Practice of e-Learning Development and Application in Biomedical Engineering Education in Europe

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Abstract: E-learning can provide many advantages for Biomedical Engineering (BME) educationt. An increasing number of applications of e-learning urges a need to find methods how to evaluate them. The aim of this study was to investigate how e-learning has been developing so far (during the years 2006-2009) among BME education offering centers in Europe and to make an estimate of its development in the near future. Therefore, three questionnaires have been prepared and sent to BME education offering centers in Europe in September, 2006, January, 2008 and January, 2010. In general, results show that teachers are interested in further developments and implementations of e-learning for BME education.

1. Introduction

Review of e-learning literature [1], [2], [3], [4] reveals that e-learning can provide advantages for Biomedical Engineering (BME) education. There is no single definition for BME, thus, Bronzino [5] suggests that it is *an interdisciplinary branch of engineering that ranges from theoretical, non experimental undertakings to state-of-the-art applications and encompasses research, development, implementation, and operation*. In the article by LaPlaca et al., [6] the BME field is defined as *the result of the merger between traditional engineering disciplines such as mechanical, chemical, and electrical engineering and the biology-based disciplines of life science and medicine in order to improve procedures such as diagnostic testing, noninvasive surgical techniques, and patient rehabilitation and to apply quantitative analyses to biological problems*. In general, the BME field provides solutions, which have to challenge to remain relevant, while society and technologies continuously change. At the same time BME education has to develop, not just to follow but also anticipate the needs of a changing society and their technologies.

According to the World Factbook [7] there are more than 4 billion (2008) mobile cellular phones in use (60% of the population) and more than 1.6 billion Internet users (2008). The fast development of information and communication technologies (ICTs) provides many opportunities for new teaching contexts where e-learning [8], distance [9], network [10], portable [11], mobile [12] or ubiquitous learning [13] offers new learning possibilities both for teachers and students. According to Nagy [14] the term "e-learning" may be considered as an umbrella term describing any type of learning that depends on or is enhanced by the latest ICTs. In general, e-learning is not very precise and is used inconsistently, thus it can be defined as *the use of digital media and communication technologies, and in particular the online environment, to support learning activities* [15]. In order to grasp the meaning of e-learning on the global scale, the previously mentioned words and synonyms were entered into the Internet search engine, i.e., Google. Only for the key word "e-learning" about 91 500 000 hits were found in 0.33 seconds. This proves the huge interest but also the enormous amount of information available about e-learning.

An increasing number of implementations of e-learning applications urge the need to find methods on how to evaluate them. Several related quality assurance systems have been created and are still in the process of development in Europe. For example, the Bologna Process [16] introduces a three-cycle system and invites to consider how to make pedagogy more student-centered and addresses the needs of graduates to be given adequately studies. European Association for Quality Assurance in Higher Education (ENQA) [17] provides Standards and Guidelines for Quality Assurance for the Higher Education. The ERASMUS programme [18] has brought mobility to a wide range of students from different countries and backgrounds. The commonly used ECTS, learner-centered system for credit accumulation and transfer¸ allows seeking for the recognition of what students have learned at home, abroad, in formal education, through self-study or through work experience [18]. In the BME field, BIOMEDEA [19] suggests Criteria for the Accreditation of Biomedical Engineering Programs in Europe. A study by the European Quality Observatory [20] reveals that there also exist practices for quality assessment in e-learning and suggests further developments.

The European Virtual Campus for Biomedical Engineering, EVICAB, has been developed as a platform for common BME e-learning [21]. The objective of the EVICAB project [22] was to develop, build up and evaluate sustainable, dynamic solutions for virtual mobility and e-learning, according to the Bologna process:

i. Mutually support the harmonization of the European higher education programs,
ii. Improve the quality of and comparability between the programs, and
iii. Advance the post-graduate studies, qualification and certification.

The aim of this study was to investigate how BME education centers in Europe implement and has developed e-learning from 2006 to 2009, and to make an estimate of its continuing development in the near future. Therefore, in order to predict the future, we made a multivariate analysis of the BME e-courses. It is anticipated that the results may motivate the planning of future e-learning in BME and become useful in defining educational plans and goals. Therefore, three questionnaires were prepared and sent out to BME education centers in Europe in September, 2006, January, 2008 and January, 2010.

This paper is based mostly on data obtained from the first and second questionnaires. The educational centers were identified from the survey list in the BIOMEDEA report [23] and by inspecting the national BME societies that were published on the World Wide Web (WWW) [24]. The same list of contact addresses was used for all questionnaires, thus during the time some of them discontinued but newcomers were not included. The target group consisted of teachers and programme coordinators, responsible for education by designing courses and / or curricula.

This paper was written in generic manner so that it can serve as a reference or a starting point for any other e-learning initiative having similar goals.

2. Methods

The aim of the first questionnaire "Existing and planned BME distance courses in Europe" was to get information from experiences of other similar initiatives in the past and to prepare for contribution in the harmonization process of e-learning in BME [24]. The questionnaire was prepared in two versions; an extended version was answered by the European Virtual Campus for Biomedical Engineering (EVICAB) members including 23 questions; and a shorter one for other identified and presumable educational centers comprising 16 questions. The questionnaire was structured according to the following sections [24]:

- Practical issues containing information about the e-course duration, workload, operative language, topic and cycle of qualification.
- Internal and external quality assurance revealing whether the courses comply to the standards set by the ENQA or not.
- Student mobility, lifelong learning and transparency revealing the expected nationality and age distribution of the enrolled students. Transparency of educational content and learning outcome were included since it is expected to affect students' choices.
- Supplementary issues such as the interest in pedagogical approach and the promotion of e-courses through the EVICAB platform.

The questionnaire was sent out to a total of 263 persons in April – July, 2006.

The aim of the second questionnaire "Implementing and conducting of EVICAB courses" was to collect information if e-courses were or could be recognized and applied by BME education centers in Europe. The questionnaire included 5 questions and was sent out to the previously identified responders using an online system [25] in December, 2007 – January, 2008.

In the third questionnaire "Existing and planned BME distance courses, application and recognition of BME virtual education in Europe" questions from the previous two surveys were combined. Altogether there were 30 questions. The aim of the questionnaire was to observe the development process in BME e-learning in Europe. It was sent out to a total of 231 respondents using the abovementioned online system [25]. The questionnaire was administered in December, 2009 - February, 2010.

This paper was written mainly based on data obtained from the first and second questionnaires. Due to low number of respondents, the third questionnaire was not considered as sufficient. Results were structured into 5 categories: practical student issues, internal and external quality assurance, students' mobility, lifelong learning and transparency, application and recognition, and other issues. Data was processed and information was collected into clustered column charts, Figures 1-10. Charts represent percentage distribution of e-courses.

3. Results

3.1 Number of responders

In the first questionnaire we received 62 answers (~23 percent of the asked persons) where 16 answers (~26 percent of the received answers) stated that BME distance courses existed or were planned at a certain university, summing up to a total of 20 e-courses. The second questionnaire received 34 answers and in the third questionnaire we received only 16 answers, where 13 answers informed about existing or planned BME e-courses.

3.2 Practical issues

More than half of BME education centers in Europe have reported on available e-courses and more than half of these e-courses are delivered in English, Figure 1.

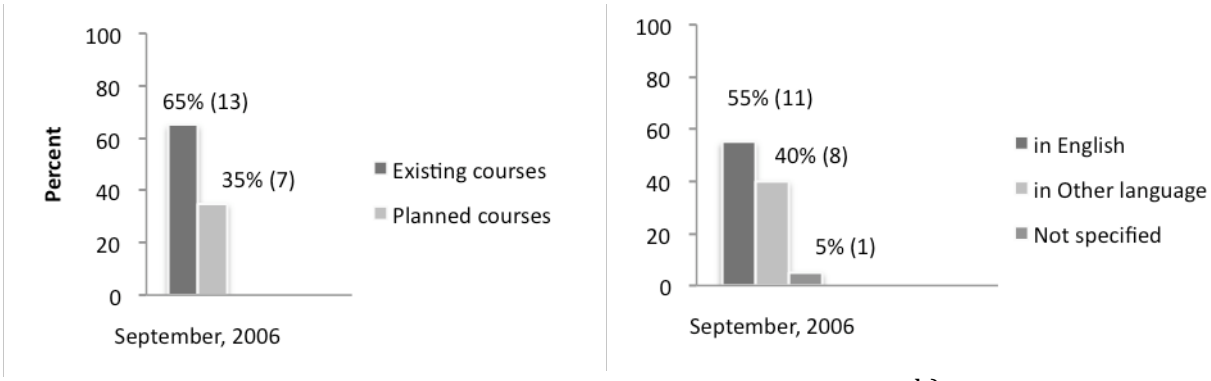

Figure 1. a) Plot of existing and planned e-courses (indicates the real number of e-courses) b) Histogram of e-courses in different languages.

From the survey it could be concluded that most BME e-courses belong to the second cycle (Master of Science) of qualification, Figure 2.

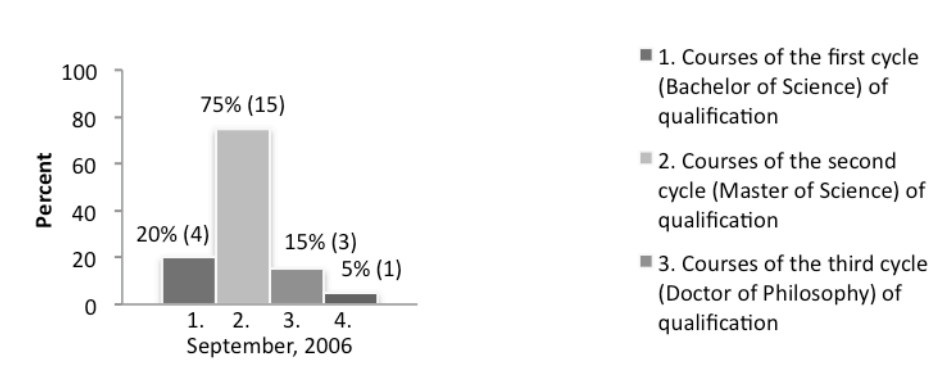

Figure 2. Distribution of e-courses displayed as the belonging to the cycle of qualification.

The most common e-course topics were Biomedical Instrumentation and Technology together with Imaging Systems and Image Processing. Figure 3.

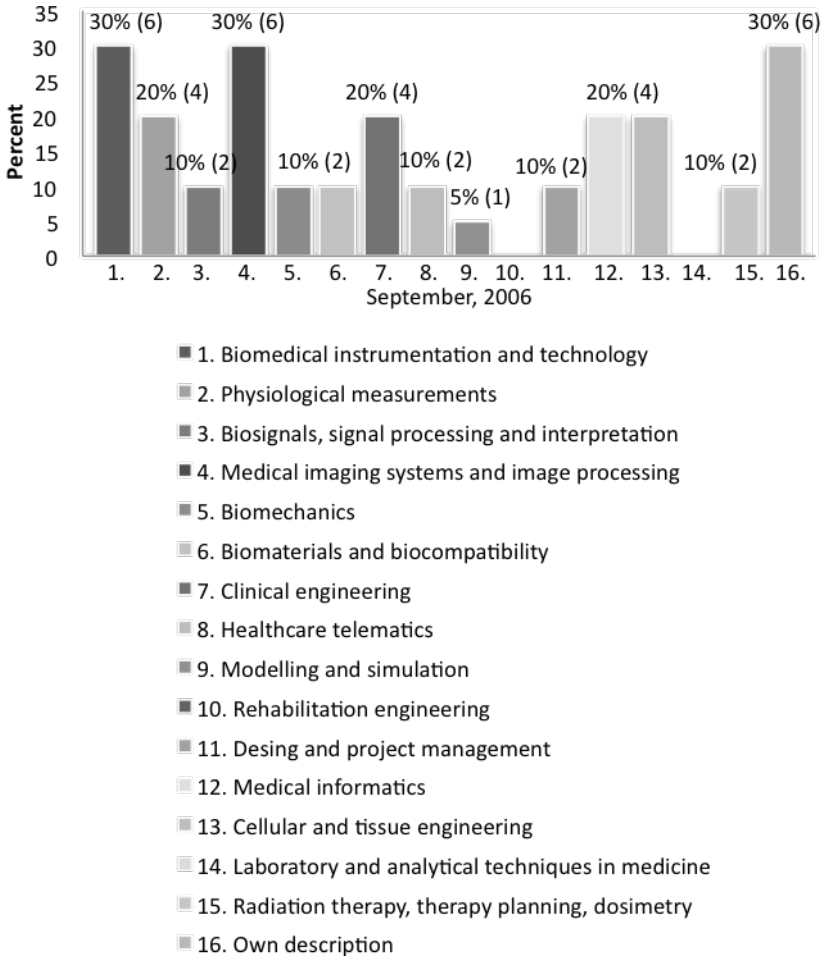

Figure 3. Distribution of e-course according to the topics defined by BIOMEDEA [19].

ECTS credits have been widely used to define workload of e-courses. Half of the recently reported e-courses award students with 5 ECTS credits. Several educational institutes reported courses having more than 60 ECTS credits. We

have reason to believe that this indicates some kind of misinterpretation since such a workload would render full time studies of a year or more. The enrollment in the e-courses varies between 5 to 40 students, Figure 4.

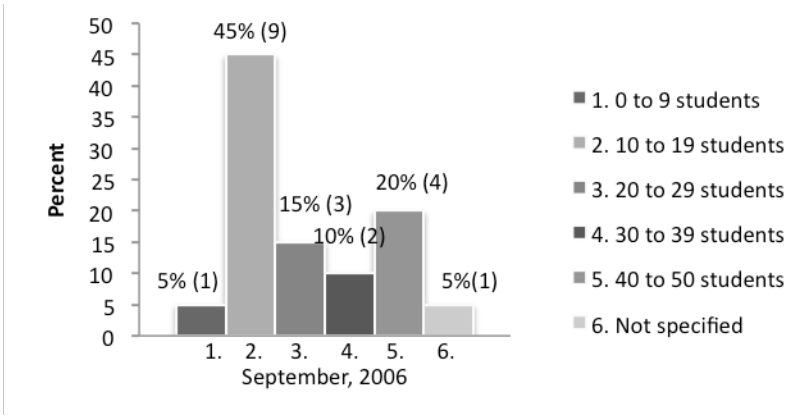

Figure 4. Histogram distribution of e-courses with the number of enrolled students.

The most important resources from people to machines belonging to the e-courses were: tutors, course literature, PCs / Internet, laboratory works, student work, e-platform and demonstrations.

The duration of the e-courses lasted between 10 to 15 weeks (~57 percent), one being a part-time course (24 weeks) and the remaining being short courses, 4 to 7 weeks long, until September, 2006. Most of the courses (~57 percent) were available during the fall semester, while only one of the courses were running independently of time. The majority of the e-courses were delivered each academic year (82 percent), until January, 2010.

3.3 Internal and external quality assurance

Several different measures have been proposed for use as indicators of quality assurance in BME e-courses. The most common measures until September, 2006 were:

1. Feedback by students.
2. Internal quality controls at a university level.
3. Peer review and internal work at an institutional level

This priority list changed between the surveys and now the most common measures until January, 2010 were:

1. Internal quality controls at a university level.
2. Feedback by students.
3. External reviews.

Figure 5. The distribution of e-courses according to measures taken for quality assurance.

The external quality assurance systems in use until September, 2006 were:

- at the national level, e.g., controls by external bodies or reviewers, use of field expertise in an educational context , assuring the quality of teaching or tutoring (for majority of e-courses),
- at the international associations, e.g., ENQA (for minority of e-course).

External quality assurance bodies in use until January, 2010 were mainly at the national level, e.g., as part of the Faculty of Medicine or national higher education quality agency.

Continuous measures were taken to assure a qualified and competent teaching staff that facilitates student learning. Until September, 2006 there measures were:

- participation in relevant seminars and standardization initiatives,
- visits to another universities,
- teachers with other education background.

Continuous measures until January, 2010 were:

- pedagogical training,
- seminars within teaching projects,
- survey and faculty control,
- mentorship programmes,
- students' evaluation,
- self and peer assessment.

3.4 Student mobility, lifelong learning and transparency

More than half of the e-courses have been publishing the learning outcomes. The trend to publish the students' assessment criteria has increased during the past years. The most frequent means of publishing course outcomes (goals) was WWW and course home pages. For several courses, the outcomes were delivered to the students directly, by means of handouts until September 2006. Up-to date impartial and objective information about the e-courses was published regularly (once a year) by minority of respondents in order to attract students to enroll in the courses.

Usually 5 to 30 students enrolled from other universities and among those about 5 to 10 students came from foreign universities. It was also reported that only several students had working experience in BME until September 2006 [24].

Communication between students, teachers and tutors within the e-courses was arranged in multimodal ways. Thus, the direct, face-to-face communication was preferred, Figure 6.

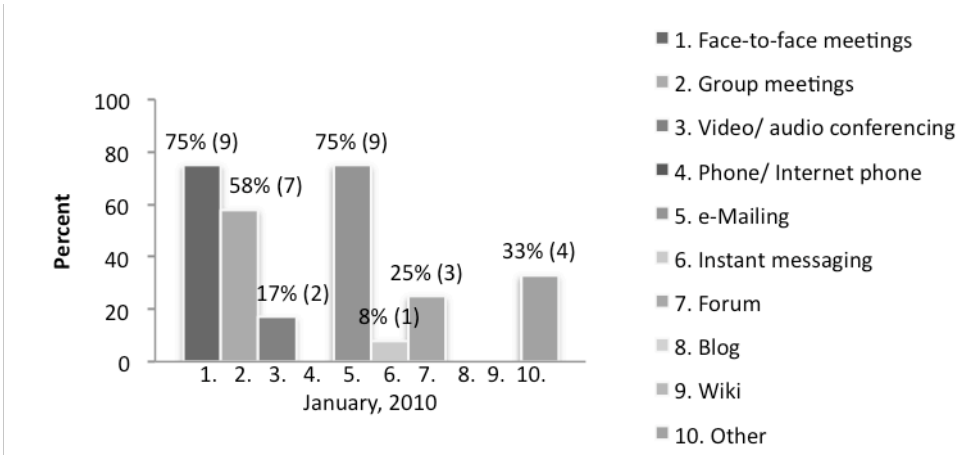

Figure 6. Histogram showing communication strategies between students, teachers and tutors in e-courses.

3.5 Application and recognition

More than half of the respondents informed that they have been using or plan to use, in their own teaching the material provided by EVICAB, Figure 7.

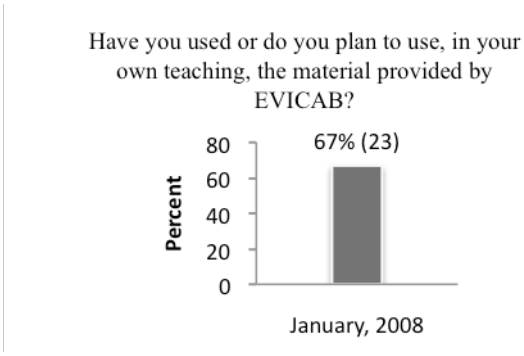

Figure 7. Usage of material provided by EVICAB. Number in parenthesis indicates the real number of persons / answers.

The responders stated that they would encourage their students to participate in virtual exchange studies, using EVICAB resources and recognize their learning outcomes, Figure 8.

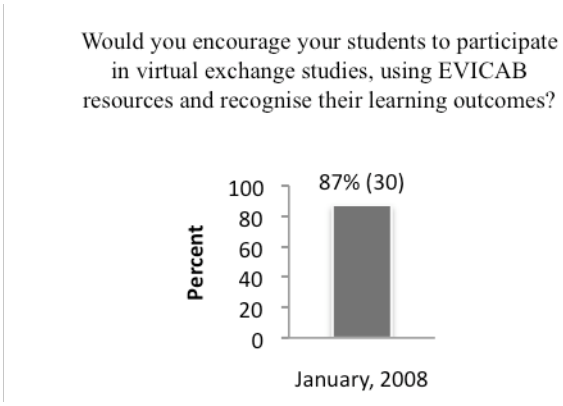

Figure 8. Percentage of course stake holders that would like to encourage students to participate in virtual exchange studies.

Recognition of learning can primarily be made through the accreditation of credit points and grading. Results of the survey showed that that educators prefer Erasmus exchange contracts when recognizing credit points and grades from other universities. Earlier, before January, 2008, educators considered also other options, e.g., own university agreement or bilateral university agreement, Figure 9.

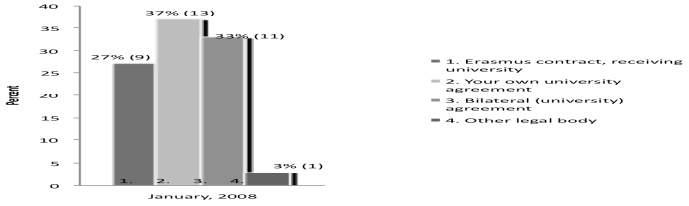

Figure 9. Histogram display of recognition procedures.

Majority of teachers indicated that they are or would be able to provide different specific educational resources to the virtual education, e.g., in EVICAB portal. Lecture materials including slides and animations are the most common resources. In addition, video lectures, textbooks, e-books and virtual laboratory works can be provided. The number of virtual laboratory works is quite low, although every teacher in engineering education understands how important they are for the learning process, Figure 10.

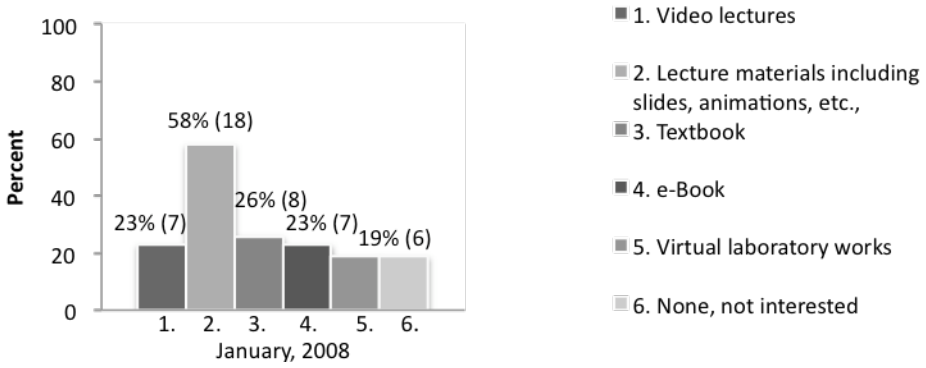

Figure 10. Percentage use of educational resources in e-courses.

3.6 Supplementary issues

The teachers and programme coordinators expressed interest in virtual education; almost 83 percent of responders stated that they would like to promote their e-course through virtual learning platforms, based on comparable and mutually recognized qualifications. The responders were also interested in the possibility to answer a follow-up questionnaire concerning the pedagogical issues and development of e-learning in BME.

4. Discussion and conclusions

The purpose of this report is, through three different but linked surveys, to present how e-learning has been developing and has been applied in BME education. The main findings of the study are following.

Practical issues

- BME e-courses have been developed and established during the investigation period. The predominant language for delivered e-courses are English and they belong to the second cycle (Master of Science) of qualification. Most of the e-courses are awarded with 5 ECTS credits and last from 1 to 3 months. Usually, in the range 5 to 40 students are enrolled in the e-courses.

Internal and external quality assurance

- The survey results showed that measures for quality assurance of e-courses, may have a large variation.
- The consequence is, there is no common system for quality assurance in BME e-learning. Therefore, the primary concern should be, not to develop new quality concepts, but to adapt already existing ones.

Student mobility, lifelong learning and transparency

- The number of students, enrolling in e-courses from other universities, has been increasing. This indicates that learning is becoming more mobile, i.e., not limited by a physical campus programme of only one educational center.
- The fact that students do not have to relocate in order to participate in e-courses creates new concept, i.e., “virtual mobility”.

- BME education centers provide information about e-courses content, their learning outcomes and assessment criteria. The transparency of e-courses can motivate more students to enroll.
- BME students do not have much working experience in the field. It may be assumed that students, who enroll in e-courses, require basic knowledge and information.
- There are different possibilities for communication between students and teachers in e-courses, e.g., forums, instant messaging or video / audio conferencing. Thus, teachers prefer face-to-face communication and group meetings.

Application and recognition

- Teachers have a lot of experience in working with virtual educational materials.
- The majority of teachers have developed or are able to provide lecture materials including slides and animations for virtual education.
- Teachers encourage students to participate in virtual exchange studies and recognize their learning outcomes.
- E-courses still support a teacher-centered approach, where knowledge is unidirectional, i.e., from teacher to students. Therefore, there is a great need for virtual laboratory work and exercises, where students could apply theoretical knowledge and develop practical skills.

Other issues

- Teachers have shown interest to further develop virtual education for BME and to promote e-courses via virtual platform based on comparable and mutually recognized qualifications.

Despite the obtained data, the presented report cannot reveal so accurate information due to limited amount of responses. Not all responders could be reached because of outdated email addresses or changed positions. The benefit of such survey would be that it allows getting reliable, not publicly available information from the key persons who are responsible for education by designing courses and / or curricula. In general, our surveys prove that teachers are interested in further developments and implementations of e-learning for BME education.

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