Evaluation of Students' Attitudes towards Virtual Learning Objects for Biomedical Engineering

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***Abstract*— The goal of this paper is to evaluate students' attitudes towards virtual learning objects for biomedical engineering (BME). Students were able to attend traditional classroom lectures, learn virtually, or both. We developed questionnaire to collect students' feedback and analyzed web log-ins. It is envisioned that results of this study will inform the development of the future virtual campus for BME and for other study areas.**

***Index Terms*— e-Learning, educational technology, feedback, quality analysis and evaluation**

I. Introduction

Tertiary education has seen a massive transformation over the last few decades [1], [2]. The goals have changed from teaching facts into helping students to learn how to find relevant information, how to assess it, how to organize different and distributed information into entity, how to engage in critical reflection and dialogue [3], [4]. Meanwhile, learning has moved towards more student-centered [3], problem-based [5], challenge-based [6], or cooperative learning [7]. The practice of using technology to deliver coursework has also created new opportunities for teaching and learning. For example, audio and video records [8], compact and digital versatile disks (CDs and DVDs) [9], personal computers (PCs) [10], iPods [11], Internet and Web 2.0 applications, i.e., wikis, blogs and podcasts [12] have been adapted for educational purposes.

The growing awareness of the importance of innovations in education urges a need to find ways how to evaluate them. However, the evaluation is problematic [3]. Often evaluation of innovations in education is seen through learning outcomes and expressed in numerical values. This might be not reliable due to a small subject pool, students' prior knowledge, motivation, opportunity, access to materials, the Hawthorne effect, i.e., short-term improvement in performance simply as a result of observation [13], time constrains, emotional status, etc., can count on the influences affecting learning [3]. The value of control groups in education evaluation is highly questionable because random allocation of students may address initial systematic differences between experimental and control groups [3]. The simplest measurement of learning outcomes is by examination. Exam results can be showed numerically, thus they cannot measure deep learning and lifelong learning, which must be accepted as ultimate learning goals [3]. Parameters have not been developed yet for measuring deep learning and lifelong learning [14].

European Virtual Campus for Biomedical Engineering, EVICAB, aims to develop, build up and evaluate sustainable, dynamic solution for virtual mobility and e-learning in the filed of BME [15]. This paper presents an outline for evaluation of student's attitudes towards virtual learning objects.

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II. Literature review

A. Review of Education Evaluation Methods

Literature review revealed a number of different attempts to evaluate innovations in education.

For example, Silius and Tervakari [16] proposed online multidisciplinary evaluation framework for the web-based courses for learners, teachers and researchers to define factors critical in the implementation of training and learning services. The main issues within this framework were usability, pedagogical usability, added value, accessibility and information quality of web-based learning environments.

Shaw and Pieter [17] studied change in teaching strategy and views of students when asynchronous learning networks were implemented. For that purpose they developed online questionnaire. The questionnaire included structured questions restricting responses to a narrow range of alternatives and consisted of 16 statements in either text match or multiple choice formats. The text match questions allowed students to express opinions in their own words and the multiple-choice format consisted of 5 possible responses to the given statement arranged in a Likert format.

Ma et. al., [18] investigated whether virtual initiatives succeed. They suggested analyzing critical success factors in virtual education information system. Authors adopted measurement approach that recognized two types of value measures. Direct measures, which measure benefits, accrued by users and their organization units, and indirect measures, which indicate that the system is useful, based on patterns of usage and diffusion. The set of direct measures was derived from the knowledge of benefits derived in academic environments. The set of indirect measures came from the work of Rockart and DeLong [19] as well as others.

Brotherton and Abowd [20] applied four different methods for obtaining information what learning material students were

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accessing within educational capture system, also how, when, why and where they were accessing. These methods included web-login analysis with session tracking, questionnaires, controlled experiments, and classroom observations.

Donoghue [21] assessed what opportunities and tangible assets online learning resources may offer to and require from university and student body. The author used illustrative case-examples and post-course surveys. Survey questions were categorized into six specific areas of focus, i.e., student skills upon enrolment, technology availability, perception of different learning environments, value-added attributes of an online learning environment, pedagogy, and future course development. Questions were largely presented through a Likert-type format allowing interrogating quantitative and decision/ acceptance data. The survey concluded with open-ended comments for non-defined aspects. Survey forms were sent to students by email, with the choice of return by email attachment or printing and posting, if anonymity was desired.

Lee et. al., [2] analyzed how students were prepared for newly developed virtual learning environments by adapting and broadening the framework of technology acceptance model (TAM) developed by Davis, Bagozzi, and Warshaw (1989) [22]. The model proposed that perceived usefulness and perceived easiness are influenced by external variables (e.g., educator authority, university policy) and will influence attitude towards using and actual use of computers (also virtual learning environments). The model was realized through administrating questionnaire to the students. Responses were scored on four-point Likert-type scale ranging from 1-strongly disagree to 4-strongly agree.

Wegner et. al., [23] investigated the impact of Internet-based delivery system on student learning. Students were allowed to self-select into either the traditional classroom section or into the experimental Internet-based section. Problem based learning model was selected to provide comparable learning opportunities. In order to provide conclusions, students' achievements in 100-point exam and satisfaction survey results were compared.

Platteaux and Dasen [24] studied how different students perceive e-learning and what elements made the learning process efficient or not, easy or difficult. Authors gathered quantitative and qualitative data by means of questionnaire and discussion with the students and teacher. The questionnaire was distributed to the students during the last face-to-face moment of the course. The course followed blended learning model.

Aitken and Tabakov [25] designed evaluation to investigate views of student users and training experts on e-learning material using Kirkpatrick's [26] four levels model of evaluation, i.e., reaction, learning, behavior and results. Authors evaluated views of student users at levels 1 (i.e., students' perceptions) and 2 (i.e., knowledge/ skills gained). Data was collected by means of questionnaires.

B. Questionnaires for Obtaining Feedbacks

Students' feedbacks have been recognized as one of the most important considerations when evaluating teaching and learning [27]. Literature review revealed that students' feedbacks are often obtained by means of questionnaires. Other methods, e.g., interviews or classroom observations maybe useful as well, thus, questionnaires have two advantages over others: 1) provide opportunity to obtain feedbacks from the entire population of students, and 2) allow documenting experiences of the students population in more or less systematic way [28]. The process of obtaining feedbacks by means of questionnaires is relatively simple and convenient for both teachers and students; and has been accepted as a matter of routine in many institutions [28]. Due to that reason feedbacks may not always be regarded as a serious matter by those who are involved [28].

This type of evaluation is most often performed at the end of the course and frequently is linked to future arrangements and improvement decisions [29]. There are a number of studies that analyze the value of feedbacks [30], [31]. Aleamoni [32] stated that data obtained from feedbacks provide instructors with first-hand diagnostic information of the accomplishment of educational goals, level of satisfaction and influence of various course elements. Constructively used feedback data can be beneficial for students through improved teaching and learning environment. Also may provide information for the future students when selecting course units or teachers. Administrators may benefit through more accurate representation of students judgments in the decision making process [32].

There are a number of published discussions about ways how to design questionnaires. Krosnick [33] states that there is no best way; thus different phrasings or formats might yield different results. Schwarz [34] contributes that measurement of behaviors and attitudes are strongly influenced by survey instrument features, e.g., minor changes in question wording, format or context can result in major changes in the obtained results. At least five key issues [35] should be considered when designing questionnaire: 1) characteristics of different types of questions, 2) their advantages and disadvantages, 3) good practice in designing questions, 4) good practice in designing format and sequence of questions, and 5) clear instructions.

Once a questionnaire is created it is advised to try it out with a small sample similar to the potential respondents. Pretesting of pilot questionnaire may reveal ambiguities, poorly worded questions, questions that are not understood, unclear choices or clearness of instructions.

Statistically significant findings indicate that students' motivation to provide feedbacks depend upon: 1) the importance to them of improving the value of the current class and that of future classes and 2) the expectation that their evaluative feedback would lead to increased value for them and for future students [29].

Göb et. al., [36] states that the major criteria when analyzing questionnaires should be simplicity, availability, clarity, exactness and information value. Methods like principle component analysis, factor analysis, correlation analysis, t-testing or ANOVA allow describing simplicity and availability. Methods to define clarity and exactness are based on normality assumptions. These assumptions remain mostly undiscussed. Methods for retrieving information value are summing or averaging scores. However, summing or averaging may hide or distort information. For example, strong agreements and strong disagreements may be averaged,

providing a misleading impression of average agreement [36].

III. Case study

The purpose of this study case was to collect, analyze, interpret and compare attitudes of students who participated in the course, which was delivered as a traditional classroom course and also was available as a virtual course. Students' attitudes were analyzed on the basis of their responses to the questionnaire. These attitudes were important since considerable amount of time and effort is usually spent for improving traditional classroom courses and developing virtual courses, generally with little consideration of attitudes of the students.

The international course on Bioelectromagnetism (BEM) has been implemented at Tampere University of Technology (TUT), autumn 2007, 2008, 2009 and Helsinki University of Technology (HUT), spring 2009. Despite the different locations and time, the course content, teacher and requirements remained the same. Instructional materials in the course were: classroom lectures, exercises, video lectures, e-Book, and individual assignments. In addition, Internet examination was arranged. Digital material was available from the virtual campus, EVICAB. Students could make free choices individually whether to attend traditional classroom lectures or to follow them virtually as video lectures on the Internet, or both. Internet examination was compulsory for all students [37], [38].

Altogether 66 students, out of 71, who participated in BEM course and took Internet exam, provided feedbacks by answering the questionnaire. After finishing exam work they had time to reflect individually on the questionnaire, respond and return feedbacks to the course assistant. Students had different international and educational background, e.g., seeking university degree, international, visiting or exchange students (Fig.1).

The pilot version of the questionnaire (autumn, 2007) included 12 questions. Later the form was improved; 20 questions were included. Questions were closed- and opened-ended; students had possibility to express opinions by selecting one or more answers from the multiple-choice questions and to comment in own words. Some answers to the questions had grading system – Likert scale from 1 to 5; where 1 – strongly disagree (or not useful), 5 – strongly agree (or very useful).

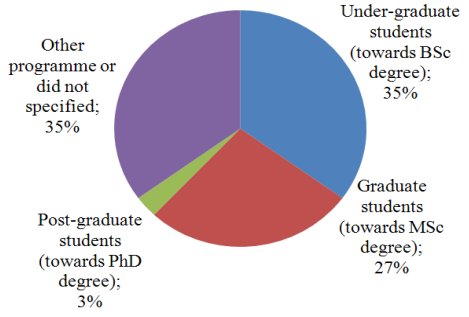

Fig. 1. Educational background of students, who participated in the course and provided feedbacks.

IV. Results

A. Questionnaire Results

Practical Issues. Based on reported amount of study time spent for this course, students were grouped into traditional classroom students and virtual class students (Table 1). Students who spent equal amount of time for traditional classroom and virtual class activities were ascribed as blended class students. Totally 35% of students spent more than half of their study time for attending traditional classroom lectures and exercise sessions; 21% of students spent half of their time for virtual learning, i.e., watching video lectures, reading e-book, doing online quizzes; and 44% of students spent equal amount of time for both - classroom lectures and virtual learning.

Students had different opinions about usefulness of instructional materials in the traditional classroom course and virtual course (Fig 2).

When students were asked what learning method they prefer as the only learning method, 67% of students preferred traditional classroom. The most common reason was that it allows interacting, i.e., to ask questions, comment and discuss with the lecturer and class participants. As the two key points in the traditional classroom lecture students indicated the lecturer – his/ her capability to present material, to raise the interest in the topic, and the content – how significant it is for the students themselves. Still 30% of students preferred virtual class on the Internet because it 'offers possibility to revise concepts', 'allows watching at any time and taking brakes', 'everyone can attend'. Thus 3% of students were not sure which learning method is the best for them.

TABLE 1
GROUPS OF STUDENTS

Group of students	Conditions
Traditional classroom students	More than 50 % of study time spent for: - attending classroom lectures, - attending classroom exercises, or attending classroom lectures + exercises
Virtual class students	More that 50% of study time spent for: - studying from video lectures, - studying from e-book, or - studying from video lectures + e-book
Blended class students	Equal amount of study time spent for traditional classroom and virtual class

Seven different elements supporting learning materials were available for the students, i.e., learning materials in video format, learning materials in audio format, instructions in written format, animations, downloadable materials (to PCs, iPods, media phones), exercises and queries on the web, and virtual comments on learning topic. Students had possibility to test these elements within EVICAB. In addition, other elements

like, self-assessing tests and quizzes, video games based on learning topic, subtitles in native language have been considered. Thus, so far, students were able only to anticipate their usefulness (Fig.3).

The most useful elements based on students' opinions were learning materials in video format, animations and instructions in written format. Students anticipated that self-assessing tests and quizzes would be useful to some extend (Fig.3).

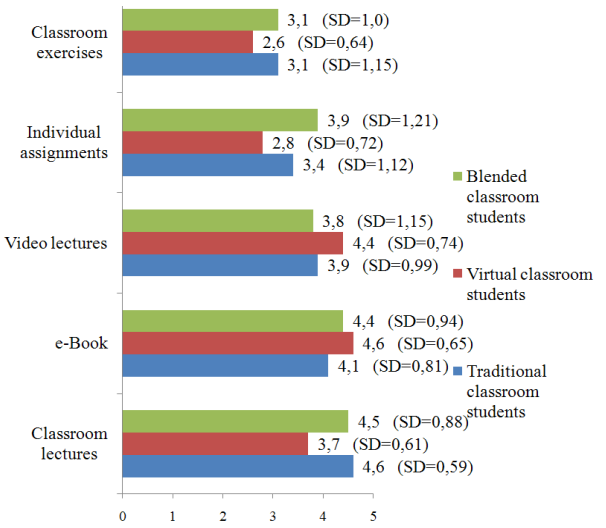

Fig. 2. Traditional classroom, virtual class, and blended class students evaluated usefulness of instructional materials of the course. Evaluation scale was from 1 (not useful) to 5 (very useful). The chart presents average values and standard deviations.

Based on students' answers, the most useful resource in virtual course would be lecture handouts then virtual demonstrations, virtual presentations and lectures, virtual laboratory works and virtual exercises.

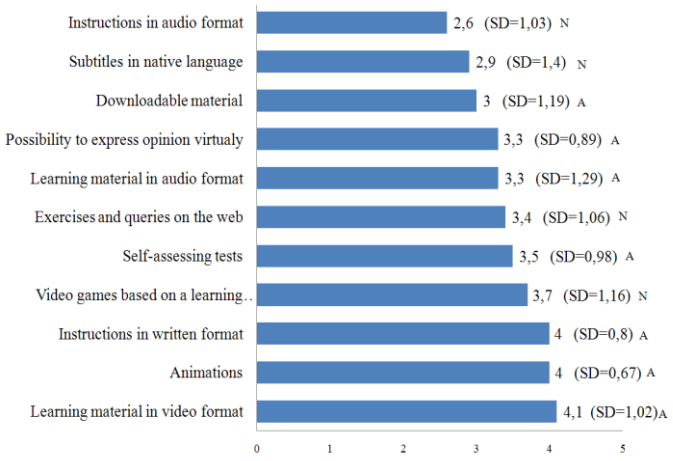

Fig. 3. Usefulness of learning elements presented as averages and standard deviations. Evaluation scale was from 1 (not useful) to 5 (very useful). A: Learning elements were available in virtual campus. Students had possibility to test them. N: Learning elements were not available in virtual campus. Students anticipated their usefulness.

When developing virtual campus, we were interested what modern technologies may be used to support virtual education. Therefore we inquired students what devices do they use to store and playback digital recordings. The majority of students, i.e., 60% use only PC, 38% use PC and other devices, e.g., iPod/ iPhone, MP3 player, and cell phone (Fig.4).

Digital format of a document or a file is important when choosing a device for accessing it. Therefore it was important to get information what is the most common recording format used by students. Students preferred downloading materials to their

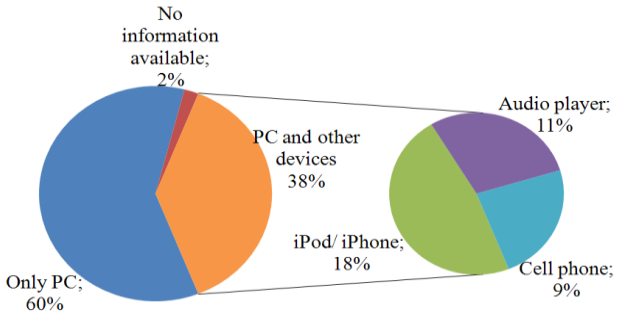

Fig. 4. Devices used by students to support learning process.

PCs (63% of answers). Downloading files can happen at low speed but once they are transferred they can be played multiple times and do not require Internet connection. Less of the students (35% of answers) like to watch streamed recordings from the Internet because it requires constant Internet connection. Podcasting and vodcasting were still quite new technologies for students (2% of answers).

We were able to ask directly 48 students whether they followed video lectures of BEM course and 83% of students followed video lectures on PCs and 6% of them on iPods. Thus, 11% of students did not follow video lectures at all only attended traditional classroom lectures.

Those who followed video lectures evaluated audio and video quality, presentation and pedagogical value of video lectures within the scale from 1 (low quality) to 5 (very high quality). Results showed that the high quality of video lectures motivated students to follow them, i.e., audio quality – 3.8 poits (out of 5), video quality – 4, presentation – 4, pedagogical value – 4.

It was important to find out what problems students may experience when accessing and streaming video lectures on PCs, downloading and watching video lectures on iPods or media phones. The problems were summarized in Table 2.

The main reason why students followed video lectures was to revise and review course material (31% of answers). In addition, students found useful to watch video lectures before exam (26%) and when not being able to attend classroom lectures due to other commitments (25%). About 10% of answers stated that video lectures were useful when not being able to attend classroom lectures due to disability or health problem. About 6% of answers indicated that video lectures were useful for studying on the go, e.g., when traveling by train,

waiting bus, spending time in waiting halls, etc. Only 2% of answers stated that video lectures were preferred more than face-to-face lectures.

Since there were students who did not follow video lectures we were interested why. The main reasons were that students preferred traditional lectures more than recordings (53% of answers), watching video lectures became dull and repetitive process (18%), and due to technical limitations, e.g., PC, player or Internet connection speed discouraged watching video lectures (11%). Minority of students (10%) was not familiar with the idea of video lectures and some (8%) were not satisfied with the quality of video lectures.

TABLE 2
COMMON PROBLEMS WHEN ACCESSING VIDEO LECTURES

Method of accessing video lectures	Common problems
Accessing and streaming video lectures on PC	1) Slow Internet connection 2) No Flash player installed 3) Wrong player, e.g., Real player 4) PC properties, e.g., 'old' laptop 5) Difficult to find right files with video lectures on website
Downloading and watching video lectures on iPod	1) Do not have own iPod 2) Do not download files to my PC
Downloading and watching video lectures on media phone	1) Too large files 2) Do not have own suitable media phone

Students' Suggestions. Students suggested several improvements for video lectures and e-book as for the learning tools. Suggestions for video lectures were:

- More detailed dynamic table of content for each video lecture.
- Good quality and control mechanism.
- An option to download video lectures.
- More informative text.
- Good and clear presentation.
- Explanation step by step so that no need to face difficulties when finding and accessing each lecture.
- Adding fast forward button so that the video can be heard at a faster rate.
- To have main points in native language (e.g., as subtitles).
- More animations and links about the subject.
- Test or quiz at the end of each video lecture.

The suggestions for e-book were:

- Better graphics and animation.
- Separate theoretical and practical material.
- Add page numbering that corresponds with subject index.
- Better search option that could be able to link topics.
- Availability in PDF format.
- Links from the e-book to corresponding video lectures.
- Summaries of chapters.
- Updated interface.
- More animations.

Video lectures contained presentation, recorded lecturer and narration, dynamic table of content, start, stop, forwarding and reversing buttons. Few students did not realize that forward and reverse buttons are synchronized with dynamic table of content, i.e., selecting topic from dynamic table of content it is possible to get to that presentation part where it is discussed in video, so it is not necessary to watch the whole lecture if one is interested only in a certain topic.

Open book Internet examination was quite a new endeavor. Students evaluated it as 3.9 (out of 5) and provided comments, which were grouped into positive and negative.

Positive comments were:

- Internet exam was not memory based.
- Was focused on understanding but not on mechanical learning.
- References were available.
- It was possible to access exam anywhere.
- Served as a learning process (possible to enhance knowledge even during the exam).
- Knowledge application was like in the real world.
- Good change.

Negative comments included:

- Boring to read from the screen.
- Traditional exam was less stressful.
- Necessary to read material in advance to know where to take references from.
- Open book Internet exam provided too many reference materials.
- Possible to copy and paste answers without understanding or knowing the meaning.
- Not absolutely sure that exam answers will end up in correct place.
- Internet connection problems or related technical issues might suddenly ruin the exam.
- Slower to write with computer than by hand.
- Not sure how well it tests knowledge.

Communication in Virtual Class. Classroom interactivity is a critical component of teaching and learning [39]. Especially it is important in virtual environment due to the distance between educator, students, and peers. Based on previous experiences students anticipated how social communication ways and technologies embedded in a course support their learning. Majority of students' answers showed that face-to- face meetings are the most acceptable way of communication (33%), then e-mailing (24%), group meetings (15%), online forum (12%), instant messaging (6%), wiki (3%), blog (3%), audio/ video conference (2%) and phone/ Internet phone (2%).

As students were able to choose how to participate in the course, it was important to find out whether availability of video lectures motivated them to skip traditional classroom lectures. The most common reason why students skipped traditional classroom lectures was another class at the same time. About 17 % of answers stated that availability of video lectures encouraged them to skip the class (Fig.5).

The language is considered to be one of the educational challenges. It is complicated to deliver education in one language so that it is acceptable by the majority of international

students. Thus students' feedbacks confirmed that the English language is suitable for the virtual learning but still 25% of students would like to have some help in a native language, e.g., subtitles. None of the students totally denied that English is suitable for virtual education.

Students' Experiences in Virtual Learning. The use of information communication technology (ICT) to enhance teaching and learning processes has been practiced for a number of years [18]. Therefore we inquired what experience do students have in virtual learning: 40% of students participated in

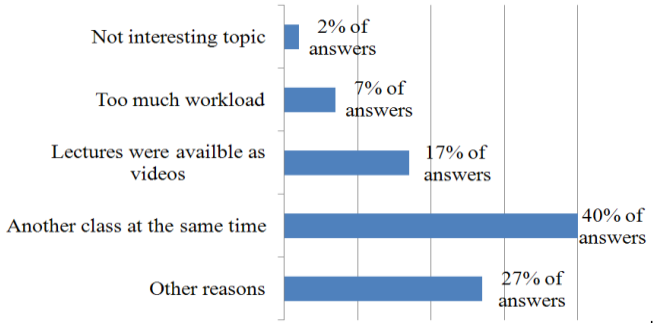

Fig. 5. The most common reasons why students did not participate in traditional classroom lectures.

virtual course earlier, 30% of students did not participate in any virtual course before, 20% of students did not participate but mentioned that would like to, 10% of students did not participate and mentioned that they are not interested to learn virtually.

To conclude their feedback students provided open-ended comments for non-defined aspects, for example: 'I found very useful to read the book and watch lectures when I could not take part in some lectures.' 'Good video material.' 'While watching the video lectures, it would be very helpful to check somewhere all special words and basic idea of the phenomena or equation which the professor mentioned in the video.' 'All the material was good I think. If there were no traditional lectures I would have used virtual material more.' 'It is a good concept and must be implemented for almost all courses in BME with availability of online lectures.' 'Virtual material is nice extra for lectures but do not replace them.' 'It would be nice to have more courses organized in a similar way. More online video lectures would be nice too.' 'There should be more videos of actual operations for inserting pacemakers, setting up ECG etc., that would make the course more interesting. "Video lectures were really good, sound and the slides combined were a really good idea.'

B. *Comparing Exam Results*

Students who responded to the questionnaire were able to choose whether to be anonymous or not; only 32% indentified their names. So it was possible to compare their preferred learning methods and final examination results. We separated these 32% of students as traditional classroom, virtual class and blended class students. Their final exam results appeared to be very similar: average exam results of all students was 2.77 (out of 5); average exam results of traditional classroom students was 2.83; average exam results of virtual students was 2.85; average exam results of blended class students was 2.60.

C. *Web Log-ins Analysis*

Log-ins analysis provided information when, from where and how (e.g., by PC, downloaded for iPod or media phone) virtual material was accessed.

Virtual users assessed learning materials every weekday, average number of visits was more than 40 per day, from all over the world, e.g., Austria, Australia, Brasilia, China, Columbia, Germany, India, Indonesia, Italy, Mexico, Norway, Peru, Singapore, etc.,

Web log-ins allowed to clarify what type of video lectures remote users accessed the most. Video lectures for PCs were accessed the most, then video lectures for iPods and video lectures for media phones.

Most of the users accessed virtual materials with Firefox browsers using Windows operating machines. This information was important as not every browser on every operating system is able to correctly decode video files.

V. Conclusions

In this paper we presented the longitudinal study for evaluating students' attitudes towards virtual learning objects for BME. Quantitative and qualitative data was collected by means of questionnaire and web log-ins system. Most of the obtained data was expressed in numerical values. Our main findings show that students accept and progressively become more interested in virtual education. In general, they say that 'it would be nice to have more courses organized in a similar way'.

Those students who were able to attend traditional classroom lectures were still interested in virtual learning. So those who were not able to attend traditional classroom lectures might found virtual learning even more useful.

Students who provided feedback were university students but log-ins analysis revealed that also users world-wide were accessing learning material. Therefore, virtual education did not replace or eliminate education on the university scale but supported and augmented on the global scale.

Nowadays technologies for virtual education are available and relative user friendly. For example, it is possible to produce video lectures and deliver them globally. Anyone can access them.

The number of people who have access to the Internet is increasing and nowadays most of university students' use Internet for their studies. Technologies might cause some problems, e.g., slow Internet connection, video files and devices compatibility, but advancements in the field are developing globally and very fast providing new and modern solutions.

Findings of this study show that students' attitudes towards virtual learning objects for BME are positive. Thus the development of learning objects should continue considering students' attitudes.

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