Education Tech Research Dev (2012) 60:83–110
DOI 10.1007/s11423-011-9215-4

DEVELOPMENT ARTICLE

Group formation based on learning styles: can it improve students' teamwork?

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Published online: 5 September 2011

Abstract This work explores the impact of teacher-led heterogeneous group formation on students' teamwork, based on students' learning styles. Fifty senior university students participated in a project-based course with two key organizational features: first, a web system (PEGASUS) was developed to help students identify their learning styles and distribute them to heterogeneous groups. Second, group facilitation meetings were introduced as a technique to help students reflect on their weak/strong traits and employ appropriate roles in their group. The study research questions focused mainly on students' attitudes regarding the learning style-based group formation approach. By applying qualitative research method students' views were recorded about the impact of styles awareness and group heterogeneity on group collaboration and possible benefits and drawbacks related to the style-based grouping approach. Evaluation data revealed that students gradually overcame their initial reservations for the innovative group formation method and were highly benefited since styles heterogeneity within the group emphasized complementarities and pluralism in students' ways of thinking. Overall, this work provides evidence that the adoption of learning styles theories in practice can be facilitated by systems for automated group formation and supportive group facilitation meetings that help avoiding the trivial and discouraging approach of using learning styles to simply label students.

Keywords Learning styles · Group formation · Technology-enhanced collaborative learning

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Introduction

Collaboration and team building skills are defined as the ability to work effectively with others, including those from diverse groups and with opposing points of view (American Management Association 2010). Furthermore, education research has emphasized that when students are actively involved in collaborative activities tend to learn best and more of what is taught, retain it longer than conventional teaching, appear more satisfied with their classes and improve project quality and performance (Dillenbourg 1999; Gross Davis 1993, Soliman and Okba 2006). Collaboration also helps students to develop social, cognitive and reasoning skills such as communicating and making ideas explicit, being responsible and cooperating with others (Schlichter 1997). The roles and interactions of the individual members may determine the group's productivity and success, and the way in which students are grouped may affect the results of the learning experience (Webster and Sudweeks 2006; Martin and Paredes 2004). Therefore, suggesting appropriate group formation might solve many problems before they arise (Muehlenbrock 2006). Research on work team diversity has begun to investigate the form of diversity that is based on psychological features of team members and includes individual differences involving personality traits and values, as well as attitudes, preferences and beliefs (Harrison et al. 2002). One of the features that can be taken into consideration when suggesting group formation is students' learning styles, which seem to constitute a valuable tool for establishing groups, according to many researchers (Al-Dujaily and Ryu 2007; Alfonseca et al. 2006; Grigoriadou et al. 2006; Martin and Paredes 2004; Muehlenbrock 2006; Wang et al. 2007).

Although students' learning style preferences seem to be valuable for team building (Yazici 2005), there is a need for supportive pedagogies to encourage attention to individual learning differences and to sensitize individuals to their own and others' preferred learning styles (Cools et al. 2009). According to Waring and Evans (2005), helping students to develop their metacognitive potential in raising awareness of one self's and others' learning should be a key goal.

Based on the above research evidence, we applied a group formation method based on students' learning styles, in order: (a) to raise students' awareness of their learning styles, and (b) to help embedding diversity in the process of group formation in a disciplined manner (that is, to include students of different learning styles in the group). After reviewing the learning styles literature, we selected to focus on a whole-brain thinking model, namely, the Raudsepp Problem Solving Styles Inventory (Raudsepp 1992) which, according to Hulme (1996), encourages students to gain insight into their thinking and learning style and helps them to formulate successful learning strategies. According to Karayan and Hulme (2003), the Raudsepp inventory is considered equivalent to the proprietary Herrmann Brain Dominance Instrument (HBDI) (Herrmann 1990) that offers considerable promise for use in education and training (Coffield et al. 2004).

Overall, this paper presents:

(i) The development of the PEGASUS web-based system (PErson-centred Group-Activity SUpport System), to (a) help students identify and reflect on their learning styles and (b) enable instructors to group students heterogeneously by establishing conditions of presumably improved collaboration.

(ii) The effect on students' collaboration of our approach that aims to reap benefits from heterogeneous group formation based on students' learning styles. We conceptualize this approach as belonging to the broader area of learner-centred pedagogy,

exemplifying the need for attention to individual learning differences. Eventually we expect that this approach will facilitate students and instructors: (a) in raising awareness of learning styles and (b) in creating improved conditions for group collaboration.

Theoretical background

Learning styles

Research has shown that there is a need for education to promote a global shift away from teacher-centred instruction, towards fostering the talents, capacities, interests and needs of the learners, which have been acquired through prior experience and social acculturation (American Psychological Association [APA] 1997). It has been argued that all individuals have a wide range of abilities across different types of intelligence (Gardner 1983) and they are happier when they use them (Robinson 2001). Individual differences seem to play an important role in learning and instruction (Jonassen and Grabowski 1993; Kolb 1984; APA 1997), and learning styles may improve students' academic performance and level of satisfaction (Layman et al. 2006; Brown et al. 2005; Voges 2005). The term "learning style" is broadly used in the literature to refer to learners' classification schemes depending principally on their dominating cognitive and psychological traits when engaged in learning activities. Kolb (1984) defines learning styles as the preferred method of perceiving and processing information, while Keefe (1979) describes learning styles as the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment. Vermunt (1996), also, describes learning styles as the relatively stable but not unchangeable consistent patterns of learning activities which are systematically linked to learning beliefs and motivational orientations. According to Vermunt (1996) learning style should not be conceived of as an unchangeable personality attribute, but as the result of the temporal interplay between personal and contextual influences. This suggests that while an individual's style should be expected to be stable when examined in a certain period of time or under specific conditions, this does not exclude the possibility that the learning style might change: (a) when different conditions occur, for example, when thinking and learning happens under pressure and stress (e.g. Hermann 1990; Caine and Caine 1991) or (b) when personality changes over time.

In the literature, terms like learning styles, cognitive styles (modes of an individual's perceptual or intellectual activities) (Messick 1976), and personality types are often used interchangeably although they are measured with different measuring approaches (Jonassen and Grabowski 1993).

A number of learning style models have been proposed over the last three decades; Kolb's Learning Styles Inventory (Kolb 1984); Hermann's Brain Dominance Model (Herrmann 1990); Felder-Silverman's Learning Model (Felder and Silverman 1988); Howard Gardener's Multiple Intelligence Theory (Gardner 1983); Myers and Briggs Type Indicator (Myers 1962); the Group Embedded Figures test (Witkin et al. 1977) and each has been used and evaluated in several learning situations.

Using learning styles in education have so far attracted both praise and criticism. While there are good pedagogical reasons for emphasizing the way in which learners differ, there

are also risks in using learning styles approach, as this approach reportedly suffers from reliability and validity, has no clear implications for pedagogy (Coffield et al. 2004; DEMOS 2005) and mostly labels students (Biggs 1999). For this reason, supportive pedagogies should be established that promote students' awareness and appreciation of different thinking and learning preferences (Cools et al. 2009). As Cain (2002) argues, what individuals learn about themselves is more important than the result of a diagnostic instrument in an assessment process. Therefore, encouraging metacognition—i.e., being aware of one's own views and beliefs about learning and actively regulating their learning processes (Flavell 1987)—seems to be the most important advantage that can be claimed by applying learning styles theory to learning and teaching (Coffield et al. 2004; DEMOS 2005; Mayes 2005; Menaker and Coleman 2007). Coffield et al. (2004), after reviewing 71 models of learning styles suggest that a knowledge of learning styles can be used to increase the self-awareness of students and tutors about their strengths and weaknesses as learners. They conclude that all the advantages claimed for metacognition can be gained by encouraging all learners to become knowledgeable about their own learning and that of others. According to Sadler-Smith (2001), the potential of such awareness lies in enabling individuals to see and to question their long-held habitual behaviors; individuals can be taught to monitor their selection and use of various learning styles and strategies. However, most students are unaware of their learning styles and if left to their own means, they are unlikely to start learning in new ways (Merrill 2000).

According to Waring and Evans (2005), personalization in the ways of learning should enable individuals to be more self-reliant in their learning and, therefore, helping students to develop their metacognitive potential in raising awareness of one self's and others' learning should be a key goal. Also, Sadler-Smith (2001) suggests that awareness of learning styles might make students more capable of adapting to different situations. Being aware of understanding and applying diverse learning styles and learning outcomes implicitly prepares students for later vocational and community realities (Petress 2004).

However, increased self-awareness should not be interpreted as support for more individualized instruction (Coffield et al. 2004). As Coffield et al. imply, simply being given the results of a completed learning styles inventory is unlikely to be helpful without a dialogue with a teacher who has both some knowledge of the individual learner and a sophisticated understanding of the theoretical basis of learning styles. Thus, dialogue seems to be a key prerequisite to personalization.

Considering all the above, we conclude that learning styles seem to play an important role in academic and social learning, assuming that they would be examined within a supportive pedagogical framework that would encourage student metacognition and teacher-student dialogue.

Collaborative learning and group formation based on learning styles

A key premise of this work is that in collaborative learning activities, the teacher may beneficially guide the group formation process by considering partners' learning styles. We argue that this assumption constitutes a major link between collaborative learning (as operationalized through the group formation process) and students' learning styles theory and practice.

In the learning context, *collaboration* could be defined as a situation in which learners interact in a collaborative and interactive way, and these interactions influence the peers' cognitive processes (Dillenbourg 1999). Research has shown that collaborative teamwork leads to more variety and creativity and can improve project quality and performance

(Soliman and Okba 2006), as it can lead to more intensive analysis or critique of the final solutions (Dillenbourg et al. 1995). Additionally, collaborative learning generates managerial skills, consensus building, and shared responsibility for success and failure (Summers et al. 2005). However, some students feel uncomfortable with collaborative learning activities and frequently view them as a threat to their performance (Ellis and Hafner 2008). Many students lack the social skills that are prerequisite to success in collaborative activities and, adapting to the new expectations and roles fostered by the environment can be threatening (Herreid 1998). The roles and interactions of the group members are very important for group's productivity (Webster and Sudweeks 2006; Martin and Paredes 2004). Therefore, appropriate group formation is an important process that might solve many problems before they arise (Muehlenbrock 2006) and may increase the probability that interaction among people would trigger learning mechanisms (Daradoumis et al. 2002). The term "learning mechanism" refers to learners activating certain cognitive processes of information processing (such as induction, deduction, compilation, etc.). Peer interaction in collaborative learning settings is expected to trigger learning mechanisms and promote the construction of knowledge (Dillenbourg 1999).

Research in collaborative learning is lately investigating techniques for group organization, aimed to gain the best learning benefits, academically and socially. "Academically" refers to the cognitive dimension, that is, benefits relevant to domain learning. "Socially" refers to the development of—mainly—communication skills. Instructors who are committed to collaborative learning need first to identify specific student characteristics for establishing groups. Jackson et al. (2003), after reviewing 63 studies and assessing the effects of diversity (distribution of personal attributes) on teams and organizations, conclude that among several personal features, group diversity based on personality and mental models is a promising research field that has not been thoroughly investigated yet. Diversity is a broadly defined term that refers to the plurality of personal attributes as expressed in the composition of a group.

Diversity based on psychological features of team members, like personality traits, attitudes and preferences is recommended by researchers in the area of team building (Bradley and Herbert 1997; Martin and Paredes 2004; Harrison et al. 2002). As time passes, increasing collaboration weakens the effects of surface-level (demographic) diversity on team outcomes but strengthens those of deep-level (psychological) diversity (Harrison et al. 2002). Another study reveals that while demographic characteristics such as age, race and gender evoke social categorization processes about diversity that may result in unfavourable team processes and outcomes, psychological characteristics such as learning style can evoke diversity of thought leading to enhanced team performance (Jules 2007). Learning styles (used here as a general term that also includes thinking styles, cognitive styles and personality types) seem to constitute a valuable tool for establishing groups, according to many researchers (Al-Dujaily and Ryu 2007; Alfonseca et al. 2006; Grigoriadou et al. 2006; Martin and Paredes 2004; Muehlenbrock 2006; Wang et al. 2007; Yazici 2005).

In Computer Supported Collaborative Learning (CSCL) systems, group formation can be performed either by the teacher or automatically by the system. Alfonseca et al. (2006) propose that automatic grouping is especially useful in the case where the students do not know each other and in the case where students tend to group themselves in a way that does not lead to a fruitful collaboration. However, although learning styles and personality types have been integrated in computer supported grouping systems (Martin and Paredes 2004; Christodoulopoulos and Papanikolaou 2007; Hishina et al. 2005; Wang et al. 2007), less attention has been paid to integrating pedagogical principles in the system design.

Considering the issue of the best pattern, although it has been referred that sometimes homogeneous groups (regarding abilities, experiences and interests) tend to be better at achieving specific aims (Johnson and Johnson 1994), in the majority of studies heterogeneous groups outperformed homogeneous in a broader range of tasks (Al-Dujaily and Ryu 2007; Alfonseca et al. 2006; Grigoriadou et al. 2006; Wang et al. 2007). Research has shown that diversity of learning styles can have a beneficial impact on learning, since the creative capability is significantly higher when the group is heterogeneous (rather than homogeneous) regarding learning styles (Herrmann 1987), as it generates different perspectives on effective strategies for dynamic group interactivity (Kolb 1999). Creative insights often occur by making connections between ideas or experiences that were previously unconnected, and this is why the best creative teams often contain specialists in different fields (Robinson 2001).

Diversity may evoke initial negative effects that gradually disappear over time allowing positive effects to evolve and this favors task conflict, better communication, and increased social integration, subsequently having a positive effect on performance (De Abreu Dos Reis et al. 2007). A variety of contextual factors (like the type of the work itself) may shape the effects of diversity observed across studies (Jackson et al. 2003). The general accepted assumption is that the potential benefits of diversity for performance are greater when the task requires creativity and innovation, whereas when the task is routine, or when speed is the goal, diversity may interfere with performance (Williams and O'Reilly 1998). Heterogeneous teams experience difficulty in reaching consensus, but because of their diversity can be synergistic and therefore ideal for creative/innovative assignments (Herrmann 1990). Additionally, it seems that driving up perceptions of fairness, is likely to drive up student satisfaction with the selection process and promote a more positive project team experience from the outset (Nicholson et al. 2002). The combination of learning preferences with collaboration suggests that there is a need to accommodate diversity of learning preferences in team building (Yazici 2005) therefore, we conclude that it is worthwhile to investigate the effect of partners' learning styles heterogeneity on their collaborative learning activity.

Regarding group size, research has shown that successful groups normally do not exceed five members, although exceptions can occur (Petress 2004). Too large size of a group invites unfair and debilitating labour divisions, allows some members to assume full responsibility, promotes sub grouping and makes group management a high priority (Petress 2004). Nevertheless, according to Petress (2004), there are some criteria that should be met for a successful group collaboration referring whether: (1) students' major reason to join a study group is to learn; (2) students are responsible and will attend group meetings regularly, on time, prepared, and in the mood for work; (3) they are willing to and able to actively participate in group work; (4) they can be tolerant of others' ideas, learning styles, and conclusions. A similar notion is advanced by Hoffman (1959), who states that a diversity of viewpoints must be accompanied by a tolerance for differences of opinion if the group is to exploit its potential creativity. Additionally, when students are allowed to choose among learning activities based on their preferences, they learn better (Lewis and Hayward 2003). Diversity awareness, tolerance, and acceptance are also other group collaboration benefits (Petress 2004). According to Kolb (1999), when group members reflect on their learning styles they may have a heightened awareness of how their styles affect group dynamics. Pettigrew (1998) also sustained that change is facilitated when people gain new insight about their own in-group, therefore organizations should support awareness training and provide insights about oneself as well as about others. Therefore, fostering students' reflection on their own and group members' learning styles seems to

play a critical role in successful collaboration and investigating styles awareness would be worthwhile.

Study design overview

Research questions

Based on the above theoretical background, we argue that a key research perspective is to explore the impact of learning style-based group diversity and learning style awareness on students' group learning activity.

Toward this objective, we, first, developed the PEGASUS system to (a) automate the process of formulating student heterogeneous groups based on learning style, and (b) help students identify and reflect on their learning styles. Furthermore, we implemented a project-based course to focus students' attention to individual learning differences while working collaboratively and explore their conceptualization regarding the conditions of collaboration.

Our aim was to gain insight into students' experiences of working together in a learning style-based heterogeneous group introduced by the teacher. By recording data regarding student reflections on their process of collaboration, we expect to understand whether our intervention created favorable learning conditions or not. In our study, we investigated students' attitudes and satisfaction, since we expect that the method of grouping itself has an appreciable effect on the students' satisfaction with the project (Nicholson et al. 2002). More specifically, during students' collaboration we recorded research data and we implemented a qualitative research methodology to analyze the following questions:

(a) What were students' attitudes concerning the learning style-based group formation approach?
(b) How did learning styles awareness affect group collaboration?
(c) How did group heterogeneity affect group collaboration?
(d) Did the overall course organization benefit students' collaboration and was it a satisfactory experience for the students?

Design of PEGASUS

The PEGASUS system development process included three major phases:

(i) Selection of an appropriate learning styles inventory.
(ii) Design of an appropriate algorithm for heterogeneous grouping.
(iii) The system implementation and validation phase.

Selection of an appropriate learning styles inventory

The system helps students in identifying their learning style by integrating a specific learning styles inventory. In general, the choice of the learning styles model depends on the context and the nature of task, since there is no model that should be used in all contexts (Rayner 2007). For the needs of the research, we selected a whole-brain thinking model, the Raudsepp Problem Solving Styles Inventory (Raudsepp 1992) which, according to Hulme (1996), encourages students to gain insight into their thinking and learning style and helps them to formulate successful learning strategies. The reliability and validity of the

Raudsepp instrument have been documented by the results of several studies available in the literature (Hulme 1998; 2000; Hulme and Karayan 2001; King 1994; Martin et al. 2000) and have been also investigated in the current study (results presented in a later "Student learning profiles" section). According to Karayan and Hulme (2003), the Raudsepp inventory is considered equivalent to the proprietary Herrmann Brain Dominance Instrument (HBDI) (Herrmann 1990), which is one of the best of the 71 tested models that met the validity and reliability criteria (Coffield et al. 2004). Both models classify students' learning preferences in the same four dimensions that represent four task-specialized brain quadrants (described in a later "Research instruments" section). Most of the models that identify learning styles classify individuals' learning styles on four or five dimensions, according to many overviews (Cassidy 2004; Coffield et al. 2004; De Bello 1990; Rayner and Riding 1997; Swanson 1995). HBDI is considered suitable for use with learners as well as with teachers and managers, as it throws light on group dynamics and encourages awareness and understanding of self and others and also it is supposed to foster creative thinking and problem solving (Coffield et al. 2004). The Raudsepp inventory was finally embedded to PEGASUS, because it requires no specialized training and can provide an inexpensive and readily accessible basis for measuring students thinking and learning styles for education research (Hulme 2000; Martin et al. 2000). The questionnaire is freely accessible and is also shorter and simpler to answer than the equivalent HBDI, which is a proprietary product of The Ned Herrmann Group, Ltd.

Design of an appropriate algorithm for automated heterogeneous grouping

An automated group formation system was necessary in order to apply a certain strategy on distributing a population to groups, which could not effectively be done manually. PEGASUS can form automatically groups of two to five students based on heterogeneity of learning profiles. To this end, an algorithm is applied to distribute students in small groups and form their "group profiles". "Group profiles" are the average profiles in the four dimensions of the members of a group and are represented in the same way with personal profiles. Next, each group profile is compared to the "class profile", i.e. the average profile of the students of the specific class. The algorithm calculates each "group variation", i.e. the Euclidean distance of the group profile from the class profile, and adds the variation to a sum. The Euclidean distance is a measure of how much a group profile varies from the reference profile (class profile). Practically this rule guarantees that the mean for each different learning style in a group is kept as close as possible to the general mean for this style (as calculated across the whole class). Diversity is enhanced by demanding that the distribution of students in groups satisfies the minimum Euclidean distance rule. The degree of heterogeneity of a groups' distribution is conversely proportional to the sum of group variations. The algorithm calculates which group distribution has the "optimal variation", i.e. the minimum summative group variation from the class profile. This in turn corresponds to the "optimal group heterogeneity".

The algorithm does not calculate the best solution but only a partially optimal solution (group distribution) while running up to a time limit. There was no need for any critical threshold, because the system allows the teacher to select the optimal distribution in terms of diversity, depending on the nature of input data. The teacher can run the algorithm as many times as she wishes, and the system saves the optimal solutions in each run. The teacher can then choose which group distribution is preferable, having in mind the minimum variation or other criteria (e.g. in the case that the teacher would like to have alternative distributions concerning the group synthesis).

Moreover, the system supports manual group formation, by allowing the teacher to select which students will be manually or automatically grouped. The system also provides statistics concerning average scores of students' profiles. Group profiles are open to teacher and teammates, in order to raise group awareness and discussion. PEGASUS supports students' negotiations of group synthesis by allowing them to accept or deny their assigned group synthesis and negotiate with the teacher. However, the negotiation option, being just an additional feature of the system, as in other group formation systems (e.g. Christodoulopoulos and Papanikolaou 2007), was not practically applied in this study.

System implementation and validation

The system implementation phase included the development of the web-based application. To validate the system, during the system development process, we conducted a number of trial runs by using scenarios with a variety of test cases to assure system integrity. We verified that the results of the system were as expected. Moreover, before the current study, the system was twice pilot tested in real conditions and verified the group formation functions.

Method

Participants and context

During the spring semester 2009, we carried out a study with fifty (27 male, 23 female) participating senior university students in a course on "Design and Evaluation of Educational Software" at the Department of Informatics of our university. The students were majoring in Computer Science with a specialization in Technology-enhanced learning. The class had two teachers who conducted the face-to-face sessions interchangeably. The course task for the students was to work in groups of four on a project assignment and to apply the phases of ADDIE model (Analysis, Design, Development, Implementation and Evaluation) in order to develop prototype educational software according to the needs of some scenario. In particular, the project tasks were the following: (1) The group had to decide and proceed to the definition of the working scenario. (2) The students had to elaborate a needs analysis document including user and technical analysis. (3) Based on the previous step, each group of students had to suggest a comprehensive design of prototype educational software, which adequately addressed the needs identified. (4) During the Development phase, the group had to develop a partial prototype of the design. The teachers shared responsibility of the groups and watched their projects. (5) The developed prototype was finally evaluated in a special evaluation session where the group presented the prototype to the teachers and the colleagues and got feedback to approve the design. Students' course assessment was based 50% on the collaborative project outcome evaluation and 50% on final written exams.

Design

Methodology

In our study we tried to monitor what happened during the course and record the benefits, shortcomings, drawbacks that students faced during their collaboration with unknown

people, based also to styles awareness, using qualitative methodology. Quantitative and mostly qualitative data were collected combining questionnaires and interviews. A phenomenographic method (Marton 1988) of analysis was applied aiming to categorize students' experiences and interpretations thus resulting in the identification of major common themes. Phenomenography is a research method designed to describe the qualitatively different ways in which a phenomenon is experienced, conceptualized or understood and the purpose of the method is the development of categories of description denoting different ways of understanding the phenomenon (Marton 1992). The phenomenographic approach was designed to answer questions about thinking and learning, especially for educational research (Marton 1988), and has been used in various educational research contexts with various populations (Vermunt 1996). A phenomenographic data analysis sorts individual perceptions, which emerge from the data collected, into specific 'categories of description' (Åkerlind 2005; Marton 1988; 1992; Uljens 1996). In our case, phenomenography was applied in order to record and categorize the different ways in which students experienced and evaluated the specific collaborative activity.

Research instruments

Quantitative data were collected using (a) the Raudsepp learning styles inventory and (b) a student attitude questionnaire.

(a) Raudsepp learning styles inventory

The Raudsepp Problem Solving Styles Inventory consists of 25 statement openers and each opener is accompanied by four possible choices for completing the sentence. The respondent has to rank each of the four choices, according to his/her preferences, from 1 (less preferred) to 4 (more preferred) (therefore, the respondents' score in a quadrant may vary between a minimum of 25 and a maximum of 100 points). An example of a Raudsepp instrument item is the following: "When starting to work on a group project, I would first like to:

(1) Determine how to organize and implement it.
(2) Understand how it would benefit each member of the group.
(3) Determine exactly how the group should be doing the project.
(4) Understand what further opportunities it might open up for the future".

Based on this ranking, the model classifies a person's thinking and learning style as belonging to four separate types (quadrants):

A. Quadrant (hereafter "Analytical"): Analytical, logical, factual, technical, quantitative
B. Quadrant ("Practical"): Sequential, conservative, structured, organized, detailed, planned
C. Quadrant ("Interpersonal"): Interpersonal, kinaesthetic, emotional, spiritual, sensory, feeling
D. Quadrant ("Holistic"): Imaginative, visual, holistic, intuitive, innovative, conceptual

In theory, the two most prominent types are those that characterize the person's learning style. For instance, a students' profile of A: 74, B: 71, C: 57 and D: 48 is characterised as Analytical-Practical.

(b) Attitude questionnaires

The attitude questionnaire included 25 Likert scaled questions (see Table 5). The questionnaire was organized in four major sections as follows: (a) The "*Reflection on*

learning styles" section, regarding students' opinions on the impact of their own style awareness; (b) the "*Group formation based on learning styles*" section, concerning students' attitude on the style-based group formation procedure; (c) the "*Group collaboration*" section, focusing on students' opinions regarding the quality of their group work, and (d) the "*Group facilitation meetings*", analyzing students' reflections on the benefits of the facilitation meetings. Additionally, one question regarding the PEGASUS system usability preceded the above sections, to verify that students did not face any serious interface problems when navigation in the system.

Students' interviews

Conducting student interviews was a key qualitative data collecting method. Applying phenomenography (Ornek 2008), semi-structured individual interviews were administered focusing on students' attitudes about the group formation procedure, their unique experience of collaboration and how it was affected by styles awareness and group heterogeneity. It was made clear to the interviewees that the interview is open and they were welcomed to further explain their understanding about the phenomena and think aloud, without being evaluated (Ornek 2008). Students were asked to (a) clarify and expand their answers to the questions of the attitude questionnaire (see Table 5), and (b) answer also some additional open questions, concerning their attitudes to style-based group formation and its impact on collaboration. These additional questions are presented in Table 1.

Procedure

The research procedure was organized in the following steps:

- Learning style identification phase
- Group formation
- Facilitation meetings during the project implementation

Table 1 Interview additional questions

Question
Which ways/media did you choose for your communication (e.g. face-to-face, telephone, e-mail, chat, MSN), in which frequency and for what purpose?
Did any partner play the role of coordinator in your group and—if yes—what exactly was his/her role?
During collaboration, how did your group deal with different ideas or views?
How did your group distribute workload and for what part of work did you assume responsibility for?
What time-management problems did you face as a group?
What were the benefits (if any) that emerged from your collaboration?
What were the difficulties (if any) that you faced during your collaboration?
What do you think are the necessary preconditions (if any) for successful collaboration with previously unknown partners?
How did the facilitation meetings help your team? (e.g. improvement of collaboration, resolving misunderstandings, role distribution, question solving about the project, better understanding your profile, improving understanding of teammates' profile, improving understanding of your contribution to the team work, project time-management, expression of views and feelings)
What other issues would you like to discuss in the facilitation meetings?
What are your recommendations for the improvement of the style-based group formation process?

- Project evaluation phase

The next paragraphs present these steps in detail.

Learning style identification phase

In the beginning of the semester, first, an introductory lecture took place, in which learning styles were theoretically introduced and it was explained how they are used to enhance students' teamwork. Second, the students were asked to fill in the Raudsepp Problem Solving Styles Inventory available online in PEGASUS. The system presented statistics concerning average values of students' results and students' style distribution according to their two highest profile scores. Students were provided with analytical information and a graphical representation about their identified profile, and were asked to give their feedback. Class and students' learning profiles were open to teachers.

Group formation

In order to distribute students in groups, the teacher activated the group formation procedure in PEGASUS and groups of 3–5 students were automatically formed based on optimal group heterogeneity of students' styles profiles. Group and team members learning profiles were open to groups for discussion.

The majority of students (92%) agreed with their initial assigned group, mainly after their first meeting. Only four students objected for practical reasons and were allowed to form their own group. Checking this group for heterogeneity we verified that it exhibited a heterogeneous profile and did not violate the basic grouping assumption of the study. The system group formation algorithm was run again (only for broke up groups) to provide new heterogeneous group synthesis. Finally, there were 13 groups of 3–5 people working on their course projects.

Facilitation meetings during the project implementation

During the course, students had to work collaboratively and submit intermediate deliverables and project documentation. Each group was free to choose the project subject. In order to initiate discussions with students about their preferred ways of learning, in line with researchers' recommendations (Coffield et al. 2004; Waring and Evans 2005), and also facilitate students' collaboration, we decided to organize group facilitation meetings. The first author acting as group facilitator conducted facilitation meetings separately for each team twice a month in order for students to get help on collaboration issues, such as project time management or role allocation. The facilitator tried to closely investigate students' attitudes concerning the innovative group formation procedure as well as the students' collaboration flow. She worked with all groups. Students were encouraged to express their viewpoints and feelings concerning their teamwork, having the opportunity to resolve any misunderstandings or hard feelings among them in a safe and friendly environment. The facilitator's concern was to help resolve specific group problems, but also keep her external influence in the group to a minimum (Petress 2004). During group facilitation meetings, students were motivated to develop positive interdependence (Johnson and Johnson 1994), and keep in mind to pay more attention to one another's personal features, relax on stereotypes and mutual criticism and spend more time and effort interacting with one another (Harrison et al. 2002).

Project evaluation phase

At the end of the course, students were asked to present their projects and defend their design decisions in the class. Students in groups knew that the project evaluation grade would be the same for all of them and that each one of them should have a unique contribution to make to the joint effort because of his or her resources and/or role and task responsibilities. Meanwhile, the group facilitator introduced individual accountability (Johnson et al. 1998) by encouraging students to allocate roles and task responsibilities, trying at the same time to keep track of students' contribution to the group work.

In the end of the whole project and a few days before written exams: (a) students were asked to fill in an attitude questionnaire (see Table 5); (b) students—and also teachers—were interviewed to record their detailed explanations on the course experiences and comment on points we believed needed clarification (all interviews were digital-recorded upon interviewees' agreement; five of the students opted not to be recorded during their interviews and for those students the researcher took notes on paper).

Data analysis

Questionnaires data

Responses in the Raudsepp questionnaire were processed to calculate the average student score for each of the four quadrants across the whole student sample population. Having 25 question items in the instrument, the possible range of the sum for each quadrant is between 25 (min) and 100 (max). The average score is considered as an indication of how strong this orientation (Analytical, Practical, etc.) is among the student population.

Responses in the attitude questionnaire (in Table 5) were expressed in a Likert scale, from 1 to 5 (5 meaning "totally agree or yes", 4 meaning "rather agree or rather yes", 3 meaning "undecided", 2 meaning "rather disagree or rather no" and 1 meaning "totally disagree or no"). The only exceptions were items I.7 and I.8 which were answered in a Likert scale from 1 meaning "disapproving", 2 meaning "fairly disapproving", 3 meaning "undecided", 4 meaning "fairly favourable" and 5 meaning "favourable".

Interview data

Interviews lasted about one and a half hours each. Approximately 75 h of recordings were processed and analyzed employing the phenomenographic methodology. The data we collected during interviews referred to each group and were usually confirmed by three or four persons (the teammates). In order to minimize the researcher's subjectivity on the findings, participants were asked to further explain their answers and provide feedback on the researcher's interpretations.

The main question of interest underlying the qualitative analysis of interviews concerned how our group formation method affected students' collaboration. The inner workings of the groups' collaboration were realized during the group facilitation meetings and mainly during the students' interviews, which helped us understand the qualitatively different ways in which students experienced, conceptualized, realized and understood collaboration. During the analysis of the collected data from students' interviews, we followed the steps of the phenomenographic analysis (Ornek 2008) in order to identify specific categories. We identified significant elements in students' answers and—based on their similarity—we grouped them in categories. We iteratively compiled, analyzed,

segmented and sorted the students' statements regarding their whole experience of collaboration. This process resulted to the identification of nine (9) initial subcategories *[Sx]* of description which were subsequently organized in four (4) main categories based on their conceptual relevance, which are presented in the next section.

Results

Quantitative data

Student learning profiles

The average scores (*M*) of all 50-student profiles in the four quadrants, as shown in Table 2, reveal that students of the specific class had their strong traits in Analytical and Practical quadrants.

Additionally, students' profile distribution according to their two highest profile scores, as shown in Fig. 1, reveals that half of the students (25/50) of this class had their two highest preferences in Analytical and Practical quadrants.

This means that the students of this class were stronger in analytical, factual and mathematical ways of thinking, as well as practical, sequential and organizational ones. This finding is consistent with the certain abilities that Informatics students are supposed to have and the view expressed that students of the same field are potentially representatives of a specific group with similar learning preferences (e.g. Gasparinatou and Grigoriadou 2008).

Table 2 Scores of students' profiles ($N = 50$)

Quadrant	*M*	*SD*	Min	Max	Cronbach's alpha
A (analytical)	70	8.5	46	90	.72
B (practical)	65	6.8	50	78	.52
C (interpersonal)	62	10.0	32	81	.80
D (holistic)	52	8.8	35	76	.75

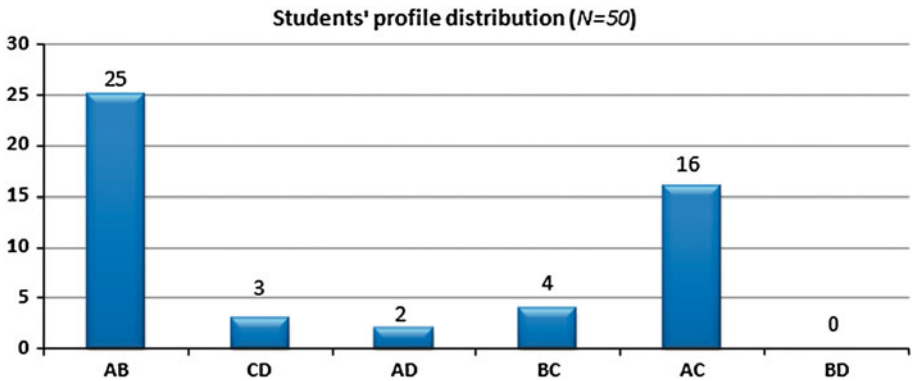

Fig. 1 Students' distribution according to their two highest profile scores (regardless of order)

Table 3 Scores of students' group profiles

	n	A (analytical)		B (practical)		C (interpersonal)		D (holistic)	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Group 1	3	70	1.2	60	3.1	69	2	50	4
Group 2	4	68	7.4	68	7.5	59	10	54	9
Group 3	3	74	9.6	71	6.1	57	4	48	11
Group 4	4	66	7.4	60	6.7	71	6	53	11
Group 5	4	69	18.1	63	9.5	64	13	54	14
Group 6	4	70	5.4	61	3.2	61	19	57	13
Group 7	4	70	8.0	64	9.7	63	5	52	10
Group 8	4	71	9.5	66	7.2	61	9	52	5
Group 9	4	72	9.7	64	7.2	61	9	52	13
Group 10	4	65	14.5	63	7.2	68	9	54	7
Group 11	4	74	3.9	67	3.4	57	11	52	6
Group 12	3	76	3.1	66	7.1	59	1	48	7
Group 13	5	66	4.7	68	5.8	61	6	54	7

Table 4 Students' feedback ($N = 50$)

Likert scale		Responses (%)
1	Totally disagree	2
2	Disagree	0
3	Undecided	17
4	Agree	77
5	Totally agree	4
	Total	100

In order to group students of the specific class, the distribution with the minimum variation from the class profile was selected by the teacher. The scores of the final group profiles are presented in Table 3.

Investigating the reliability of the Raudsepp instrument, the four items in each question were allocated to four groups (corresponding to Analytical, Practical, Interpersonal and Holistic quadrants), each consisting of 25 items and the Cronbach's alpha statistical measure was calculated for each group separately. Their values are shown in Table 2. In general, these values are quite satisfactory for Analytical, Interpersonal and Holistic groups and acceptable for the Practical Group. The value of $\alpha = .52$ for Practical Group is considered as acceptable for exploratory studies (King 2009, p. 344).

In order to assess the validity of the instrument, we used the response of the individuals regarding the degree of their agreement with the overall result of the instrument. The responses were 1 = "Totally disagree" to 5 = "Totally agree". The distribution of the answers (in percentages) is given below (Table 4):

Table 5 Students' answers to the attitude questionnaire[a]

Item	Question	*N*	*M*	*SD*
PEGASUS usability				
I.1	Was the PEGASUS system easy to use?	49	4.98	.14
Reflection on learning styles				
I.2	Did you agree with your identified learning styles profile?	50	3.81	.62
I.3	Was the information on your learning styles profile clear?	49	4.82	.44
I.4	Did the information help you to realize or confirm your strong/weak points?	49	4.35	.99
I.5	Being aware of the team members' profiles was helpful to you?	38	3.82	1.33
I.6	Would you like to learn more about learning styles?	46	4.00	1.40
Group formation based on learning styles				
I.7	What was your initial opinion about the group formation procedure?[b]	41	2.80	1.35
I.8	What is your current opinion about the group formation procedure ?[b]	49	4.53	.87
I.9	Did you accept the group synthesis proposed by the system?	49	4.67	1.11
I.10	Do you feel that group synthesis negotiation is important?	46	4.09	1.41
I.11	Do you believe that group formation based on learning styles can help the implementation of a project?	48	4.29	1.03
I.12	Reflecting on the collaboration, do you think that during the project, your personal style traits became obvious?	46	4.70	.66
I.13	Reflecting on the collaboration, do you think that during the project, your team members' style traits became obvious?	34	4.71	.72
Group collaboration				
I.14	Do you feel satisfied from your group collaboration?	49	4.57	.58
I.15	Do you feel satisfied from your group communication?	48	4.67	.66
I.16	During collaboration, did your group express different ideas or views?	48	3.60	1.07
I.17	In your group, do you think that you had balanced workload distribution?	49	4.61	.73
I.18	Do you think that your group was good at managing time?	49	4.33	1.03
I.19	Are you satisfied by your group's project outcome?	47	4.28	.68
I.20	Do you feel that the current group experience enhanced your collaboration skills?	47	4.23	1.00
I.21	Do you now feel that it is easy to collaborate with people you have not worked with before?	49	3.90	.77
I.22	Do you think that this type of group heterogeneity helps produce quality deliverables?	48	4.69	.78
I.23	Would you work with groups proposed by the system in the future?	49	4.08	1.11
Group facilitation meetings				
I.24	Do you feel that the group facilitation meetings helped?	40	3.95	1.15
I.25	Was the frequency of the group facilitation meetings adequate?	41	4.51	1.21

[a] Range of answers: (1 = totally disagree or no,…,5 = totally agree or yes

[b] Range of answers: (1 = disapproving,…,5 = favourable)

The 80.9% of the respondents answered either 4 or 5 (i.e. agreement with the results) and only the 2.1% expressed disagreement. The mean value of the rankings is $M = 3.81$ with a standard deviation of $SD = .613$ and a median of $Mdn = 4$ (see I.2 in Table 5). These statistics suggest that the individual results of the instrument are in accordance with the opinion that one has for herself or himself.

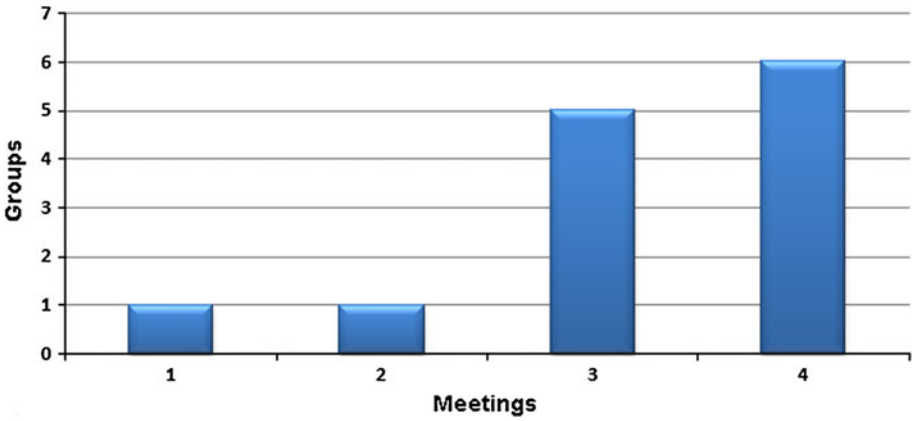

Fig. 2 Frequency distribution of group facilitation meetings

Attitude questionnaires

The questions concerning the students' opinion on four main subject categories (expressed to a continuum in a Likert scale, from 1 to 5) and students' average scores and standard deviations are presented in Table 5.

Frequency distribution of group facilitation meetings

The majority of the groups (11 out of 13) asked for group facilitation meetings three or four times during the semester. Only two groups used this function one or at most two times. Students' attendance to group facilitation meetings was a dependent variable in our research. The frequency distribution of the group facilitation meetings is shown in Fig. 2.

Qualitative data

Students' interviews

The analysis of the interview data led to the identification of four major categories and nine subcategories of classification which are presented in the following.

Category 1: learning styles in PEGASUS

[S1] Feedback on personal profile Students acknowledged that the whole experience was their first contact with learning styles and that the whole idea appealed to them. Most of the students agreed with their identified profile, and reported that information provided by the system was clear and helpful to confirm their strong and weak points, which, in many cases, they already knew. The whole learning styles idea intrigued many students who expressed their interest to get more analytical profile information, ways of collaboration with others and proposed project roles.

Students' statements:

"*I was surprised by the results, I absolutely agreed with my identified profile; it's really interesting, I wouldn't believe that this kind of thing works*."

"*It helped me realize that I have imagination and I can use it*."

Category 2: group formation based on learning styles

[S2] Students' opinion about the group formation procedure Most students reported that at the beginning, the procedure was unfamiliar and seemed strange to them and they were feeling insecure to collaborate with people they had not chosen as teammates. However, during the process, students found the group formation procedure interesting and fruitful and they would be willing to participate in system grouping in the future. Their previous experience of collaboration was with smaller groups of friends, which, as they said, was more convenient, but less effective. Some students pointed out that collaboration with friends might be less stressful and more intimate but allow for procrastination and lack of dutifulness. However, some students would still prefer to work with friends, but, as they said, they would not mind doing it again, if it was obligatory. One student mentioned that this experience is valuable and necessary for everyone prior to venturing into the workplace.
Student statement:

"*At the beginning I was unfavourable to the procedure. I was not sure whether we would be able to work well together without wasting valuable time. I was also nervous about the result of the collaboration. Now, I can say that the experience was very positive and that the team functioned really well*."

[S3] Negotiation of group synthesis Students mostly believed in the benefit of group synthesis negotiation, especially in cases that collaboration was for some reasons impossible due to prior bad collaboration experience with some colleagues, negligence, personality or priorities mismatch. On the other hand, some students believed in trying new collaborations, regardless of the people involved. Nevertheless, students pointed out that group synthesis negotiation, if necessary, should take place after the first meeting of the group.

Category: group collaboration

[S4] Teammates' styles during collaboration Not all students paid attention to their teammates' profiles from the beginning. The ones, who did, acknowledged that it was helpful to them to have a first picture of the others and to save time when assigning project tasks. Students reported that their personal as well as their teammates' style traits were obvious during collaboration. They explained that they saw the existence or the absence of specific traits as a confirmation of the respective learning styles profile. Students mentioned that the project roles were undertaken based on each one's preferences, according to personal traits and skills, which confirmed the respective personal profile. For instance, the team members that undertook the technical part were the ones that had mainly analytical and practical skills, whereas ideas came from group members that had imagination and creativity. Students that assumed responsibility for the design of the interface were the ones that had imagination, visual and artistic skills. The team members that had interpersonal abilities assumed the communication among the group members and the project stakeholders. Additionally, balanced profiles played an important balancing role during collaboration. It is worth mentioning that in some cases it seemed as if some students had

activated traits that their group had to a minimum. This was especially obvious in cases of lack of interpersonal skills of the group (Interpersonal quadrant) or lack of group imagination and creativity (Holistic quadrant).
Student statement:

"*Our styles were very obvious in collaboration; Christine was very organized, and also had many ideas and enthusiasm; Odysseus was practical and low profile; I personally am balanced, I got involved with everything*."

[S5] Group coordinator Nine (9) out of thirteen (13) groups took the initiative to create the role of the "group coordinator". In most cases, the group coordinator took upon him/her the initiative for the group communication with all project contributors (teammates, the teacher, the group facilitator, external agents). In four groups, the coordinator became a genuine project manager taking over more responsibilities, such as full-scale project management, time-management, task assignments, and evaluation of the project deliverables. Nevertheless, almost all groups that had brought up a coordinator expressed their appreciation for his/her role.
Student statement:

"*Our group coordinator was very organized. She time-managed the project and assigned our roles; we knew exactly what we had to do. Her role was very important*."

[S6] Group heterogeneity Students in many cases expressed their belief that heterogeneity can help the production of higher quality deliverables. They reported that the main benefits from group heterogeneity are complementarities in the way of thinking, work assignment according to individual skills, pluralism of viewpoints, group creativity and more complete outcomes. Creativity, according to students, emerges if everyone takes over what he likes most according to his tendencies. Homogeneity in the way of thinking is susceptible, according to students, to blind spots, might cause conflict concerning role assignments, and the outcome would tend to be unilateral and one-dimensional. Meanwhile, students expressed the opinion that not only heterogeneity but also, good mood, unselfishness, reliability, clearly agreed goals, willingness to help and probably luck are necessary preconditions for a smooth collaboration.
Student statement:

"*When you work with different personalities, the final outcome is more complete and includes diverse aspects, otherwise it's unilateral, and something is missing*."

[S7] Quality of collaboration Students' statements were very positive regarding the quality of their collaboration. Students reported that they had a smooth collaborative process, being characterized by qualities such as: participation, helpfulness, motivation, reliability. Students appeared satisfied from the frequency and the mode of their communication (face to face or distant). The majority of the groups met more than twice a week. In one case that the members of a group met only three times, they finally got a low project evaluation. However, in two other cases where groups could not meet frequently, due to time or distance limitations, their members managed to work effectively through the use of the internet services. Students also acknowledged that in-group different views were mainly expressed in the starting/early phase when groups discussed and decided the project subject. Even if the members of each group used a different approach for tasks assignments, they distributed workload in a very balanced and fair way, so that no one felt overloaded. Students were also satisfied from the way their

groups time-managed the project, despite time pressure. It was a surprise that in two cases, groups completed intermediate project phases long before deadlines. Students only in a few cases reported collaboration problems such as late start of team communication, distance problems and lack of common time availability. One group had a peer conflict that was resolved during a group facilitation meeting. Above all, students acknowledged that the whole experience helped them empower their collaborative skills and drop their initial reservations about this kind of collaboration.

Student statements:

"*We happened to have a very good collaboration atmosphere. We all had a good mood and the role assignments were easily agreed*"

"*All the partners were helpful, reliable and responsible; we all had the same goals*"

"*I didn't expect all partners to be so participative, it motivated me to get more involved*"

[S8] Student assessment of the project Even though projects were still in progress at the time of the question, the majority of students expressed their satisfaction from the final project outcome. Additionally, students appeared to be happy with the project subject chosen by the group. They expressed their wish to have had more time to build more elaborate deliverables. It is worth noticing that some groups were thinking of continuing work on their project, expanding and ameliorating it.

Student statement:

"*We liked both working together and the project assignment so much that we are planning to keep working on it on our own.*"

Category: Group facilitation meetings

[S9] Usefulness of group facilitation meetings The majority of the groups (11 out of 13), as shown in Fig. 2, asked for group facilitation meetings three or four times during the semester. Only two (2) groups used this function one or at most two times, arguing that their team did not have any particular collaboration problems or had time restrictions. Students reported that their frequency of the meetings was adequate and acknowledged their value in solving collaboration issues as well as in helping them better understand their participation in heterogeneous groups, better manage role assignments, ensure steady progress and adhere to deadlines. Additionally, during the meetings students had the chance to express their thoughts and feelings and to solve any misunderstandings among them. Concerning the topics discussed, many students expressed their desire to include technical issues, although they had the opportunity to meet the teachers for help. Some students liked the fact that conversation was open and could include more general topics, like their studies in the department. One student expressed the idea that peer assessment could be included in the meetings.

Interviewing the teachers and the group facilitator

[T] Teachers' comments The two teachers of the course were generally pleased by the students' efforts and assessed the majority of projects positively. They maintained that the system saved them valuable time by executing group formation quickly and reliably. Even though teachers did not report any difficulties concerning negotiations with students, they proposed that students' group negotiations would better be omitted. According to their

observations, groups that did not meet very often had problems in collaboration. Teachers reported that group facilitation meetings assisted their work by helping teams get organised. According to their observations, the groups that had thoroughly started working on their projects asked for the group facilitation function as an additional help to their group collaboration. On the other hand, groups with minimal involvement in the project had low interest in asking for group facilitation meetings and got a final low project evaluation.

[GF] Group facilitator's comments The group facilitator reported that, at the beginning, students were curious about the purpose of the meetings and many of them believed that technical issues would be discussed. According to her observations, groups, who had brought up a group coordinator during their collaboration, ran their projects faster than the others. The facilitator also highlighted that when students, being aware of their own and other's strengths and weaknesses, were permitted to assign roles and tasks dictated by their own interests, then excitement, group spirit, and group creativity emerged, giving the spark for significant and fruitful collaboration.

Discussion

This study implemented a qualitative research methodology to analyze (a) students' attitudes regarding the learning style-based group formation approach, (b) the impact of learning styles awareness and (c) group heterogeneity on group collaboration and (d) the possible benefits and drawbacks related to the overall course organization. The rationale of the study is that learning style-based group formation that promotes also group heterogeneity might be beneficial for student collaboration at many levels.

In general, the main conclusions are as follows:

(1) Students confirmed their identified profile and while at the beginning, most of them were skeptical about the group formation procedure they finally overcame their initial reservations and managed to collaborate productively.
(2) According to students' opinion, their learning styles were evident during collaboration. Role and task distribution according to students' interests and competencies, as a result of students' awareness of their their own and their teammates' strengths and weaknesses, benefited group creativity, and boosted group feeling.
(3) Styles heterogeneity in group formation was well accepted by students, who emphasized on complementarities and pluralism in the ways of thinking.
(4) Course organization was perceived to have a positive effect on students' collaboration. In general, students managed to have a fruitful collaboration, good project time-management and fair distribution of the workload. Group facilitation meetings helped students to face problems that might arise during collaboration. The meetings also enhanced teachers' work by having groups prepared and organized.

More analytically the main conclusions are as follows:

What were students' attitudes concerning the learning style-based group formation approach?

Quantitative and qualitative data indicate that students were intrigued by the whole learning styles idea (S1) and were happy to use the system (I.1). They mostly agreed with

their identified personal profile (I.2, S1), and reported that this knowledge helped them realize or confirm their mental strengths or weaknesses (I.4, S1).

Our initiative to put people who did not know each other to work together as a group, especially in a positive interdependence structure that links students together so one cannot succeed unless all group members succeed (Johnson et al. 1998), was probably inconvenient to many of them (I.7, S2). Even though the majority of students agreed with their assigned group (I.9, S3), and the purpose of the introduced method was presented to them, they reported that at the beginning, they were feeling insecure and reluctant to collaborate with classmates they didn't know (I.7, S2). Students were used to work primarily alone or in small groups of friends or acquaintances (S2) and were unfavourable to change, probably because, as Harman (1998) sustains, people feel consciously or unconsciously threatened by change and have a tendency to actively oppose it. This insecurity is probably the reason why some students found the negotiation option necessary (I.10, S3). However, teachers reported that the negotiation option should be omitted (T) for regularity reasons, probably having in mind prior experimentations. Students suggested that they should not use the negotiation option before the first meeting of their group (S3). Nevertheless, when students finally got involved in the process, they started to change their initial opinions about the procedure (I.7, I.8) and overbid the benefits of this kind of collaboration (I.11, S6), along with other research findings reporting that the negative effects generated by diversity gradually disappear over time allowing positive effects to evolve. (De Abreu Dos Reis et al. 2007). Moreover, many students would try again groups proposed by the system (I.23), as they were feeling more comfortable in collaborating with people they had never worked with before (I.21).

How did styles awareness affect group collaboration?

Even though students had not paid too much attention to their teammates' profiles from the beginning (I.5, S4), they acknowledged that styles profiles became evident during the activity (I.12, I.13, S4). Students, in several cases acknowledged that the existence or absence of specific traits in themselves or the others was a confirmation of the respective styles profiles (S4). Students, being aware of their own and their teammates' strengths and weaknesses (S1, S4), appear to have a a clear awareness of their own contribution to collaboration (S4). As other studies also emphasize (Kolb 1984; Pettigrew 1998; Petress 2004), when group members reflect on their learning styles they may have a heightened awareness of how their styles affect group dynamics. Group facilitation meetings seem to have helped students elaborate their styles profile, and raise self and group awareness about everyone's contribution to collaborative work (I.24, I.25, S9, GF). As Coffield et al. (2004) state, a styles profile is unlikely to be helpful without a dialogue with someone who has a theoretical background on learning styles.

Students also seemed very content to have allocated roles and tasks according to styles knowledge (S4). Group creativity seemed to emerge when everyone took over what he liked most according to his interests and competencies (S6, GF). As Herrmann (1990) emphasizes, if people can pursuit, develop and expand their interests, then growth and change in mental capacity and range of thinking can follow. When students are allowed to choose among learning activities based on their preferences, they learn better (Lewis and Hayward 2003). Among the roles students allocated, the role of the group coordinator was mostly praised and appreciated by the groups that adopted it (S5). According to the group facilitator's feeling, those groups were better organized and ran their projects faster than the others (GF).

How did group heterogeneity affect group collaboration?

Considering group heterogeneity, students expressed their belief that styles heterogeneity promotes complementarities and pluralism in the ways of thinking, group effectiveness and emergence of group creativity (S6). It seems that students, having been moved outside their comfort zone, and letting themselves try a new collaboration framework, quickly realized and appreciated the benefits of being different but complementary (I.11, I.22, S4, S6). On the other hand, homogeneity, according to students, might cause conflict concerning role assignments, and might produce unilateral outcomes (S6). Herrmann (1987) maintains that people in heterogeneous groups have the opportunity to learn from each other and the output of the mixed group can be significantly higher than the output of the homogeneous one. Students believe that heterogeneity has potential benefits for their group performance (I.22, S6, S8), in line with the general accepted assumption (Williams and O'Reilly 1998) that diversity is more beneficial when the type of the teamwork requires creativity and innovation rather than routine tasks. It is interesting here to highlight that during collaboration, it seemed as if some students had activated traits that their group had to a minimum (S4). This may be not only due to the team spirit, but also because, as Herrmann (1990) sustains, through one's understanding that many mental options are available, he is prepared to be open to these options and to apply them on a case by case basis. Finally, students believe that collaboration is not only a matter of styles but, as other researchers also emphasize (Petress 2004), other factors play a significant role, like group members' reliability, good mood, mutual respect and empathy, clearly agreed goals, willingness to help, flexibility and adaptability (S6).

Did the overall course organisation benefit students' collaboration and was it a satisfactory experience for the students?

Students reported that they had a fruitful, intimate reliable and smooth collaboration (I.14, S7), highlighting the production of quality project deliverables (I.19, S8) and building collaborative skills (I.20, S7). Students managed to distribute workload in a very balanced and fair way (I.17, S7). They appeared satisfied from the frequency and the patterns of their communication (face to face or distant) (I.15, S7) and from the way their groups time-managed the project (I.18, S7). It was a surprise that in two cases, groups completed intermediate project phases long before deadlines (S7). However, as teachers confirmed, groups that were late beginners or kept postponing meetings, performed worse than the others (S7, T). Regular meeting attendance is also referred to other studies as one of the criteria for successful group collaboration (Petress 2004).

Considering group facilitation meetings, teachers argued that they enhanced their work by having groups prepared and organized (T). Moreover, the meetings offered to students the freedom to express their thoughts and feelings in a safe and friendly environment and to allocate tasks drawn from their own interests, which in turn motivated them in many cases to collaborate smoothly and productively (S9, GF). According to teachers' observations (T), the groups that had methodically started working on their projects asked for the group facilitation function, unlike the groups with minimal involvement, who claimed that they had not any particular collaboration problems, or they had time restrictions (S9). However those statements were later defeated and the groups were shown to have a loose collaboration, getting also a low project evaluation (grade). Besides, during the interviews,

groups that used the group facilitation function reported greater degree of satisfaction from their collaboration than the ones who had low interest in asking for group facilitation meetings. Learning styles did not seem to play a significant role on whether some groups used the group facilitation function or not.

Limitations

Although this study has carefully selected a learning style inventory which appears promising in the educational context, we acknowledge the fact that another style taxonomy might provide even deeper insight on the impact of style-based grouping. We believe, however, that this issue could not be possibly resolved on the basis of a comparative analysis of the different style inventories, but only by providing further field research evidence on the impact of various style taxonomies on students' collaboration.

Conclusions

This paper presented and discussed an approach that pays attention to individual learning differences and organizes students in heterogeneous groups. In our approach we tried to raise students' awareness of their learning preferences, so that students become aware of and appreciate different thinking and learning preferences (Hulme 1996). We also tried to apply a personalized pedagogy and create a learner-centered environment by providing optimal conditions for learning and dynamically involve students in the process of learning, in the following ways:

- Raise students' styles awareness by discussing their profiles during group facilitation meetings.
- Involve students in the assessment of their identified personal profile.
- Propose diverse group arrangements based on students' styles profile.
- Make available group and teammates profiles to groups.
- Provide choice and control concerning project outcomes as well as role and task allocation.
- Facilitate groups' collaboration by organizing regular group facilitation meetings.

From the analysis and interpretation of the collected data, we could argue that the students, overcoming their initial reservations for the innovative group formation method, were content to collaborate with each other productively within their group setting. According to students' opinion, their learning styles were prominent during collaboration. Moreover, students becoming aware of their own individual as well as their teammates' mental strengths and weaknesses, began to honour differences and consider everyone as talented and competent. This awareness can be facilitated through encouraging dialogue about learning styles diversity. Styles heterogeneity in group formation was well accepted by students, who emphasized on complementarities and pluralism in the ways of thinking. However, care should be taken in order for groups to efficiently face problems that might arise during collaboration, possibly by keeping group facilitation meetings. Based on our experience, we could argue that the adoption of learning styles theories in learning and teaching should be explored in close relationship to supportive pedagogies and promising models of course organization that foster individual and group awareness and dialogue.

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