Investigating the scientific process skills of medical students in relation to medical decision making: Research on basic medical science competence.

Študija o obvladanju znanstvenoprocesnih veščin pri študentih medicine, ki so potrebne za sprejemanje odločitev: Raziskovanje osnovne medicinskostrokovne pristojnsti.

Kurtulus Ongel,[1] Haluk Mergen,[2] Ebru Katırcı,[3] Cennet Ak,[3] Ismail Sarıkan,[3] Sule Ozkan,[3] Gokhan Cesur,[4] Sevinc Erdal[5]

[1] Assistant Professor, Department of Family Medicine, Faculty of Medicine, University of Suleyman Demırel, Isparta, Turkey.

[2] Specialist of Family Medicine, Faculty of Medicine, University of Uludag, Bursa, Turkey.

[3] Research Assistant of Family Medicine, Department of Family Medicine, Faculty of Medicine, University of Suleyman Demirel, Isparta, Turkey.

[4] Research Assistant of Physiology, Department of Physiology, Faculty of Medicine, University of Suleyman Demirel, Isparta, Turkey.

[5] Science Education Specialist, Columbus, OH, USA.

Abstract

Background: Medical students are expected to convey scientific literacy and possess certain scientific skills prior to being admitted to medical schools. Laboratory practices being provided during their education play a crucial role in their professional development and the usefulness of these practices is possible and can be enriched if the students possess prior scientific skills. The purpose of this study is to determine the scientific process skills of second year medical students in Suleyman Demirel University, Faculty of Medicine, Turkey.

Methods: The study was conducted in April 2006 by using the Scientific Process Skills Questionnaire (SPSQ) for laboratory practices. Randomly selected (n = 76) second year medical students participated in the study.

Results: Nine basic scientific process skills were investigated. All of the students responded correctly to the question that measured their ability to interpret data. Students abilities to set up hypothesis and make estimations were found quite high. (94.7 %, 92.1 % respectively) The two skills that were challenging to students were the ability to make an observation and their proficiency in scales. The percentage of correct responses to those questions were 50 % and 50.5 % respectively.

Conclusions: The study suggests that students in the study group possess the necessary scientific process skills at some degree (86 %). However, this ratio, thus the productivity of laboratory practices can be enhanced by building up on skills such as making observations and interpreting scales. Quality in medical education cannot be achieved if we do not provide our students with basic scientific process skills early in their education.

Izvleček

Namen: Od študentov medicine se pričakuje znanstvenoprocesna pismenost in določene spretnosti. Laboratorijska praksa med študijem igra ključno vlogo pri poklicnem razvoju študentov. Koristi od nje je mogoče še poglobiti, če so študentje že prej znanstvenoproce-

Korespondenca/ Correspondence:
Asist. Prof. dr. Kurtulus Ongel
1807/3 sok. No:4/7
Bostanlı Karsıyaka
35540 Izmir – TURKEY
Tel: +90.505.6487644
Fax: +90.246.2371165
E-mail: kurtulusongel@gmail.com

Ključne besede:
znanstvenoprocesne veščine, sprejemanje odločitev, medicinsko izobraževanje, laboratorijska praksa, klinične veščine.

Key words:
scientific process skills, medical desicion making, medical education, laboratory practices, clinical skills.

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sno pismeni. Študija namerava ugotoviti, v kolikšni meri obvladajo te veščine študentje 2. letnika Sulejmanove univerze v Turčiji.

Metode: Študija je potekala v aprilu 2006 z uporabo vprašalnika o znanstvenoprocesnih veščinah za laboratorijsko prakso. Sodelovalo je 72 naključno izbranih študentov (SPSQ).

Rezultati: Proučevanih je bilo 9 osnovnih znanstvenoprocesnih veščin. Vsi študentje so pravilno odgovorili na vprašanje, ki je merilo njihovo sposobnost interpretiranja podatkov. Precej visoke so bile sposobnosti študentov za oblikovanje hipotez in ocen (94,7 % oz. 92.1 %). Veščini, ki sta bili za študente zahtevnejši, sta bili sposobnost opazovanja in izdelava računov. Odstotek pravilnih odgovorov na ti dve vprašanji je bil 50 % oz. 50,5 %.

Zaključki: Sklepamo, da študentje v proučevani skupini v določeni meri obvladajo potrebne znanstvenoprocesne veščine (86 %). Vendar bi bil ta delež lahko večji in s tem produktivnost laboratorijske prakse ustreznejša z osvojenimi veščinami, kot sta opazovanje in interpretiranje številčnih rezultatov. Kakovosti medicinskega izobraževanja ne moremo doseči, če študentom ne zagotovimo osnovnih znanstvenoprocesnih veščin že zgodaj v času njihovega izobraževanja.

Introduction

Scientific literacy is a major part of peoples' lives where they use scientific principles and processes in everyday life, from making personal decisions to diagnosing deadly diseases. In the last two decades, many nations have placed great amount of emphasis on creating scientifically literate citizens in an effort to compete in the growing global economy.[1] It is expected that scientific literacy would be achieved early in life and people would build on those skills as they choose their profession and acquire more specific skills required by their field. In the medical field, much of scientific literacy and decision making rely on scientific process skills; which in time translate into more complex skills such as clinical skills.[2]

Medical students are expected to convey scientific literacy and possess certain scientific skills prior to being admitted to medical schools. Institutions use various types of evaluation strategies from standardized tests to essays to select the right candidates who possess these skills. However; some studies suggest that in time students are exposed to a hidden curriculum that places the acquisition of biomedical knowledge above clinical skills.[3] On the other hand, laboratory practices that are offered during the first and second years of medical education provide great venue not only for skill development but also the acquisition of the required biomedical knowledge as well. The usefulness of these practices however is possible and can be enriched if the students possess prior scientific process skills, like making observations and using tools to gather, analyze, and interpret data.

National Science Education Standards by National Research Council (NRC) suggests scientific inquiry as a means of teaching and learning of science in the early years.[1] It is stated that some of the benefits of this multifaceted activity is to help acquire the following scientific skills: observation, communication, classification, measurement, inference and prediction; which are also referred in the study as the *scientific process skills*. These basic skills enable everyone, including medical doctors, to conduct objective investigations and to make desicions based on concrete results.

Observation, the first of the scientific process skills involves noting the attributes of objects and situations through the use of the senses.[4] Shapiro et all suggest that observation, including identification of key pieces of data, pattern recognition, and interpretation of significance and meaning, are key elements in medical decision making.[5] **Classification** goes one step further by grouping together objects or situations based on shared attributes. A sample application of this skill in the medical field can be the classifaction of severity of diseases; which in some cases can result in fatalities. In a study, Ozuah reports that most asthmatic children receive inadequate therapy based on inaccurate classification of asthma severity.[6] *Measurement* refers to expressing physical characteristics in quantitative ways and can include skills such as estimation and controlling for changeability. *Communication* harvests the first three skills together to report to others what has been found by experimentation. Although forming patient-physician relationships fall under this category, this skill is more intricate then it is presented. For instance, Supino suggests that in medical schools the development of the hypothesis and its critical relation to subsequent activities in the research investigation are relatively overlooked in medical school curricula.[7]

The other two and the more sophisticated scientific skills are the *Inference* and *Prediction*. They not only require to see and report results but also expect students to extract meaning from them in comparision to what is already known.[8] It is also essential for a student to be able to distinguish his objective observations from his inferences and predictions. This is because scientific inquiry depend on objectivity and an avoidance of hasty assumptions in experimentation.

All of the scientific process skills contribute to a larger purpose, namely problem solving; which can also be called "*medical decision making*" in the medical field. The aim of this study is to determine the scientific process skills of second year medical students in laboratory practices in relation to their decision making.

In this study the following scientific process skills were investigated: making observations, classification, measurement, controlling for changeability, interpreting data and measurements, making inferences and predictions, formulating hypothesis and designing experiments. Although there is no single model of generally accepted medical decision making exists,[3] nor the list of scientific skills necessary to do so, these skills were chosen due to their strong associations with the medical decision making process.

Table 1: Scientific Process Skills investigated by each of the SPSQ questions

Question Number	Scientific Process Skill
Question 1	Observation
Question 2	Classification
Question 3	Making inferences
Question 4	Predicting
Question 5	Controlling Variables
Question 6	Interpreting Data
Question 7	Measurement
Question 8	Formulating a hypothesis
Question 9	Experimenting

Material and Methods

The study was conducted in April 2006 by using the Scientific Process Skills Questionnaire (SPSQ) which was prepared to investigate the scientific process skills of medical students in laboratory practices (Form 1). The questionnaire was adapted and modified from previously developed two science skills questinnaires.[9,10] The questions were designed with the help of the experts in the science education field. The nine questions in the questionnaire correspond to the scientific skills investigated as shown in Table 1.

The participants of the study were the randomly selected second-year medical school students (n = 76) from the Suleyman Demirel University, Turkey. Since there are relatively few studies in this area, an exploratory approach was used in data analysis. Data were tabulated and analyzed by SPSS software.

Results

Nine basic scientific process skills that are stated in Table 1 were investigated in the study. Percentage of correct answers given by students are presented in Table 2. Overall, with a 86 % success rate, the students showed a considerable achievement in the scientific process skills that were questioned. All of the students responded correctly to the question that measured their ability to interpret data. (Question 6) This skill is one of the more extensive skills and can range from interpreting a graphic to assigning meaning to an observation. Furthermore, seeing the relationship between experiments and their findings requires this skill.[3] The most common application of this skill in the medical field is defining a certain disease based on laboratory findings.

Students were also pretty successful in making hypthesis, making estimations, and setting up experiments. (Questions 8, 4 and 9) The percentage of correct answers to these questions were 94.7 %, 92.1 % and 84.2 % respectively. Question 8 tested students' abilities to set up a hypothesis; which is explaining thoughts by testable findings. The process of making hypothesis and then try to confirm this hypothesis forms the basis of medical science. This skill is very crucial and widely used in diagnosing diseases. Question 4 investigated students' abilities to make estimations, that is to make a conjecture about future events and conditions depending on current data. In order to estimate something, in addition to acting on existing information, students are expected to use their perceptions of a given subject.[11] Which is one of the basic principles of patient examination. The last question is designed to test students' abilities to design an experiment, which involves changing and controlling variables and consists of all other processes.

Results revealed that students found Questions 5, 3 and 2 somewhat difficult, with the success rate of 78.9 %, 76.3 %, and 73.7 %. Results also showed that students who answered incorrectly to Questions 5 and 3 all chose the same incorrect answers; which were C and D. Question 5 concerns the ability to control changeability; which involves modifying one variable and examining the resulting adjustments.[12] The third question was investigating text production, meaning to make a decision by interpreting observations or laboratory tests. It depends on students' previous acquaintance with, understanding of, knowledge about, and experience with this subject. Since doctors make decisions about their patients by text production, this is a very essential attribute in the medical field. Second question was examining the students' ability to make classifications: to separate items, events, or knowledge from one another, according to similar features and using special tables or method.[4] Classification is very important for cognitive development since people interpret every piece of new knowledge according to their mental classification schemes.[12] Similarly, physicians classify diseases and their symptoms as well as their degrees of severity.

The two skills that were challenging to students were the ability to make an observation and their proficiency in scales (Questions 1 and 7). The percentage of correct responses to those questions were 50 % and 50.5 % respectively. If a physician can evaluate the results of an observation correctly then he can easily differentiate between different diseases, thus make the correct diagnosis. Question 7 measures students' proficiency in scales, meaning the comparison of quantitative observations with traditional standards. For this skill to develop, it requires time and experimentation.[4] In the medical field, a doctor who has the ability to use scales can easily use and interpret scientific measurement devices.

Table 2: Students' answers in the Scientific Process Skills Questionnaire based on answer category

Question \ Answer	A	B	C	D
	N (%)	n (%)	n (%)	N (%)
1	4 (5.3)	14 (18.4)	20 (26.3)	**38 (50.0)**
2	–	**56 (73.7)**	2 (2.26)	18 (23.7)
3	–	**58 (76.3)**	–	18 (27.3)
4	2 (2.6)	**70 (92.1)**	2 (2.6)	2 (2.6)
5	**60 (78.9)**	–	16 (21.1)	–
6	–	**76 (100.0)**	–	–
7	4 (5.3)	22 (28.9)	**46 (50.5)**	4 (5.3)
8	–	2 (2.6)	**72 (94.7)**	2 (2.6)
9	–	6 (7.9)	6 (7.9)	**64 (84.2)**

Discussion

Although the significance is well-known, scientific process skills have been an area that was overlooked in medical education for many years. It was assumed that the students already possess those skills prior to entering medical school and ready to advance. With this study, not only the basic essential skills

Form 1: Scientific Process Skills Questionnaire (SPSQ) For Laboratory Practices

Scientific process skills questionnaire (SPSQ) for laboratory practices

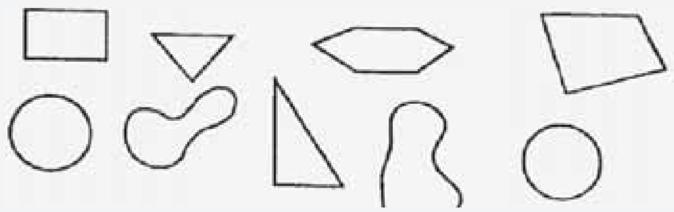
Dear student;

This questionnaire seeks to measure your understanding about scientific process skills for laboratory practices. The questionnaire consists of nine important questions.

This exercise should help you think about the possible affects of the laboratory practices for your future clinical implications. Please respond to all parts carefully and diligently to the best of your ability. Your participation is very important and valuable. All responses will only be used for the purposes of this study and nothing else.

Thank you for participating. For further information, contact Assist. Prof. Dr. Kurtulus Ongel at Family Medicine Department in the Faculty of Medicine.

1. Which of the following is only an observation?
   a. Liver macroscopically has dark color so it must be bloody.
   b. Baby is sucking her mothers' breast very fast, she must be very hungry.
   c. I think prosthesis is made of steel.
   d. Child's arm is separated into two during the accident.
2. If you are asked to classify the following objects, which special feature would you pick?
   a. Square and non-square.
   b. Bordered and non-bordered shapes.

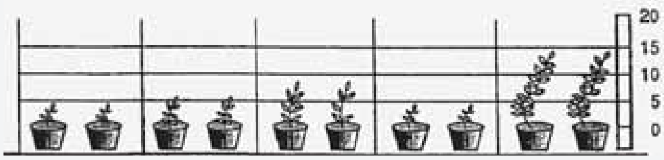


   c. Triangles and squares.
   d. Straight borders and curve borders.
3. Powder X is mixed wih liquids A,B,and C. It is observed that small bubbles appeared in liquid A; no change was seen in liquids B and C. Which of the following conclusions can be drawn based on the above observations?
   a. A and C liquids are the same.
   b. A and B liquids are not the same.
   c. B and C liquids are completely the same.
   d. A liquid is completely the same with B and C liquids.
4. Carefully look at the figures below, which of them sink faster in a cup of water ?
   a. An empty iron box.
   b. Crystallized rock.
   c. Box made of wood.
   d. One piece of sponge

5. An experiment was conducted to detect the effects of electrical fields on rat populations. For the experiment two of the same size rat cages were selected and 10 rats were placed in each of the cages. Then one of the cages were exposed to 50Hz electrical field whereas the other has not. Same conditions were applied to both of the rat populations (oxygen, food etc.). In order to detect the difference, the rat characteristics were observed and recorded after one week. How can you improve this experiment without adding another changeability ?

a. By preparing more rat cages and exposing them to various levels of electrical field
b. By placing more rats into these two cages.
c. By preparing more cages with differant number of rats and exposing them to various levels of electrical field .
d. By applying different electric fields to these two cages.

6. This experiment shows the growth of beans during a 20 day period.
Based on the data provided; what can be said about the experiment?



Growing Time	20 days	20 days	20 days	20 days	20 days
Amount of nutriment	2 gram	2 gram	2 gram	2 gram	2 gram
Amount of water added	50 ml/day	75 ml/day	100 ml/day	65 ml/day	150 ml/day

a. If we add more nutriment to the beans, they will grow faster.
b. With certain amount of nutriment; if more water is added to the beans, they will grow faster.
c. With certain amount of nutriment; if more water is added to the beans, they will grow slowly.
d. With certain amount of water; if more nutriment is added to the beans, they will grow slowly.

7. If a picture of a classroom want to be drawn on a paper what might be a proper proportioned measurement ?
a. 1 cm = 650 m
b. 1 cm = 20 cm
c. 1 cm = 90 cm
d. 1 cm = 4000 m^2

8. After examining the table below; what kind of hypothesis do you set up between the solving time of the substance and the water temperature ?
Average Solving Time
a. There is no differance between solving times due to the water temperature.

Substance	20° C water	40° C water	50° C water	60° C water
20 g sugar	80 second	40 second	20 second	5 second
20 g salt	60 second	30 second	16 second	3 second

b. If water temperature decreases, average solving time becomes shorter.
c. If water temperature increases, average solving time becomes shorter.
d. İt is impossible to make any hypothesis according to these data.

9. If someone wants to detect the appropriate temperature for his fishes in the aquarium. What do you propose he would do?
a. You must put 6 different kind of fishes to 6 different aquariums and hold the aquarium temperatures stable at 25° C degrees.
b. You must put 6 fishes in one aquarium and increase water temperature with 10 minutes intervals from 10° C degree to 15° C, 20° C, 25° C, 30° C, and last 40° C degree.
c. You must take 6 aquariums. By holding aquarium temperature stable at 25° C degree, put 6 fishes to all of the aquariums. Watch the fishes activities, after changes in the water.
d. You must take 6 aquariums with different water temperatures (15° C, 20° C, 25° C, 30° C, 35° C and 40° C) and put 6 fishes. Watch the fishes' activities in each aquarium.

This questionnaire is adapted from the Science Process Test in the IOWA Assesment Book (1998) as well as with the help of Assist. Prof. Dr. Esin Sahin Pekmez and Ass. Prof. Dr. Bilge Taskin Can.

were investigated but also the shortcomings of medical students were revealed. The study shows that students in the study group possess the necessary scientific process skills at some degree (86 %). They feel comfortable in interpreting data, making hypthesis, making estimations, and setting up experiments. However, this ratio is not sufficient and can be enhanced by building up on skills such as making observations and interpreting scales. We believe further research is needed in order to clearly determine the specific skills necessary. Interviewing students about their answers and conducting another skills test would be two approaches that might help us to draw improved conclusions. It should also be note that the generalizibility of the results is limited with the medical school examined.

There are numerous studies that underline the importance of skill development in various branches of medicine. Kowalczyk and Leggett, in their study, point out the importance of medical doctors' skills for radiologic technology.[13] These skills are not only useful for internal medical branches; but also doctors may transfer these skills from the experimental model to patients in surgical medical branches as well. For example, Piechaud and Pansadoro, mention the importance of skills for urologic laparoscopy.[14] In another study by Lie et all, investigate validating measures of third year medical students' use of interpreters by standardized patients and faculty observers.[15] All of the above studies similarly declare the need for better and validated measures for skills used in medical education. The results of our study support these findings. Furthermore, we believe that quality in medical education cannot be achieved if we do not provide our students with basic scientific process skills early in their education and on a regular basis.

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