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Retention of Basic Sciences Knowledge at Clinical Years of Medical Curriculum

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Aim To explore the association between the knowledge of basic (physiology and biochemistry) and clinical sciences (internal medicine) among medical students, and determine the level of retained basic science knowledge at the fifth year of medical studies.

Methods Medical students attending the second (n = 145, response rate 60%) or the fifth year (n = 176, response rate 73%) of medical studies at the Zagreb University School of Medicine in Croatia were given an anonymous knowledge test with 15 pairs of questions developed specifically for this purpose. Each pair consisted of a basic and clinical question, with the correct answer to the basic question explaining the physiological or biochemical background of the clinical question. Three pairs of questions were excluded from the analysis due to poor psychometric characteristics.

Results We found statistically significant correlation between basic and clinical tests scores for both groups of students ($r = 0.47$, $P<0.001$ for the second year and $r = 0.45$, $P<0.001$ for the fifth year). 2×2 within-between measures ANOVA revealed a significant interaction effect for knowledge test and study year (Wilks $\lambda = 0.55$, $F_{1, 319} = 262.7$, $P<0.001$; effect size = 0.45), showing that fifth year students scored lower on the basic test than second year students but obtained higher scores on the clinical test.

Conclusion Core basic science knowledge is lost during the clinical years of medical studies. Although remembering and understanding basic science concepts as a background of clinical statements at the clinical years does not directly affect clinical knowledge, there is a positive correlation between retained basic science concepts and clinical knowledge.

Plato (1) wrote: "Right opinion, being incapable of giving a reason, is not knowledge (for how can knowledge be devoid of reason? nor again, ignorance, for neither can ignorance attain the truth), but is clearly something which is a mean between ignorance and wisdom."

Medical students build their clinical knowledge on the ground of previously obtained basic knowledge. Nevertheless, many senior undergraduate students indicate informally that they do not remember much from their basic science medical courses and that the content of those courses does not seem relevant to their later clinical work or studies (2).

The portion of knowledge retained by the students seems to be the central question for medical education (3). If students are unable to use the knowledge they had once been taught, if that knowledge becomes inert and inaccessible, then teaching such knowledge becomes questionable (4-6).

A loss of knowledge among senior medical students was confirmed by all the studies conducted. Watt (7) found a 21.5% decline in preclinical knowledge of oral biology when the same test was administered 20 months later to dental students. Krebs (8) discovered that medical students retained only 65% of the simple basic science knowledge. D'Eon (2) found a considerable knowledge loss among medical students in the three basic science courses tested and this loss was not uniform across courses (relative knowledge loss over the ten months was 18% of immunology, 52% of neuroanatomy, and 19% of physiology). Knowledge loss does not seem to be related to the marks on the final examination or the assessment of course quality by the students (2).

However, longitudinal data from five medical schools across the USA confirm the strong associations between levels of performance in medical school and clinical competence in residency (9). Failure rates on certifying examinations and board certification status were significantly associated with the assessment of basic sciences knowledge during medical school education. These findings strongly refute the pessimistic view which claims that what is learned in medical school is irrelevant to the practice of medicine (9).

The aim of the study was to explore the level of basic knowledge of physiology and biochemistry and how it influenced the knowledge of clinical medicine among second and fifth year medical students. Tested clinical concepts were supposed to be known to second year students as well, since they were taught as examples of applied basic science in medicine in the second year courses. Comparison of basic medical knowledge between second and fifth year medical students can illustrate whether basic science concepts are retained at the fifth year of medical studies and ascertain if senior students accept clinical knowledge with sufficient insight into causality of the processes learned.

Participants and Methods

Participants

The study sample included medical students from the second and fifth year of Zagreb University School of Medicine. All students filled out a brief demographic questionnaire before answering the knowledge test (Table 1).

Of all the second year students, 145 (60%) filled out the test at the end of June and at the beginning of July 2005, after they had completed

Table 1. Demographic characteristics of students involved in the study at the Zagreb University School of Medicine.

	No. (%) of the students in the year	
Characteristic	second	fifth
Total	145 (100)	176 (100)
Male	54 (37)	65 (37)
GPA*:		
≥4.1	56 (41)	37 (22)
3.6-4.0	50 (36)	50 (29)
≥3.5	32 (23)	84 (49)

*Grade point average (GPA). Grades at the medical school range from 2 – satisfactory to 5 – outstanding. Since not all the students filled in their GPA in the questionnaire, the GPA groups were designed from n = 138 for the second year and n = 171 for the fifth year. GPA results refer to the year of 2005, when the students filled out the test.

their physiology and biochemistry courses. Of all the fifth year students, 176 (73%) filled out the test before their introductory lessons from the fifth year in October 2005. Passing the examination from internal medicine was a requirement for enrolling into the fifth year of study.

Full data for analysis were available for 321 students. The proportion of male students was similar for both years (37%). There was no difference in either basic or clinical knowledge between male and female students.

Knowledge test

We developed two sets of 15 open-ended questions (see web-extra material). The first part of the test consisted of questions on basic sciences, and the second examined related clinical facts. The order of questions was random, so that it would not be obvious that they form 15 pairs. We created the questions according to standard textbooks of physiology, biochemistry, and internal medicine used at the Zagreb University School of Medicine. A test of 30 questions was formed because it covered enough knowledge for analysis. The time to answer the whole test was 20 minutes. Each question pair represented a single topic. The basic questions were formed in such a way that the correct answer explained the physiological or biochemical background of the clinical question. One question pair was later omitted from the analysis because the connection between the basic and clinical question was too obvious. In the final analysis, there were 7 physiology and 7 biochemistry question pairs. Clinical questions were formed in a way that both second and fifth year students were equally familiarized with them. This was possible because the clinical concepts involved were covered by the biochemistry and physiology textbooks for the second study year, and second year students have just completed their physiology and biochemistry courses.

For each set of questions, we examined inter-item and item-total correlations for items in each set, separately for each year. We excluded two items from the test (question pairs 11 and 13) because their item-total correlation was close to zero, which indicated that the item did not belong into the test. The Cronbach α coefficient for 12 basic questions was 0.60 for second and 0.65 for fifth year students. For 12 clinical questions it was 0.54 for second, and 0.57 for fifth year students.

Statistical analysis

We used Kolmogorov-Smirnov test to investigate the normality of distribution of scores on the two sets of questions. Since the distribution was normal, we calculated Pearson r coefficient of correlation between the scores on the basic and clinical sets of questions, for each group separately. We used mixed between-within subjects ANOVA to investigate the effect of the test and the study year, as well as their interaction. Assumptions for this procedure (homogeneity of variance, independence of measurement, normality of distribution) were met. The level of statistical significance was set at $P<0.05$. All statistical procedures were performed using the Statistical Package for the Social Sciences, version 13.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

For the second year, the mean number of correct answers out of 12 questions was 7.9 ± 2.3 for basic and 8.6 ± 1.9 for clinical questions. For fifth year students, the score was was 5.5 ± 2.6 for basic and 10.3 ± 1.7 for clinical questions. We found statistically significant correlation between basic and clinical tests scores for both groups of students ($r = 0.47$, $P<0.001$ for the second year and $r = 0.45$, $P<0.001$ for the fifth year; Figure 1). However, the correlation for all students taken together, although statistically significant, was lower ($r = 0.17$, $P = 0.002$).

Next we performed 2×2 between-within subjects ANOVA to compare students' results

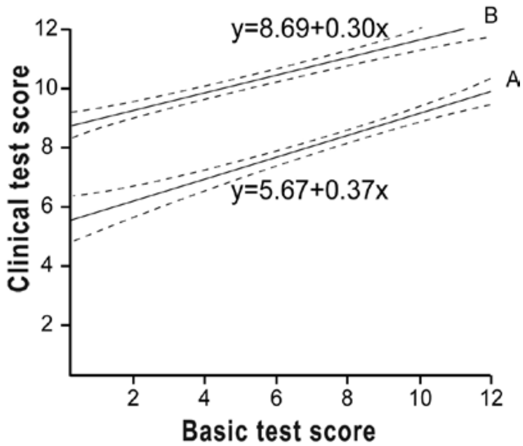

Figure 1. Association between the basic and clinical test scores for students attending the second (**A**) and fifth (**B**) study year. Lines represent estimated regression line with 95% confidence intervals.

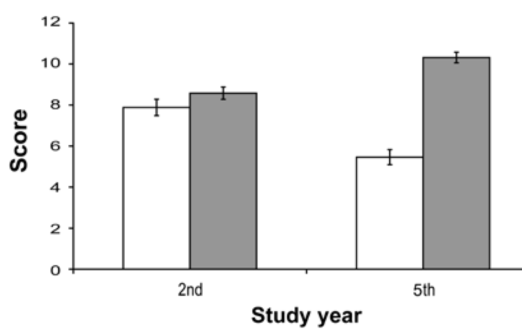

Figure 2. Test scores (mean±95% confidence interval) of second and fifth year students for basic (open columns) and clinical (closed columns) questions.

on the two sets of questions, as well as to determine the interaction between the study year and score on the test. We found statistically significant effect for the test score indicating that both second and fifth year students scored better on the clinical test (Wilks $\lambda=0.41$, $F_{1,\ 319}=467.9$, $P<0.001$; effect size = 0.60). There was no significant overall effect of the study year ($F_{1,319}=2.81$, $P=0.094$). However, we found a significant interaction effect (Wilks $\lambda=0.55$, $F_{1,\ 319}=262.7$, $P<0.001$; effect size = 0.45); which showed that fifth year students scored lower on basic questions than second year students, but obtained higher scores on clinical questions (Figure 2). It indicates that clinical knowledge is not based on knowledge of basic processes.

Discussion

Our study showed a significant correlation between the knowledge of the basic and clinical medical facts by students of preclinical and clinical years of medical studies. However, a possible explanation may be that better students answered both sets of questions more successfully in general and not to the causative relationship between basic and clinical knowledge. This is supported by our finding that fifth year students scored higher on clinical questions, but lower on basic questions than second year students. This finding challenges the idea that basic knowledge has a direct influence on the successful answering to clinical questions because, if this causative relationship existed, we would necessarily obtain higher level of basic knowledge in fifth year students.

These results suggest that clinical knowledge can be learned without complete understanding of its basic science background.

These results also imply that, while acquiring knowledge on a medical topic, clinical fact is not always memorized together with its basic background, but rather that the two types of knowledge are learned and memorized independently. For example, a student may know that oliguria causes an increase in blood pressure, without necessarily remembering the basic hemodynamic equation which explains that blood pressure is increased because of the increase in heart minute volume.

Although some studies of clinical reasoning showed little evidence that clinicians used basic science in routine diagnosis (10), it was also shown that knowledge of basic science may have value in clinical diagnosis by helping students recall or reconstruct the relationship between features and diagnosis (11). Because of its conceptual coherence, basic science was more memorable and helped students to reconstruct the features of individual disease categories after the initial symptom lists had been forgotten (11).

The field of hypertension management is a good example of the importance of the relationship between basic knowledge and clinical practice. In that field, progressive knowledge of physiology of the sympathetic nervous system, the kidney, and the renin-angiotensin system led to the progressive understanding of the mechanisms of elevated blood pressure and to the development of an array of effective blood pressure lowering drugs, thanks to which hypertension is now a controllable disease (12).

The reason for lower basic knowledge in fifth year students may be due to the fact that clinical textbooks do not provide a detailed coverage of basic science background and basic concepts are generally not required in the exams, so they are gradually forgotten. On the other hand, students of the fifth year are overwhelmed with the numerous clinical facts that need to be memorized and slowly lose their insight into basic science. For example, only 53% of participants in our study still remembered that oxygen was the terminal acceptor of electrons in the process of food oxygenation. It is important to point out that strong long-term memory, as previous research showed, is directly associated with over-learning in the initial phase and the proper distributing and renewal of study matter over longer intervals of time (13). Previous research also found that the focus on meaning and understanding rather than memorization, adequate time to learn, especially of complex material, and deliberate effective engagement with the task (practice) are course elements that promote initial learning (14).

The differences between second and fifth year students may also be partially related to the importance attributed to basic science facts by the two student populations. It was shown that senior students, as opposed to junior students, validated the learning objectives of basic sciences as less relevant to clinical practice, while biochemistry basic items were considered to be the most irrelevant (15). Also, fewer basic science than clinical items were regarded as core knowledge (16).

The limitation of this study is the fact that 12 question pairs which qualified for the statistical analysis covered a rather narrow range of medical topics and knowledge. Also, a logical connection between questions in a pair was only assumed. This was a cross-sectional study and we need longitudinal studies to provide a more comprehensive insight into the issue by measuring the performance of students in preclinical and clinical years of medical studies, during the internship year, and later in their medical practice. A finding that clinical knowledge is not necessarily rooted in understanding basic processes calls for future research efforts which should aim to explore the elements necessary for successful performing of the medical tasks (9), as well as the factors that influence the connection between preclinical and clinical knowledge, such as different types of medical school curricula, methods of teaching and study materials, and students' awareness of the importance of basic sciences. The objective should be a collaboratively and interdepartmentally developed basic science medical curriculum, created by both science and clinical faculty members, which would integrate more clinical knowledge into preclinical years (17).

Medical schools must show that they have a system to evaluate the extent to which their educational objectives are achieved, especially if the ultimate criterion of educational effectiveness in medicine is the quality of care rendered to patients. Medical schools undertaking innovative educational programs will particularly need a method of evaluating the results, beyond just mastering individual courses (9).

We believe that this study illustrates an informally accepted attitude among students that basic medical subjects are just peripherally associated with the profession they had chosen. It could also be used as a basis for discussion about the methods and programs of learning medicine, since scientific study is not just the introduction to clinical learning, as it is seen in many preclinical courses, but rather a foundation and bedrock for life (18).

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