ABSTRACT
Grouping students in e-learning using alternative methodologies offers complementary results in education. Today's trend in education is to integrate computer-based tasks with practical activities. Students are often encouraged to work in groups to solve complex tasks and develop collaboration skills. But classical grouping strategies can’t be used in e-learning environments where there’s little or no physical interaction between parties. We introduce a computer-based grouping method that takes into account the alternative student typologies and the neuro-linguistic programming (NLP) profile. Typologies are determined, according to the Enneagram methodology, with the RHETI test and refined with a MBTI test. The NLP profile is evaluated by an eye-tracking system, based on eye movement patterns. A correlation between enneagram and the MBTI typology is performed to refine the grouping process. Case studies show that groups created using this method show an increased communication among the members and better practical results. This is due to the members’ compatibility, which facilitates better collaboration.

KEY WORDS
e-learning, enneagram, MBTI, eye tracking

1. Introduction

1.1 Background

Alternative grouping strategies for students have been extensively studied in past years. Over time, many solutions were proposed to solve the unsatisfactory aspects of the school system. While most of these were often rejected, the traditional structure remained unchanged.

Driven by recent technological advances, one new approach – electronic supported learning and teaching (e-learning) is increasingly used in addition to traditional education. In e-learning, the student has a more active role than in traditional learning, being involved in the lesson structure, while the teacher acts as a mediator.

E-learning facilitates group learning activities, also called cooperative learning. By working in groups, students develop collaboration skills and they are easier to manage by the teacher.

Cooperative learning is effective when students work together to accomplish shared goals and when positive structures are in place to support that process [1]. Different grouping strategies have been proposed in literature.

A common strategy is based on the students’ skills. In this case, each group uses an expert to minimize the knowledge gap between the group members.

Another grouping strategy consists in choosing the students that are more likely to accommodate a predefined role. For example, one student may be in charge of the design, another could do task management, and another may actually perform the activity. Roles allow students to discover, exercise and develop individual skills, while the entire group benefits from the collaboration of its specialists.

Roles are a common social psychology factor with significant influence for groups. But other grouping strategies also take into account factors like relationships, power or dependence, [2].

Following, we present some methods that are closely related to our alternative approach.

Grouping based on Myers-Briggs Type Indicator (MBTI). MBTI [10] is a personality test that measures four aspects of people's personalities: Extroverted versus Introverted (E/I), iNtuitive versus Sensing (N/S), Thinking versus Feeling (T/F) and Perceiving versus Judging (P/J). Combinations of these aspects generate 16 different personality types. Many studies have investigated the use of the MBTI test in education [11, 12, 13].

Shen et al. [13] propose a grouping strategy based on 5 tiers. For example, Tier 0 contains the personalities that are most suited for team leadership: ISTJ – Inspector – pragmatic, detailed, organized; ESTJ – Supervisor – practical, realistic, decisive. Placing ISTJs and ESTJs
within the same group, due to the inherent potential for a power struggle to develop, is not advised.

Amato et al. [12] use Myers-Briggs personality profiles to evaluate the consistence and the progress of a group. She classifies groups containing similar personalities as compatible and groups that “blend individuals with different talents and preferences” as complementary. She finds that students with no prior group experience prefer compatible groups due to the comfort of such a structure, while students with experience prefer complementary groups where their talent is valued.

Grouping based on the learning strategy. F. Tian et al. [14] propose a grouping method based on a fuzzy analysis of student personalities and their learning strategies. They use an extension of Raymond Cattell’s 16 Personality Factors [15] model to determine a student’s personality and learning strategy. When grouping students, the fuzzy algorithm ensures that students with common learning characteristics are part of the same cluster. This way they can better collaborate and improve their skills.

1.2 Problem statement and approach

This paper extends our previous results [16], and addresses the problem of student grouping in e-learning, where little or no physical interaction takes place between the teacher and his students. Given these circumstances, we can only rely on the computer for analyzing the psychological and technical profile of the students.

The goal is to divide the class of students into groups and assign roles accordingly, in order to maximize the efficiency for team-based projects.

To achieve this, we first observe the students during individual practical activities, using our e-learning environment. This consists of a Content Management System (CMS) and an eye tracking system [3]. The eye tracking system, not only provides assistance when a student has difficulties in following a visual presentation, but is also able to detect some aspects of a student’s personality (e.g. predisposition to visual elements, audio elements, spoken communication etc.). These aspects define the NLP (Neuro-Linguistic Programming) profile of a student.

In the next step, we use the RHETI (Riso-Hudson Enneagram Type Indicator) [4] test, to determine the students enneagram typologies and a MBTI test to determine the corresponding typology [10]. A correlation between enneagram and the MBTI typology is performed to refine the grouping process. Finally, we divide the class into groups and assign roles, considering the typologies and the NLP profiles.

The grouping strategy we use is based on typology compatibilities, which are a result of the psychological interpretation of the Enneagram. Some typologies prove to show better progress if connected to their psychological complement. Members of such groups achieve better results than members of groups that don’t take into account the personality factor or the compatibilities between personalities [5].

1.3 Outline

This paper is organized as follows: the next section details the personality factors considered for our solution, section 3 describes the proposed grouping strategies, results are discussed in section 4, while section 5 provides some conclusions of our work.

2. Personality factors

2.1 The Enneagram of Personality

The Enneagram of Personality (known as the Enneagram) is used in a variety of contexts, including business, psychotherapy, spiritual development work, art and education. It is an application of the Enneagram figure in connection with personality features, including nine main typologies (Fig. 1).

The points on the Enneagram figure indicate a number of ways in which nine principal ego-archetypal forms, or types of human personality, called Enneatypes, are psychologically connected. Enneatypes are referred to by different names, or more general by numbers. These are some of the variations (Fig.1 b):

a. 1. Perfectionist, Reformer
   2. Helper, Giver
   3. Performer, Producer, Achiever
   4. Tragic Romantic, Individualist, Connoisseur
   5. Observer, Investigator, Sage
   6. Devil’s Advocate, Loyalist, Troubleshooter, Guardian
   7. Epicure, Enthusiast, Visionary, Dreamer, Generalist
   8. Boss, Top Dog, Challenger, Confroner
   9. Mediator, Peacemaker, Preservationist

b. 1. Perfectionist, Reformer
   2. Helper, Giver
   3. Performer, Producer, Achiever
   4. Tragic Romantic, Individualist, Connoisseur
   5. Observer, Investigator, Sage
   6. Devil’s Advocate, Loyalist, Troubleshooter, Guardian
   7. Epicure, Enthusiast, Visionary, Dreamer, Generalist
   8. Boss, Top Dog, Challenger, Confroner
   9. Mediator, Peacemaker, Preservationist

Fig. 1. Enneagram and Typologies

Each Enneatype (chief feature) corresponds to a distinctive and habitual pattern of thinking and emotions. The Enneatype of an individual can be determined using the RHETI (Riso-Hudson Enneagram Type Indicator) test, which contains 144 paired statements.

Based on the Enneatypes, different strategies can be considered to define working groups of students (or any other types).

Ideally, when all 9 Enneatypes manifest within a group, the members’ evolution is more rapid. But it’s possible to have a group with a limited number of typologies, less than 9. In this case, the unity, cohesion and communication are very important.
Our aim is to create a harmonious group where members with compatible Enneatypes can easily collaborate and obtain valuable results. But only typologies are not sufficient for assigning roles to the group members.

2.2 MBTI and Enneagram methodologies

The MBTI and Enneagram are two different personality typologies. As alternative methodologies they work well when are used in conjunction [17].

MBTI was developed in the early 1940's by Myers & Briggs that extended Jung's model. The model looks at the conscious functions of taking in information through the functions of Sensing and Intuition and making decisions through Thinking or Feeling. MBTI model is very accessible and therefore most often practiced. MBTI literature focuses on the positive or more neutral aspects of the types before considering a stress situation.

The Enneagram has an esoteric history based on ancient civilizations. It dates back before the mystic schools of Islam and from ancient Greek civilization using “Tetrakits” as a Pythagorean symbol. The Sufis, Greeks, Cabalists used aspects of the Enneagram in the spiritual development of initiates. The Enneagram looks how the 9 different typologies influence our orientation to the world. The Enneagram model is considered as focused to the shadow aspects of personality. As real world applications of the Enneagram model we have orientations for business and self-development.

A mapping between MBTI typologies and Enneatypes

Different mappings from MBTI to Enneagram are presented in literature. There isn’t a direct correlation accepted, but there are some things that may be typical however given the understanding that there is an exception to every one of these forced correlations. A possible correspondence can be [19]:

- Enneagram 1 and I*TJ
- Enneagram 2 and E*FJ
- Enneagram 3 and E*TP
- Enneagram 4 and INFJ
- Enneagram 5 and I*TP
- Enneagram 6 and ISFJ
- Enneagram 7 and E*FP
- Enneagram 8 and E*TJ
- Enneagram 9 and I*FP

Some authors and researchers have mapped this even more extensively than these limited correlations, [17], [18].

The correspondence between Enneatypes and MBTI types helps to refine the grouping process.

2.3 Correlating eye movement patterns with personality features

Using NLP (Neuro-Linguistic Programming), it is possible to classify the persons based on some specific characteristics of eye movement patterns in different structures [6]. If we are able to determine the predominant pattern for a person, we can send a message that is adapted and suited for that person.

The visual structure is representative for persons that are sensible to visual materials, graphics, images, etc. Such a person will have a precise ocular movement based on a moment attitude. When they think, they will raise the eyes having a visual contact.

The auditory structure is based on hearing. Persons in this category are sensible to sound effects, noise and voice tonality. When they are looking for something, their eyes go to the left or right side.

The sensitive structure includes persons that are sensible to extra verbal communication. A down movement of eyes when they communicate and a left-right movement is characteristic to them.

Not as a specific structure, but as a combination of different structures are the kinesthesias persons. The general movement and the need for space is their characteristic. When they speak they are moving and the action memory is very important. The eyes have no precise movement. So an up, down, left and right movement appears during the person activity.

3. Proposed grouping strategy

3.1 Scenario

We use e-learning for teaching software-related disciplines: Basic Object Oriented Programming, Software Engineering in Telecommunications at licencese level, and Advanced Elements to Develop Software in Telecommunications at master level. Each course is followed by practical learning activities.

The first part of each module is dedicated on making students familiar with the technologies used for the practical activities. We take advantage of this accommodation period and observe the students. This observation done by the eye tracking system they use to follow the theoretical aspects and by the teacher who conducts the practical activities.

At the middle of the semester, the students need to be assigned to working groups. Each working group is given a project, which is evaluated at the end of the semester. Within the group, each student plays a well-defined role. Being a software project, the roles we support are: manager, designer, analyst, programmer, tester and technical writer. Not all groups can have a manifestation of each role, due to the limited number of members.

Such a scenario raises two questions regarding student grouping: 1) What is the best grouping strategy that maximizes the students’ potential in solving the required task? 2) If efficient grouping requires knowledge about one’s personality, how can such knowledge be acquired by a computer?
First, we approach the second problem. We determine two features for each student (Fig. 2):

1. The NLP profile $N$. The eye tracking system does this, while the student is using the e-learning environment during the first part of the module.
2. The typology $T$, according to the Enneagram. The typology is evaluated using the RHETI test, which students take before the group assignment and is refined with a MBTI test.

Given the feature set $(T, N)$, the grouping strategy is a function from $(T, N)$ to $(G, R)$. This process is detailed at the end of this section.

3.2 The e-learning platform

The massive penetration of mobile computing is reflected by the fact that almost every student nowadays owns a laptop. Also, due to the evolving communications needs, most laptops are fitted with an integrated webcam. We use this widely available technology to implement a student-centered e-learning solution.

Students use their laptops to follow course material presentations. During the course, some areas of each slide capture the attention of certain students. This is measured by analyzing their eye movements, captured by integrated webcams. When difficulty (manifested through an increased interest over some elements of the visual scene) is detected, it is recorded and the student is automatically shown supplementary explanations. If more students encounter the same issue, the teacher is notified so that he can insist on explaining it to the students. At the end of the class, a report is generated based on the recorded difficult sections for later review.

The e-learning platform has two components, corresponding to the two parties involved in the learning process (Fig. 3):

- **Learning assistant** – intended to help the course attendants by tracking their progress and providing computer assistance.
- **Teaching assistant** – used by the course owner to supervise the learning process.

The Learning assistant relies on the webcam to evaluate the subject’s reaction for the visual scene. Roughly, the visual scene is composed of text regions and images. These elements are called Regions of Interest (ROI). A typical reaction to a text region is to read the entire text and focus on the elements that are new to the subject or are intentionally marked as important (i.e. some words in bold). Behavior that can be associated with learning difficulty consists of longer focus on certain areas of the visual scene or an irregular reading pattern.

The eye-tracking component of the Learning assistant is based on the Machine Perception Toolbox (MPT) framework [7], which supplies cross-platform libraries for real-time perception primitives, including face detection, eye detection, blink detection, color tracking. MPT provides support for eye detection, which we used to implement real-time eye tracking.

Figure 4 shows the eye-tracking window where the face is delimited by a white rectangle and the eyes are marked with two smaller rectangles. The eye-tracking engine evaluates the eyes position for every frame, eliminates the aberrant values, and averages the normalized consistent values every 15 frames. Normalization is done by taking into account the head position in the video frame. Resulting values are sent to the scene tracking component for analysis.

Identifying the important elements to the subject is called scene tracking. In the process of scene tracking, the subject’s gaze needs to be translated into a ROI. First, we evaluate the fixation count for each element in the scene, and then we select the elements above a certain threshold. Each course slide is apriori annotated by the knowledge processor and the position of a ROI on the screen is known. Therefore, we only take into account the fixations that fall over such elements and ignore the rest.
Scene tracking often identifies more than one element. Because there’s a limited amount of time the student is facing one scene, we need to pick the most important elements of the scene. We call this selection of elements interest tracking.

For simplification, we pick the first most focused element by the subject. This is the student’s main interest regarding the visual scene. The element of interest is then sent to the Teaching assistant for statistical processing. Based on the interest sent, a response is received in the form of new knowledge – extra information related to the scene’s most observed element.

The Teaching assistant is a CMS intended to host and manage the information transmitted to the students during the learning process. First, the teacher creates the course materials. The course flow resembles a typical presentation, slide by slide.

The knowledge processor is the automatic process that does ROI identification and tagging. It analyzes the content and breaks it into knowledge units. Each knowledge unit can be a text block or an image.

Text blocks are split into text segments and stop words are removed. Each text segment is linked to its semantically similar terms. The semantic analysis uses a dictionary called WordNet [8] to search for synonyms. Images are added a semantic description.

The semantic information about the visual scene is used as search patterns by the interactive knowledge module. We use Wikipedia as a source for new knowledge. When a search pattern links to a Wikipedia page, that page is sent to the Learning assistant as new knowledge based on subject’s interest.

A video demonstration of our e-learning platform can be found at http://mercur.utcluj.ro/eyetracking/

3.3 Student grouping

When creating groups of students we want to maximize the positive interactions between the group members. This can be done if we take into account the compatibilities between the group members. In other words, we want to have all nine Enneatypes to manifest as complementary aspects.

The manifestation of all typologies can be realized considering a limited number of members, less than nine, but with specific interactions. A group needs to have at least three members in order to achieve an optimum structure (the three’s law).

One strategy may consider that the Enneagram is organized in three triads (Fig. 5), and the Enneatypes in each triad are thought to share similar characteristics. Rohr refers to these as the Gut, Heart, and Head triads [9]. Theoretically, one of these areas predominates in each of us. An optimal group structure needs to have at least one representative from each triad, but not any representative.

Gut-people are known to be direct, territorial, concerned with power, ruled by aggression. Their predominant emotion is anger and their mind may be troubled by ethical self-doubts and self-blame. They act instinctively, spontaneously and intuitively.

Heart-people are ruled by feelings. They are often concerned with what others think of them, seeing themselves as being for others and often believing they know what’s best for them. Their predominant emotion is anxiety, they dislike being alone, may feel sad and ashamed.

Head-people are methodical and orderly, detached from their emotions. They try to apprehend every situation, understand the pattern of events and their place within it. Their predominant emotion is fear.

The grouping process starts with identifying the Chief Feature. This can be a base Enneagram type (Enneatype), or a combination of two adjacent types, as, for example, Four and Five. This combination can be regarded as a subtype. The types on each side of the Chief Feature are called wings (Three and One are wings for Two). In case of a subtype, one wing is the weaker type of the two composing the subtype.

Each Enneatype is connected with two other types, in different triads. The connection is marked with a path (line) in the Enneagram representation. For example Nine is connected to Three and Six. These connections show how one Enneatype behaves under integrative (growth) or disintegrative (stress) conditions. The integrative / disintegrative behavior follows the directions shown in Figure 5. For example, under stress Nine will behave like a Six, while in growth will behave like a Three.

We considered in our research one base typology (Chief Feature), one typology on the integration direction and one typology on the disintegration direction, Fig. 5. In this way it is possible to define efficient groups using a general Enneagram test and an adequate interpretation. Such groups have a representative from each Enneagram triad, which complete each other.

The ideal group structure will have members with typologies 3, 6 and 9. Other possible grouping typologies are: (1, 7, 4), (2, 4, 8), (4, 1, 2), (5, 8, 7), (7, 5, 1), (8, 5, 2), using 1, 2, 4, 5, 7 and 8 as Chief Feature.

The use of Enneatypes for the group structure ensures the typology diversity. In this moment some refinements where introduced based on the corresponding MBTI typologies.

But this is not sufficient if we want to maximize the success of a group. In order to do this, we combine the
Enneagram rule with the NLP profiles determined by the eye tracking system to obtain groups with representative figures from each NLP structure: visual, audio, sensitive, and kinesthesia.

4. Results

Case studies were conducted over a period of more years with students in their first and third year of Bachelor of Science classes, and the students in the first year of Master of Science. Students were observed during the practical activities of the Basic Object Oriented Programming with C++ and Software Engineering courses for bachelors and for Advanced Elements to Develop Software in Telecommunications at the masters. Each practical activity class consisted of two stages: a documentation stage, when the students were presented a summary of the theoretical aspects and a working stage, when the students put in practice what they learned.

The first part of each semester is dedicated on observing the students. This observation done by the eye tracking system they use to follow the theoretical aspects and by the teacher who conducts the practical activities. At the middle of the semester, the students take the RHETI and MBTI test and are assigned to working groups according to the proposed strategy. Each working group is assigned a project, which is evaluated at the end of the semester.

Each year, we apply this method on half the students, while the other half are grouped using the skill-based strategy (one expert in each group). These students are used as a reference to compare the results.

The first part of the group project consists in creating a “Task notebook” based on the specifications. Then, the group will divide the main tasks to each member and in the “External/Internal Reunion meetings” the drawbacks will be clearly specified and analyzed. Any new proposed solution will not be rejected being criticized, and if possible, a new solution will be chosen in the meeting. This practice encourages the creativity and originality. The Internal Reunions include only the group members, while the External Reunion requires the presence of the teacher. The final result is a “Specification Notebook” and the implementation of the product.

Mental connections that are feature the development of new technical solutions are not limited to the classical standard solutions. Group meetings are intended to stimulate brainstorming.

During their work on the project all the groups were suggested to use the brainstorming technique. Group brainstorming is effective when all members share their experience and creativity.

The total number of working groups observed during our experiments was 61. Out of these team groups, only about half accepted to use the brainstorming technique to develop projects (during the case study period, the technique was optional).

At the end of the experiments, three aspects were relevant:
1. Members of teams that were grouped based on compatibility typologies using enneatypes and MBTI showed better improvement, not in terms of acquired knowledge in particular, but in terms of learning how to combine knowledge with creativity. In about 25% of the brainstorming groups the evolution was spectacular.
2. Members of teams assigned using the proposed strategy proved to communicate more than members of classical teams. Communication featured brainstorming and all these aspects manifested in making the group more productive.
3. The developed products were original, full of creativity and more reliable.

As examples of some projects topics developed by the 2010-2011 Master of Science students we mention:
- Organic computing
- Workflow foundation based on Microsoft technologies
- Workflow application- PassFlow with Oracle BPMN Suite
- UML design
- HMI based on biometry
- Basic software testing
- Software testing – new methodologies
- HCI - FriendlyPC
- HCI - SpeechInteraction

Figure 6 presents the user interface of one of these projects.

![Figure 6. HCI – FriendlyPC](image)

Another experiment was conducted during the summer first year students’ internship at the Cluj-Napoca subsidiary of Wirtek, a Danish software company. Three rounds of internship stages were scheduled, while each internship stage took three weeks. Twelve students were admitted for each stage and they were grouped in two teams.
The internship was focused on developing software projects considering new technologies in C# and Java. The first round included the best students. They were grouped considering preferences, in the teams dividing process. The second round of students was divided considering an Enneagram methodology and was composed by students with lower software skills. The third round was grouped in accordance with some personality criteria established by the software company. The final evaluation, done by the software company analyzed obtained technical abilities, general training responses and team collaboration abilities. The first set of students obtained the best technical results with a linear evolution. The collaboration process during the teams was limited, each student working on dedicated tasks. The second set started with huge difficulties considering technical abilities. The compatibilities of the members from the teams helped them to evolve in an exponential mode. The final evaluation revealed very promising results for acquired technical abilities and the relations among the members were very opened and harmonious.

In the third set, the teams were created based on the company’s criteria, which involved five personality types. The final evaluation concluded that the second set of students showed better improvement than the first and third set, in terms of technical skills and social interaction.

5. Conclusion

In this paper, we propose a grouping strategy for e-learning environments, where there’s little or no physical interaction between the teacher and its students. But effective grouping strategies take into account personality factors, which are hard to evaluate by a computer. Since our e-learning platform features an eye tracking solution, we use this to create a student’s neuro-linguistic programming (NLP) profile, while he is actively using it. Another original aspect of our work is the use of typologies, determined according to the Enneagram methodology, with the RHETI test. A refinement is considered based on a MBTI test.

Groups are composed of 3 members, of compatible typologies. Compatibilities are according to the integrative and disintegrative directions on the Enneagram. This also ensures that each group has a member from each Enneagram triad. The NLP profile also plays a role in the group structure, as each group needs to have a representative of each defined profile. We conducted case studies to test our solution over more years, with students with different levels of group work experience. Our results show that groups created using this method perform better than groups that don’t take into account the personality factor, in terms of self-development and group communication.

During the work on their assignment, all the groups were suggested to use the brainstorming technique. Members of groups that used brainstorming showed better improvement, not in terms of acquired knowledge in particular, but in terms of learning how to combine knowledge with creativity.

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