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Blended learning is an effective strategy for acquiring competence in public health biostatistics

Natasa Milic[1] · Srdjan Masic[1] · Vesna Bjegovic-Mikanovic[1] · Goran Trajkovic[1] · Jelena Marinkovic[1] · Jelena Milin-Lazovic[1] · Zoran Bukumiric[1] · Marko Savic[1] · Andja Cirkovic[1] · Milan Gajic[1] · Dejana Stanisavljevic[1]

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Abstract
Objectives We sought to determine whether blended learning is an effective strategy for acquiring competence in public health biostatistics.
Methods The trial was conducted with 69 Masters' students of public health attending the School of Public Health at University of Belgrade. Students were exposed to the traditional and blended learning styles. Blended learning included a combination of face-to-face and distance learning methodologies integrated into a single course. Curriculum development was guided by competencies as suggested by the Association of Schools of Public Health in the European Region (ASPHER). Teaching methods were compared according to the final competence score.
Results Forty-four students were enrolled in the traditional method of education delivery, and 25 to the blended learning format. Mean exam scores for the blended learning group were higher than for the on-site group for both the final statistics score (89.65 ± 6.93 vs. 78.21 ± 13.26; $p < 0.001$) and knowledge test score (35.89 ± 3.66 vs. 22.56 ± 7.12; $p < 0.001$), with estimated large effect size ($d > 0.8$).
Conclusions A blended learning approach is an attractive and effective way of acquiring biostatistics competence for Masters of Public Health (MPH) graduate students.

Keywords Public health · Master · Competences · Biostatistics · Blended learning

✉ Natasa Milic
milic.natasa@mayo.edu

1 Faculty of Medicine, University of Belgrade, Belgrade, Serbia

Introduction

Competency is the capability to apply a designated set of knowledge, skills, and attitudes to achieve an acceptable level of performance in the world of practice (Hooper et al. 2014). The World Health Organization (WHO) defines competency as the acquisition of a combination of technical knowledge, skills, and behavior (WHO 2006). Higher education curricula based on competencies provide a better monitoring of educational programmes and ensure that, upon the completion of a certain educational degree, graduates are able to meet the challenges of everyday work tasks in their respective fields. In 2006, the Association of Schools of Public Health in the European Region (ASPHER) began to develop key competencies in public health education. The final list of competencies was sent to the European Ministries of Health for revision in 2011, and was adopted by European members of WHO at the end of 2012. The list was included in the European Action Plan for Strengthening Public Health Capacities and Services. ASPHER currently consists of 107 members devoted to strengthening the role of public health through educational improvements and training of public health professionals. The organization encompasses 42 European countries and is comprised of more than 5000 scientists and experts in the field (The Association of Schools of Public Health in the European Region (2017), http://www.aspher.org).

The need for a better trained workforce in the field of public health has been clearly recognized by public health professionals in Europe and worldwide (Bjegovic-Mikanovic et al. 2014). The results of a pilot study evaluating the stages of implementation of core competencies offered by selected schools of public health in Europe suggested the ongoing importance of conducting further comprehensive analyses to identify both met and unmet needs in public health education and training (Otok and Foldspang 2016). The need for competency in biostatistics resulted from the health sciences becoming increasingly quantitative. The use of statistical tools has become widespread in health research, but these tools are often misused and misinterpreted (Casadevall and Fang 2016; Weissgerber et al. 2015, 2016a). Some authorities have gone so far as to issue a warning on the use of p values (Leek and Peng 2015; Baker 2016). Better statistical training in the health sciences has been recommended previously by us and others (Casadevall and Fang 2016; Weissgerber et al. 2016b; Sullivan et al. 2014). According to the ASPHER competency model, statistics is a specific competency defined as the science of the collection, summary, analysis, and interpretation of numerical information that is subject to random or systemic variation. There are currently 80 Masters of Public Health (MPH) programs that are accredited in Europe (Bjegovic-Mikanovic et al. 2014). Masters of Public Health curricula commonly are guided by certain proposed core competencies, but the curricula can also be more specifically focused on certain populations or particular fields within public health (Calhoun et al. 2008). Biostatistics competencies, however, have to provide certain skill sets and knowledge base in the field of public health to each candidate regardless of the courses which he/she attends. The adaptation of coursework in biostatistics to a student's specific field of research may be difficult, especially for those who attend institutions with limited resources. New learning methods and environments have been suggested, particularly for these situations, as ways to improve biostatistics education (Bjegovic-Mikanovic et al. 2014; Milic et al. 2016a; Weissgerber et al. 2016b). We recently implemented a blended learning format for teaching applied statistics to medical students (Milic et al. 2016a, b). Blended learning included a combination of face-to-face and distance learning methodologies integrated into a single course. Student performance was higher overall in those using the blended learning approach compared to those using the traditional on-site training. In this study, we sought to determine whether blended learning is an effective teaching strategy for acquiring competencies in public health biostatistics.

Methods

This was a prospective trial conducted with MPH students attending the School of Public Health, University of Belgrade. We compared different teaching modalities to gained competencies in biostatistics for MPH students enrolled for the academic years 2012/2013 to 2015/2016. The trial was conducted on two groups of students, with one group exposed to the traditional classroom, i.e., on-site learning style (2012/2013 and 2013/2014) and the second group exposed to a blended learning style (2014/2015 and 2015/2016). They were compared according to the success achieved in pre-exam and exam activities, as well as by a final competence score.

The content of the biostatistics course was developed using established principles of curriculum development and was guided by competencies as suggested by ASPHER. Table 1 lists the 35 specific competencies included in this model. The Biostatistics in Public Health course was developed as an obligatory introductory course, with most ($n = 23$) of the listed competencies included in its curriculum (65.7% were actually completed). Lectures, seminars, discussion clubs, and practical class work were used as means to acquire the mandatory competencies, which included the following: definition of statistics as a science, inference, parameter, probability, random sampling, probability sampling, stratified sampling, normal distribution, statistical power, point estimate, interval estimate, confidence interval, association, correlation, significance, statistical test, parametric vs. non-parametric test, Student's t test, chi-square test, non-parametric tests, predictor, regression, and linear regression. We used a variety of statistical software packages to demonstrate the practical application of statistical methods in public health research. The same curriculum was introduced in 2014 using a blended learning format which added a Web-based learning environment to the traditional on-site format to facilitate the acquisition of competencies in public health biostatistics (Fig. 1). Learning objectives and course content were identical for the blended and on-site formats of the course, and were taught by the same instructors. The blended teaching approach was supported by the interactive multimedia didactic materials which were accessed through the Moodle Learning Management System (LMS). These materials contained the same information as that used in the face-to-face classes, and were available for use until course completion. Students were also provided with reading material to accompany or complement each lecture, as well as copies of all lecture slides. Both online and on-site courses included structured live group activities and case discussions, in addition to formal lectures. Online students also had the option of posting questions through a Web portal to facilitate discussions with fellow students and course faculty. On-site courses included time for questions and discussion during and after lectures. The elements of the blended learning course are provided in detail in Fig. 1.

The formal evaluation of student achievement was identical for both learning modalities and consisted of:

1. Course activities throughout the year
2. A final exam: (a) a "Problem Solving" section which consisted of three analytical problems that needed to

Table 1 Association of Schools of Public Health in the European Region (ASPHER) model of competencies and presence of these competencies in the biostatistics curriculum of the Masters' program of public health at School of Public Health, University of Belgrade (SPH UB)

ASPHER Competence[a]	SPH UB Yes (+)/no (−)	ASPHER Competence[a]	SPH UB Yes (+)/no (−)
Definition of statistics as a science	+	Significance	+
Inference	+	Statistical test	+
Parameter	+	Parametric vs. non-parametric test	+
Probability	+	Student's *t* test	+
Random sampling	+	Chi-square test (χ^2)	+
Probability sampling	+	Non-parametric tests	+
Stratified sampling	+	Predictor	+
The normal distribution	+	Simple stratified analysis	−
The binominal distribution	−	Standardization	−
The Poisson distribution	−	Direct standardization	−
Statistical power	+	Indirect standardization	−
Point estimate	+	Survival analysis	−
Interval estimate	+	Regression	+
Confidence interval	+	Additive and multiplicative	−
Association	+	Prediction models	
Confounding	−	Logistic regression	−
Interaction	−	Linear regression	+
Correlation	+	Randomization	−

[a]Birt and Foldspang (2011)

be resolved using various statistical software packages, and (b) a knowledge-based test, which consisted of 20 multiple-choice questions, each with four answer alternatives. Test scores ranged from 0–40. Questions were related to descriptive statistics (frequency tables, measures of central tendency, measures of dispersion, types of distributions, and measures of association) and inferential statistics (basic concepts in inferential statistics, estimation, and hypothesis testing). Students were given 40 min to complete the knowledge test. The grading of the final exams was done completely electronically to exclude grading bias by the teaching faculty. Students completed the final exam on a computer in the informatics classroom. Exam questions were randomly selected from a "Question bank" and then automatically checked for correct answers. The "Problem Solving" portion followed the same process. Students had to solve calculations using statistics software and then input answers into the system, which would again check for correct answers.

3. The final score for overall statistics achievement was calculated by summing the activities during classes (weighted 0.3), the problem-based component (weighted 0.3), and the knowledge test score (weighted 0.4).

The final statistics score (ranging from 0 to 100) was defined as the primary endpoint, but all four outcome variables were compared between the two learning groups to assess the relative efficacy of the blended learning approach. The overall academic quality and performance of the cohort of MPH students from 2012 to 2014 was found to be equivalent to that of the MPH students in the 2014–2016 cohort, with analysis performed prior to assessing the two learning formats. A questionnaire to capture self-reported computer literacy, student satisfaction, and perceptions of the blended module was distributed for completion after the conclusion of the module. Responses for computer literacy and student satisfaction were ranked using the 5-point Likert scale, while the responses for perceptions of the blended module were open-ended. Ethical approvals for the study and consent procedure were obtained from the Institutional Review Board (IRB) of the Faculty of Medicine of the University Belgrade to which the School of Public Health belongs. Informed consent was obtained from all participants before conducting the study. Verbal informed consent was obtained from the students attending the on-site classes and recorded by a research assistant. Written consent was obtained from students attending the online classes.

Statistical analysis

Descriptive statistics were calculated for the student characteristics and outcome measures, and reported as mean

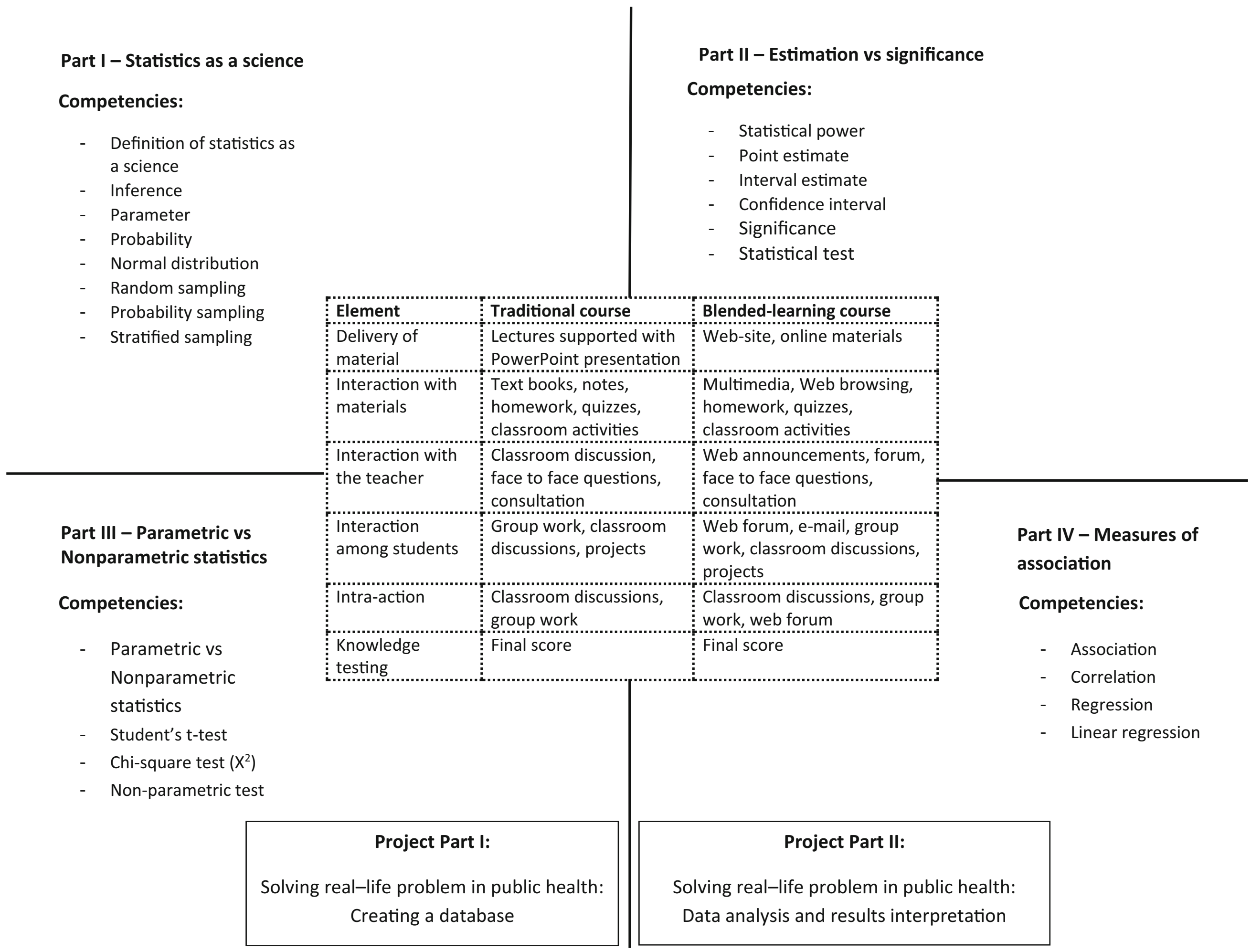

Fig. 1 Structure of the Biostatistics in Public Health course (legend: SPH UB—School of Public Health, University of Belgrade). The course development was guided by competencies suggested by the Association of Schools of Public Health in the European Region (Birt and Foldspang 2011)

with standard deviation or number and percentage, as appropriate. A median with interquartile range (IQR) was used to demonstrate students' scores for questions with a 5-point Likert Scale (1—lowest, 5—highest value). Differences between groups were analyzed using Student's *t* test for continuous variables, and the Pearson chi-squared test for categorical variables. The relative size of the effect was assessed based on standardized estimates of effect size according to Cohen's benchmarks (Cohen 1988), which defined *d* as the difference between the means divided by pooled standard deviation. An effect size is a quantitative measure of the strength of a phenomenon, where a larger absolute value indicates a stronger effect. Reporting effect sizes is considered good practice when presenting empirical research findings, as an estimate of effect complements statistical hypothesis testing. All tests were two-tailed. $p < 0.05$ was considered statistically significant. The IBM SPSS 25 (Chicago, IL, 2017) package was used for these analyses.

Results

An existing biostatistics course in the School of Public Health of the University of Belgrade was redesigned in 2014 using a blended learning format. Twenty-five students were enrolled in the course during the 2014/15 and 2015/16 school years. Student achievement in a blended learning environment was compared to that of 44 students enrolled in the traditional method of education delivery during the 2012/13 and 2013/14 school years. Mean exam scores for the blended learning student group were significantly higher than for the on-site student group for both the final statistics score (89.65 ± 6.93 vs. 78.21 ± 13.26; $p < 0.001$) and knowledge test score (35.89 ± 3.66 vs. 22.56 ± 7.12; $p < 0.001$). Results for the students who took the final exam and achieved points for different activities during their Masters training are given in Table 2. The calculated effect sizes for the final score and knowledge test difference were 1.08 and 2.35, respectively, which stands for a "large" effect size according to Cohen's guidelines for describing effect sizes. The dropout rates (i.e., students who did not attempt to pass the final exam during the school year) were 33 and 8% for the on-site and blended groups, respectively, indicating that students from the blended learning group were more likely to complete their course obligations in a timely manner. Prior to the analyses of the learning outcomes, we examined the equivalence of the studied groups based on students' academic performance as assessed by grade point average (GPA) (ranging from 0 to 10), and the rate of completion of other exams during their MPH training. There were no differences between the two groups with respect to these characteristics ($p = 0.532$ and $p = 0.895$). The GPA for the on-site and blended learning groups was 8.9 ± 0.6 vs. 9.0 ± 0.5, while the rate of completion of other exams was 85.1 vs. 86.2%, respectively.

Students indicated a high level of self-reported computer literacy (median 4, IQR 4–5) and a high level of satisfaction (median 5, IQR 4–5) with the blended learning module. Blended learning was generally regarded as both acceptable and interesting for students. Students acknowledged that a clear structure and frequent signposting were necessary for the blended learning modules to function optimally. They stated that the format of progressing from basic to more complex ideas was logical and facilitated studying and comprehension. Face-to-face learning augmented the knowledge acquired through the online program. However, students also reported going back to the online program to clarify points obtained from face-to-face learning. The presence of easy to understand materials that were always available for review lowered student stress and anxiety. The time flexibility inherent in the technology-based learning was described as a major strength. The majority of students reported being satisfied with the interactive components, such as examples from practice tests, which led to increased engagement and improved understanding of the topics. Students noted that in a traditional learning environment, they would not have completed the pre-class reading assignments, and that by being included in the online program, they were forced to do so. They later described being more adequately prepared for face-to-face learning, which led to more effective discussions and efficient learning.

Discussion

In this study, we sought to determine whether the introduction of a new learning environment based on modern information and communication technologies might facilitate acquiring competencies in public health biostatistics. The development of our curriculum was guided by the formal competencies suggested by ASPHER, and these competencies were used as a primary measure of student achievement. Students who were exposed to the blended learning format displayed better results when compared to those who were exposed to the traditional on-site learning environment.

All significant public health institutions agree on the central importance of introducing modernized teaching and learning concepts based on core public health competencies, which in turn, should lead to an effective performance level in the public health working environment (Bjegovic-Mikanovic et al. 2014). Academic institutions of higher learning are searching for appropriate strategies to improve competency-based education (Bjegovic-Mikanovic et al. 2014), which should increase the global attractiveness of their academic programmes. Academic professionals increasingly are taking advantage of new Web-based technologies for life-long learning. The focus, in fact, is on a blended learning format that utilizes both the traditional classroom face-to-face learning and distance learning via the Web. The adoption and implementation of these technological advances in the teaching and learning processes has varied widely. Barriers to implementing these changes

Table 2 Comparison of traditional and blended learning styles in the trial conducted with Masters' students attending the School of Public Health, University of Belgrade

Variable	On-site learning $n = 44$	Blended learning $n = 25$	Effect size d[a]	p
Number of students who took the final exam, n (%)	34 (77%)	23 (92%)		
Pre-exam activities, (0–30), mean ± SD	29.48 ± 1.15	29.54 ± 1.04	0.05	0.842
Solving problems score, (0–30), mean ± SD	26.04 ± 10.95	24.22 ± 4.87	0.21	0.454
Knowledge test score (0–40), mean ± SD	22.56 ± 7.12	35.89 ± 3.66	2.35	< 0.001
Final statistics score (0–100), mean ± SD	78.21 ± 13.26	89.65 ± 6.93	1.08	< 0.001

Blended learning included a combination of face-to-face and distance learning methodologies integrated into a single course. The curriculum development was guided by competencies suggested by the Association of Schools of Public Health in the European Region (Birt and Foldspang 2011)

[a]An effect size is a quantitative measure of the strength of a phenomenon, where a larger absolute value indicates a stronger effect

are more often linked to human resistance associated with adopting a new teaching approach than to limitations of computer-assisted technologies.

There are several reasons why blended learning may enhance the quality of biostatistics education in global health. Our collaborative group recently demonstrated the benefit of applying a blended learning approach to a biostatistics core course for medical students (Milic 2016a). The main advantage of applying the combination of online and traditional learning environments to the teaching of existing curricula lies in its inherent flexibility that fulfils the needs of both learners and educators. Increased accessibility to learning materials and efficient exchange of information optimize time management result in a streamlined learning environment with subsequent less anxiety. Ease of distribution and ability to update course material in real time are further examples of the advantages of online classrooms (Milic 2016a). The presented capabilities of online technologies support the implementation of blended learning curricula and may encourage higher educational institutions to look beyond their traditional teaching methods and to develop a more student oriented, i.e., personalized instruction (Lewin et al. 2009; Pereira et al. 2007; Liu et al. 2016). In this study, similar to the study by Morton et al. (2016), students felt that online learning should not serve as a replacement, but rather serve as a supplement to improve upon face-to-face learning by preparing students for a more efficient learning experience. Students generally agreed that the best use for the online learning component is to provide basic knowledge, whereas face-to-face learning is a more effective way to form and communicate abstract ideas. The role of educators in the future will be to find the correct balance between face-to-face and online teaching methodologies.

All educational curricula should be adjusted to the needs of practice, and in the case of public health, these needs are defined internationally through competencies, the masteries of which should be obligatory for public health graduates (Bjegovic-Mikanovic et al. 2013). The ASPHER model of MPH competencies aims to provide a basic list of necessary core knowledge and skills. The competencies listed in this model are also meant to be useful to institutions to guide in the design of their course work, and to provide Masters' students with a systematic and concise list of learning expectations (Bjegovic-Mikanovic et al. 2013). The list is intended to be used as a resource, but not a prescriptive mandate, consequently, there are large variations in the presently available curricula in MPH biostatistics programs among ASPHER members. A pilot study conducted by our group, which included 21 of the total number of ASPHER member institutions, was performed to establish how many of the 35 suggested ASPHER biostatistics competencies were actually covered in their programs. The number of taught and completed ASPHER competencies in these programs ranged from 12 (34.3%) to 32 (91.4%), with most of the programs (67%) accomplishing more than 50% of the suggested ASPHER competencies. The biostatistics program of the School of Public Health, University of Belgrade covered 23 (65.7%), of the ASPHER 35 competencies. Recent studies have demonstrated that when choosing MPH elective course work, certain topics are relatively infrequently chosen by students, including biostatistics (asph.org, http://www.asph.org/UserFiles/DataReport2010.pdf). The biostatistics course during MPH training may be the only exposure that many students have to formal biostatistics, so it is, therefore, critically important that key competencies in biostatistics are acquired by all students. In this study, we provide evidence suggesting that a blended learning format for biostatistics classes may improve acquiring competencies for MPH students. Overall, student competency performance was higher in those using blended learning than for those in the traditional on-site training group, with a large effect size. A knowledge gain favoring the blended learning model was detected for both the knowledge test and the final competence score. Additional competencies should be developed at our institution to meet the challenge of covering this comprehensive discipline.

The significance of biostatistics in public health education is indisputable, as the estimations of public health opportunities and threats are based upon statistical methods that provide scientific support for the identification of health problems, setting of goals for health promotion and prevention of diseases, defining priorities for allocation of funds for health care, and defining the influence of specific interventions (Stroup and Smith 1996; Brimacombe 2014). There are only approximately 80 accredited programs in public health, despite the 107 members of ASPHER. Most of these programs are organized according to the Bologna format, and consist predominantly of MPH programs, but also include undergraduate and doctoral programs (Bjegovic-Mikanovic et al. 2013). Models of competence understandably often are developed to accommodate the needs and specific aims of individual public health institutions and their respective student bodies. These accommodations result in variabilities in the types and numbers of competencies deemed relevant for any particular educational program (ASPH Education Committee (2017), http://www.aspph.org/app/uploads/2014/04/Version2.31_FINAL.pdf). The Bologna Declaration, however, promotes comparability, compatibility, and transparency of study programs, the success of which are measured by learning outcomes and competencies. It should be an expectation that all ASPHER members adjust their programs in accordance with the formal ASPHER competency model for the MPH to provide standardization, international recognition, and consistency within the European realm of higher education. This would additionally facilitate the mobility of students within European countries. Competencies listed in the ASPHER model should be periodically evaluated and modified based on changes in the public health field, with subsequent re-evaluations and updates in the MPH curricula to reflect these changes and ensure the continued relevance of the educational material presented to students (ceph.org, http://ceph.org/assets/SPH-Criteria-2011.pdf).

This study does have its limitations. The learning formats which we studied were not evaluated concurrently within the same time frame, but rather, each format was studied during a distinct 2 years period. It, therefore, cannot be conclusively stated that the differences in the scores between the two student cohorts are due solely to the learning formats. It is possible that the additional teaching experience obtained by the instructors while teaching the traditional on-site format in 2012–2014 might have impacted their teaching of the blended format that was undertaken 2 years later and influenced the results. We feel that this is not very likely, however, as all of the instructors who participated already had at least 10 years of teaching experience at the time of the start of the traditional on-site learning portion of the study in 2012. The on-site learning group also was almost double the size of the blended learning group, because more students had an interest in the MPH program when the Bologna format first was introduced in 2012, while later, this number significantly decreased, possibly resulting in a selection bias. Additional information on aggregate student performance in other subjects/programs during MPH training was analyzed to overcome these limitations, which in turn demonstrated equivalence between the groups, with little to no period effects in other courses, lending support to the claim of a real intervention effect. The results demonstrated are from a single center study, which presents the work of a collaborative group with extensive experience in developing blended learning modules in biostatistics, and may not reflect the situations of educators with less experience. In perspective, additional adjustments of acquired competencies should be made by the European schools of public health to provide for enhanced mobility of students within higher education.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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