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Does basic science knowledge correlate with clinical reasoning in assessments of first-year medical students?

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Abstract

Previous research has investigated the outcomes of Problem-based Learning (PBL), but little research has compared competencies in PBL and associated clinical reasoning skills with other competencies in medical education. We used results from formative and summative exams during the first block of medical education to investigate how the performance of beginning, undergraduate medical students on online clinical cases and additional clinical-reasoning questions related to their basic-science knowledge. We found a moderate correlation between clinical-reasoning and basic-science performance. However, the level of correlation suggests that distinct knowledge and skills are involved in clinical reasoning beyond those associated with basic-science knowledge.

Keywords: Problem-based learning; online clinical cases; formative assessment; summative assessment; medical education.

1. Introduction

Several studies have examined outcomes of problem-based learning on cognitive and motivational effects on students (Dolmans & Schmidt, 2006), on clerkship performance (Distlehorst, 2005), and on performance on standardized exams (Newman, 2003). In addition, longer-range effects of PBL on physician competencies have been examined (Koh et al, 2008). There has also been a fair amount of discussion about how to develop, in medical students, the critical thinking skills and types of expertise observed for experienced physicians (Patel, Glaser & Arocha, 2000). Although several studies have examined the role of basic-science knowledge in clinical diagnosis by both novices and experts (see Woods, 2007), it is also important to understand how and whether the ability of medical students to diagnose and to propose evidence-based treatments for patients in clinical cases relates to their competencies in the basic sciences. In particular, no one has studied whether, and to what degree, the basic-science knowledge of students predicts their ability to propose appropriate diagnoses and treatments in clinical cases and

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whether the same set of skills appears to underlie acquisition of basic-science knowledge and development of clinical problem-solving abilities.

In the two-year, integrated, pre-clerkship curriculum of the David Geffen School of Medicine at UCLA, each week begins and ends with a two-hour, problem-based learning session related to the content of the week. Students practice clinical reasoning, including diagnosis, treatment, accessing the medical literature and assessing the strength of evidence as part of problem-based learning. In the present research, we have examined the ability, based on their performance on both formative and summative assessments, of beginning medical students to diagnose and propose evidence-based treatments for clinical presentations and how this relates to their ability to perform well on basic-science, knowledge-based exam questions.

2. Methods

This study focused on the 161 undergraduate medical students that matriculated to the David Geffen School of Medicine in August, 2009. The pre-clerkship curriculum consists of a series of nine, integrated, systems-based "blocks". Block 1, "Foundations of Medicine 1", encompasses all didactic, laboratory and small group teaching for the first 8 weeks of medical school. During Block 1, students study genetics, early embryology, molecular and cell biology, membrane transport and electrophysiology, cell injury and adaptation, immunology, principles of pharmacology, histopathology, surface anatomy and an introduction to the autonomic and peripheral nervous system. This block also focuses on the skin and immune system as its targeted systems. All students are required to take weekly, "formative" assessments (i.e. the scores do not contribute to the final grade) throughout the first 7 weeks of Block 1 with a summative assessment (i.e. final exam) at the end of the block. All assessments are completed online and are comprised of both closed-book, timed components and open-book, untimed components (see Krasne, et al., 2006). Closed-book assessments are aimed at evaluating factual recall and image recognition whereas open-book assessments are designed to evaluate higher order skills including the ability to synthesize and apply factual knowledge to complex questions as well as to effectively utilize resources. The only assessment that was "monitored" was the closed-book, timed component of the summative assessment (i.e. final exam). The questions for all assessments were formulated by the two course co-chairs with the exception of those for Pharmacology (for which 40% of the questions were formulated by the faculty lecturer in that subject) and doctoring/clinical skills, which comprised questions related to interviewing and physical examination. Although assessments focused more heavily on the basic science material presented via lectures and laboratories, they had significant content from clinical reasoning and from doctoring & clinical skills as well.

2.1. Formative Assessment of Clinical Reasoning and Basic Science Knowledge

The first part of a PBL case on melanoma was presented online to 160 first-year medical students (one student was ill) at the beginning of Week 5 of Block 1, a week devoted to studying neoplasia. The online case was presented as an 18-question, open-book, untimed, formative assessment in which the students were asked to identify and categorize pertinent patient data from a videotaped interview, develop a differential diagnosis based on information from the interview and physical exam and a photograph of the lesion, propose actions to be taken, analyze histology, interpret pathology and surgery reports and identify areas of knowledge that required further research (i.e. "learning issues"). The student responses were scored by the tutors for the PBL groups they facilitated using a rubric developed by the investigators. In addition to the PBL case, there were 19 "clinical reasoning" questions on the weekly formative assessments (4 closed-book and 15 open-book); these included probability calculations, accessing and interpreting medical literature, recalling and interpreting journal articles assigned as part of Problem-based Learning or as background for clinical reasoning content in lectures, and identifying patient-centered outcomes. We combined the questions from the online PBL case with the clinical reasoning questions on weekly formative assessments and used the proportion answered correctly by students to yield a "clinical reasoning" score. There were 206 basic science questions (127 closed-book and 79 open-book) on the 7 required formative assessments. The proportion of questions answered correctly on basic science knowledge on the weekly formative assessments yielded a "basic science" score.

2.2. Summative Assessment of Clinical Reasoning and Basic Science Knowledge

As part of the open-book portion of the final (summative) exam for Block 1, a "mini-case" consisting of a brief, four-part case with four (short-answer) questions was presented online to 161 first-year students in Block 1. This case consisted of a brief presentation of a patient with flaccid bullae and erosions who had been non-responsive to antibiotic treatment for bullous pemphigoid. Students were asked to propose a differential diagnosis, listing the diagnoses in order of likelihood; they were then asked to fill in a matrix in which they proposed questions and procedures to differentiate among their differential diagnoses indicating whether the possible outcomes would increase, decrease, or leave unaffected the likelihood of each of the diagnoses; the next question showed histology of a punch biopsy and direct IgG immunofluorescence and asked the students for a definitive diagnosis or limited set of possibilities; finally, the students were asked to propose a first-line of treatment along with the single, best piece of evidence supporting their treatment. Questions were score by the PBL tutors for students in their groups based on a rubric formulated by the authors. In addition to this mini-case, six (multiple-choice) questions were included in the open-book exam that related to clinical reasoning. The latter consisted of questions requiring students to access and assess the medical literature. The questions related to epidemiology, cost-benefit analysis, clinical diagnosis or outcomes, and interpretation of probability data. We compared the proportion of the clinical-reasoning questions answered correctly ("clinical reasoning" score) with the percentage of basic-science questions answered correctly ("basic science" score) on the final exam (comprised of 36 open-book and 81 closed-book questions).

2.3. Analysis

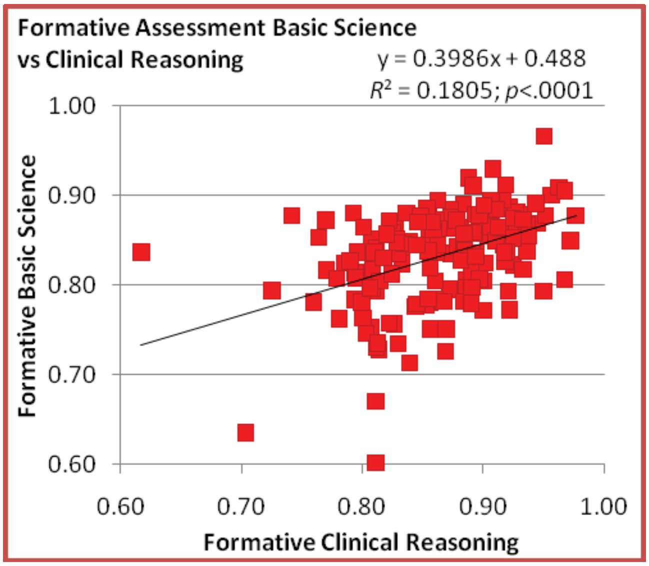
In analyzing the data for correlations between clinical cases/clinical reasoning and exam performance in the present analysis, all exam and clinical-case questions were given the same value (1 point), even though they were not given the same number of points on the assessments, and only the proportion of correct answers was used. This "normalizing" allowed us to compare performance by subject rather than by relative question weights on the exam. Also, on the summative ("final") exam, each question was assigned to only one discipline (the most "relevant" one) even though more than competency may have been involved in answering the question. This discrimination was necessary to assure that correlations measured among subject areas would not reflect overlapping questions. On the weekly formative assessments, questions were categorized only as "basic science", "clinical reasoning", or "doctoring/clinical skills", and there was no overlap in questions between these assessments and the online PBL case completed by the students in Week 5. The Pearson product-moment correlation coefficient, R, the coefficient of determination, R^2, Student's t associated with the value of r, and two-tailed probabilities, p, were calculated for all data correlations. A value of r in the range 0.3-0.7 was considered to indicate a moderate correlation, with lower values indicating a weak correlation and higher values a strong correlation.

3. Results

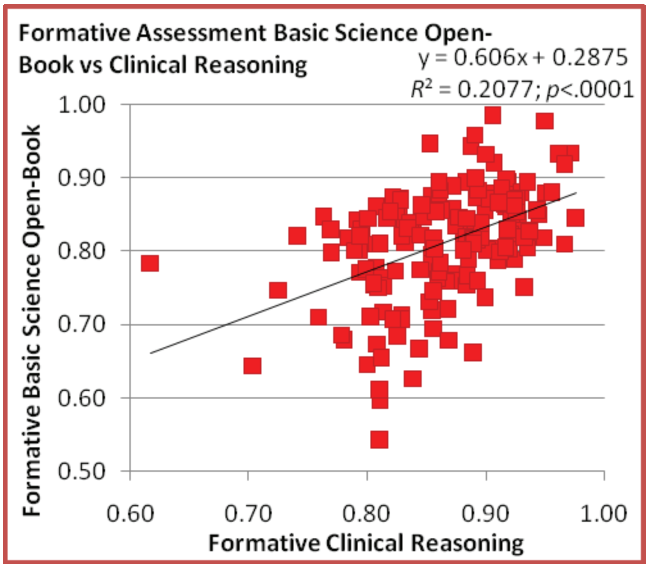
3.1. Formative Assessments vs Online PBL Case

The mean scores for formative assessments of "clinical-reasoning" and "basic-science" equaled 86.4(±5.7SD)% and 82.7(±5.4SD)%, respectively. Performance on clinical reasoning was moderately well correlated with that of "basic science" on formative assessments, with R equal to 0.434 (R^2 = 0.1805; t=5.9, df=158, p<0.0001). Figure 1A shows the data underlying this analysis. Because 33 or the 37 clinical reasoning questions were open-book, were untimed, and were aimed at evaluating higher-order skills, we expected performance on the case to correlate more closely with the open-book than the closed-book formative assessments, and this data is shown in Figures 1B and C, respectively. The correlation of formative "clinical reasoning" scores with "basic science" scores for the open-book questions was clearly stronger than that with "basic science" scores for the closed-book questions with R equal to 0.455 (R^2=0.2063; t=6.43 df=158, p<.0001) when compared with open-book and R equal to 0.297 (R^2=0.0882; t=3.91, df=158, p=.00014) when compared with closed-book "basic science" scores.

1A


Formative Assessment Basic Science
vs Clinical Reasoning
y = 0.3986x + 0.488
R² = 0.1805; p<.0001
1.00
0.90
0.80
0.70
0.60
Formative Basic Science
0.60
0.70
0.80
0.90
1.00
Formative Clinical Reasoning

1B


Formative Assessment Basic Science Open-
Book vs Clinical Reasoning
y = 0.606x + 0.2875
R² = 0.2077; p<.0001
1.00
0.90
0.80
0.70
0.60
0.50
Formative Basic Science Open-Book
0.60
0.70
0.80
0.90
1.00
Formative Clinical Reasoning

1C

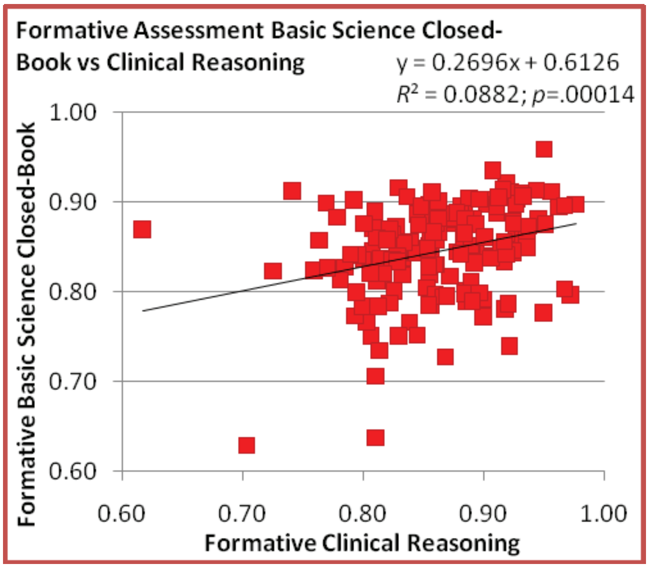
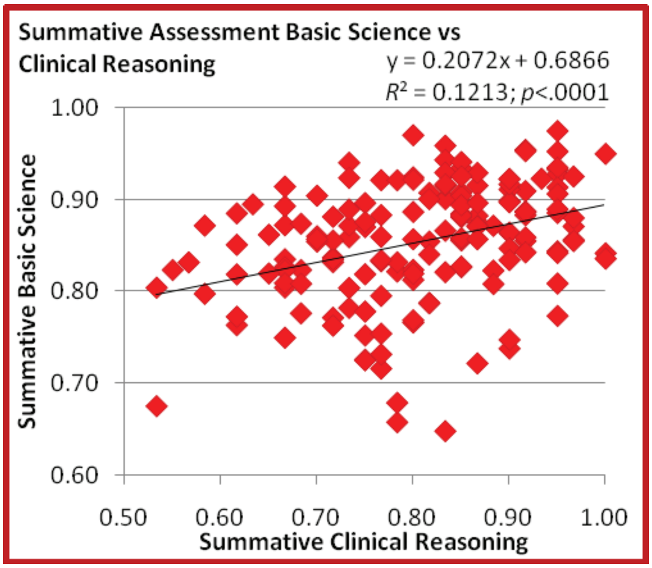


Figure 1. Mean scores on formative assessments for weeks 1-7 compared to scores on the online PBL Case in week 5. The mean scores for all assessments (A), closed-book (B) and open-book (C) formative assessments are compared to scores on online PBL Case.

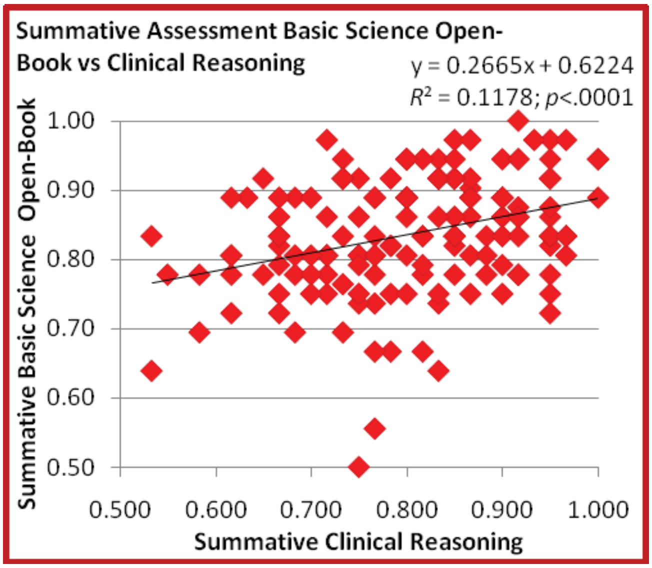
Summative Assessment of Basic Science Knowledge, Online Mini-case/Clinical-Reasoning Skills, and Interviewing/Clinical-Skills

For performance on the final (summative) exam, the mean scores for the clinical-reasoning questions, 80.6 (±10.82SD)% was similar to, albeit lower than, that for the basic science questions, 85.4 (±6.44SD)%. Performance on clinical-reasoning also correlated moderately well with performance on the basic-science questions on the final exam, as seen in Figure 2A, the correlation coefficient, *R*, being equal to 0.348 (R^2=0.1213; *t*=4.68, *df*=159, *p*<0.0001). Because the mini-case and other clinical-reasoning questions were aimed at evaluating higher-order skills, we again expected performance on these to correlate more closely with the open-book than the closed-book part of the final exam, and this data is shown in Figures 2B and C, respectively. The correlation between performance on open-book basic science questions on the final exam and the clinical-reasoning final exam questions, for which *R* equals 0.343 (R^2=0.1178; *t*=4.59; *df*=159, *p*<.0001), was clearly stronger than that for the closed-book basic science questions on the final exam and the clinical-reasoning final exam questions, for which *R* equals 0.267 (R^2=0.0713, *t*=3.5; *df*=159, *p*=.0006).

2A


Summative Assessment Basic Science vs
Clinical Reasoning
y = 0.2072x + 0.6866
R² = 0.1213; p<.0001
Summative Basic Science
1.00
0.90
0.80
0.70
0.60
0.50
0.60
0.70
0.80
0.90
1.00
Summative Clinical Reasoning

2B


Summative Assessment Basic Science Open-
Book vs Clinical Reasoning
y = 0.2665x + 0.6224
R² = 0.1178; p<.0001
Summative Basic Science Open-Book
1.00
0.90
0.80
0.70
0.60
0.50
0.500
0.600
0.700
0.800
0.900
1.000
Summative Clinical Reasoning

2C

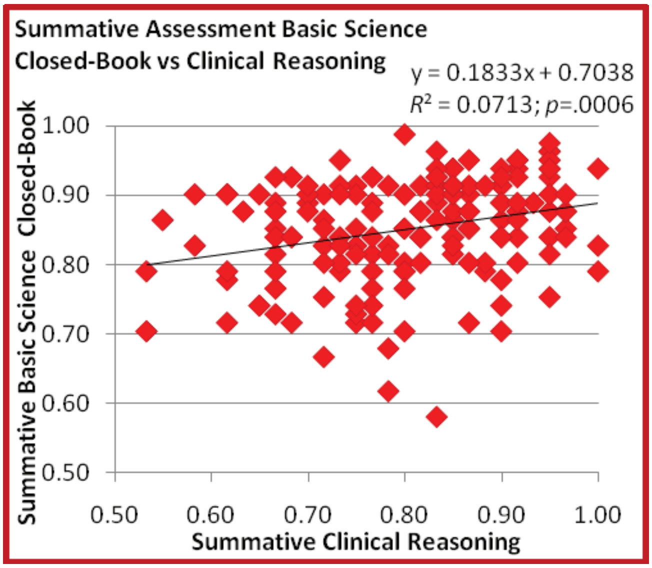


Figure 2. Mean scores for Basic Science disciplines on the closed-book (A) and open-book (B) parts of the final exam vs performance on the mini-case and clinical-reasoning questions.

For the final (summative) exam, we also analyzed whether the correlation between the clinical-reasoning questions and the basic sciences questions differed from that between questions for any given basic-science discipline and all other basic sciences as well as for that between questions on doctoring/clinical-skills and those on basic sciences. These correlations are shown for each of the basic science disciplines (excepting cell injury and repair, for which the correlation could not be analyzed for lack of variability, since there were only 6 questions, and all but 2 students missed either 0 or 1 question), as well as for doctoring/clinical-skills and for clinical-reasoning as compared to all other basic science questions. Although all of the correlation coefficients are in the "moderate" range, there is a wide range of values, from doctoring/clinical-skills with borderline moderate/poor correlation to inflammation/immunology that correlates with the other basic sciences at the "strong end" of the moderate range. Interestingly, although correlation between clinical-reasoning and basic-science questions is in the moderate range, it is at the lower end, being next lowest to doctoring/clinical skills.

Table 1. Means, Correlation and Regression Coefficients of Discipline vs Other Basic Sciences in Order of Descending Correlation

Mean Score	Discipline	*r*	r^2	*t* (*df*=159)	*p* (two-tailed)
89%	Inflammation/Immunology	0.595	0.3536	9.33	<.0001
85%	Genetics	0.547	0.2995	8.24	<.0001
69%	Physiology	0.528	0.279	7.84	<.0001
83%	Neoplasia	0.481	0.2316	6.92	<.0001
87%	Molecular/Cell biology	0.477	0.2276	6.85	<.0001
86%	Anatomy/Histopath/Embryol	0.467	0.218	6.66	<.0001
87%	Pharmacology	0.364	0.1327	4.93	<.0001
81%	Clinical reasoning	0.348	0.121	4.68	<.0001
88%	Doctoring/Clinical skills	0.299	0.0891	3.94	0.00012

4. Discussion

Beginning medical students have little knowledge of specific diseases, how to discriminate among them in formulating a diagnosis and how to treat them. Thus, providing an assessment that allows access to resources allows us to test the students' clinical reasoning skills and ability to access and interpret the relevant medical literature in the absence of such disease-specific knowledge. Based on such testing, we observed a moderate, and highly significant, correlation between student performance on the clinical-reasoning (including proposed diagnoses and treatments for online clinical cases) and basic-science components of the assessments, whether formative or summative. Because the clinical cases and other clinical reasoning questions were presented almost entirely in "open book" format, we expected to see a stronger correlation of performance on these exam items with the "open-book" basic science questions (that relied more on reasoning than factual knowledge) than with "closed-book" basic science questions (that relied more on factual recall and image recognition), and such a relationship was observed. The correlation between clinical reasoning and basic-science knowledge also appeared to be stronger for the formative than the summative assessments; however, this latter relationship may have resulted from the more limited sample on the final exam, there being only 10 clinical reasoning questions on the final exam (including the mini-case) compared to 37 such questions in the combined weekly formative assessments and online PBL case. Based on the results from the summative assessments, the correlation between clinical reasoning and basic science knowledge was less strong than that between any individual basic-science discipline and all other basic sciences. These findings suggest that distinct areas of knowledge and skills are required for clinical reasoning processes beyond those required for performing well in the basic biomedical sciences. The observations presented here argue in favor of pre-clerkship curricula that have components targeted specifically at teaching, and evaluating, clinical reasoning skills in addition to the basic biomedical sciences.

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