.

5 Discussion and Conclusions

The main goal of this paper was to present an AmI system approach that analyzed the interaction of student's in learning activities using technologies connected to the Internet. In this case, a specific subject was focused (Adobe Photoshop) and it was analyzed in four different lessons, using four different learning style approach. For this case it was observed the performance of the class and each student. An example of the results of one student was showed and we can observe that this student's for the same subject react differently depend on the leaning style applied. In the first lesson, with the exercise of video without audio, this student had a similar decrease in evolution in the attention level, keyboard, and mouse velocity. However, this was not observed in the other lessons. In case of lesson two, exercises only with images, we can observe that when the level of attention is lowest is where the mouse velocity is higher. That might indicate that this student is in other application where the mouse velocity is needed.

Related with the level of attention in the four lessons for this student, we can conclude that is more homogeneous in three (exercise with only text) and have a better average in lessons one (exercise only with video) and three (exercise only with text).

This approach was implemented in the form of a distributed architecture that constantly collects, processes, stores, analyzes and monitors data describing individual behavior.

Regarding learning styles, the system only analyses the student's actions by the percentage of work-related tasks and the interaction with the mouse and the keyboard. When the system has enough data for each student, it will be possible to advise the teacher with the aim to improve the attention level. It will also be possible to analyze the students' profiles, taking into account their individual characteristics, and to propose new strategies and actions. Given that the teacher is informed about the behavior of each student and each one's learning style, she/he will be able to maximize students' attention and, consequently, the performance of the teaching-learning process.

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Technology-Based Learning Experiences and Game-Based Learning Studies

Toward a Cognitive Robotics Laboratory Based on a Technology Enhanced Learning Approach

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Abstract. Educational Robotics is an innovative way for increasing the attractiveness of science education and scientific careers for young people. It promotes the development of system thinking and problem solving through design, creation and programming of tangible artifacts for creating personally meaningful objects and addressing real-world societal needs. Cognitive robotics is about doing robotics that deals with cognitive phenomena such e.g., as perception, attention, and learning. As a consequence, it is regarded as very beneficial if university program studies include the teaching of both theoretical and practical knowledge on robotics and cognitive robotics as well. To follow these guidelines, we introduce a three-year plan aimed at designing, launching, and evaluating an CR course, based on a Laboratory according to a TEL approach.

Keywords: TEL · Educational cognitive robotics · Internet of things

1 Introduction

Robots are becoming an integral component of our entire society and have great potential in being utilized in everyday lives, e.g., at home and at school. This impact of social robotics is so crucial that to promote a deeper understanding of the area a great number of methodologies, courses, initiatives and competitions have been developed in the last decades (see e.g., [3]), strengthening the Educational Robotics research field [4].

Educational Robotics is an innovative way for increasing the attractiveness of science education and scientific careers for young learners. As a multidisciplinary field, robotics promotes the development of system thinking and problem solving through the design, creation and programming of tangible artifacts for creating meaningful objects and addressing real-world societal needs. Has IEEE community of Robotics observed, robots are becoming day by day more complex:

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> *"There is growing need for robots that can* **interact safely with people** *in everyday situations. These robots have to be able to* **anticipate the effects** *of their own actions as well as the actions and needs of the people around them. To achieve this, two streams of research need to merge, one concerned with physical systems specifically designed to* **interact with unconstrained environments** *and another focusing on control architectures that explicitly take into account the need to* **acquire and use experience**. *The merging of these two areas has brought about the field of Cognitive Robotics. This is a multi-disciplinary science that draws on research in adaptive robotics as well as cognitive science and artificial intelligence, and often exploits models based on biological cognition*[1]*."*

Summarizing, Cognitive Robotics (CR) is a specialization of the Robotics research field; it is a new approach to robot programming based on action and high level primitives for perception, where primitives draw inspiration from ideas in Cognitive Science. It is then obvious that it would be very beneficial if scientific and technological university program studies include the teaching of both theoretical and practical knowledge on robotics. In this context, current curricula need to be improved and new learning approaches need to be developed for improving skills among young people. Moreover, an exploration of the multidisciplinary potential of robotics in general, and in CR in particular, towards an innovative learning approach is required for fostering students' creativity leading to collaborative entrepreneurial, industrial and research careers.

As reported in [3], in the last decades in Europe, all the educational robotics activities and the diversity of the teaching approaches enabled on one hand enormous creativity and potential but prevented on the other hand to some extent, a coordinated approach and a broader and more serious evaluation, making a comparison among learning approaches next to be impossible.

To this aim, in Sect. 2, we first report a categorization of the educational robotics activities and their contextualization in Europe and in Italy, by looking at workshops, robot competitions, existing networks and offering courses. We also report on more recent literature studies [4] in order to identify what it is crucial to experiment new way to teach and learn robotics and cognitive robotics in university settings [1,7]. We then focus, in Sect. 3 on our direct experience in the University of L'Aquila, sketching the overall situation of the educational robotics and focusing on the main aspects of the CR course. In particular, we discuss a three-years plan aimed at designing, launching, and evaluating an CR course, based on a laboratory according to a TEL approach. The aim of this plan is twofold: on the one hand we want to allow students to learn CR and on the other hand we want to improve the acceptability of such discipline. We hence envisioned a continual and iterative design of the course during these three years based on a formative evaluation as suggested by the literature [9].

[1] Quoting from http://www.ieee-ras.org/cognitive-robotics.

2 Educational Robotics in Europe

As reported in [3], one of the first workshop explicitly on the topic educational robotics in Europe was organized by Fraunhofer IAIS in 2001 in Germany focused on the integration of robots in the education of computer scientist held in Bonn in 2005 as part of the annual conference of the German Society of Computer Science. Examples of a trend that invested more resources on robotics in education are WEROB2016 and WEBOB2016 as well as WONDER2015. More recently, several Workshops are promoting Arduino-Based Robots as Wide Spectrum Learning Support Tools [4]; research and practices for robotics in Science, Maths, Informatics and Technology (STEM) Education have been largely discussed also in 2016 in “Educational Robotics” workshop [11].

From the side of robot competitions in Europe, the most prominent international ones are the FIRST Lego League [6] (imported from the very structured, broad and successful FIRST initiative in the US) and RoboCupJunior[2]. More recently, Eurobot[3] and euRobotics, organized by the European Robotics League[4] represented the most important excellence network in Europe.

In Italy, *Roberta-Goes-EU* project[5], aspires to encourage young people, especially girls, to take up technological studies and to teach robotics in general. Explicit networks like Scuola di Robotica [1] build networks of active, involved people in parallel to their research or development activities in educational robotics. The Italian school-net *PIONEER* promotes in a cooperative environment setting-up a model of minirobot experiences [1]. Robotiko[6] and Scuola di Robotica[7] are two among the largest italian schools promoting educational robotics through constructionism and cooperative learning models. Furthermore, the Universities of Roma, Torino, Milano, Pisa and obviously L’Aquila, just to name a few, offer to their students specific courses of robotic engineering.

Research in the field of educational robotics has for years placed emphasis on the interplay between the invention of new technologies and the development of innovative ways of learning: new pedagogical ideas can lead to new technologies, and vice-versa. The seminal work of Seymour Papert on constructionist learning [1] with on-screen and physical turtle robots has led much of the research in the field over this time, including literature from Europe, America, Africa and Asia. In a recent and in depth report on teaching robotics and presenting educational robotics curricula and activities [12], authors design and analyze learning environments as well as evaluation means for measuring the impact of robotics on the students’ learning success, presenting interesting programming approaches as well as new applications, the latest tools, systems and components for using

2 http://www.robocupjr.it.
3 http://www.eurobot.org.
4 http://www.eu-robotics.net/robotics_league.
5 http://roberta-home.de/en/roberta-network.
6 http://www.robotiko.it.
7 http://www.scuoladirobotica.it.

robotics, covering the whole educative range, from elementary school to high school, college, university and beyond, for continuing education and possibly outreach and workforce development.

The main findings of all the surveys works are that:

1. The pedagogical theories appearing to underpin the learning experiences are social constructivism and constructionism;
2. Educational robotics can increase students engagement and interest;
3. Research in educational robotics lacks detailed and structured description of learning context, design of the learning experience, and activities/experiments that would allow to make them replicable and to make a sound comparison.

Our work moves from these considerations towards a possible activity plan based on a TEL based approach, designed to support not only the students' learning process, but also the pedagogical design experienced via a formative evaluation. One of its major purposes of a formative evaluation is, in fact improving the eventual effectiveness of the educational materials/tool while they are still in the design and development phase.

3 Educational Robotics at the University of L'Aquila

By analyzing the state of the art so far reported, it is possible to recognize two categories of robotics educational activities, according to the role that robotics play in the learning process:

- *Robotics as learning target*: which includes educational activities where robotics is being studied as a subject on its own. It includes educational activities aimed at configuring a learning environment that will actively involve learners in the solution of authentic problems focusing on Robotics-related subjects, such as robot construction and artificial intelligence.
- *Robotics as learning tool*: in which robotics is proposed as a tool for teaching and learning other school subjects at different school levels. Robotics as learning tool is usually seen as an interdisciplinary, project-based learning activity drawing mostly on STEM and offering major new benefits to education in general at all levels.

Nowadays, the University of L'Aquila offers the robotics courses reported in Table 1.

Table 1. Courses related to robotics at the University of L'Aquila.

Bachelor vs. Master	Name of study course	Course name	Theoretical vs. Practical
Bachelor	Information Eng.	Industrial Robotics	Theoretical
Bachelor and Master	Information Eng., Computer Science	Intelligent systems and Robotics Laboratory	Theoretical and Practical
Master	Automatics and Computer Eng.	Laboratory of Automatics	Practical
Master	Automatics and Computer Eng.	Industrial Robotics	Theoretical and Practical
Master	Computer Science	Computational Intelligence	Theoretical

3.1 A Cognitive Robotics Laboratory Based on a TEL Approach

The "Intelligent Systems and Robotics Laboratory" course (row 2), differently from the others mainly focused on industrial robotics, focus on CR. It is an optional course, accessible both from undergraduate and master students able to obtain overall 6 European Credit Transfer System (ECTS). It is both theoretical and practical as well as laboratory based: its program includes 5 h per week (2 h theoretical/3 h practical) for a period of 3 months for the classroom lessons in addition to autonomous student work. In the context of CR, the focus is towards developing robots that safely share a working space with humans, i.e., capable to anticipate the effect of their own actions and that of people [13].

Coherently with findings reported in Sect. 2 the CR is based on constructivism pedagogical theories: students can practice to design, assemble and test, do-it-yourself projects focused on multi-agent declarative systems as higher level of abstraction in the robot control, such as the DALI framework based on Prolog and Python languages, as low-level reactive control layer on top of the hardware, as described in [5]. Given its characteristics, CR is used as learning tool and learning target at the same time; furthermore, since technology plays a significant role to improve the quality and outcomes of learning, the course is to be considered based on a TEL approach according to the definition given in [14].

The course was launched in the academic year 2015/2016 and is being designed and refined within a three years plan according to the results of a formative evaluation (the goal of formative assessment is to monitor student learning to provide ongoing feedback that can be used by instructors to improve their teaching and by students to improve their learning [9]): the experience and the student evaluation of year $i-1$ are used to refine the course in year i. Table 2 summarizes the plan by identifying the objectives of each year in terms of instructional goals, experienced modus operandi, and TEL tools.

During the first year (academic year 2015–2016) all the scheduled activities dealt with virtual robotics educational tools built upon Morse Python based robotic simulator [8] and V-REP general purpose simulator. The deliverables of the project assigned to students were: a design documentation, a working set of

Python program to control the robot via interprocess communication, a video showing the virtual robot behavior in the virtual robotic simulator. Instructional goals were evaluated at the end of the course.

In the second year (the current academic year 2016–2017), according to the evaluation of the previous year, the virtual robotics experience was compressed in the first half of the course, while, for the second half of the course the laboratory was equipped with sufficient basic robotic hardware, including:

- Bluetooth controllable commercial robot toys
- RaspberryPI 3 single board computers and Arduino starter kits
- Internet of Things sensors kits
- Motorized 4 wheel robot cases
- Deep learning robot kits
- HTC Vive room scale virtual reality headset
- Oculus Rift desktop scale virtual reality headset

Students experienced this HW laboratory in team, grouped depending on their starting skills and role capacity fulfillment. In all cases, students' groups were requested to: nominate a group coordinator, define roles, produce design documentation, use a source server for coding, agree on a date for final project test with the robot "on-the-road". Only afterwards each student was able to discuss her/his contribution to get the personal mark outcome. During this second

Table 2. Three-years designed plan of our course.

Year	Instructional goals	Modus operandi	TEL tools
1	(1) Know how to design a CR application; (2) Know how to implement a working prototype by means of virtualization and cloud computing techniques; (3) Be able to use and design virtual reality simulation tools	Working alone	Moodle, Virtual Robotics
2	(4) Be able to express a mobile robotic architecture; (5) Be familiar with mobile robotics; (6) Be able to learn robotic operative systems and languages; (7) Be able to judge the quality of a CR project	Working in team	Moodle, Virtual Rob. + HW Rob.
3	(8) Be able to select hardware and software or to develop mobile cognitive robots; (9) Be able to explain a cognitive mobile robot design; (10) Be able to analyze sensor and navigation data; (11) Understand the complexity of a CR system in a real life situation	Working in team, evaluating products with end-users	Moodle, Virtual Rob. + HW Rob

year the virtual robotics experience was done after the first half of the course, while the remaining instructional goals were evaluated at the and of the course.

For the third year (academic year 2017–2018) we plan to refine the course structure in the following way: the course will be divided in three parts, where the first two will correspond to the two parts of the second year and the third one will be added to include the instructional goals specified in row 3 of Table 2; in particular, we will add a cognitive test of the robot, that shall include an interaction with end-users in a real life environment measuring and validating the robot efficacy during the interaction with them.

3.2 Course Data and Activities

During the first two years we evaluated the students' opinion (the participation in the survey was voluntary) and the effect of the our course by means of qualitative studies carried out on 9 students during the 2015/16 and on 16 students during 2016/17 academic years. In the first year there was an average of 12 students in class, 15 enrolled online. At the end of the semester 9 students passed the final exam discussing the virtual robotic project. In the second year there was an average of 20 students in class (2 from Erasmus + programs), 24 enrolled online. At the current time, the final exam was done by the end of the semester by all 13, with an outcome of full mark. We here report the more interesting developed projects:

– **Mii Robot Hack Project (MRHP)**: a commercial toy robot with self-balancing 2 wheels locomotion, bluetooth connection and on board proximity sensors. The robot is left to explore an unconstrained environment with virtual obstacles made by red pieces of paper left on the ground. A top camera is watching the scene, connected to a RaspberryPi-3 [10] computer that tracks the robot position, calculates the collision points and sends bluetooth command to the robot to avoid the virtual walls.
– **Smart 4 Wheels Explorer Project (S4WEP)**: a bottom-up assembled project starting from a 4 wheels robot case, with 1 Arduino UNO for motor control, 2 Arduino NANO[8] [2] for sensors (ultrasound range sensor and compass sensor), 1 RaspberryPI-3[9] main controller with the SensHat [10] expansion board.

4 Discussion and Conclusions

In this paper we reported on a three-year plan within a TEL approach for computer science and engineering students to get acquainted in a important emerging field of technology that is at the base of the incoming industry 4.0 wave. Coherently with findings carried out from the state of the art, the proposed CR is based on constructivism pedagogical theories and differently from these findings,

[8] http://www.arduino.cc.
[9] http://www.raspberrypi.org.

we designed a plan evaluating it in a formative way and, notwithstanding we did not concluded a complete iteration (we are currently at the second of the three designed years), we obtained good results demonstrated by the good quality of built projects. As shown in Table 3, from the first to the second year, the number of students improves and the dropout increases indicating a general improvement of the attractiveness of the course; the success rate apparently decreases; in fact the number of students passing the final exam is not definitively (the current academic year is not finished yet). Finally, analyzing the qualitative data stored via Moodle regarding the satisfaction of the course, we highlights that students are more satisfied the current year wrt the previous one.

Table 3. Formative evaluation results.

Students	Dropout	Success rate	Satisfaction of the course
27	33%	75%	70%
47	27%	67%	90%

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First Steps Towards the Design of Tangibles for Graph Algorithmic Thinking

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Abstract. The paper presents exploratory steps of the design of interactive tangible objects for the scaffolding of algorithmic thinking of 9–13 years old school classes, and specifically graph algorithmic thinking. By following a participatory design process, such tangibles are rapidly designed and used in studies with their intended users–learners and their teachers. The paper presents an exploratory study with designers and teachers, and lessons learnt from it.

Keywords: Algorithmic thinking · Interactive tangible objects · Interaction design · Participatory design

1 Introduction

Computational Thinking (CT) represents a universally applicable attitude and a set of skills for everyone, not just computer scientists [22]; it includes, as core part, *Algorithmic Thinking* (AT). AT is a way of getting to a solution through the modelling and clear definition of the steps needed to solve a problem [12]. In many countries, Computer Science (CS) education in primary or secondary schools (K-12) has reached a significant turning point, shifting its focus from ICT-oriented to rigorous CS concepts, and moving towards CT, in general, and AT, specifically [11]. Time is thus mature for introducing AT education in primary and secondary schools: teaching AT should in fact be done from primary schools, then continuing in middle and secondary schools [1,13,15]. According to such authors, pupils aged 5–11 years have already much potential for learning about algorithms and computation. Moreover, the use of tangibles for introducing children to AT, through physical activities, potentially fosters the interplay between abstraction and concreteness, and can sustain their learning through a multi-sensory experience [13].

The general purpose of the research presented in this paper is to introduce AT at school through physical activities with smart interactive tangible objects (*tangibles*, from now on); the specific purpose of the research is to introduce

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children to graph AT, given the abstract nature of graph AT and its potential applicability to different learning scenarios for primary and middle classes.

The paper starts by providing background information in Sect. 2. Section 3 outlines and motivates the chosen participatory design approach to the development of tangibles for graph AT. Section 4 presents a prototype of tangibles for graph AT, explored and used in the studies presented in Sect. 5. The paper ends providing conclusion and novel ideas for future work in Sect. 6

2 Background

The context of our research lies at the intersection of Computer Science education and *interaction design* (ID). Literature on CS education highlights three main categories of educational approaches to CT, in general, and AT, in particular. The most popular approach is based on *coding*, and programming languages specifically designed for children have been proposed, the best known among them being Scratch [18]. We may contrast the coding approach with proposals, such as *CS-unplugged* by Bell [2], aimed at teaching CS without computers. CS-unplugged is a collection of instructional activities based on playful activities and puzzles, using cards, strings, crayons, and lots of physical movement around the classroom. It has inspired many authors to propose variations, all united by teaching CT, and AT, through hands-on or physical activities, e.g., algomotricity [3], puzzles [16], graph theory [15]. Activities of this nature are prevalent in primary schools [5], but also in secondary schools [3], especially when the school does not have programming resources.

In between the two approaches, we find proposals dealing with tangibles. Pedagogy research has shown that physical activities with tangibles are beneficial for multi-sensory learning, especially for young students [20]. Among them, there are activities concerning CT introduction through robotics [17], for example the TangibleK program, that uses robotics as a tool for engaging children in developing CT skills [4]. Teaching AT through tangibles has also received increasing attention in recent years [12]. AT has been introduced, for instance, with a haptic model [7,13], which turned out to be helpful in different learning contexts [10]. Another example is a tangible computational drum kit with programmable behaviors [21]. Finally, in [14] the making of a gamified interactive tangible for a sorting algorithm was presented, where gamification is as in [9].

The design of tangibles for graph AT has two dimensions to consider: (1) usability, which examines how tangibles can be used as intended by their expected users; (2) learner experience, that is, how tangibles can support an enhanced experience for the scaffolding of graph AT [6]. Considering both dimensions entails the need to put in place a series of studies concerning the usability and learner experience with prototypes of tangibles, and uncover novel learning scenarios. That motivates the adopted design approach, which is explained next.

3 A Participatory Design Process for Tangibles for Graph AT

Meta-design and other end-user development approaches, such as [8], do not provide fixed solutions but a framework within which users and designers alike can continuously contribute to the development. The process allows designers and users to mutually learn in the field, continuously analyse the context of usage of such tangibles and adapt them accordingly. This is the design approach adopted for tangibles for graph AT.

The design process crucially requires prototype solutions, and their usage in field studies, where designers and users collaborate to uncover usability issues, as well as unforeseen design possibilities, e.g., novel learning scenarios. In the work reported in this paper, users, participating in the process, are 9–13 years old pupils from primary and middle schools, and, crucially, their teachers.

The tangibles for graph AT should be used in class for reasoning about graph[1] modeling and algorithms. The design process started with a preliminary context of use analysis. According to the analysis, graphs and graph algorithms are seldom introduced in schools: graphs are often considered difficult for school classes by teachers. With the introduction of tangibles, graph AT can be introduced at school, starting with 9 years old children.

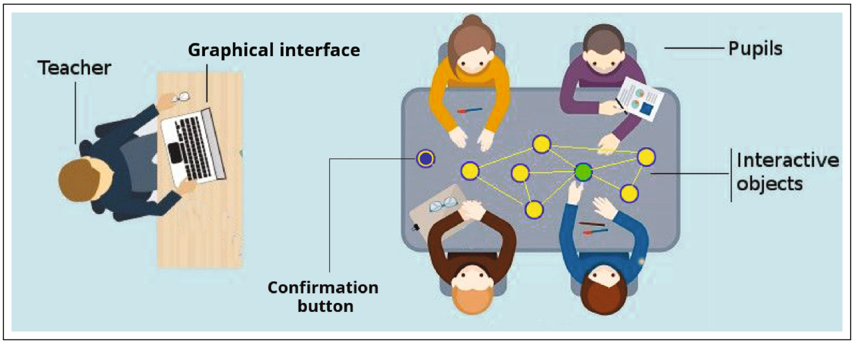

Fig. 1. Envisioned usage.

The preliminary context of use analysis triggered the rapid design of *vertical prototype* solutions of tangibles, which implement few but critical functionalities for graph AT, and the definition of initial *learning scenarios*, with specific learning goals, for primary and middle schools. Figure 1 sketches one of such scenarios. It shows a group of 4 pupils building a graph with: tangibles acting as nodes; connection cables, acting as edges; a tangible, the "confirmation button", which is pushed at the conclusion of the learning scenario. A class teacher monitors children's activities with her/his computer and a dedicated interface.

[1] A(n unordered) graph is a pair $G = (V, E)$, where $V = \{v_1, \ldots, v_n\}$ is a finite set of nodes and $E = \{\{v_i, v_j\} \,|v_i, v_j \in V\}$ is a finite set of edges between nodes.

4 The Design of a Prototype of Tangibles for Graph AT

This section describes an exploratory prototype of tangibles for graph AT. It implements a client-server architecture with Python 2.7. Clients are tangibles for nodes and the confirmation button, described above; the server is on the teacher's computer and manages also her/his interface.

As for interaction design choices, edges are Ethernet cables, which are just passive links, and provide no interaction. Nodes are interactive and hide all hardware components inside cardboard boxes. Nodes provide the features shown in Fig. 2 with a Raspberry PI 3, an USB power bank, three RJ45 ports, a button, a RGB node LED, three RGB edge LEDs, wires and resistors. Specifically, each node has a node LED to communicate feedback about the node, three sockets for connecting edges, each of them with an edge LED to communicate feedback about the edge, and a node button to activate the node.

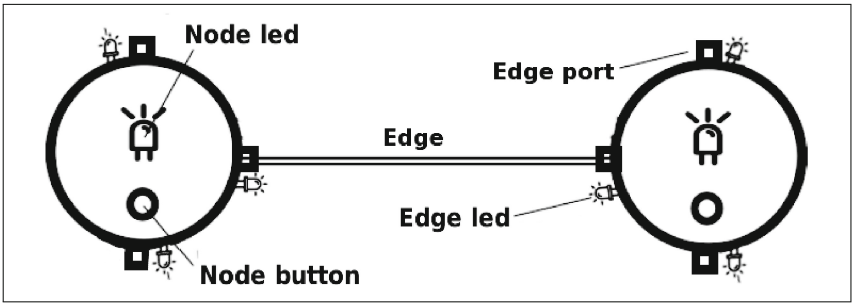

Fig. 2. Two tangibles for nodes, connected by an edge.

In Fig. 3, the graphical interface shows the graph present on the table, and the current status of verified graph properties for such graph. The confirmation button has the same hardware as the nodes, without LEDs and sockets.

Switching on LED nodes means that nodes are part of a graph or other types of feedback related to properties of the graph. Users can use a cable to create an edge between two nodes: the cable is plugged into sockets in nodes/cardboxes. When the cable connects two nodes, edge LEDs can switch on to indicate that the two nodes are connected, or to show feedback concerning other graph properties.

Feedback concerning graph properties depends on the learning scenario. Suppose that the scenario aims at making children model a real life situation and construct a simple graph. In case the graph, constructed by children, is not simple, edge LEDs for loops or parallel edges will blink red.

Once pupils complete their learning scenario with tangibles for graph AT, they have to signal it, so as to get a final feedback. For instance, suppose the learning scenario aims at teaching learners to construct a connected graph. When the button is triggered, positive final feedback is given as follows: all node LEDs are on, with the same color. In case of negative final feedback, after blinking red, node LEDs of different strongly connected components have different colors.

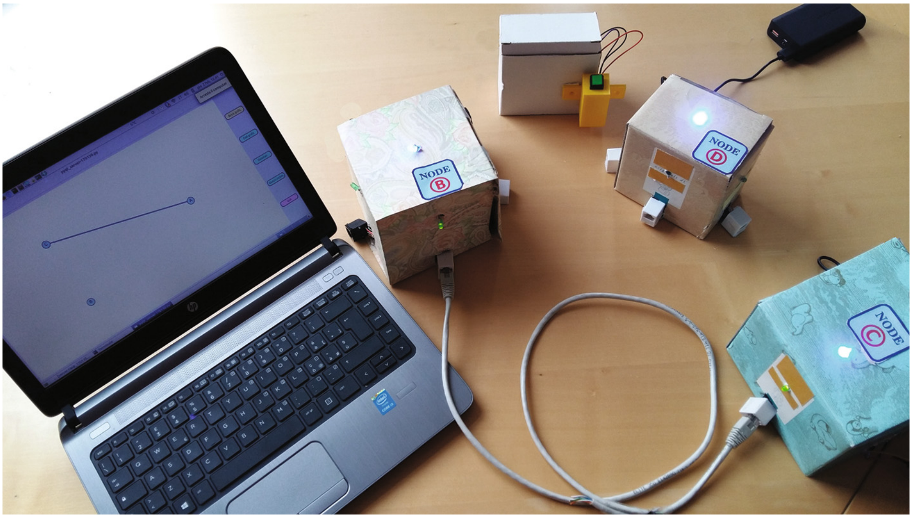

Fig. 3. Exploratory cartoon-based prototype of tangibles for graph AT.

5 Exploratory Study with the Prototype for Graph AT

The interactive tangibles have been reviewed with experts of interaction design, then experienced in an exploratory study with teachers.

Interaction designers focused on the interaction design choices, guided by Nielsen heuristics [19]. The main usability issue was the *consistency* of design choices for the explanatory feedback. Another usability issue was traced back to the usage of *metaphors and mental models*: when pupils choose a wrong node or edge, sometimes LED lights blinked, remaining green. Interaction designers suggested that the feedback use a more standard metaphor: LED lights can blink, but they should be red, to signal an error situation. A final usability issue was concerned with *visibility* of the feedback with cubic boxes: LED lights which are not in the line of sight of participants are not visible, and hence participants cannot always see the related feedback.

All detected usability issues were fixed before giving the prototypes to teachers, as explained next.

5.1 Study Design

Participants and Roles. In the study with teachers, two interaction designers acted as experts of interaction design whereas two teachers acted as experts of learning contexts as well as users of the developed technology. A designer acted as moderator, for communicating with teachers, and the other gathered qualitative data by tracing them in field notes.

Goal and Material. The study goal was gathering qualitative data in relation to usability issues and novel design possibilities for the interactive tangibles. The evaluation was thus formative and concerning the most recent prototype version of the tangibles for graph AT. Figure 3 shows the prototype, detailed in Sect. 4. The evaluation also used scenarios, which are described below, and refined them through the usage of the prototype, as described next.

Scenarios. The *first scenario* was the basic one: it outlined how the prototype could be used with a class to construct a graph, in which nodes represent users of a social network, and edges represent friendship relations in the social network. Starting from the result of the first, the *second scenario* exemplified how to construct a simple graph, whereas the *third scenario* exemplified how to construct a connected graph. The second and third scenarios continued with the social network metaphor. Note that all scenarios envisioned that a group of learners would physically construct the graph whereas the others would watch them performing the construction.

5.2 Study Results

Teachers and Novel scenarios

Usability issues. Teachers found the design choices clear for their pupils. One stressed that green LED lights act as traffic lights, and hence their feedback should be clear to pupils—meaning that choices are correct. Another teacher was concerned with the fragility of the objects, "pupils can easily tramp on them", and hence suggested that the tangibles stay on a table.

Uncovered scenarios. A teacher and one of the designers reasoned on a first novel usage scenario for a middle school class. In this scenario, the class is split in two: a group of pupils would use the tangibles; the rest of the class would follow the visualization of graph construction on a wide monitor, and reason on construction choices with the teacher.

The same teacher also suggested that the tangibles be used to teach children properties of binary relations on a set (the graph edges), which are part of traditional curricula—reflexivity and asymmetry. The other teacher agreed on the idea, expanded on it, and crafted a general novel scenario: the interactive tangibles can both scaffold curricular learning goals, that is, teaching properties of binary relations on a set, and introduce novel learning goals, such as teaching graph algorithms.

6 Conclusions

In this paper we presented the first findings from our experience, aimed at introducing an AT activity at school. Our interactive tangibles shall be used to convey modeling of real life problems with graphs, and solving them with graph algorithms; such activities are highly valuable, but seldom present in current curricula. A prototype has been developed, then evaluated with teachers on three simple scenarios, which were refined with them. In the next weeks we shall experience the prototype and the novel scenarios in a class of 12 years old pupils. The evaluation has shown a potential for using such interactive tangibles in different educational scenarios, to foster AT and scaffold curricular learning goals.

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EOLo: A Serious Mobile Game to Support Learning Processes

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Abstract. A great deal of interest is now being given to the use of serious games to improve specific issues of learning processes at different levels of education both in primary and secondary schools as well as in universities worldwide. The aim of this paper is to propose a serious game model supported by mobile computing for improving learning of specific topics regarding AVC (Adaptive Virtual Courses). The model incorporates three main modules: the web-based backend, the mobile application (game) and finally, the instructional design module in charge of the game content management. The implementation of the model was achieved through the development of EOLo, a functional prototype which was validated using a case study applied to a secondary school English course. The results show that students are motivated with the use of EOLo thanks to the healthy competition offered by the game during the development of learning activities. In addition, the system allows the detection of learning failures and from these generates a proactive feedback based on the recommendation of educational resources.

Keywords: Serious games · Recommendation systems · Web services · Mobile learning

1 Introduction

Several techniques and teaching-learning mechanisms are incorporated into mobile devices in order to take advantage of the large number of users who have this kind of technology. However, currently these technologies are used as leisure mechanisms and just for fun purposes [1, 2]. Traditional games do not focus on learning encouragement, only on delectation, entertainment, and amusement [3]. From this, serious games appear as a viable alternative to this kind of problems because are systems that seek firstly to motivate and entertain students while having an educational character to achieve learning objectives, solve problems, learn a specific topic or develop skills, always attempting to improve learning [4]. According to [5] serious games do not necessarily foster deeper engagement and learning; hence, it is required to specifically work on the game based instructional design.

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The aim of this paper is to propose a serious game model making emphasis on the system instructional design. The proposed model is supported by mobile computing for improving learning of specific topics regarding AVC (Adaptive Virtual Courses). The implementation of the model was achieved through the development of EOLo, a functional prototype which was validated using a case study applied to a secondary school English course.

The rest of the paper is organized as follows: while Sect. 2 examines the conceptual framework of this research, Sect. 3 presents some related works. Section 4 describes the serious game model proposed and Sect. 5 presents the implementation and validation of the prototype. The last Section draws the conclusions and future research directions.

2 Conceptual Framework

Following are the main concepts and fields related with this research.

A serious game can be defined as a system that seeks firstly to motivate and entertain students while having an educational character to achieve learning objectives, solve problems, learn a specific topic or develop skills, always attempting to improve learning. Serious games are being built at different levels of education both in primary and secondary schools as well as in universities worldwide. According to [6] the use of serious games involves also private companies and concerns several fields and professions such as aerospace (flight simulators), health (simulation of surgical operations, emergencies), finance (training compliance and financial issues learning), trading (simulation of fictitious companies), and tourism (hospitality training). In addition, it is important to highlight that serious games have not been only used for individual learning processes, but for Collaborative Learning Environments obtaining satisfactory results [7].

Recommendation Systems (RS) are a tool aims at providing users with useful information results searched and recovered according to their needs, making predictions about matching them to their preferences and delivering those items that could be closer than expected [8]. In the case of educational resources and learning objects, the system should be able to recommend learning objects adapted to one or more user's profile characteristics using metadata [9].

A Web service is a technology that uses a set of protocols and standards that serve to exchange data between software applications which have been developed in different programming languages. In addition, a web service answers the web clients and sends them the requested resources. Among the best known standard formats for the data to be exchanged are XML (Extensible Markup Language) and Web Services Description Language (WSDL) that corresponds to a XML-based description of the functional requirements needed to establish communication with web services.

Mobile computing is currently being used by students in order to support learning processes since allow them to online collaborate with other users while solving a learning problem. In addition, students can use their mobile devices anywhere and anytime in order to perform learning activities developed by the teacher through AVC (adaptive virtual courses) adapted to students' needs and preferences.

3 Related Works

This section presents some related works with the research field, and compares them in order to identify their strengths and weaknesses.

Bubphasuwan et al. [1] propose a serious game for improving English and mathematical skills for novice practitioners who are defined as non-professional learners or primary school students, to emphasize the skill and knowledge acquisition. The ultimate goal for the novice was to gain knowledge, skills, and experiences throughout their practicing and learning from the game. The game was implemented on Android OS by using Java programming language. On the flow side of the game, the player plays as a cashier of the grocery shop, the cashier has to wait for the customer and listen to what they want to buy. Then, the cashier has to select an item for the customer. The player selects the correct item in order to increase the score by tapping at the item on the shelf. Finally, the player also has to calculate total price and change for each customer. The player has to repeat these steps until the shop is close. Despite the game provided interesting game story that allows the novice practitioners to practice their English listening and mathematic skills, the game does not provide feedback about the learning failures and it is weak providing motivation to the user through competition with other players.

Sajana et al. [10] propose to learn concepts via serious games together with linear programmed instruction methodology which provides innovative ways to become more engaged in Learning with intrinsic motivation. They develop a game which was mainly indented for novice learners and is based on visualizations of different programming concepts as real life scenarios and on the interpretation of concepts. The proposed game does not have an instructional design module which offers the possibility of adding more questions of different topics with different levels of difficulty.

Soares et al. [11] developed an application for gesture recognition in Portuguese Sign Language (PSL) focused in helping disabled deaf and/or mute and hearing children to learn PSL. The authors present a serious game for children in the 1st cycle (primary Portuguese school) between the ages of 6 to 10 years. The game is based on a story, in order to promote the motivation of the students in the learning of the Portuguese Sign Language.

Considering the research works previously reviewed one of the improvements proposed in this paper in order to enhance serious mobile games is the integration of different features being reflected in the instructional design of the game. These issues give students a higher level of learning on the AVC topics. In addition, the features concern the generation of healthy competition, the detection of learning faults and the feedback offered by the mobile learning environment allow the users of the game to feel motivated and engaged to use the tool, which in turn increases the levels of learning achieved by the game.

4 Model Proposed

The proposed learning model takes advantage of the incorporation of serious games into teaching-learning processes. Therefore, an iterative and incremental process is performed for the architectural design, starting from the definition of a list of requirements that allowed the subsequent construction of a data model that evolved in each one of the iterations. This evolution is carried out in accordance with the new requirements and functionalities that were added to the application.

Figure 1 exhibits the architecture proposed that considers a modular Web-service based architecture composed of three modules:

- **Back-end Module:** corresponds to the application controllers' platform. In this component all the methods concerning query, writing, and storage in the database are performed. Some of the methods are exposed through RESTful Web services in order to be consumed by the mobile application and other modules.
- **EOLo Mobile Application Module:** corresponds to the mobile application deployed on the student devices. In this component all the interfaces that allow to communicate to the user with the mobile device are deployed. This application consumes the Web Services exposed by the Back-End.
- **Instructional Design Module:** this component allows the teacher to perform the instructional design of the modules along with their assessments, educational objectives, answers, educational resources, etc. Furthermore, the teacher can manage and visualize the progress of his/her students within each of the modules.

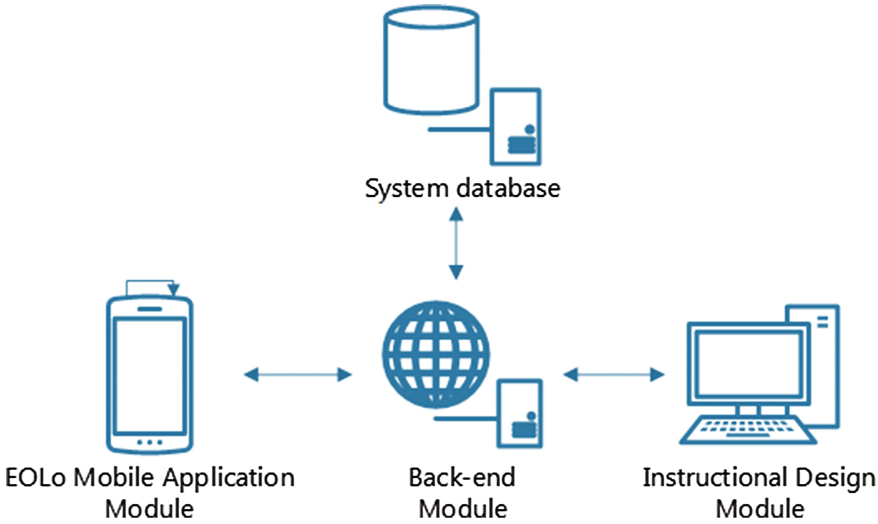

Fig. 1. System architecture model

Figure 2 shows the relational model that represents the entities of the model proposed. This model allows storing all the application data such as users, resources, assessments, questions, answers, modules, topics, among others. The most representative entity is the educational module that is composed of subjects that contain assessments, which are aimed at achieving the educational objectives proposed by the teacher. Likewise, the question has multiple response options that can be marked as correct or incorrect. The assessment results as well as the options selected by the students are stored within the historical question and assessment entities. Finally, the resources associated with the assessment process allow feedback from students in case the results are not the best.

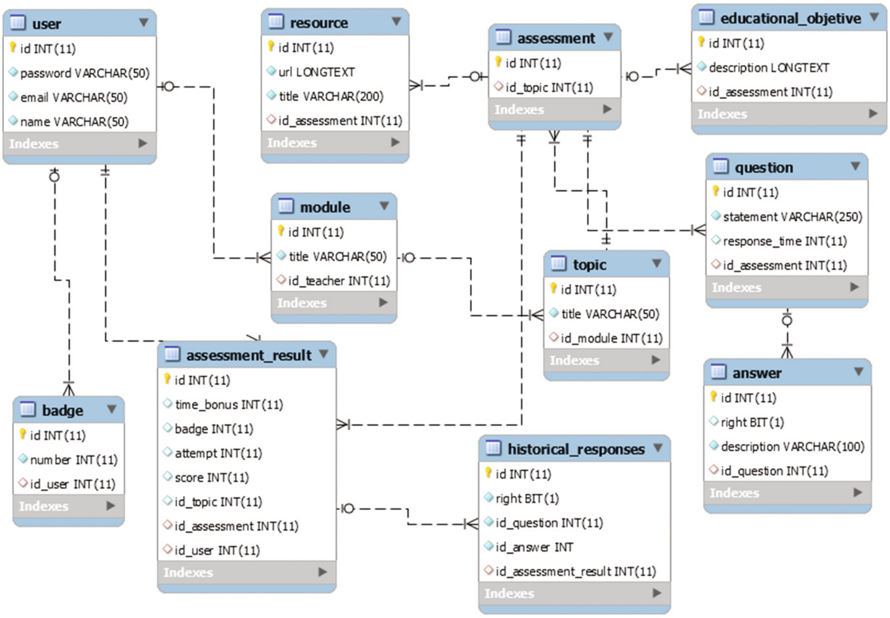

Fig. 2. Application data model

Based on the presented model the game incorporates a series of assessments that the student will have to overcome in order to achieve the proposed objectives. To incorporate the serious game notion to the system several mechanisms are proposed, such as: (1) a tutor who will guide and explain the dynamics of the game. (2) A navigation map of the module that shows the student's progress and the scores obtained in each topic. (3) A positions table that allows to see the scores obtained by the students during the execution of each module which generates competition among them. Scores are determined according to performance obtained by students in each of the assessments. It is important to highlight that if the student gets a performance above 90% a bonus will be awarded to him/her. Furthermore, the assessments have an established deadline for their execution. Once an assessment has been completed the remaining time will also grant bonus points to the student that accomplish it.

At the end of the module, students will be able to visualize the results of their assessments and the system will perform a feedback and recommends educational resources that help strengthen the students' knowledge if required to be done.

5 Model Implementation and Validation

Several tools and technologies were used to implement each of the components of the model proposed. The back-end is developed in the Java programming language under a RESTful service-oriented approach. The database connection manager is handled with Spring and relational entity mapping is performed using Hibernate. The Back-End application is deployed to an Apache Tomcat server. The presented data model has been deployed by means of MySQL database engine version 5.6.17.

The instructional design module was developed using the Angular web development framework with HTML. This tool was deployed on an Apache server and communicates with the web services exposed by the Back-end module. Figure 3 shows the platform deployment in which the teacher can add modules, evaluations, feedbacks, educational objectives, answers, educational resources, and scores.

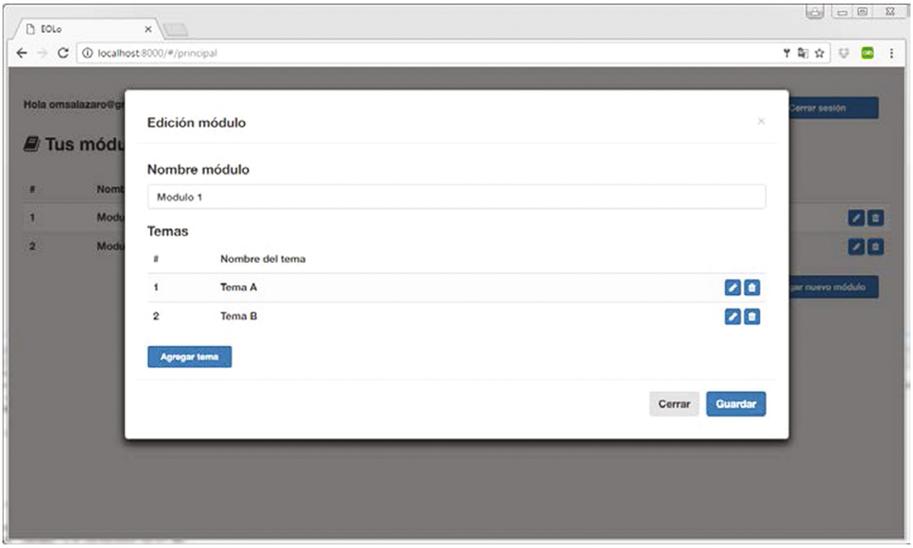

Fig. 3. Deployment of the instructional design module

On the other hand, the mobile application is developed in JAVA for Android Operating System using the ADT (Android Development Tool) framework. It runs on Android versions greater than 2.5 by installing a file with *APK extension. EOLo serious game system unfolds within a pirate world context in which the student will be conquering islands and finding treasures. During the learning experience a tutor will guide them in order to explain concepts, encourage them in case of finding shortcomings or recognize and communicate them the good performance obtained in assessments.

The validation of the system was performed through a case study applied to a secondary school English course. This case study considered the construction of a module with topics related to English language grammar using the previously presented instructional design tool. On the other hand, the students were able to interact with the mobile application and expressed positive feelings during the learning process thanks to the healthy competition offered by the game during the development of learning activities. In addition, they expressed the advantages of having a tutor who could guide them during the execution of the game-based application and they recognized the importance of the educational resource recommendations made by the system. For the student's interaction measurement with the application, a usage log was incorporated that stored the deployment of learning activities. In addition, a survey was conducted in order to reflect the level of student satisfaction in the interaction with the system. Finally, each of the activities could be qualified by the students, allowing measuring the quality and satisfaction level in real time (Fig. 4).

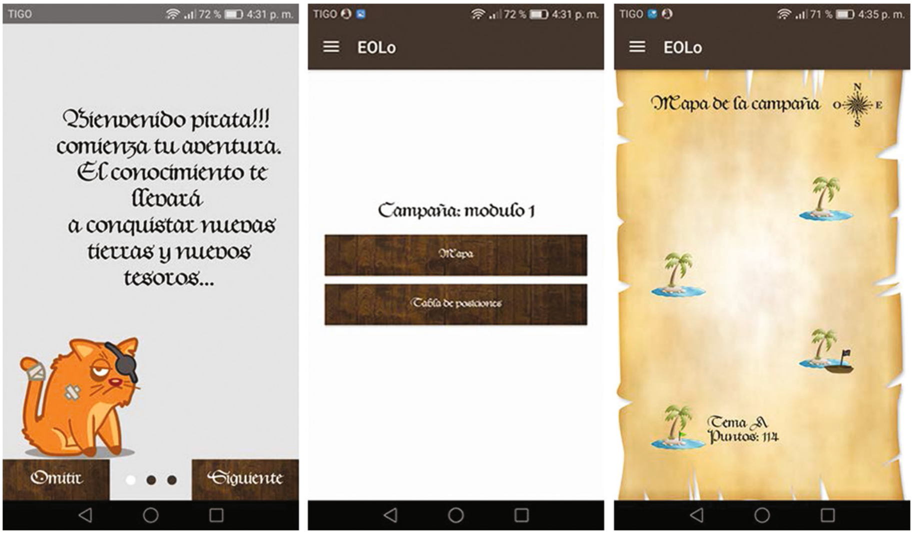

Fig. 4. EOLo serious game mobile application.

6 Conclusions and Future Work

The results show that students are motivated with the use of EOLo thanks to the healthy competition offered by the game during the development of learning activities. In addition, the system allows the detection of learning failures and from these generates a proactive feedback using educational resources recommendation.

As future work we propose to extend the game using global positioning tools, which allow the game to be deployed in open environments. In addition, it is important to incorporate the notion of challenges in the game promoting the competition through recognitions such badges or awards. The group challenges that consider rankings could discourage students with low score, for this reason; we want to include individual challenges that will keep students motivated on a continuous way. Finally, we seek to diversify the question typologies within assessments using as support multimedia resources such as videos, audio, images, etc.

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SNIFF: A Game-Based Assessment and Training Tool for the Sense of Smell

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Abstract. In this paper, we describe SNIFF, an integrated software and hardware environment meant to assess and train the sense of smell with a gamified approach. The sense of smell is usually neglected in digital application, but is important because it can foster motivation and engagement in learners.

SNIFF can be played in two modes, the assessment and the training which exploits the functionalities of an intelligent tutoring systems support. SNIFF was preliminary tested on 19 people to validate stimuli and the tool effectiveness in discriminating people smelling abilities.

Keywords: Smell · Assessment and training tools · Intelligent tutoring systems

1 Introduction

In animals, olfaction is a necessary source of information to rely on for surviving activities, such as hunting and localization of partners or predators. In humans, olfaction, as a chemical sense which stands between the distance and close senses, is believed to be a secondary way to know the world around, but it plays an important role for cognitive functions.

Many studies have focused on olfactory memory [10] that indicates both memory about odours and memory evoked by odours. It has some peculiarities: it is nominal, episodic, non-semantic and very durable [13]. Moreover olfactory memory is regulated by specific rules for the emotional sphere [20]. This peculiarity can be fruitfully exploited for learning environment, becoming the starting point for multisensory applications which put together digital tools and physical materials, thus fostering motivation and engagement by users, also with special needs.

Olfaction has been used as a precocious indicator of diseases such as Parkinson [17], and multisensory elements have been introduced in learning methodologies, such as storytelling, widely employed to support children and adults with special needs [8]. It gathers attention from people with profound intellectual and

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mental disabilities [18] and, as it touches the emotional dimension of individuals with disabilities, it helps keeping the person focused on the story. These studies are focused on a small subgroup of the population, but we do believe that humans can retake olfaction as a source of information and that educational specialists can use it to enrich learning stimuli.

For these reasons, in our opinion, it is important to renew tools to assess and train the sense of smell and include them in game-based learning environments. The present paper addresses this issue by proposing a tool that can be both used to assess and train the sense of smell, thus offering to starting point of multi-sensory learning application, SNIFF. To underline SNIFF new elements, we start describing related tools and their use.

2 Tools to Assess and Train the Sense of Smell

There are various tools to assess the sense of smell, based on experimental methods, which can be distinguished in objective and subjective measures, without and with participants collaboration. An objective measurement of olfactory functionalities is important in neurological context, as it allows to evaluate smell disorders as hyposmia, a reduced ability to detect odors or anosmia, the complete inability to detect odors. An example of objective method is ERPS, event-related potentials, in particular sensorial ERPS.

The subjective measure, instead, relies on the presentation to the participants of an olfactory stimulus that must be perceived and then recognized. This is the case of the so-called sniff tests in which participants must inspire odour from containers [9]. Moreover there are olfactometers that measure the response to odours during sleep [1] or the ability to identify a target odour [11].

Complementary to this methodology, there are some tests for qualitative odour recognition, such as the UPSIT, the University of Pennsylvania Smell Identification Test (UPSIT). It can be self-administered and uses microencapsulated odorants released by scratching standardized odor-impregnated test booklets [6]. From this test, the CC-SIT, Cross-Cultural Smell Identification Test, was developed, a newer and faster version with 12 stimuli [5].

Together with the described tools, which are mainly used in medicine and neuropsychology fields, there are various materials, coming from the educational context, which aim at stimulating the sense of smell. For example, the Montessori method [15] proposed a wide variety of materials that favor active exploration and try to stimulate all children senses.

Specific materials, named Montessori sensorial materials are widely used in the Montessori classroom to help a child develop and refine her five senses. They offer the chance to engage the learning child sight, touch, sense of smell, taste and hearing, also promoting action which is especially important in the first phases of human development [12].

To recover the sense of smell, that is instead, almost completely neglected in digital application, and exploit its potentialities in promoting motivation in learners, the authors propose a twofold pathway which, on one side aims at assessing smell abilities in different populations and on the other, to train this sense.

This approach represents the pre-requisite for multisensory tools as educational materials [2,16], applied to story-telling [3], to books [4], to cognitive assessment [7].

In what follows, the prototype SNIFF, dedicated to smell test and training, is described in detail, together with some preliminary data on its use.

3 SNIFF Description

SNIFF is a Technology Enhanced Learning application which is intended to assess and stimulate the sense of smell, usually neglected in digital applications. It is represented in Fig. 1. SNIFF is inspired by the Montessori approach, in particular by the material named smelling bottles or jars, present in the sensorial area of Montessori classroom. SNIFF proposes to the user a game about smell, using the Game-base approach to learning [19]. Gamification, which has been fruitfully applied to a wide variety of contexts, including tests, can also transform the assessing setting in a game. This technique gives some remarkable advantages, such as a more accurate data recording process, a high-level of engagement on the possibility of preventing the participant to be aware of undergoing an assessment procedure, thus mitigating the response biases related to test. SNIFF [3] is conceived as a game with 30 attempts, each consisting in the association of a smell with the corresponding image that is proposed by the software. These 30 exercises reside in the database, which collects the smell activities that help to refine the olfactory sense in children.

SNIFF augments 30 smelling jars with RFID that can be read by the table, where the antenna resides.

Fig. 1. SNIFF: the child interacting with the smelling jars and the SNIFF software

It recovers traditional psycho-pedagogical Montessori-inspired activities, exploiting TEL materials to build hybrid educational materials which augment the traditional smelling bottles.

SNIFF was implemented using STELT (Smart Technologies to Enhance Learning and Teaching), an integrated software and hardware platform to build educational materials. It allows to design and implement learning materials based on artificial intelligence and tangible interfaces, for example physical objects which are equipped with RFID sensors, as tools to support user-computer interactions [14].

STELT includes three modules: the first one is devoted to storyboarding and allows to build customized personalized scenarios; the second one is recording that offers the functionalitied to rack users' data interaction; the third one implements adaptive tutoring, that delivers on-time feedbacks.

3.1 SNIFF Structure

SNIFF has a structure that includes two functioning modes, one devoted to assessment and one to training:

a. **Assessment mode**: this module is meant to evaluate the smelling abilities and proposes the 30 odours. The systems records how many odours are correctly recognized and how many errors are committed;
b. **Training mode**: this module has the goal to help refining smell discrimination abilities. It uses the data on correct and wrong answers to adapt to the single player.

The training module, in order to facilitate recognition, also foresees a condition in which the jars are divided into 5 groups of 6 odours, identified by a coloured jar. This categorization is casual and not semantic. The system asks for the selection of a specific smell, within a reduced group of jars, identified with the chromatic categorization (i.e. the request is search only between the red and yellow jars). SNIFF assessment module can be considered a TEL version of subjective methods to measure olfactory abilities, whereas the training module is a TEL material to stimulate the sense of smell. Let us describe in more detail the SNIFF tutoring system.

3.2 SNIFF Tutoring System

When SNIFF is played in the training mode, the SNIFF tutoring system is active. It has been introduced with the purpose to provide a personalized pathway to improve everyone's sense of smell. SNIFF adapts to the player abilities in two different ways:

- If the player fails the recognition, SNIFF decreases the difficulty level reducing the numerosity of the groups to look for the odour within; if the player is able to recognize the stimulus, in the next exercise the level will becomes higher, widening the group.
- If the player fails the recognition of a certain odour, the associated probability to be proposed increases, otherwise, if the odour is correctly recognized, it decreases.

Let us give an example of how the SNIFF tutoring system works in the training mode. The participants starts from an intermediate level where she is asked to recognize a certain smell between two sub-groups ("Find the honey smell. It is in a yellow or blue jar"). If she fails, next time she will be asked to find it in a smaller groups ("It is in a blue jar"); if she correctly identifies the smell, she moves to a more difficult level ("Find the orange smell. It is in a yellow, blue or green jar"). In case of failure, the probability of presentation of a certain smell increases. SNIFF gives an appropriate and immediate feedback to the player. If she finds the correct smell, the system shows on the screen a little curiosity on the found smell. If the choice is incorrect, it says which was the right odour or invites to go on searching.

3.3 SNIFF Learning Analytics

One of the goals of SNIFF is to collect data about players interaction with the hardware/software system, which is done by a module for learning analytics where data are recorded and analyzed. The analysis is done a different level of granularity: single player for a certain stimuls, single player for the entire session, aggregated data for gender, age, special features such as smoking or not, etc.

4 SNIFF Preliminary Validation

We have run a preliminary validation in order to run a stimuli analysis and get some feedback on the tool to improve it.

4.1 Participants and Procedure

SNIFF has been preliminary tested on a group of 19 people, 12 males and 7 females with an average age of 21,06 and without any neurological impairment. We arranged an experimental design with four conditions, WITH and WITHOUT tutor crossed with WITH and WITHOUT facilitation, in order to understand the effectiveness of the tutoring functions and of the role of the physical facilitation. The experiment runs as follows: the experimenter introduces the participant to the experimental session, telling that it is a game to assess olfactory abilities. During each session SNIFF presents to the participants a number of images, for example a fruit or a plant and the participant has to look for the corresponding smelling jar.

The participant does not receive any help from the experimenter and goes on until all sessions are over. The participants were then interviewed to have feedbacks about the tool. In this paper we describe the results about one of the cited conditions, namely the one with the tutoring system and the facilitation for stimuli.

5 Results

In this section we report some preliminary results on the first trials. In this moment the focus was kept to the stimuli analysis in order to improve and make SNIFF more flexible.

In fact in some situation using 30 stimuli can be too much, so we wanted to identify the discrimination chance offered by each stimulus. The first analysis was focused on stimuli validation. The ratio error-number of presentation was computed and the stimuli were put in order according to an increasing criterion, as represented in Fig. 2, on the left.

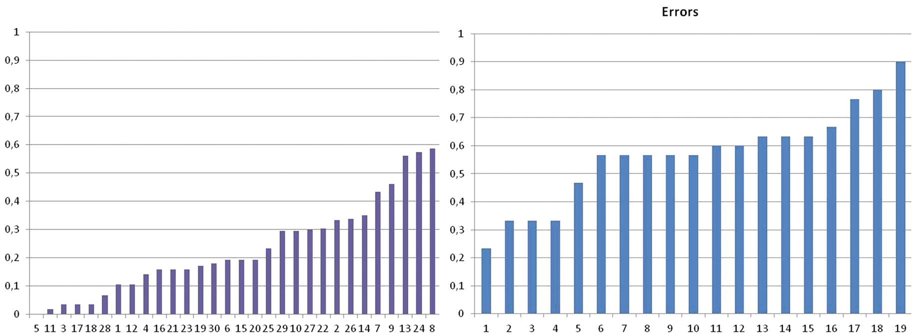

Fig. 2. Average errors for each stimulus (left) and errors by participants (right)

It emerges that some stimuli are much more frequently recognized than others. Interestingly the familiarity with the stimuli doesn't affect its recognition. The stimulus 5, corresponding to honey has been always recognized, whereas the stimulus 8, corresponding to the rose, which is also very familiar, has not been recognized more than half of the times.

A great variability is also observed between participants. In Fig. 2 the number of errors for each participants are reported, on the right. In fact some participants commit few errors, whereas some other have correctly identified only 3 stimuli. Smoking participants had a performance that was comparable to non-smoking ones.

6 Conclusions and Future Directions

Smell is a neglected sense in the digital world and, when it is introduced, it stimulates a great interest. The participants reported that it was very stimulating to play with SNIFF and they didn't get bored. They found very appealing to put to test their smelling activities, which was a completely new challenge for them. In the following of this project, we will run a more structured user experience study with questionnaires on usability to complement the interview. The data on stimuli and participants indicate that SNIFF tools is able to discriminate smelling abilities, to distinguish good smellers from bad ones.

Moreover some stimuli are better discriminating than others and will be included in a more agile version of the tool, to be used, for example, in rehabilitation context.

SNIFF is currently a prototype which can be developed in three complementary directions: Assessing tool: it can be a subjective assessing tool, employed in neuro-psychological context to give hint on smell functionality. In this case only stimuli which can effectively discriminate smelling abilities will be kept: this requires a stimuli validation.
Learning material for smell: it can be a game-based learning material for smell. This direction consists in renewing traditional Montessori materials with TEL methodologies and by exploiting the intelligent tutoring system to support smelling abilities improvement.
Module for smell: it can be a module dedicated to smell in wider learning applications, meant to stimulate all sense together with cognitive abilities, as in the cited case of story-telling.

Even if the SNIFF validation as assessing and training tool is still a long way to be followed, there is no doubt that introducing multisensory elements in educational application can be a powerful element to produce innovative teaching and learning technologies. Smell can vehiculate traditional educational contents in a richer and more appealing way, thus facilitating memorization, and vehiculate new educational contents, for example related to nature and to nutrition education.

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