

# THE ROLE OF COMPUTER-AIDED ASSESSMENT IN TEACHING OF LAW IN HEALTH PROTECTION: A COMPARISON OF STUDENT PERFORMANCE IN COMPUTER-BASED AND PAPER MULTIPLE-CHOICE QUESTIONS TESTS

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## Abstract

In the academic year 2013/14, Nursing students of Warsaw Medical University participated in the "Law in health protection" course conducted in the form of blended-learning. The e-learning course was put on Moodle e-learning platform: <http://www.nzd.moodle.wum.edu.pl/> and it comprised a total of 11 thematic modules; 10 modules ended with a test in the following format: best answer from a list of possible answers (MCQ, multiple-choice question). Students awarded credits for the course and seminars were allowed to take a final exam conducted in the form of a paper-and-pen test.

### Aim of study

Assessment of efficiency of teaching with the use of a combination of e-learning tools and traditional "in-class" teaching, with reference to the results of the final exam evaluating the competence in the "Law in health protection" course.

### Materials and Methods

351 Nursing students, including first-year ( $n = 148$ ) and second-year ( $n = 114$ ) full-time Master's degree students as well as first-year part-time students ( $n = 89$ ). The results achieved during the e-learning part of the course were obtained in 10 tests (240 random questions) conducted in the MCQ format. The results of the final competence evaluation exam were obtained in 60 MCQs.

The correlation between the results obtained in the form of computer-aided assessment and the final exam results (paper-and-pen test) was analysed to assess the efficiency of e-learning.

A non-parametric Kruskal-Wallis rank test were used for the analysis of differences between the results obtained in e-learning tests and the final exam.

The quality of the exam was assessed by establishing the level of simplicity and differentiating power of particular questions and the reliability of the exam was assessed by estimating Cronbach's  $\alpha$  coefficient (the Kuder-Richardson coefficient for dichotomous items).

The significance level for all analyses was established at  $P < 0.05$ .

### Results

The correlation between the results obtained in the computer-aided assessment and those obtained in the final exam (paper-and-pen test) amounted to  $r = 0.33$  ( $P < 0.001$ ). The correlations between the results obtained in e-learning tests and the final exam with reference to the Nursing legislation and General and medical law were also statistically significant ( $r = 0.21$  and  $r = 0.16$ , respectively,  $P < 0.003$ ). The results of computer tests were markedly better among second-year full-time students, as compared to first-year part-time students ( $P = 0.032$ ).

The reliability of the exam was at  $\alpha = 0.675$ . Following a content-related analysis, questions with low differentiating efficiency were removed, which increased the exam reliability to the value of  $\alpha = 0.714$ . Moreover, the strength of correlation between the results of the exam and e-learning tests in the thematic areas of Nursing legislation ( $r = 0.24$ ,  $P < 0.001$ ) and General and medical law ( $r = 0.192$ ,  $P < 0.001$ ) was also improved.

### Conclusions

Well-planned blended-learning, in which remote teaching methods support traditional in-class education, may be a very effective tool in teaching the Law in health protection course. The use of battery of tests in e-learning allows students to achieve necessary competence that can be well

verified in a well-planned final exam. MCQ tests, as a form of competence check, constitute a convenient method to assess student achievements that is at the same time relatively easy to be evaluated and improved.

Keywords: medical education, distance learning, multiple-choice questions (MCQs), computer-aided assessment.

## 1 INTRODUCTION

The present teaching programme for BA and MA Nursing students in Poland is based on teaching standards included in the Regulation of the Minister of Research and Higher Education of May 9th, 2012 on educational standards for the following majors: medicine, medicine and dentistry, pharmacy, nursing and midwifery [1].

According to the present educational standards, each graduate should:

- know the basic legal terminology and the role of law in society, particularly of human rights and labour law;
- know the basic issues related to health insurance and its systems in Poland and European Union; characterize compulsory and voluntary insurance schemes and selected healthcare policy guidelines in Poland and EU member states;
- know the legal basis of practising medical professions: rights and duties of a nurse, organizational structure and rules of functioning of a professional self-government of nurses and midwives, tasks of self-government concerning granting license to practise a profession and issuing permission for performing an individual or collective nursing practice;
- differentiate criminal, civil, and worker's liability related to nursing practice;
- be familiar with the Patient Charter, Charter on Human Rights, and Charter on Children's Rights.

In the academic year 2013/14, Nursing students of Warsaw Medical University participated in the "*Law in health protection*" course conducted in the form of blended-learning. According to the curriculum of the Nursing major in the MA programme, the "*Law in health protection*" course comprises 35 class hours: 10 hours of seminars and 25 hours of lectures. However, due to a very large number of hours of teaching classes offered during a Master's degree Nursing programme, the lectures in the "*Law in health protection*" course were conducted late in the afternoon, which did not favour effectiveness. Moreover, a vast majority of Master's degree students take on employment, often shift work, which additionally impedes effective studying [2-5]. Therefore, in the academic year 2011/2012, for the first time in the history of the Faculty of Health Science, Warsaw Medical University, an e-learning course was started within the class hours previously devoted to lectures in order to improve the quality of teaching law. Seminars did not undergo changes, they were run in a traditional form by an academic teacher.

The e-learning "Law in health protection" course was put on a free of charge Moodle e-learning platform (Modular Object-Oriented Dynamic Learning Environment): <http://www.nzd.moodle.wum.edu.pl/> and it included 10 thematic modules:

- Introduction to law.
- Legal system of the Republic of Poland.
- Human Rights, Children's Rights.
- Introduction to medical law.
- Patients' rights.
- Nurses and Midwives Act.
- Act on Professional Self-Government of Nurses and Midwives.
- Codes of Professional Conduct of Nurses.
- Nursing organizations.
- Convention on the Rights of Persons with Disabilities.

Teaching-related materials used in the course included, among others, valid legislative acts with commentaries by lecturers, links to reliable websites, films, radio programs, as well as passages from the literature chosen by an academic teacher, and PowerPoint presentations with commentaries.

The course was obligatory for all students. Credit was given for:

- passing 9 single-attempt tests (approximately 30 questions each) done on the Internet with a time limit for each question of 1 minute.
- writing an essay on obeying patient's rights at a workplace/or providing treatment.

Students awarded credits for the e-learning course and seminars, were allowed to take a final exam conducted in the form of a paper-and-pen test. A written exam comprising the learning content of the e-learning course and the seminar was prepared in compliance with the format of "best answer from a list of possible answers" (MCQs, multiple-choice questions). The number of points scored on the exam constituted the basis for a course grade obtained for the "*Education in Health Protection Law*" course.

The increasing importance of using various e-learning tools in teaching makes it necessary to evaluate the effectiveness of these education forms [6,7]. Computer-aided techniques were first used in teaching nursing as early as in the mid-60s. [8] and various forms of computer-based learning were widely introduced to the higher education starting gradually in the mid-80s. [9]. Adams (2004) [10] and Glen (2005) [11] have noted the array of terms used to describe the use of computers in nurse education, including computer assisted instruction, computer based learning, programmed instruction, computer-mediated education, computer facilitated teaching, web-based learning, Internet learning, e-learning, interactive multimedia learning and online learning. The assessment of quality and effectiveness of these forms of teaching is of interest for researchers, irrespective of the above mentioned various computer-aided techniques designed for teaching students and verifying their achievements [12-15].

The study results presented here concern the assessment of efficiency of teaching with the use of a combination of e-learning tools and traditional "in-class" teaching, with reference to the results of the final exam evaluating the competence in the "*Law in health protection*" course.

## 2 MATERIALS AND METHODS

The analysis involved a total of 351 Nursing students, including first-year (n = 148) and second-year (n = 114) full-time Master's degree students as well as first-year part-time students (n = 89). The results obtained during the e-learning training comprised 10 MCQ tests related to the following areas (the number of randomly selected questions is given in brackets): *Introduction to law* (40), *Legal system of the Republic of Poland* (30), *Human Rights and Children's Rights* (25), *Introduction to medical law* (10), *Nurses and Midwives Act* (30), *Post-graduate Education of Nurses and Midwives* (30), *Act on Professional Self-Government of Nurses and Midwives* (30), *Codes of Professional Conduct of Nurses* (10), *Nursing organizations* (25), *Convention on the Rights of Persons with Disabilities* (10). The results of the final exam assessing the competencies comprised a total of 60 MCQ questions, including 35 questions on *Nursing legislation* and 25 questions on *General and medical law*.

Raw data were preprocessed using TESTY version 7 (Testy komputerowe, Copyright © 1994-2014 by Sławomir Zalewski). Information was read in the database, processed in EXCEL (Microsoft, 2010) and exported to STATISTICA (StatSoft, Inc. (2011), version 10) for further analysis. All programs were used in compliance with WUM license.

Normal distribution parameters of particular exam results were assessed using the Shapiro-Wilk test and data were screened for outliers using Grubbs test. The correlation between the results obtained in the form of computer-aided assessment and the final exam results (paper-and-pen test) was analysed to assess the efficiency of e-learning. Pearson's r linear correlation coefficient was used to assess the correlation. A similar correlation analysis was conducted for the results in the following thematic areas: *Nursing legislation* and *General and medical law*.

A non-parametric Kruskal-Wallis rank test, post-hoc RIR Tukey test and single factor ANOVA test were used for the analysis of differences between the results obtained in e-learning tests and the final exam taken by full-time students (first and second years) and part-time students (first year).

The quality of the particular exam questions was assessed by establishing the easiness factor and substitute differentiating power and the reliability of the exam was assessed by establishing Cronbach's  $\alpha$ -coefficient (the Kuder-Richardson coefficient for dichotomous items) [16]. The significance level for all analyses was established at  $p < 0.05$ .

### 3 RESULTS

An analysis of the MCQ exam results with regard to the nature of the distribution of this variable demonstrated a non-symmetric (negatively skewed) data diverging from the normal distribution (curtosis  $\neq 0$  and Shapiro-Wilk test,  $P < 0.001$ ). This kind of distribution of a variable is typical of selective exams. Mean score was  $42.6 \pm 5.30$  (CI for the mean: 42.1 – 43.2), with the range of data between 26.0 – 54.0. No outliers were found among the exam results (Grubbs test,  $P > 0.05$ ).

The Cronbach's  $\alpha$ -coefficient was established to assess the internal coherence of test questions. The obtained value of  $\alpha = 0.675$  showed a relatively high reliability of the MCQ exam. A detailed question evaluation allowed for the selection of six questions with a negative correlation, i.e. significantly decreasing the reliability of the exam. After eliminating these questions from the exam set, the overall test reliability increased and  $\alpha$ -coefficient amounted to 0.714.

In order to compare the MCQ exam results in the three groups of students (first and second year full-time students and first year part-time students) analysis with the Kruskal-Wallis ANOVA rank test was performed. No statistically significant differences were found between the groups, even though the median for the exam results among the part-time students was lower compared to the first and second year full-time students (medians of 42.0, 43.0, and 44.0, respectively). A similar comparative analysis was conducted for the e-learning test results. Due to the fact that the condition of homogeneity of variance was met (Levene's test,  $P > 0.05$ ) and there were no significantly correlated mean values and standard deviation, the assessment was performed with the use of a single factor ANOVA test. A statistically significant difference was found in the mean results in e-learning classes obtained by particular groups of students ( $P = 0.02$ ). Significantly better results in Moodle courses were obtained by the second year full-time students (mean of  $220.4 \pm 7.15$ ), as compared to the first year full-time and part-time students (means of  $218.1 \pm 9.49$  and  $217.3 \pm 8.20$ , respectively).

The correlation between the MCQ exam results and e-learning results was analysed in order to assess the effectiveness of the computer-aided assessment. Pearson's  $r$  linear correlation coefficient ( $r = 0.33$ ,  $P < 0.001$ ) demonstrated a significant correlation between the results of students obtained on Moodle platform and their score on the written test (Fig. 1). A similar correlation analysis was conducted for two selected thematic areas. Statistically significant correlations ( $r$  of 0.16 and 0.21,  $P = 0.003$ , respectively) were found for the issues related to the general and medical law as well as for legislation related to nursing and midwife practice. With the correction for the questions with negative correlation included, the strength of the correlation increased ( $r$  of 0.19 and 0.24,  $P = 0.003$ , respectively). A more detailed analysis of ten thematic fields that constituted the subject area of the e-learning courses also showed a significant correlation with the total point score on the final exam (Table 1).

### 4 DISCUSSION

Despite the obvious fact that nursing education should comprise clinical sciences and primary health care issues, related fields such as sociology, psychology and legal issues are also important elements constituting complex competences of a well-educated nurse. Apart from traditional forms of teaching such as lectures and seminars, computer techniques are gaining importance also in nursing education [15]. Computer-assisted learning is a common form of education, and computer-assisted teaching is an integral part of the system of education, including the higher education system [6, 7, 12-14]. Apart from benefits resulting, for instance, from the decrease in costs in the case of e-learning classes compared to traditional classes, the use of these modern forms of teaching is strongly justified also by an increase in students' knowledge and understanding of a particular subject and allowing students to direct their own learning. However, a systematic review by Lewis et al. (2005) showed that these evident benefits resulting from using computer-assisted learning were not always reflected in the study results [15]. Similar observations were presented by Bloomfield et al. (2008) in a review of the literature related to the analysis of the efficacy of computer-aided assessment in teaching clinical skills [14]. Among the prospective benefits mentioned by the authors, skills related to the improvement of teaching efficacy and more individualized adjustment of content to educational needs of a particular student are of great importance [13-15, 17].

Among authors of various studies on the efficacy of teaching using computer-aided assessment, there are two different opinions on how the quality of this form of teaching can be evaluated. On the one hand, there is a stream of research based on a qualitative analysis using focus groups or different types of questionnaires [4, 5, 18]. On the other hand, an assessment comprises quantitative data

derived from an analysis of correlations between the use of a particular teaching method and the results [19]. Jones and McCormac (1992) demonstrated that questionnaire study results should be treated sceptically owing to the difficulty in standardizing students' interpretation of words used in questionnaires [19]. Jones and McCormac argued that the evaluation should be based on student performance, although student opinion and comment should also be taken into account [19]. The present analysis of the efficacy of blended learning involved an assessment of this form of teaching with reference to the results of a written test. This is a follow-up study of a previously published study with a survey questionnaire related to the opinions of nursing students on the presentation of the learning content of the "*Law in health protection*" course in the form of an e-learning course [4,5].

MCQ exam acted as a summative assessment. The exam comprised groups of questions related to knowledge and skills each students should have acquired in the "*Law in health protection*" course. Therefore, the quality of the MCQ exam as a tool used for evaluating the assumed learning outcomes was assessed at the very beginning.

The internal coherence of test questions was measured by the test reliability that was assessed by the Cronbach's  $\alpha$ -coefficient. This coefficient determines the degree of correlation between the questions used in the exam, i.e. whether they sufficiently evaluate the knowledge and skills of a student. Earl Babbie indicated prerequisites for reliability: objectivity of the measurement conditions and precision in scoring [20]. Insufficient reliability of tools used for assessment contributes to a low degree of confidence since particular results differ markedly in similar conditions. It is assumed that a 100-question test has sufficient reliability if  $\alpha$ -coefficient is not lower than 0.7. In the present 60-question MCQ exam,  $\alpha$ -coefficient amounted to 0.675, which means that it slightly diverged from the assumed threshold. A detailed analysis of an intratest correlation between particular questions allowed for the selection of six questions with the lowest discrimination capability, i.e. a negative correlation. The exclusion of the defective questions increased the overall test reliability to the value of  $\alpha = 0.714$ . At the value of  $\alpha = 0.7$ , random errors constitute 30% of the variability of the results. According to Guilford (1954), individual and not only intergroup differentiation occurs with  $\alpha$ -coefficient amounting to 0.7-0.8 [21]. Therefore, it can be assumed that the test tool used for the summative assessment met the reliability requirements.

Apart from reliability, validity constitutes another important element of each exam. Validity should be understood as usefulness of a given tool in assessment of a particular set of student's skills, i.e. ability to measure the degree to which the assumed learning outcomes were achieved [22]. Validity of a particular assessment method may vary depending on how well a student knows the assessment tool. Using the same question sets several times, first during the e-learning programme and then during the final exam, may also be a problem. A phenomenon called "overall testing experience" [23] may be avoided when different sets of tasks are used and when an exam includes tasks created by persons not involved in creating e-learning tests. Due to the fact that a point score obtained on the MCQ exam constituted the basis for the final assessment of a student on the "*Law in health protection*" course, this tool should have accurately assessed the field of competence coinciding with the learning outcomes assumed for this course. High internal validity (known also as content validity) of a particular tool may only be achieved by developing a strict test plan [24] consistent with the outcomes defined in the educational standards. Such a plan was prepared by the authors of the final exam to ensure adequate validity of the final grade.

Since the MCQ exam is supposed to stratify students with respect to the degree to which the learning outcomes were achieved, this tool should allow for discrimination of students in several fields of knowledge and skills that are important for the "*Law in health protection*" course. Therefore, exam questions were assigned to two thematic fields: (1) legislation relating to professional self-government of nurses and midwives and knowledge of the Act on the Profession of Nurse and Midwife; (2) using general and medical law. Both thematic fields referred to the learning content presented during the e-learning courses. These topic areas were also previously evaluated in the form of a component grade on MCQ tests on Moodle platform. The analysis demonstrated that there was a significant positive correlation between the point scores for both thematic fields obtained on the final exam. A linear correlation was also observed in the analysis of particular thematic modules in terms of the total point score on the final exam. Confirmation of a general good adjustment of the final exam to the learning content presented on the e-learning courses in the present results did not have to prove high quality of this form of teaching. The problem of "an excessive adjustment" of MCQ test to a particular teaching programme was described by Cronbach who pointed to the fact that, if the content of exam tasks reflects the subject matter covered e.g. in lectures rather than the assumed learning outcomes, then such a tool does not provide valid measurement results [25]. Accepting these limitations, it may be

stated that external evaluation is the best method of objective assessment of the quality of teaching carried out both in the form of e-learning and traditional courses. We may here refer to a statement by Peter Knight: "in general, external exams are more reliable, but they cannot be equally valid as internal exams, since their content is less related to the course of education in a given teaching unit" [26].

During the analysis of the quality of teaching in the form of computer-aided assessment, attention was also pointed to what extent the effectiveness of e-learning depends on the mode of study. We observed that, in general, full-time students achieved better results. This was confirmed by better results achieved by full-time students on e-learning tests as well as on the final exam. In the context of the above mentioned differences, the opinions of part-time students presented in the qualitative study by Gotlib et al. (2012) are worth highlighting [4]. These students more often said that e-learning courses were time-consuming and too extensive. A part of negative opinions concerned also the fact that the time for solving compulsory tests was too short [4]. Moreover, part-time students more often reported encountering technical difficulties using Moodle platform and problems with the access to a broadband Internet connection [3]. May the above mentioned restrictions discovered in the survey be reflected in the quantitative analysis comparing groups of full-time and part-time students? It was found that the results of tests carried out during the e-learning courses and the point score obtained on the final exam was lower among part-time students compared to full-time students. An indirect conclusion may be drawn that worse results of the part-time students may be associated with a technological barrier and poorer absorption of information presented in a digital form. More frequently reported need of direct contact with a teacher may also confirm these assumptions. However, it is worth emphasising that in the pre-Internet era, Gleydura et al. (1995) [27] demonstrated that computer-assisted learning has also been championed for offering student nurses an opportunity to develop computer-literacy skills in preparation for their future role in an increasingly technical practice environment. Therefore it seems that technical and communication difficulties [28] should not constitute an argument against the effectiveness of e-learning. Billings et al. (2005) [29] indicated that computer skills, confidence, and proficiency increase after completing an online course. Considering the continuous development of digital and information and telecommunication technologies as well as their increasing application in nursing practice, it should be aimed to improve IT competencies among this professional group rather than limit the use of computer tools in education.

The analysis of the results achieved by students on tests in e-learning courses and the final written exam showed a difference with reference to the year of studies at which the "*Law in health protection*" course was carried out. Second year students gained significantly better results compared to first year students, regardless of the mode of study. These differences may result from several factors. Firstly, students in higher years may be better at organising their time and it is easier for them to be self-disciplined. Secondly, second year students can define their educational needs much better and they have greater motivation to learn legal aspects that are important in professional practice. First year students are at the beginning of their professional activity and a large group among them do not practise their profession at all. Both factors mentioned above are essential for the effectiveness of e-learning. O'Neil et al. (2004) [30] emphasized that, to be successful in the online environment, students must be able to identify their own learning needs, make plans to achieve learning objectives, and be knowledgeable about online course expectations. The issue of professional socialization constitutes another possible cause of the observed differences in the effectiveness of e-learning with reference to the years of studies. The socialization process involves, among others, mutual interactions between students and good relations with lecturers and teachers of practical aspects of professional activity [31]. More experienced second year students have a better chance for success in distance learning because they have already had an opportunity to establish good relations with their peers and to become familiar with the university environment. Billings *et al.* (2001) [31] found that socialization was moderately correlated with active learning, feedback, interaction with peers, and student-faculty interactions; feelings of isolation were negatively correlated with socialization. However, it needs to be stressed that, despite more difficult initial conditions, first year students have a good chance for success in e-learning at the very beginning of their university education as well as at later stages. Considering the fact that teaching based on various computer techniques may positively influence certain character features of a student developing motivation and an active learner attitude, the introduction of e-learning in the first year of studies should not be heavily criticised. The role of a student transforms from the one of passive recipient to the one of active learner, who assumes responsibility for learning; a self-motivator who is committed to learn at a distance; an autonomous learner who possesses self-discipline; and a self-directed learner with time management skills [29, 32].

## 5 CONCLUSIONS

Well-planned blended-learning, in which remote teaching methods support traditional in-class education, may be a very effective tool in teaching the *Law in health protection* course. The use of battery of tests in e-learning allows students to achieve necessary competence that can be well verified in a well-planned final exam. MCQ tests, as a form of competence check, constitute a convenient method to assess student achievements and, at the same time, they are relatively easy to be evaluated and improved. A continuous monitoring of the effectiveness of tools used in teaching and achievement check should constitute the basis of every curriculum with an outcome-based approach.

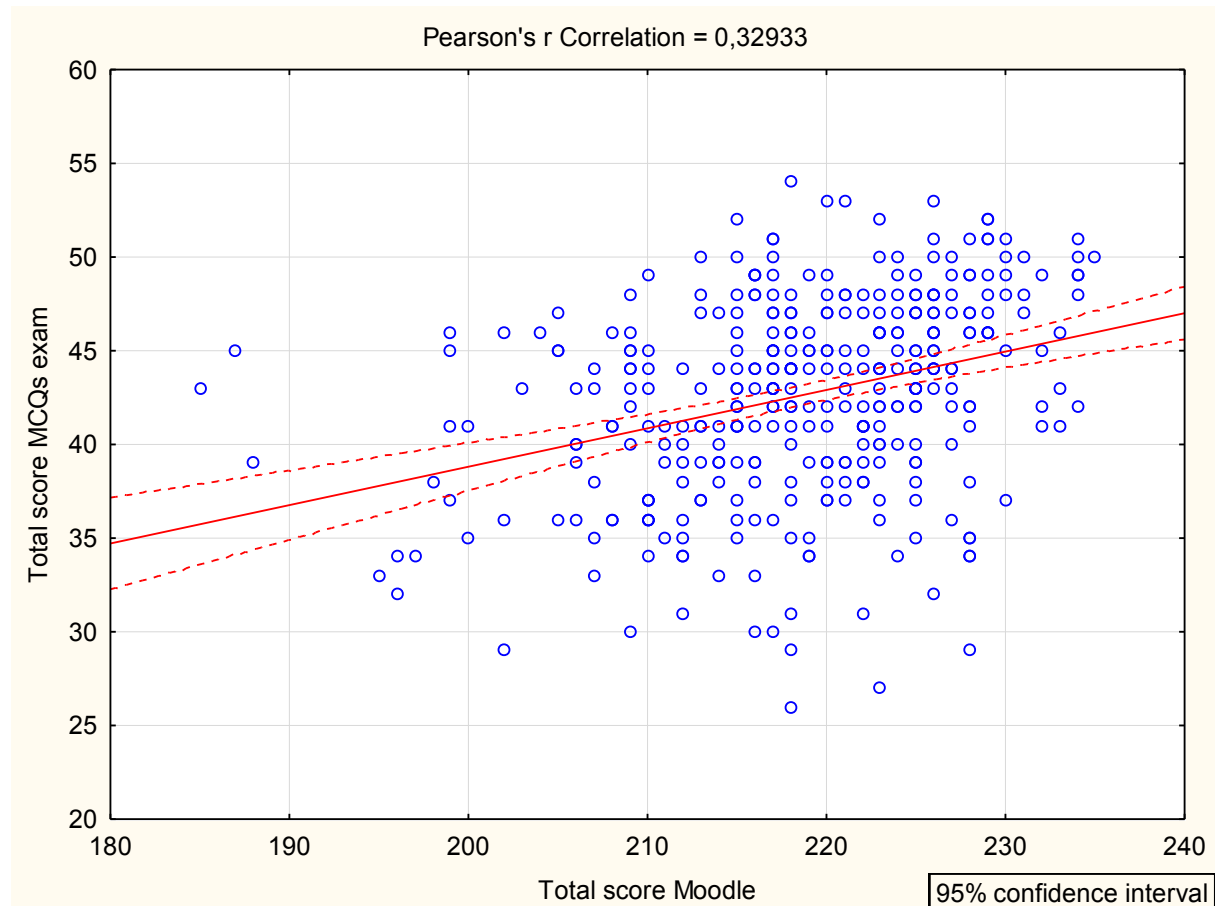


Figure 1. Scatter diagram for analysis of correlations between results of tests conducted on e-learning classes and point score on the final written exam.

Table 1 Correlation matrix for relation between total point score on MCQ exam and students' achievements on particular thematic modules presented on e-learning courses.

Thematic field	1	2	3	4	5	6	7	8	9	10
<b>Total score MCQ exam</b>	0.18*	0.06***	0.14**	0.24*	0.25*	0.18*	0.21*	0.18*	0.16**	0.12**

Thematic fields: 1 - Introduction to law, 2 - Legal system of the Republic of Poland, 3 - Human Rights and Children's Rights, 4 - Introduction to medical law, 5 - Polish and world nursing organizations, 6 - Codes of Professional Conduct of Nurses, 7 - Act on Professional Self-Government of Nurses and Midwives, 8 - Nurses and Midwives Act, 9 - Post-graduate Education of Nurses and Midwives, 10 - Convention on the Rights of Persons with Disabilities

\*  $P < 0.01$ , \*\*  $P = 0.01$ , \*\*\*  $P > 0.05$

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