# Student modelling in blended learning environment

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**Abstract**. *This paper presents the student modelling within blended learning environment at University surroundings. It is presented with the model SOBEL (Student-Oriented Blended Learning Environment) in which course can be carried out, partly with a traditional instruction and partly using e-learning systems. As blended learning approach best combines both instructions' advantages, it presents good foundation for student modelling development. The main plan is to carry out three year long research (years 2009-2012; six semesters). The research encompasses courses Introduction to programming, Web services and programming, and Web design. With this paper we present research results achieved in the first three semesters.*

**Keywords.** Blended learning, learning environment, student modelling

## 1 Introduction

In order to enhance the quality of educational process, action research has carried out and associate results have analyzed through the implemented blended learning environment. As integration of a traditional instruction and e-learning, blended learning, enables improvement of a classroom experience and learning, using information and communications technology. Learning environment that enables blended learning encompasses traditional instruction and e-learning. E-learning is implemented using learning management system (LMS) Moodle and various software programs. Student modelling approach is being observed within the blended learning environment. Both student modelling and blended learning environment constitute our developed model SOBEL (Student-Oriented Blended Learning Environment). Its development and research last for the last two years, and this is the first time that associate results are being presented during this research. The research is carried out within University of Centre for Professional Studies. The goal of the associate research is to ensure higher quality of the educational process. Also, it is important to change observed issues during the research.

Section 2 describes the main theories that are necessary for better understanding the process of student modelling in the blended learning environment. Section 3 presents the SOBEL with its main characteristics, structure, actors and functionalities. Its structure is also presented using complexity science representations. Section 4 presents carried out research, its analysis and results in the first three semesters.

## 2 Theoretical background

The process of student modelling in the blended learning environment encompasses various theories. Therefore, it is necessary to present their most significant aspects for better understanding of the SOBEL significance. Those theories are blended learning, student modelling and complexity science.

*Blended learning.*

Pedagogical and didactical elements enable more efficient student's learning and teaching [1]. The learning is a process of blurred environment with versatile main elements which aren't full controlled by individuals. The new digital age don't need some new learning theory, yet needs the model of integration of different learning theories that could be able to design appropriate e-learning course contents [2].

Blended learning represents integration of face-to-face and online learning to help enhance the classroom experience and extend learning through the innovative use of information and communications technology [3]. Blended strategies enables: blended learning applicable, enhanced student engagement and learning through online activities to the course curriculum, improved effectiveness and efficiencies by reducing a lecture time. Selecting and sequencing proper elements lead towards the desired outcome – learning [4]. In the context of blended learning, the concept of learning design has particular relevance. Its foundation lies in the relationship between activities and the need for coherence between different course elements [5]. Since every course has different type of educational process, there can't be one model that fits all. Therefore, the significance of the blended learning lies in the ability of customizing learning environment and addressing educational process towards students' specific needs [6]. Blended learning has to be defined through the specific institution and needs to emerge from local curricular and institutional goals.

Student-oriented learning encompasses the following characteristics: student-determined navigational path through the material, content adjusted for the student's bandwidth, the instructional material or test adjusted for the student's familiarity with a material, student may pose a question to designated expert and receive timely response, student can evaluate learning module and etc [7].

*Student modelling.*

Student model presents system's beliefs about the student's knowledge, and provides all necessary information (learning history, goals, capabilities and beliefs) for developing course contents according student's needs [8]. Also, it encompasses the definition of a certain method of collecting and maintaining information for model, and definition of method for managing information in order of providing assistance towards student. Student model is a data structure, and diagnostic is a process which manages it [9]. It can be said that the student model and the diagnostic model are tightly connected. Therefore they are designed together during the process of student modelling. VanLehn's student modelling approach is partially defined through structural properties of the student model, and partially through properties of the input available to the diagnosis module, within Intelligent Tutoring Systems (ITS) as a special class of e-learning systems. The data classification of the student model has three dimensions: bandwidth (related to input), target knowledge type and differences between student and expert (related to structural properties of the student model).

*Student modelling and complexity science.*

Student modelling is a process that can't be entirely predictable. It is a process that depends on many interconnected and independent factors. Since student modelling in blended learning environment can be seen as type of system that depends on variety of dependent and independent factors, that system can be considered as the complex system, which dynamics structure can be shown with complexity science representations.

The complex systems are value-laden multilevel and multidimensional systems of systems, which cannot be predictable in a conventional scientific sense [10]. Since science presents the process of reconstructing theory from data, science can be seen as the process of reconstructing the system dynamics from data. Regarding changing environment of complex systems, new multilevel data collection protocols and new formalism are required to reconstruct intra-level and inter-level dynamics and capacity. Respectively, complex systems require at least the system's current state description, and definition of appropriate transition rules that will transform system's states. Accordingly, the complexity can be managed using ontology and virtual world [11]. A necessary condition for complexity is that there are interactions between parts of the system, with emerging system properties [12]. Emerging properties makes constitute properties of the complex system that is new and emergent against those many parts put together [13]. Usually, learning environments are characterized by higher level relations between many elements, and therefore they can be shown using multidimensional generalization of the network theory. Many complex systems have multidimensional and multilevel structure, and all possible changes can be represented with numerical functions or with relational structure [14]. Every event gives a way of marking system time, and in socio-technical systems, the time can be measured with some structural events. Various events can appear at any level of the system, making a structure of higher level in a hierarchy.

Regarding relational hypergraph structure, hypergraph can be defined on the finite set $X=\{x_1,x_2,\ldots,x_n\}$ to be a family of subsets of X, $H=\{E_1,E_2,\ldots,E_m\}$ such that (1) $E_i\neq\emptyset$ for all i=1,2,...,m and (2) $X=\cup_i E_i$ for i=1,2,...,m [15]. The sets $E_j$ are called hypergraph edges or simply edges. Therefore, any finite class of finite sets $\{E_1,E_2,\ldots,E_m\}$, will be called a finite hypergraph with vertex set $X=\cup_i E_i$, for i=1,2,...,m. There is a binary relation, R, between the vertices and edges of a hypergraph with $E_iRx_j$ if and only $x_i$ belongs to $E_j$. This can be represented in the usual way by an incidence matrix, M, where $m_{ij}=1$ if $x_iRE_j$ and $m_{ij}=0$ otherwise.

## 3 Student modelling approach

Blended learning environment within the SOBEL follows the blended learning theory. Also, student modelling approach is enabled in a blended way, but also following some of previously referred existing student modelling theories. The connection of this approach within the blended learning environment is structurally shown using mathematical representations of the complexity science.

### 3.1 SOBEL model design

The SOBEL is defined through its actors and functionalities. Actors are experts, teacher, student and administrator.

*Main SOBEL functionalities.*

The SOBEL has five main functionalities, as follows: (1) domain knowledge base design (concerned on domain experts' creation and acquisition of domain literature, which are later on used by teacher as a knowledge base); (2) the course contents design (teacher creates and designs course contents for teaching and learning using domain knowledge base; teacher organizes all needed course contents into certain teaching units in a form of specific guidelines for a certain time period); (3) learning and teaching (together with knowledge testing, makes the most comprehensive phase; it includes all teacher's and student's activities within the educational process); (4) knowledge testing (evaluation of student's knowledge on instructed course contents and appropriate guidance for further learning and teaching), and finally, (5) the e-learning system administration (a utility which enables ease usage of the e-learning system for all learning environment actors).

The SOBEL can be structurally divided into three blended learning approaches (traditional instruction, e-learning, self-paced learning) and into two auxiliary processes (domain and course contents design, e-learning system administration) (Fig. 1). Domain and course contents design precedes the main process of teaching, learning and knowledge testing, which at all couldn't be able to start without defining complete course structure and processes.

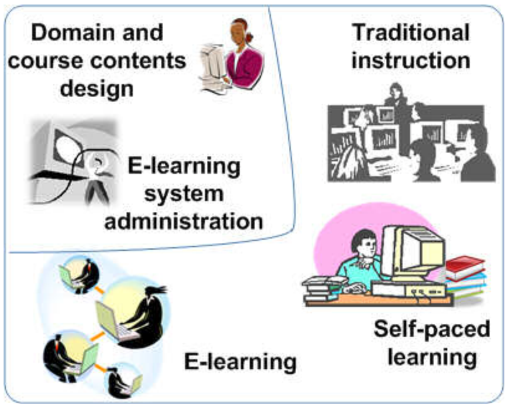

Figure 1. SOBEL structural view

The proposed blended learning design can be implemented in various ways regarding the essence of educational process functionalities (learning, teaching, and knowledge testing). Learning scenarios encompasses various methods for implementing applicable and valid blended learning environment. Methods are assigned according certain chronological arranged learning phases and approaches. Every learning approach contains particular characteristics, tools and techniques. One of the blended learning scenarios presents a course where contents are presented partly in a classroom, and partly using e-learning or students' self-paced learning. E-learning helps with delivery of course contents, evaluation, for communication. Other blended learning scenario encompasses more activities in traditional instruction than at e-learning part.

### 3.2 Mathematical and complexity foundation for SOBEL

During the development of the student model in proposed SOBEL, arise student model issues that can be showed using a complexity science. The complexity can be managed by using ontologies and virtual world of certain system. Fig. 2 shows the ontology for the student model in the SOBEL.

VanLehn's student modelling approach is adopted through the model SOBEL. Although student model dimensions are differently represented, since this model encompasses distinct knowledge representation and distinct system type. Accordingly, VanLehn’s ITS rules can’t fully work for this kind of blended learning system [9]. Therefore, three student model dimensions are altered, customized and mathematical represented through the SOBEL environment. Besides that, since proposed learning environment contains some different other possibilities, it is necessary to define additional student model dimension that are specially developed. So, our student modelling approach in the proposed learning environment represents a contribution in the area of student modelling in e-learning systems.

In this proposed student model approach, course contents are concerned with basic programming skills, web programming and design. We have defined student model in five-dimensional space for the SOBEL, regarding two aspects: domain knowledge (bandwidth, target knowledge type, differences between student and expert), and non-domain knowledge (collaboration, traditional instruction attendance). VanLehn’s associate terms remained, but their inner representations aren’t the same.

Regarding knowledge type, course contents and tasks are mostly designed as textual and graphical guidelines. Usually they provide specific step-by-step examples, and not some structure of concepts that system generates using certain rules. Task encompasses many other exercises which student has to solve in order to obtain final solution of the task, although every exercise individually can sometimes stand alone. Those exercises present intermediate states. Also tasks can be formed as a question with a simple answer from a knowledge base. Altogether, teacher guides the educational process and not e-learning system. Knowledge differences between student and expert encompass every difference in student’s knowledge compared with expected knowledge, in solving certain task and exercise. Every task has its own weighted points which are assigned according complexity level and its mutual dependability. Also, there is a library of all students’ possible incorrect answers, some existed from earlier research, and some that are dynamically collected during the current process of testing and evaluating. Regarding student model dimensions, diagnostic techniques that could be possible altered and used in the proposed SOBEL are: plan recognition interactive diagnostic, generate and test and decision. Teacher leads diagnostics using information obtained from the blended learning environment.

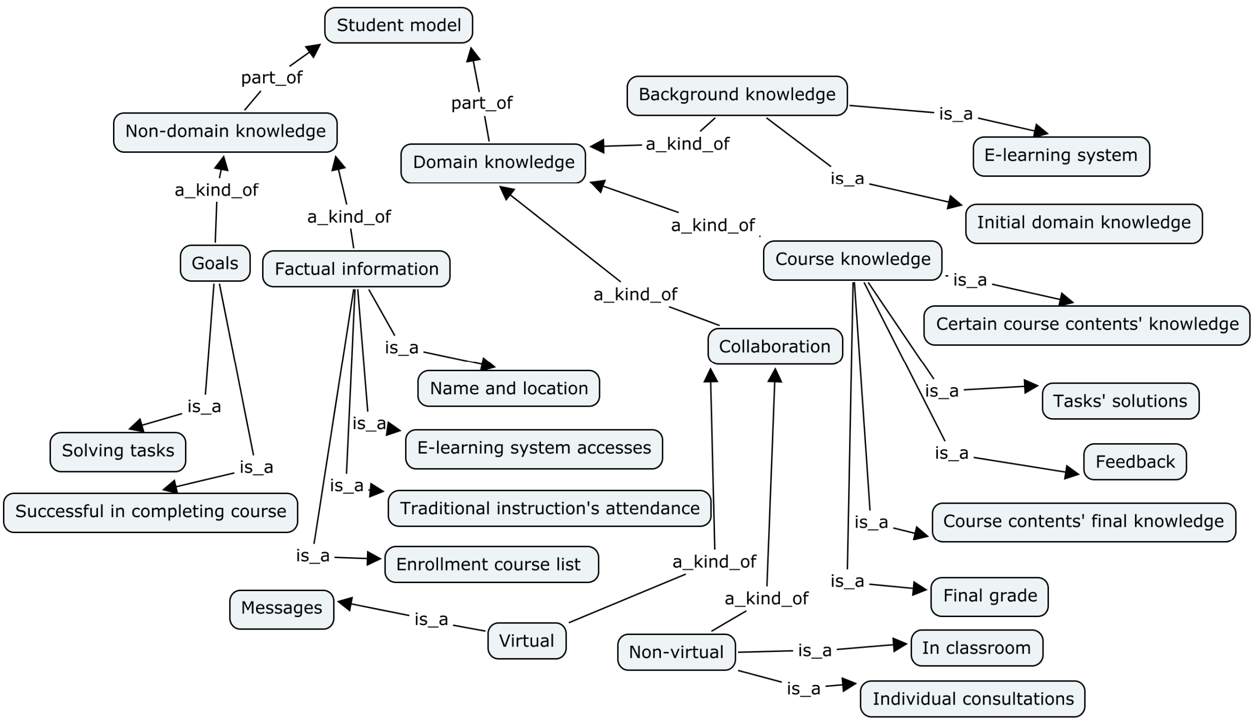


Figure 2. Ontology for the student model in the SOBEL

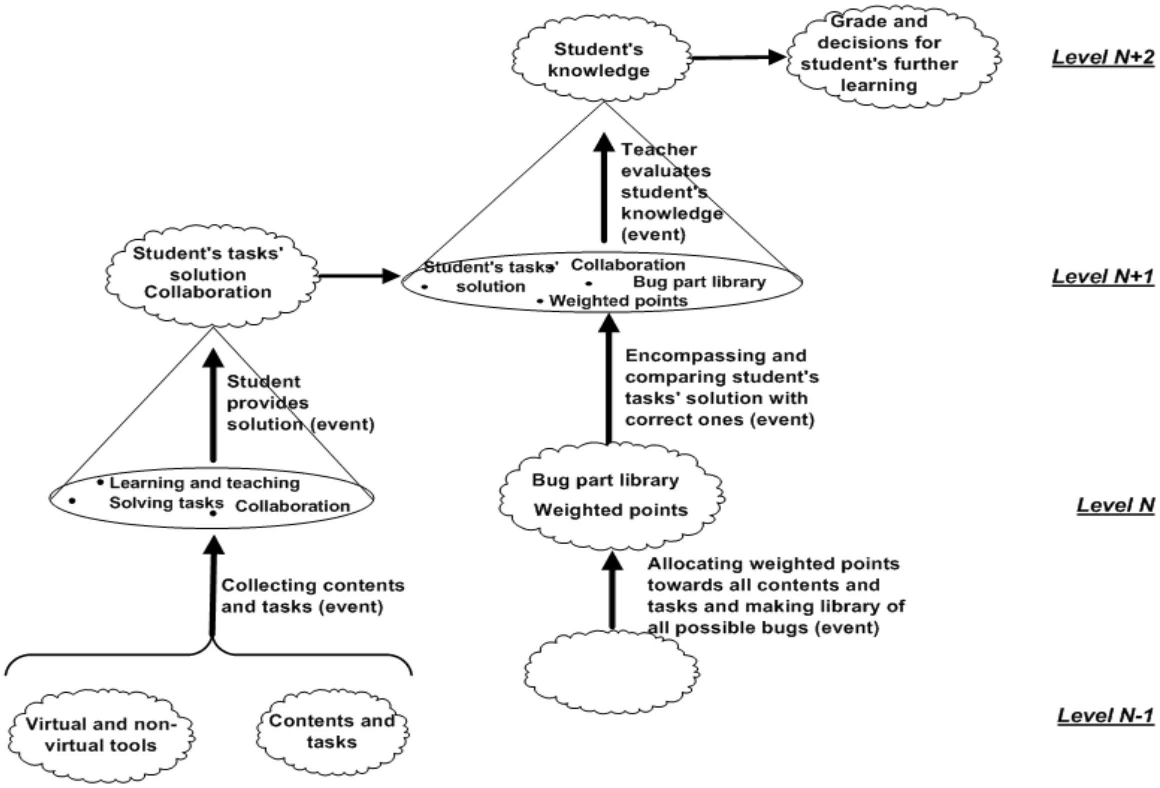


Figure 3. Multilevel and multidimensional events formation of the student modelling within SOBEL

The relational structure (relevant for the educational process and associate student modelling) presents main parts of a complex system, and it can be defined by an ontology, a hypergraph and an incidence matrix. Accordingly, using multilevel and multidimensional dynamics, the SOBEL levels and dimensions can be shown by defining structural events within and between the levels.

We define hypergraph on finite set $X=\{x_1,x_2,x_3,x_4,x_5,x_6,x_7,x_8,x_9\}$, where follows, $x_1$={course contents weighted points}, $x_2$={tasks weighted points}, $x_3$={exercise contents weighted points}, $x_4$={correct weighted points}, $x_5$={mistake weighted points}, $x_6$={correction weighted points}, $x_7$={collaboration with teacher}, $x_8$={collaboration with students}, $x_9$={traditional instruction attendance}, and $H=\{E_1,E_2,E_3,E_4\}$, where follows $E_1$={students solutions}, $E_2$={collaboration}, $E_3$={traditional instruction attendance}, $E_4$={grade}. For hypergraph $H_E(X,R)$ is defined incidence matrix presented M with Table 1.

Table 1. The incidence matrix M of $H_E(X,R)$

| | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ |
|---|---|---|---|---|---|---|---|---|---|
| $E_1$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| $E_2$ | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| $E_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| $E_4$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Fig. 3 shows student modelling appropriate states' flow using multidimensional and multilevel structure. Every event is represented with some structural event which marks the progress of system time. Doing so, those events create a structure of higher level in a hierarchy. Commonly, it can be said that Fig 3. shows the virtual world of the SOBEL.

# 4 Experimental research

Following section presents analysis and results of carried out research within the context of student modelling approach in blended learning environment.

## 4.1 Research environment

The current research presents action research that uses the method of an experiment with one group of 165 students (Table 2). The research encompasses three different courses in the period of two academic years 2009-2010 and 2010-2011 at University of Split, University Centre for Professional Studies, in the department of Information Technology. There are complete results from one course *Introduction to programming,* and partially results from other two courses *Web services and programming* and *Web design*, that are only one year results. The second research year is still in the progress and we are expecting associate results. Therefore, there are complete research results for overall 112 students.

The course *Introduction to programming* conducts on the first year of a study. The main difference between two research years is that latter research year has included initial and final test. The course *Web services and programming* conducts on the second year of a study. As for previous course, the latter research year has included initial and final test, and some new e-learning elements. The course *Web design* conducts on the third year of a study. The second research year has included initial and final test, and some new e-learning elements, which results are still expecting.

Table 2. Research experiment sample

| Course | Research year | Enrolled students |
|---|---|---|
| Introduction to programming | 2009- 10<br>2010- 11 | 40<br>31 |
| Web services and programming | 2009- 10<br>2010- 11 | 23<br>33 |
| Web design | 2009- 10<br>2010- 11 | 18<br>20 |

Our student modelling approach at the blended learning environment is still underway. We expect that action research results will show that this approach of managing educational process will enable good quality of conducted instruction. That quality can be seen through students' grades and achievements. Therefore, those aspects can be seen in the following chapter.

## 4.2 Analysis and interpretation of students' achievements

The analysis shows for each course individually appropriate results obtained from the blended learning environment. Since the modelling process is still evolving, some research parameters haven't be done in every academic year. Therefore, research parameters that stand for instruction quality and can be equally compared will be shown.

For the course Introduction to programming laboratory exercises are completely observed for both research years. Results shows that in the first year 31 students (total 40) have successfully passed all tasks and duties, and in the second research year all 31 students. Fig. 4 shows results from students' initial and final tests for the course *Introduction to programming* in the second research year. It can be seen that their results has just slightly increased. Main reasons could be found in course overloaded by contents, lack of time for writing the final test, and un-seriousness of first year students. Therefore those aspects need to change for the next research university year.

Average students' grades through three instructed units and proper tasks results (including students overall grade) for courses *Web services and programming* and *Web design,* are at high level (Fig. 5, Fig. 6). Only for the latter course, grades are little lower. With a motivating blended learning environment, these courses take place at higher university year of the study, and students have more interest in presented contents. Therefore, those higher students' grades are expected.

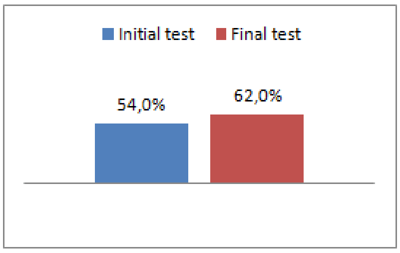


Figure 4. The results of initial and final test for the course *Introduction to programming* in second research year

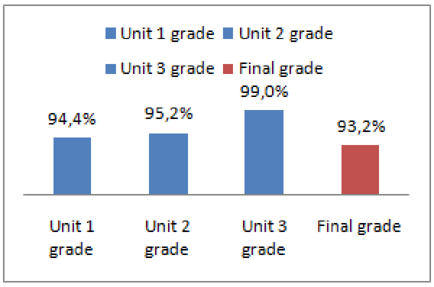


Figure 5. Average students' grades for the course *Web services and programming*

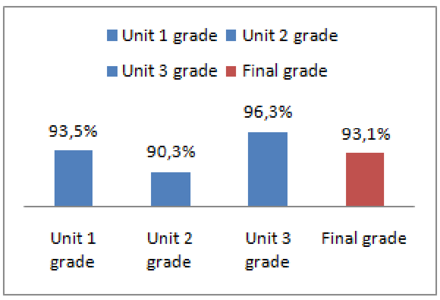


Figure 6. Average students' grades for the course *Web design*

Fig. 7 presents average of all students' attendance on a traditional instruction for courses *Introduction to programming* (in both research years), and for courses *Web services and programming* and *Web design*, for the first research year. It can be said that the attendance average is fairly good, but could be better for the courses *Web services and programming* and *Introduction to programming*. Those courses conduct on earlier academic year than the course *Web design*. Therefore, students haven't still realized that their attendance is of greater importance for easier resolving contents tasks. "Live" teacher is in a classroom and available for helping them in understanding and resolving certain tasks problems. Students from the older academic year are more aware of that, so theirs average attendance is moderately higher.

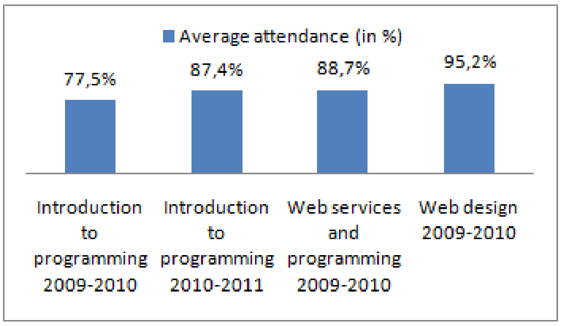


Figure 7. Average traditional instruction attendance (in %) for all courses

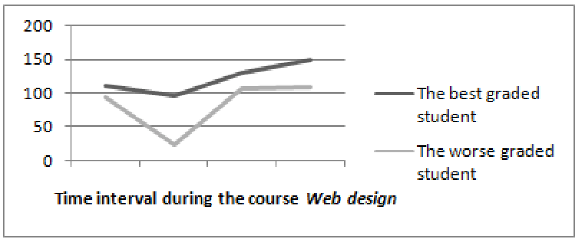


Figure 8. Lowest and highest graded student's activity on Moodle during course *Web design*

Fig. 8 presents the highest and the lowest graded student's Moodle activities during the whole semester for the course *Web design*. It can be seen that the highest graded student has been visiting more often e-learning system than the lowest graded student. Accordingly, the highest graded student had greater motivation and interest in course contents, which is expected regarding it is last academic year course and student needs to have higher motivation for his/her individual work without teacher's instructions. For other two courses can be applied similar results, as it can be seen on Fig. 8.

For now, forum is the main communication tool, so it shows students' interest in course activities and events. During whole semester a forum activity is distributed into classes: poor, good and increased communication. It can be seen that the students' communication level isn't much active, especially for the course *Web services and programming* which is on the second academic year (poor 72%, good 22%, increased 6%). Students on the second year are less active at internet activities then students on older years. Those students developed higher personal communication, usually learn according teacher instructions, and don't prefer searching for some other materials on the Internet. While, students on the first academic year (course *Introduction to programming*) although it isn't expected being so much online, yet they are more interested in all course activities and events, even more than students on the last year (poor 45%, good 26%, increased 29%). That is because towards them whole learning environment is new, and they are willing to explore. While, students from the last year (course *Web design*) are already familiar with the learning environment and with the educational process, so they communicate only when they have to (poor 44%, good 39%, increased 17%). Therefore in any case, some certain actions have to be performed in order to motivate students in online collaboration not only for course contents, but also for some social interaction outside classroom, especially because it is about students who attend information technology study.

## 5 Conclusion

Regarding all observed research areas, it can be concluded that the educational process within this kind of blended learning environment, contributes the quality of the educational process.

Action research of the student modelling approach within blended learning environment is still in a progress, and we are expecting final research results from a second research year, and following ones. This paper presents first research results which are encouraging, and the following research year will give a broadly research presentation due to higher number of students and research years.

Encouraging results and overall impressions can also be seen through carried out questionnaires at the end of a course semester. Majority of students are satisfied with the new environment, and wants to continue learning and teaching using that method. Also, they are pleased having all needed course contents at one place, and still where they can also communicate with each other, outside classroom boundaries. Overall, using blended learning environment for students learning makes easier, better and more interesting.

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