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Collaboration and Learning Styles in Pure Online Courses: an Action Research

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Abstract: Collaboration provides numerous possibilities for realisation of active learning/teaching concepts in e-learning. For this reason it is recomendable to determine the optimal way in which to develop collaborative activities, with the possibility of adapting the appropriate modules' use in accordance with learners' characteristics. The paper presents a description of a behaviour pattern analysis, which deals with learners with different learning styles using collaborative modules. An action research was conducted using data from Master degree program that is conducted purely online. The research goals were to find out if there was a potential for improvement of collaborative modules usage, utilizing students' preferences and produce recommendations for module future usage. The results showed that there was no difference among learners with different styles regarding either the frequency of access to collaborative modules or the frequency of different actions performed on these modules. Based on these results, a recommendation emerged to keep using these modules in similar way as before and put effort in finding additional data that could be used in further adaptation construct.

Keywords: Learning style, Felder-Silverman learning style model, Kolb learning style model, collaboration modules, electronic courses
Categories: L.0, L.2, L.3, I.5

1 Introduction

Many e-learning facilitators consider using some form of learning management system (LMS), also known as web-based learning system. The Institute of Electrical and Electronics Engineers (IEEE) Learning Technology Standard Committee defines a *web-based learning system* as a *learning technology system that utilises web-browsers as the primary approach to interacting with learners*, and the *Internet* as the *primary strategy for communication among its subsystems and with other systems* [IEEE, 03]. Web-based learning offers various benefits over conventional classroom-based learning: flexible time and place of use; easily updatable learning materials; it fosters interaction between the learner and the teacher; it can incorporate multiple media such as text, audio, graphics, video and animation; it enables learners to form learning communities; instructors can easily monitor learners' progress and it allows a learner-centred approach that can address many differences among learners [Jolliffe,

01]. However, monitoring student behaviour may emerge as a problem in online education using LMS [Graf, 09].

In blended learning scenarios the learning/teaching relies on both traditional learning/teaching and e-learning [Harriman, 04]. It is up to the teacher to decide what activities are to be conducted in the classroom or in the virtual environment. In pure e-learning scenarios the complete learning/teaching process appears to happen online, in the LMS environment. All resources such as files or Shareable Content Object Reference Model (SCORM) packages are put in the virtual course. Communication modules are also available, making communication and collaboration possible both synchronously and asynchronously.

Collaboration is a very important component of the learning process, and this area is in focus of interest in the field of Web based education [Cavus, 07]. According to [Rohaan, 08] collaborative learning is in range of the teaching methods which is necessary for effective teaching of technology subjects. Collaborative activities equip learners with greater opportunities for increased social presence and a greater sense of online community, both of which have been associated with positive online course outcomes [Rovai, 02]. As stated in [Caeiro-Rodríguez, 05], today more emphasis is placed upon the design of learning activities, especially collaborative, instead of the content to be transferred. Such activities assume interaction among students and/or between students and teacher that generates new knowledge. When translated to the virtual environment, collaboration activities take the form of forums, chats, wiki-pages, workshops, and so on. Working on the mutual task, several students are organising, interacting and building an original work. Teacher may assign the task or learners may set it by themselves informally.

The important, tightly coupled, features of learning/teaching are activity tracking and progress monitoring. These are also implemented in the LMS: reports about particular modules or the course as a whole may provide teachers with substantial insight into the learners' activities. Logs are usually stored in a database, from which they can be extracted and analysed in a more comprehensive manner. In that way much useful information can be gained, making future course planning more efficient.

Learning styles have been defined in several ways, i.e.: "a certain specified pattern of behaviour according to which the individual approaches learning experience" [Campbell, 96]. Finding out more about individuals' learning styles means knowing more about the learner's preferred way of interacting with the learning environment and with the teacher, thus extending the possibilities for learning improvement [Franzoni, 09]. The complete course design can be designed as user-centric, having learner's preferences as main input [Saeed, 09].

Many learning style classifications have been defined. In [Coffield, 04] there are 13 styles models analysed in favour of producing a practical recommendation for pedagogical use.

One of the most popular learning style classifications is Kolb's [Kolb, 84]. It describes four categories of learners (accommodators, divergers, assimilators, and convergers) according to learning preference – is it based on concrete experience, on theories and so on. Kolb's learning style is determined using an appropriate inventory containing 12 grading categories [Kolb, 76]. However, there is also another approach: namely, determining the style according to the learner's actions.

Another popular learning style model is Felder and Silverman's [Felder, 88]. In this model learners are classified according to four dimensions, using an appropriate inventory Felder & Soloman [Felder, 11]. (Hereafter, this model will be referenced as the (Felder-Silverman's.)

This paper has the following structure:

After the literature review, the purpose of this study is outlined, including the motives and action guidelines for the research. The methodology section deals with the participants and the tools and techniques used to gather and process data. In the results section a preview of research outputs are outlined. These are further discussed in the following section. The conclusion and future work are given at the end.

2 Related work

There are many papers that deal with identifying learning styles and adapting online courses to fit different learning styles. Daga [Daga, 09] gives a comprehensive analysis of the literature; Kolb's style model was the most commonly used, followed by Felder and Silverman's. For this reason, in this study precisely these two models were selected.

Milosevic et al. presented a student model built according to learning styles, using Kolb's model and motivation [Milosevic, 06]. The model was created according to the IMS Global Learning Consortium (IMS) specification that was implemented in this research using learner's style by controlling the lesson's semantic density. This paper contains very useful tables, showing how learning style, mixed with certain motivation levels, affects the choice of preferred learning material type. In relation to this work, the motivation was not included in the study because the aim of the research is related to learning styles and their impact on the selection of collaborative activities. Parameters of studies for possible further adaptation are those two styles of learning.

In [Essalmi, 10] personalisation model is produced according to 16 different parameters. Four parameters were learning styles: Kolb's, Honey-Mumford's, Felder-Silverman's and La Garanderie. The model dealt with 2-level personalisation in which the teacher was able to choose the personalisation form using the defined strategy.

In [Miller, 05] Miller conducted research that used both Gregorc's and Kolb's learning style models. The results showed that using Gregorc's style had a strong effect on the amount of the subject that was learned. However, Kolb's style showed no correlation with the amount of learned information. Besides the effect on the amount of the learned subject, learning styles can influence the path by which students move through the learning environments. Leagle and Janicki used Kolb's inventory to determine whether learners belong to one of two groups: reflective observers (observers) or active experimenters (experimenters) [Leagle, 06]. The learners' navigational habits were also analysed. It is shown that learning style has a strong influence on the navigation paths and the efficiency of the learning process. This, therefore, provides a solid motive for adapting learning environments. The research aimed at increasing the efficiency of the learning process; however, some research suggests that success in learning depends on learning style, or, within the online environment, students with different learning styles can equally learn. For

example, how learning styles and learning patterns affect learning success at web-based courses using WebCT was investigated in [Lu, 03]. It was found that "at the graduate level, students are able to learn equally well in WebCT online courses despite their different learning styles".

In [Klasnja-Milicevic, 11] there is described a system that automatically retains learning styles through data mining techniques. The learning material is then presented in form of lesson sequences depending on the learner's style. In relation to the mentioned paper, data mining techniques are not used to identify learning styles, as this is accomplished using questionnaires. Data mining techniques are used to analyze log files from the system in order to get any recommendations for students of different styles. While in the conducted research OLAP cube is a key element of the basis for further work, in [Lee, 09] decision tree approach was used to analyse data in a web learning environment. In that paper a strong connection between navigational patterns and cognitive traits has been found. It has been shown that "Field Independent learners frequently use backward/forward buttons and spent less time for navigation. On the other hand, Field Dependent learners often use main menu and have more repeated visiting." Furthermore, suggestions are made about adaptivity and adaptability, which should be implemented in order to make use of this information and improve learning efficiency.

In [Özpolat, 09] a learner model is built by processing the learner profile over the clustered data. Those data are acquired through the learning system. In relation to the aforementioned work in conducted research, the data are, after taking the learning is the system, divided into clusters compared to the respective styles and background styles was determined by questionnaire.

In [Ruiz, 08] an algorithm for adaptation was proposed. The defined steps were:

1. Select a good taxonomy of learning styles to classify the user.
2. Develop techniques to introduce adaptation into the system and design the adaptation by selecting techniques that are adequate for the selected learning styles.
3. Implement the designed adaptation on a computer.
4. Select the technologies that are adequate for the adaptation.

Still, many confronted conclusions may be found in literature.

Dag and Grecer [Daga, 2009] concluded another factors beside learning styles should be involved in order to apply them to build a better online course.

Papanikolaou et al. [Papanikolaou, 2006] also pointed out the lack of strong evidence that there is a strong link between styles and on-line student performance, introducing additional features into adaptation model, such as reflection and externalization.

Through various related work analysis it is concluded that there is no definite conclusion stated regarding influence of the learning styles to student success in online learning. Speaking of its key collaborative activities, it is left for further research to investigate whether styles influence their usage and what model is most convenient to be engaged.

3 Purpose of the Study

Moodle, the open source learning management system that is becoming increasingly popular, was used in this research [Dugiamas, 11]. This system enables course

creators to organize the online learning environment efficiently. Moodle learning management system does not allow detailed monitoring of users' activities or evaluation of the course's structure and efficiency in the teaching process. According to [Heinström, 00] it is very important to be aware of differences of students' personalities and different approaches to the tasks and respect these differences during the processes of planning and teaching. The current education is labeled as paradox if educator is transmitting the same information to all learners in the same way [Vartiainen, 12]. Also, Hung and Crooks [Hung, 09] pointed out that teachers could provide adaptive feedback if they know online learning behaviors of their students.

In order to obtain recommendations for different learning styles a thorough analysis is necessary.

An action research is realised with the purpose of identifying potentials for adaptive use of collaborative modules according to different learning styles. According to Riding et al. [Riding, 95] action research has been used in many areas and could be successful approach for improving quality of teaching. Results gained in this study can be used when Moodle courses are next constructed and additional data and student feedback can be collected.

Action research goals:

- Determine the differences among learners with different learning styles using collaborative modules on Moodle electronic courses.
- Examine the possibility for using data mining technologies to acquire information according to learning styles.
- Develop and test methodology for future research, for the next generation of students.

The research objectives:

- Survey analysis application as a matter of learner classification according to learning style (Kolb's and Felder-Silverman's).
- Data collection.
- Data preprocessing: clean and prepare the LMS's log files.
- Pattern evaluation: determine behaviour patterns based on reports and their evaluation.

Within the action research, the following hypotheses are formulated:

1) H_0: There is no significant difference in access to collaborative activities according to Kolb's model of learner style.

H_1: There is a significant difference in access to collaborative activities according to Kolb's model of learner style.

2) H_0: There is no significant difference in access to collaborative activities according to Felder-Silverman's model of learner style.

H_1: There is a significant difference in access to collaborative activities according to Felder-Silverman's model of learner style.

4 Methodology

4.1 Participants

This research was conducted at the Technical Faculty in Cacak, using data from Moodle LMS. Students involved in research are enrolled in a MSc study program - Master in e-learning. This program has been conducted for 4 years, and now Moodle LMS within this program includes 39 different courses. The complete teaching process at this study program is conducted through online activities using the LMS (http://e-lab.tfc.kg.ac.rs/moodle/login/index.php). Students log in with their accounts, enrol to their courses and perform activities such as viewing or editing content. Activities are saved with metadata and timestamps.

For research purposes three mandatory courses were selected, having 27 students enrolled and further involved in the research. Participants in the descriptive statistical analysis are the same for Kolb's and Felder – Silverman, but for Kolb there were fewer participants. Out of 27 students surveyed, 9 were female and 18 male. Data about students who took part in the research are given in Table 1[see Tab. 1].

The control group consisted of 10 students, 5 males and 5 females. This group is devoid of effects of the experimental variable and serves to control the importance of the impact of the variable being investigated. This group of 10 students is balanced with the experimental group regarding all the variables relevant to the studied phenomenon, except for the independent variable.

Gender	Frequency	Percent	Valid percent	Cumulative percent
Male	18	66.7	66.7	66.7
Female	9	33.3	33.3	100.0
Total	27	100.0	100.0	

Table 1: Participants' information

Log data was used from the following courses: Infrastructure for e-learning, Tools and technologies for e-learning, and Teaching and learning in e-education. All of these courses had numerous modules and activities that students use for gaining new knowledge and skills. All of the above courses, whose logs were analyzed, are obligatory for Master's degree students. In addition to learning materials offered in different forms and as part of distinct modules and courses, there are also modules that provide options for collaborative learning (hereafter, collaborative modules). Collaborative modules include forums, wiki pages, and chats. This research has been conducted concerning these modules, using appropriate log data.

4.2 Instruments and Tools

According to Kolb [Kolb, 76], the Learning Style Inventory (LSI) has been used to determine learners' styles. It is a scoring instrument consisting of 12 items, developed by David A. Kolb. It can be easily implemented online. An online questionnaire for determining the learning style was created in this research. The questionnaire was implemented within the Moodle learning management system. The participants of the

research were informed of the purpose and anonymity of the questionnaire. After answering to all items, student gets his position in 4-dimension diagram, according to Kolb's model. Learner may identify himself as one of four styles, or as an indifferent – which is a mix of all styles. Table 2 lists the different features of learning styles [see Tab. 2].

Learning style	They learn best through…
The assimilator	Thinking and watching
The accommodator	Feeling and doing
The diverger	Feeling and watching
The converger	Thinking and doing

Table 2: Features of learning styles [Manochehr, 06]

The Felder-Silverman's inventory is used for classification according to Felder-Silverman's model [Felder, 88]. Learners' preferences were evaluated according to four categories: active/reflective, sensing/intuitive, visual/verbal, and sequential/global. The questionnaire, containing 44 items, was constructed and presented to learners. Every preference category was tagged for every learner. For example, if a learner mostly selected answers that indicated student is an active learner, then student's active/reflective score was positive and student was labelled as active, and if student selected answers that indicated student is not an active learner, then student's active/reflective score was negative and student was labelled as reflective. A similar principle was applied to the other three categories. Diapason including -3 and 3 was considered to be mild, or undefined. Therefore, every learner could be labelled with three possible styles. This would have yielded too many possible categories (81), making the research less legitimate, so it was decided that only two categories for classification should be used: active/reflective and visual/verbal. This decision was based upon preferences that come with these styles, and upon a related work where a similar approach was taken [Alfonseca, 06]. Nine labels were assigned to students: active/sensing (1), active/intuitive (2), active/undefined (3), reflective/visual (4), reflective/verbal (5), reflective/undefined (6), undefined/visual (7), undefined/verbal (8), and undefined/undefined (9).

The following tools were used for data mining and log analysis: Microsoft Visual Studio 2008 [Microsoft, 08]) and Microsoft SQL Server Management Studio [Microsoft, 09].

4.3 Procedures

4.3.1 Data collection

Electronic surveys were used to determine learning style association and data mining techniques were used to gather log file data. The survey instrument was delivered using the Internet to ease participation and data acquisition. The analysed log data was taken from the Moodle server.

4.3.2 Data preprocessing

In this phase the Moodle log data was prepared and rearranged so it could be used in the subsequent steps of the process. According to [Tyagi, 10] the key issue for mining is data quality, meaning the accuracy, completeness, consistency, timeliness, believability, interpretability and accessibility.

Moodle log was queried to gather data only for observed courses. Data was exported to comma separated values format, which is friendly for further editing in spreadsheet software. At first, all columns used by Moodle were exported [see Fig. 1]. Some data, such as IP address or "info" are not relevant for the analysis, so it was necessary to process it and omit these columns.

	A	B	C	D	E	F	G	H	J	K
1	id	time	userid	ip	course	module	cmid	action	url	info
2	703004	1290418610	6	212.200.65.73	59	assignment	5118	update	view.php?id=5118	186
3	703689	1290425917	6	212.200.65.73	59	assignment	5118	update	view.php?id=5118	186
4	754361	1291578896	6	212.200.65.74	59	assignment	5151	update	view.php?id=5151	187
5	785567	1292273390	6	212.200.65.73	59	assignment	5170	update	view.php?id=5170	188
6	808147	1292843833	6	147.91.1.45	59	assignment	5181	update	view.php?id=5181	189
7	825022	1293297059	6	10.1.1.75	59	assignment	5195	update	view.php?id=5195	190

Figure 1: Overview of one part of log file before data

Figure 2 [see Fig. 2] presents the log files after the process of preprocessing.

	A	B	C	D	E	F	G
1	id	Day	Month	Hour	Minute	module	action
2	761515	7	12	20	45	assignment	upload
3	801731	18	12	0	2	assignment	upload
4	801800	18	12	0	10	assignment	upload
5	801811	18	12	0	13	assignment	upload
6	704164	22	11	13	14	assignment	view
7	704264	22	11	13	40	assignment	view

Figure 2: Overview of one part of log file after data preprocessing

According to [Lloyd-Williams, 97] those two processes (selection and pre-processing) demand extreme care because the most important part of the mentioned processes is to get relevant data for analysis.

4.3.3 Data analysis

Accuracy and precision of the implementation of the phases preceding the analysis of the data are the basis for obtaining relevant results.

After the survey was conducted, learners were classified according to Kolb's [12] four style categories: assimilators, accommodators, divergers, and convergers. Learners were also classified according to Felder-Silverman's six categories [Felder, 88].

Collected log files were, after preprocessing, also split into four record groups according to learning style. Moreover, log-classification was conducted according to Felder-Silverman's model.

Preprocessed data is imported into relational database system, in order to be further used with OLAP.

After preprocessing, dimensions and an On Line Analytical Processing (OLAP) cube were created. OLAP systems organise data using a multidimensional paradigm in the form of data cubes, each of which is a combination of multiple dimensions with multiple levels per dimension. According to [Nebic, 10], OLAP might be used to determine the time when the most intensive activities on the system occur. In this paper OLAP techniques are used for the purpose of obtaining distribution of access to collaboration modules.

Before creating a cube, the data source and data source view were created. Data does not originate in an OLAP database, instead it uses another database, in this case a relational database, as a source. Data source view has two purposes:

- It allows the identification of which tables and views from the data source will be used in the concrete Analysis Service Project.
- It retrieves and stores the metadata about those objects, which allows cubes to be built without an active open connection to the data source having to be maintained.

After the data source and data source view were created, the cube dimensions were formed. A dimension is the major analytical object. Dimensions have attributes, and they have relationships with facts. In this research, the dimensions in the OLAP cube are: minute, hour, day, month, year, activity and module. Their function is to add qualitative information to the numeric information contained in the facts. Creating dimensions and cubes leads to the final of the first phase of work in Visual Studio. This phase involves deployment solutions. Deployment solution passes several phases, and all phases should be successfully completed to continue the work within SQL Server Management Studio. Microsoft SQL Server suite includes: integration services that support extract, transform and load (ETL) processes; analysis services that provide analytical capabilities; and reporting services that are used to define, generate, store and manage reports. For the purpose of this paper and OLAP database management the analysis service was used.

Figure 3 [see Fig. 3] shows the OLAP cube.

The cube preview was produced in SQL Server Management Studio following and access distribution to collaborative modules from students with different learning styles, according to both chosen models. Four groups were formed according to Kolb's model and six groups were formed according to Felder-Silverman's model. (Nine groups were initially defined, but all learners fit into six of them.)

The statistical analysis was conducted in order to obtain existence of the statistical difference among the means of the dependent variables in four groups. These groups are made upon Kolb's model. One-way analysis of variance (ANOVA) was used to determine the significance of the differences in the means of dependent variables among student groups according to Kolb's model, accessing the collaborative modules [Postareff, 07].

In this paper the method mentioned was used to determine whether there is a significant statistical difference among student groups with different learning styles (Kolb's model and Felder-Silverman's) when accessing the collaborative modules.

A similar approach was conducted using the classification according to the Felder-Silverman's model.

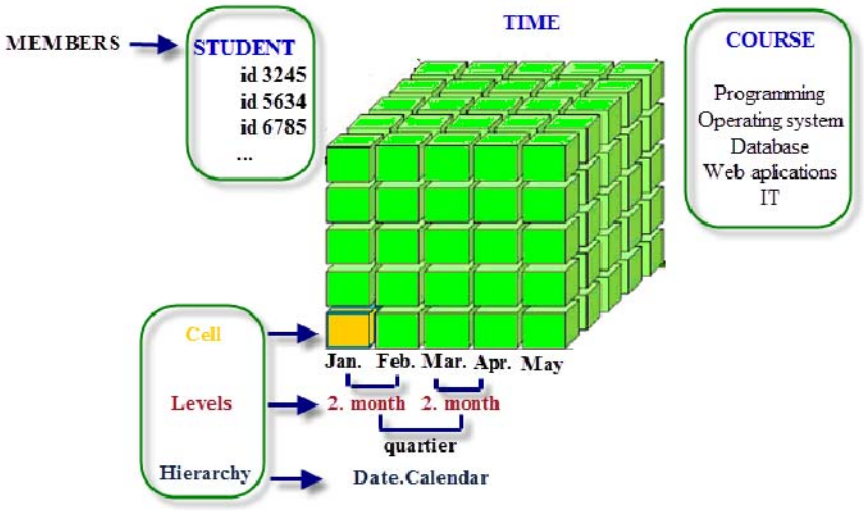

Figure 3: Olap cube [Blagojevic, 11; Panteleon, 08]

5 Results

All the learners surveyed answered all the survey questions. Learners completed two surveys, so that learning profile could be estimated according to both learning styles.

They were classified according to four categories using Kolb's model: assimilators, accommodators, divergers and convergers. They were classified according to six categories using the other learning style model. Furthermore, the results are shown for formed groups according to both style models, first Kolb's then Felder-Silverman's.

5.1 Results for Kolb's style

One-way ANOVA was used to determine whether there are significant differences in access to collaborative modules by different groups of learners, categorised according to Kolb's model. Analysis was made in two directions: the distribution of access to modules and module access distribution for common actions inside specific collaboration modules (chat, forum, wiki). These common actions are: add, update and view.

The results in Table 3 [see Tab. 3] give a summary of learning styles (on Kolb's model). The data about style refers to 22 learners, the number of learners range from 4 to 10, the mean is 5.5 and the standard deviation is 1.134.

	N	*Minimum*	*Maximum*	*Mean*	*Std.*
Kolb's learning style (participants)	*22*	*4*	*10*	*5.5*	*1.134*

Table 3: Descriptive statistical indicators for participants according to Kolb's model

Table 4 [see Tab. 4] shows Levene's test of variance homogeneity. Using this test, the variances in the results of all four subgroups is examined (Subgroups: As-assimilators, Ac-accommodators, Di-divergers, and Co-convergers). The dependent variable is number of times a learner accessed every collaborative module, while the independent variable is the learning style. Significance value in this test (Sig) was .211. Being greater than .05, it did not jeopardise the assumption of variance homogeneity. This proves the null hypothesis (H_0), meaning that there is no significant statistical difference among learners with different learning styles (Kolb's model) regarding access to collaborative modules.

Levene Statistic	**df1**	**df2**	**Sig.**
1.881	3	8	.211

Table 4: Test of Homogeneity of variances for each style (Kolb's model)

Table 5 [see Tab. 5] shows variance analysis of different groups and within group analysis. Sum of squares, residual, number of freedom degrees, and quotient *F*, which represent variance among groups divided by variance within the groups, are shown. The Sig value is shown in the table, which is greater than .05, indicating that there is no significant statistical difference among the mean values of the dependent variable in the four groups.

LogCount					
	Sum of Squares	***df***	**Mean Square**	***F***	**Sig.**
Among groups	4.615E7	3	1.538E7	1.081	.411
Within groups	1.138E8	8	1.423E7		
Total	1.600E8	11			

Table 5: ANOVA for groups of learners with different learning styles

The results shown in Tables 4 and 5 indicate that the null hypothesis (1- H_0) should be accepted, meaning that there is no significant statistical difference among groups of learners who belong to different learning styles (Kolb's model) when accessing collaborative modules.

Moreover, distribution of common module actions is made, having the following actions: add, update, and view. The dependent variable was presented as the number of actions that were conducted over collaborative modules, while the independent variable was learning style. The results shown in Table 6 [see Tab. 6] indicate that there is no significant statistical difference among groups regarding actions that are considered common for collaborative modules. The Sig value, which is greater than .05, indicates this.

CountModule					
	Sum of Squares	***df***	**Mean Square**	***F***	**Sig.**
Among groups	7,709E7	5	1,542E7	,798	,572
Within groups	2,318E8	12	1,932E7		
Total	3,089E8	17			

Table 6: ANOVA for different groups of actions

5.2 Results for learning style – Felder-Silverman's model

The distribution of learners with different styles (according to Felder-Silverman's model) access to collaborative modules and distribution regarding common actions (add, update, and view) are shown in the following tables.

Table 7 [see Tab. 7] gives a summary of the information with learning style as the variable. There is style data for 27 learners and learners' ranges vary from 0 to 10, the mean is 5.5 and the standard deviation is 1.134.

	N	**Minimum**	**Maximum**	**Mean**	**Std.**
Felder-Silverman's learning style (participants)	27	0	10	5.5	1.134

Table 7: Descriptive statistical indicators for participants according to Felder-Silverman's model

Table 8 [see Tab. 8] shows variance analysis among and within groups. Sum of squares, residual, number of freedom degrees and quotient *F*, representing variance among groups divided by variance within groups, are shown. The sig value is shown in the table, which is greater than .05, indicating that there is no significant statistical difference among the means of the dependent variables in the four groups. This proves the null hypothesis (H_0), which means there is no significant statistical

difference among learners with different learning styles (Felder-Silverman's model) regarding access to collaborative modules.

Number of common module actions (add, update, and view) was also treated as a variable, and learning style was independent one. Results shown in Table 9 [see Tab. 9] suggest that there is no significant statistical difference among groups regarding common actions. This conclusion is supported by the Sig value, which is greater than .05.

CountModule					
	Sum of Squares	***df***	**Mean Square**	***F***	**Sig.**
Among groups	7.709E7	5	1.542E7	.798	.572
Within groups	2.318E8	12	1.932E7		
Total	3.089E8	17			

Table 8: ANOVA for different groups (Felder-Silverman's model)

CountAction					
	Sum of Squares	***df***	**Mean Square**	***F***	**Sig.**
Among groups	5.250E7	5	1.050E7	.611	.693
Within groups	2.061E8	12	1.717E7		
Total	2.586E8	17			

Table 9: ANOVA for different groups of actions

According to the above analysis, the null hypothesis (2- H_0) is accepted and the alternate hypothesis (2- H_1) is rejected. There is no statistically significant difference in access to collaborative modules among learners with different styles (Kolb's Model).

Also, the null hypothesis (2- H_0) is accepted and (2- H_1) is rejected, hence there is no statistically significant difference in access to collaborative modules among learners with different styles (Felder-Silverman's model).

6 Discussion

According to [Zapalska, 06] it is necessary to identify learning styles so that teaching strategies can be properly prepared. Teaching strategies that are formed with learning styles in mind would provide learners with control over their personal learning styles and the learning process. In this research the purpose is matched with the aforementioned conclusions, putting the focus on collaborative learning.

In [40][Martin, 2004] it is proposed that two out of four Felder-Silverman's dimensions (sensing/intuitive and sequential/global) could help students in their individual learning while the other two dimensions could help students in their

collaborative learning. Deibel [Deibel, 05] used active/reflective and sequential/global dimensions for managing collaborative groups. In opposition to these suggestions, this research did not find significant statistical differences among learners with different learning styles (according to the Felder-Silverman's model). In this research the active/reflective and visual/verbal dimensions were taken into account. The approach suggested by Martin and Paredes was not tested with real learners, while in this research a reverse procedure was used: learners were assessed first and recommendations for the use of collaborative modules second. Moreover, no significant difference was found for Kolb's model either.

According to [Alfonseca, 06] results there is no significant difference in access to collaborative modules among learners of various learning styles; there is a need to group learners of different styles to gain maximal achievement within collaborative modules.

This research shows that there are no statistical differences among learners with different styles (both models) even in terms of actions (add, update, and view) within the collaborative modules (chat, forum, and wiki). These results show that learners with different styles perform actions such as add, view, and update approximately equally. However, according to Alfonseca, it might be possible to gain more efficient and fruitful work within collaborative modules.

The action research, which had the purpose of improving collaborative module use, indicates that there is no need for course adaptation according to preferable use of collaborative modules regarding learning styles.

We strongly recommend that further research investigate whether there is a specific learning style preference for learners within collaborative activities. Additionally, having in mind that this research regarded learners in the lifelong learning community, it is questionable whether the same issue would arise within the undergraduate learner environment.

Therefore, in next class generation the similar research is going to be conducted in order to check the reliability of concluding remarks. Also, research should be conducted among different populations, where learners are regularly organised throughout the semester.

The process of planning other actions will depend on newly gained results and on the data gathered from learners' feedback. There is no research deadline for the previously planned and conducted research. This means there is no end to this research, but it will be based on a continuous process of course modification and feedback processing.

With the repetition of suggested sequence and system evaluation, with newly gathered results and group interviews with learners, Moodle courses could be modified or remain in the same form.

Limitations of the research are that the samples did not include representatives of all learning styles, following Felder-Silverman's model. Having the nature of research in mind (action research), the sample size could not be larger than it was, but in upcoming cycles a larger number of participants is expected. The participants in this study were selected from only one institution. Thus, it may not be possible to generalise the results of this study to learners in other institutions and/or countries. Future work is oriented towards the next research cycle that is already determined

according to the action plan, but also to learners grouping and measuring success within collaborative modules.

Additionally, an effort should be made to analyse learners' structure more carefully. People may develop learning styles that are not initially preferred, thus neglecting the need for learning style consideration.

7 Conclusions and Future Work

The presented work focused on discovering potential differences in using collaborative modules among learners with different learning styles. This paper introduced the use of OLAP and statistical techniques in pattern analysis of different styles behaviour.

The use of the afore-mentioned approach in the analysis of behavior patterns yields significant results, which currently cannot be provided by a reporting system within the Moodle LMS.

Advantages of this approach are seen in the precise information that can be obtained for each individual, but also for groups of individuals, as shown in the example regarding different learning styles. The drawback is the need for an above average computer performance, as the number of records of user activity increases over time.

Results show that there is no statistical difference among different learning styles in access to collaborative modules, keeping the null hypothesis. Additionally, there is no difference found in common specific actions during usage of these modules.

Moreover, neither Kolb's nor the Felder-Silverman's model showed differences. Therefore, neither of these can be selected as a more appropriate model in this context.

The results of the action research conducted for the presented generation indicate that the use of collaborative modules should be identical for all participants in the course, regardless of the style they belong to.

Results are significant for planning further action research conducted for the next generation of students. Also, it scaffolds the claim, that appears in literature, that influence of learning styles on learner's performance should be researched in combination with more parameters.

Furthermore, it has been verified (using data mining techniques combed with statistical methods) that behaviour patterns may be successfully analysed, by arranging groups according to style and determining the effect of grouping in collaborative learning. That brings further capabilities for research in this area.

The future work relates to the implementation of the action research in the next generation of students, and making the proposal for the improvement of the existing system through the use of collaborative modules in accordance with the learning styles students belong to.

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References

[Alfonseca, 06] Alfonseca, E., Carro, R., Martin, E., Ortigosa, A., & Paredes, P.:The impact of learning styles on student grouping for collaborative learning: A case study. User Modeling and User-Adapted Interaction, 16, (3-4) (2006), 377-401

[Blagojevic, 11] Blagojevic, M., & Baric, S.: The appliance of OLAP and Microsoft SQL Server Analysis Services in the analysis of user behavior patterns, Prec. ICEST Conference, Niš, (2011)

[Caeiro-Rodríguez, 05] Caeiro-Rodriguez M., Llamas-Nistal M., Anido-Rifon L.: "From Contents to Activities: Modelling Units of Learning", Journal of Universal Computer Science, 11, 9 (2005),1458-1469

[Campbell, 96] Campbell, L., Campbell, D., & Dickinson, D.: "Teaching and learning through multiple intelligence", Allyn & Bacon, Needham Heights, MA, (1996)

[Cavus, 07] Cavus, N., Ibrahim, D.: "Assessing the Success Rate of Students Using a Learning Management System Together with a Collaborative Tool in Web-Based Teaching of Programming Languages"; Journal of Educational Computing Research, 36, 3 (2007), 301-321

[Coffield, 04] Coffield, F., Moseley, D., Hall, E., & Ecclestone, K.: "Should we be using learning styles?"; (2004),

http://www.acdowd-designs.com/sfsu_860_11/ShouldWeBeUsingLearningStyles.pdf

[Daga, 09] Daga, F., Geçerb, A.: "Relations between online learning and learning styles"; Procedia Social and Behavioral Sciences, 1 (2009), 862-871

[Deibel, 05] Deibel, K.: "Team Formation Methods for Increasing Interaction During In-Class Group Work"; ITiCSE '05 Proceedings of the 10th annual conference on innovation and technology in computer science education, Caparica, Portugal — June 26-29, (2005), 291-295

[Dugiamas, 11] Dugiamas, M. (2011). Moodle (version 2.1) [Computer Software]. Moodle Pty Ltd. , http://moodle.org

[Essalmi, 10] Essalmi, F., Ayed, L. J. B., Jemni, M., Kinshuk, & Graf, S.: „A fully personalization strategy of E-learning scenarios"; Computers in Human Behavior, 26 (2010), 581-591

[Felder, 88] Felder, R. M., Silverman, L. K.: "Learning and teaching styles in engineering education"; Engineering Education, 78, 7 (1988), 674-681

[Felder, 11] Felder, R. M., Soloman B. Q.: "Index of Learning Styles"; http://www.ncsu.edu/felder-public/ILSpage.html

[Franzoni, 09] Franzoni, A. L., & Assar, S.: "Student learning styles adaptation method based on teaching strategies and electronic media"; Educational Technology & Society, 12, 4 (2009),15-29

[Graf, 09] Graf, S., Kinshuk, & Liu, T.C: "Supporting Teachers in identifying students' learning styles in learning management systems: An automatic student modelling approach"; Educational Technology & Society, 12, 4 (2009), 3-14

[Harriman, 04] Harriman G.: "What is blended learning? E-Learning Resources"; http://www.grayharriman.com/blended_learning.htm

[Heinström, 00] Heinström, J.: "The impact of personality and approaches to learning on information behaviour"; Information Research, 5, 3 (2000), http://informationr.net/ir/5-3/paper78.html

[Hung, 09] Hung, J.L., Crooks, S.M.: "Examining Online Learning Patterns with Data Mining Techniques in Peer-Moderated and Teacher-Moderated Courses"; Journal of Educational Computing Research, 40, 2 (2009), 183-210

[IEEE, 03] IEEE Learning Technologies Standard Committee (LTSC) (2003), 1484.1-2003 IEEE Standard for Learning Technology-Learning Technology Systems Architecture, Retrieved August 1, 2011, from http://ieeexplore.ieee.org/servlet/opac?punumber=8897

[Jollife, 01] Jolliffe, A., Ritter, J., & Stevens, D.: "The online learning handbook: Developing and using web-based learning"; London, UK: Kogan Page, (2001)

[Klasnja-Milicevic, 2011] Klasnja-Milicevic, A., Vesin, B., Ivanovic, M., & Budimac, Z.: "E-Learning personalization based on hybrid recommendation strategy and learning style identification"; Computers & Education, 56 (2011), 885-899

[Kolb, 84] Kolb, D. A.: "Experiential learning: Experience as the source of learning and development"; New Jersey: Prentice Hall, (1984)

[Kolb, 76] Kolb. D. A.: "Learning style inventory: Technical manual"; Boston, Mass.: McBer and Company, (1976)

[Leagle, 06] Leagle, J., & Janicki, T.: "The effect of learning styles on the navigation needs of web-based learners"; Computers in Human Behavior, 22 (2006) 885-898

[Lee, 09] Lee, M. W., Chen, S. Y., Chrysostomou, K., & Liu, X.: "Mining students' behavior in web-based learning programs"; Expert Systems with Applications, 36, 3459-3464.

[Lloyd-Williams, 97] Lloyd-Williams, M.: "Discovering the hidden secrets in your data - the data mining approach to information Information Research", 3, 2 (1997), http://informationr.net/ir/3-2/paper36.html

[Lu, 03] Lu, J., Yu, C. S., & Liu, C.: "Learning style, learning patterns, and learning performance in a WebCT-based MIS course"; Information and Management, 40 (2003) 497-507

[Manochehr, 06] Manochehr, N.: "The influence of learning styles on learners in e-learning environments: An empirical study"; Computers in Higher Education Economics Review, 18 (2006), 10-14

[Martin, 04] Martin, E., & Paredes, P.: "Using learning styles for dynamic group formation in adaptive collaborative hypermedia systems"; Proceedings of the First

International Workshop on Adaptive Hypermedia and Collaborative web-based Systems (AHCW 2004), (2004), 188-198

[Microsoft, 08] Microsoft Visual Studio 2008, Software, http://msdn.microsoft.com/en-us/academic, id subscriber: 70050889

[Microsoft, 09] Microsoft SQL Server, Software, http://msdn.microsoft.com/en-us/academic, id subscriber: 70050889

[Miller, 05] Miller, L. M.: "Using learning styles to evaluate computer-based instruction. Computers in Human Behavior", 21 (2005), 287-306

[Milosevic, 06] Milosevic, D., Brkovic, M., & Bjekic, D.: "Designing Lesson content in adaptive learning environments"; International Journal of Emerging Technologies in Learning, 1, 2 (2006)

[Nebic, 10] Nebic, Z., & Mahnic, V.: "Data warehouse for an e-learning platform"; Proceedings of the 14th WSEAS international conference on Computers: part of the 14th WSEAS CSCC multiconference, (2010), 415-421

[Özpolat, 09] Özpolat, E., & Akar, G. B.: "Automatic detection of learning styles for an e-learning system"; Computers & Education, 53, (2009), 355-367

[Pantaleon, 08] Panteleon, MEZ.: "New trends in database systems: Methods, Tools, Applications, Chapter: Data warehouse and Olap technology"; <http://personales.unican.es/zorrillm/BDAvanzadas/Teoria/Zorrilla07-DW-OLAP.pdf> [accessed 13.01.12].

[Papanikolaou, 06] Papanikolaou, K.A.: "Designing learner-controlled educational interactions based on learning/cognitive style and learner behaviour"; Interacting with Computers, 18, 356–384

[Postareff, 07] Postareff, L., Lindblom-Ylanne, S., & Nevgi, A.: "The effect of pedagogical training on teaching in higher education"; Teaching and Teacher Education, 23 (2007), 557-571

[Riding, 95] Riding, P. Fowell, S. and Levy, P.: "An action research approach to curriculum development"; Information Research, **1**, 1 (1995), http://InformationR.net/ir/1-1/paper2.html

[Rohaan, 08] Rohaan, E., Taconis, R., Jochems, W.: "Analysing teacher knowledge for technology education in primary schools"; International Journal of Technology and Design Education, 20 (2008), 15-26

[Rovai, 02] Rovai, A. P.: "Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks"; The Internet and Higher Education 5, (2002), 319-332

[Ruiz, 08] Ruiz, M. P. P., Diaz, M. J. F., Soler, F. O., & Pérez, J. R. P.: "Adaptation in current e-learning systems"; Computer Standards & Interfaces, 30 (2008), 62-70

[Saeed, 09] Saeed, N., Yang, Y., Sinnappan, S.: "Emerging web technologies in higher education: A case of incorporating Blogs, Podcasts and Social Bookmarks in a

web programming course based on students' learning styles and technology preferences"; Educational Technology & Society, 12, 4 (2009), 98-109

[Tyagi, 10] Tyagi, N. K., Solanky, A. K., & Tyagy, S.: "An algorithmic approach to data preprocessing in web usage mining"; International Journal of Information Technology and Knowledge Management, 2, 2 (2010), 279-283

[Vartiainen, 12] Vartiainen, H. et al.: "Design-Oriented Pedagogy for Technology-Enhanced Learning to Cross Over the Borders between Formal and Informal Environments"; Journal of Universal Computer Science, 18, 15 (2012), 2097-2119

[Zapalska, 06] Zapalska, A., Brozik, D.: "Learning Styles and Online Education"; Campus-Wide Information Systems, 23, 5 (2006), 325-335