ORIGINAL ARTICLE

Pattern-Based Learning: An Educational Model for Radiology Residents

Background: Studies show that planning, strategy making, and modeling have greater impact on the achievement of learners than other educational factors. The aim of the present study was to evaluate the changes in clinical competency of radiology residents by teaching and training educational models of radiologic Pattern recognition - diagnostic Approach - Feedback on diagnosis (PAF).

Methods: This semi-experimental study was performed at Mashhad University of Medical Sciences from 2018 up to 2020. The participants were 60 radiology residents divided randomly into two groups of 30 subjects in two educational centers. Eight training sessions were held at one of the two educational centers for teaching this model to assistants. Then, the clinical competency of residents was evaluated by four exams. In addition, residents' satisfaction was also determined by a confidential survey conducted by the university. The parametric tests were used for data analysis. $P<0.0.5$ was considered as the significance level.

Results: Comparison of the scores of two groups in OSCE exam showed that in the second and third-year of being assistance, the scores of the intervention group were significantly better than the control group ($P=0.02$ & 0.05), but no significant difference was found between the two groups in the formative (qualitative) and multiple-choice question exams. About 82.7% of radiology residents were satisfied with this educational model.

Conclusion: Pattern-based learning, including PAF, is a practical suggestion for problem-based learning in medical imaging. It can lead to improvement of the clinical competency in radiology residents, especially levels 2 or 3.

Keywords: Radiology, Clinical Competency, Educational Model, Problem-based learning

Hossein Karimi Moonaghi[1,2,3], Seyed Ali Alamdaran[4,*], Ali Emadzadeh[3], Bita Abbasi[4], Parmiss Ghazi Hoseini[4], Elham Bakhtiari[5]

[1]Nursing and Midwifery Care Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

[2]Department of Medical Education, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

[3]Department of Medical Surgical Nursing, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran

[4]Department of Radiology, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

[5]Clinical Research Development Unit, Khatam Hospital, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

[*]Mashhad University of Medical Sciences, Akbar Children Hospital Shahid Kaveh Blvd. Mashhad, 9177897157 Iran

Tel: +98 9155112578
Fax: +98 5138709201
Email: alamdarana@mums.ac.ir

التعلم القائم على النمط: نموذج تعليمي لطلاب مساعدى متخصص الأشعة

الخلفية و الهدف: تظهر الدراسات أن التخطيط و الاستراتيجية و النمذجة لها تأثير أكبر على نجاح المتعلمين من العوامل التعليمية الأخرى. كان هدفنا هو تقييم التغييرات في الكفاءة السريرية لطلاب مساعدي الأشعة من خلال تعليم النموذج التعليمي هو : معرفة التصميم الإشعاعي- النهج الإشعاعي - ردود الفعل التشخيصية.

الطريقة: تم إجراء هذه الدراسة شبه التجريبية في جامعة مشهد للعلوم الطبية بين عامي ٢٠١٨ و ٢٠٢٠. كان المشاركون في الدراسة ٦٠ طالبا مساعدًا للأشعة تم تقسيمهم عشوائيًا إلى عقدتين من ٣٠ في مركزين تدريب. في أحد مراكز التدريب ، تم عقد ٨ دورات تدريبية لتعريف الطلاب بهذا النموذج التدريبي. في نهاية العام الدراسي تم تقييم الكفاءة السريرية لهم من خلال أربعة اختبارات مختلفة و تم تحديد رضاهم من خلال التقييمات السِّرِّية للجامعة. تم استخدام الاختبارات البارامترية للتحليل الإحصائي واعتبر $P<0.0.5$ مستوى معنويًا.

النتائج: أظهرت مقارنة درجات مجموعتين في اختبار OSCE أنه في مساعدي السنة الثانية و الثالثة ، كانت درجات مجموعة التدخل أفضل بكثير من المجموعة الضابطة و لكن في الاختبارات بين الفصل الدراسي التى كانت من نوع تكوينى و اسئله متعدده الخيارات و النهائي التى كانت لم يلاحظ فرق كبير بين المجموعتين.

الخلاصة: يتضمن التعلم القائم على الخطة "معرفة التصميم الإشعاعي- النهج الإشعاعي - ردود الفعل التشخيصية" هي اقتراح عملي للتعلم القائم على المشكلات في التصوير الطبي الذي يمكن أن يؤدي إلى تحسين الكفاءة السريرية لمساعدي الأشعة ، خاصة في العامين ٢ و ٣.

الكلمات المفتاحية: الكفاءة السريرية ، النموذج التربوي ، التدريب الشعاعي ، اختبار OSCE

یادگیری مبتنی بر الگو: یک مدل آموزشی برای دستیاران رادیولوژی

زمینه و هدف: مطالعات نشان می دهد که برنامه ریزی، راهبردسازی و مدل سازی نسبت به سایر عوامل آموزشی اثر بیشتری در موفقیت فراگیران دارد. هدف ما بررسی تغییرات صلاحیت بالینی دستیاران رادیولوژی با آموزش مدل آموزشی شناخت طرح رادیولوژیک- برخورد رادیولوژیک – بازخورد تشخیصی می باشد.

روش: این مطالعه نیمه تجربی در دانشگاه علوم پزشکی مشهد بین سال های ۲۰۱۸ تا ۲۰۲۰ انجام شد. شرکت کننده ها در پژوهش ۶۰ دستیار را دیولوژی بودند که بطور تصادفی به دو گره سی نفری در دو مرکز آموزشی تقسیم شده بودند. در یکی از مراکز آموزشی هشت جلسه آموزشی برای آشنائی دستیاران با این مدل آموزشی برگذار شد. در انتهای سال تحصیلی صلاحیت بالینی دستیاران با چهار آزمون مختلف ارزشیابی شد و میزان رضایت دستیاران به وسیله ارزشیابیهای محرمانه دانشگاه تعیین گردید. تست های پارامتریک جهت تحلیل آمری استفاده شد و $P<0.0.5$ بعنوان قابل اهمیت در نظر گرفته شد.

یافته ها: مقایسه نمرات دو گروه در آزمون اسکی نشان داد که نمرات در گروه مورد مداخله بطور محسوسی نسبت به گروه کنترل بهتر بود ($P=0.02$ & 0.05) ولی در آزمون های تکوینی (کیفی) و چندگزینه ای میان ترم و نهائی اختلاف معنی داری بین دو گروه مشاهده نشد. میزان رضایت دستیاران از این مدل آموزشی ۸۲٫۷٪ بود.

نتیجه گیری: یادگیری طرح محور شامل شناخت طرح رادیولوژیک- برخورد رادیولوژیک – بازخورد تشخیصی یک پیشنهاد کاربردی برای یادگیری مسئله محور در تصویربرداری پزشکی است که می تواند منجر به بهبود صلاحیت بالینی دستیاران رادیولوژی به ویژه در سال دوم و سوم گردد.

واژه های کلیدی: صلاحیت بالینی، مدل آموزشی، آموزش رادیولوژی، آزمون اسکی

ریڈیالوجی ریزیڈنٹس کے لئے ماڈل پر مبنی تعلیمی طریقہ

بیک گراونڈ : تحقیقات سے پتہ چلتا ہے کہ منصوبہ بندی، حکمت عملی بنانا، اور ماڈل سے تعلیم دینا تعلیم دینے کے دیگر طریقوں سے زیادہ موثر واقع ہوتے ہیں۔ ریڈیالوجی ریزیڈنٹس کو ماڈل کے ذریعے تعلیم دینے کا ہدف ان کی کلینیکل صلاحیتوں میں اضافہ اور تشخیص مرض میں مدد کرنا ہے۔

روش : یہ تحقیق مشہد یونیورسٹی آف میڈیکل سائنسس میں دوہزار اٹھارہ سے دوہزار بیس میں انجام دی گئي۔ تحقیق میں ریڈیالوجی کے ساٹھ ریزیڈنٹس نے شرکت کی۔ ان لوگوں کو تیس تیس کے دو گروہوں میں تقسیم کیا گیا۔ ایک گروہ کے لئے ایک مرکز میں ماڈل کے ذریعے تعلیم دی گئی اور سال کے آخر میں ان ریزیڈنز کا چار طریقوں سے امتحان لیا گیا اور اس کورس پر انہیں کتنا اطمینان تھا اسکا خفیہ طریقوں سے اندازہ لگایا گیا۔ پیرا میٹریک ٹسٹوں کے ذریعے ڈیٹا کا تجزیہ کیا گیا۔

نتیجے: امتحان میں دونوں گروہوں کے نمبروں کا موازنہ کرنے سے واضح ہوتا ہے کہ جس گروہ کو ماڈل سے تعلیم دی گئي تھی اسکے نمبر دوسرے گروہ کی نسبت بہت اچھے تھے لیکن آبجیکٹیو امتحان میں ان کے نمبروں میں خاص فرق نہیں تھا۔ طلبا اس روش سے بیاسی اعشاریہ سات فیصد راضی تھے ۔

سفارش : پی اے ایف روش میڈیکل تصویر برداری میں ایک اہم روش ہے اس سے ریڈیالوجی کے ریزیڈنٹس کی صلاحیتوں میں اضافہ ہوسکتا ہے۔

کلیدی الفاظ : ریڈیالوجی ، ماڈل ، پی اے ایف

INTRODUCTION

In most medical sciences, science includes a set of mental concepts (knowledge), as well as performing clinical skills. There are several learning goals in these disciplines which can be achieved through a variety of educational models or patterns (1). Studies indicate that programming, planning, strategy making, and modeling have a higher impact on academic achievement of learners than other educational factors. Therefore, the necessity of planning and designing educational processes is evident in achieving educational goals, as well as eliminating occupational needs and academic achievement of students (1, 2, 3).

Compared to other disciplines, in radiology specialty the images and visual intelligence play a major role in teaching and learning, and this causes some differences in its domain (4). In addition, although there are various teaching methods in this specialty and students with different learning styles are selected for radiology residency; however, the most essential clinical competency and learning goal in this discipline is to achieve the correct diagnosis through using images. The combination of the two (i.e., domain and goal) has differentiated this discipline from other medical disciplines (5). This can justify the use of a specific educational model for radiology.

In addition, the main textbooks are written as subject-centered or disease-centered in radiology specialty, and although there are numerous diseases, each group of diseases has a specific and unique radiologic pattern or appearance. The introduction and classification of these patterns are presented sporadically in a variety of books and articles.

Lack of proper understanding and short-term sustainability of concepts are disadvantages of the traditional method of learning, therefore new educational methods are required (5).

In this study, the main purpose was to evaluate the changes in clinical competency of radiology residents by teaching and training educational models of radiologic Pattern recognition - diagnostic Approach - Feedback on diagnosis (PAF).

This model has three stages: introduction of radiology patterns or radiological classification of lesions, explanation of a specific diagnostic approach or guidance for each type of radiology pattern, and final diagnostic feedback obtained from follow-up, search, or patient questioning (Table 1).

METHODS

This experimental study was designed and implemented in the Radiology and Medical Education Departments of Mashhad University of Medical Sciences from 2017 to 2019. All radiology residents (60 residents) participated and randomly divided into two groups in this study. Simple randomization was performed, using envelopes enclosed by an assistant manager who was not involved in the evaluation and data analysis. As the intervention was an educational program, blinding was not an option. Randomization, as well as intervention, did not interfere with the routine education. In the first step, the educational model of PAF in radiology specialty, which was presented in the introduction, has been edited by researchers. Then, the level of basic skills of the residents was determined by performing a pre-test of objective structured clinical examination (OSCE).

The variables of this study included the following skills: diagnosis of the radiological pattern, description of the radiological pattern by expressing at least three radiological features, selection of correct diagnostic approach by expressing the appropriate complementary diagnostic approach, presentation of correct diagnosis and differential diagnosis, scores of the OSCE, the formative (qualitative) exam score, and scores of multi-choice exams in the mid-term and the final of term.

The multi-choice exams in the mid-term and the final of term were done with the usage of multi-choice questions. The question paper consisted of 150 four-choice questions.

An objective structural clinical examination (OSCE) was used for reliable assessment of clinical skills and competencies. Thirty electronic OSCE 'station' were designed with the help of computers to interpret the digital radiological images in the context of a specific clinical scenario. Four elements were necessary to the perfect presentation of any X-ray; describing abnormal findings, expression of the classification of predominant radiologic pattern of the lesion, suggesting an appropriate approach or guidelines for each type of radiologic pattern, expressing differential diagnosis and probable diagnosis by linking the abnormalities with the clinical scenario (Figure 1).

The multi-choice exams in the mid-term and the final of term were performed through multi-choice questions. The question paper consisted of 150 four-choice questions.

The formative assessment was the qualitative judgments of assistant's performances in the day-to-day interactions using various criteria (such as resident's progress and the effectiveness). This was done by 15 radiologists' colleague during every course and was recorded at the end of each course. The scores were collected during the academic year and were recorded as formative scores after averaging.

Table 1. The steps, definition, and description of pattern-based learning as an educational model

Steps	Definitions	Descriptions
Pattern	Radiologic pattern recognition	Expression of classification of radiologic pattern of the lesion
Approach	Diagnostic approach (guideline)	Expression of specific diagnostic approach or guidelines for each type of radiologic pattern
Feedback	Feedback on diagnosis	Feedback of final diagnosis from patient's follow-up, search, or questioning

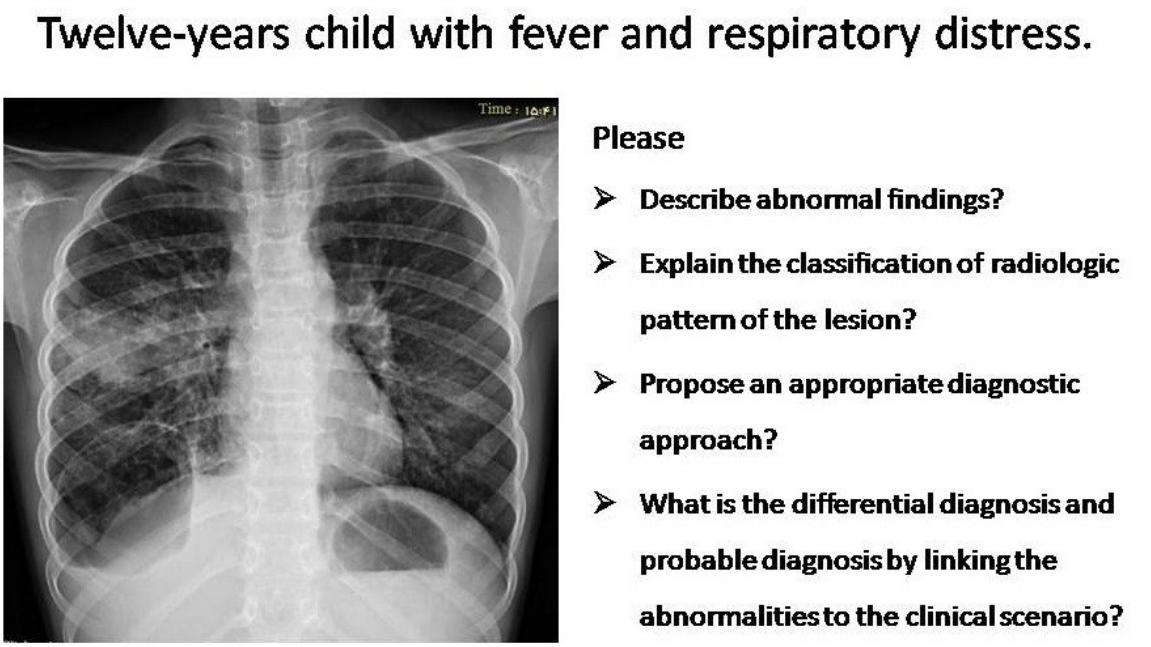

Figure 1. One example of stations of OSCE exam

Eight training sessions were held in a programmed lecture format with answering the questions, as well as guiding discovery learning at one of the two educational centers (Qa'em Hospital) for first, second, and third-year residents was done. The application method of this model was taught to residents in three modalities of simple radiography, contrast radiography, and CT scans as follows: A number of the radiologic patterns in each of these modalities was introduced to the radiology resident, and the diagnostic approach in each pattern instructed so that the student was first able to recognize the radiological pattern of the disease, and then select the relevant diagnostic approach. Afterward, at the feedback step, the student needed to be actively informed of the final diagnosis through follow-up, questioning from colleagues, or literature searching.

Finally, the clinical competency of residents was evaluated through participation in the OSCE (post-test), annual standard upgrading tests of the university, including three tests: OSCE exam, the formative (qualitative) exam, and multi-choice exams in the mid-term and the final of term.

The validity of these tests was confirmed by the expert opinions of radiology colleagues with attention to compliance with the objectives. Since the way of question selection is the same in each year, the reliability of the test will probably be reliable based on the yearly exam. Residents' satisfaction with the proposed model was also determined by a confidential survey conducted by the university.

Statistical analysis was performed using SPSS software version 16.0 (SPSS Institute, Inc., Chicago, IL, USA). All experimental values were presented as mean ± standard deviation (SD) or frequency and frequency percentage. Because of the normal distribution, parametric tests were used for data analysis. A paired sample t-test was used for pre- and post-intervention analysis. In all calculations, $p<0.05$ was considered as the significance level.

RESULTS

The 60 radiology residents (30 males) were included in this study. The mean age of the residents was 28.41 ± 1.74 years in the intervention group and 30.24 ±3.65 years in the control group. According to the Mann-Whitney test, there was no significant difference between the two groups ($p = 0.05$).

The male assistants were 8 (26.7%) in the intervention group and 17 (56.7%) in the control group and there was a significant difference ($p = 0.01$) in the two groups. The effect of gender on the score of residents was evaluated by the linear regression method and the results showed that in both control and intervention groups, gender had no significant effect on the residents' score ($p > 0.05$).

The results of the present survey showed that 82.7% of radiology residents were satisfied with this educational method.

Comparison of the two groups with the OSCE post-test results:

No significant difference was found in the evaluated variables on first and second year residents; however, in third year assistants, the difference in two variables of pattern recognition in plain X- ray, and selection of the appropriate diagnostic approach in CT scan modality was significant ($P=0.007$, $P=0.03$ and $P=0.02$, respectively) (Table 2). Among all the assistants, there was no significant difference between the two groups in all variables in the post-test OSCE scores.

Table 2. Third-year students' scores in our variables

Variables		Intervention group	Control group	P value
Plain x-ray	Pattern recognition	3.77±0.44	2.11±1.59	0.007
	Pattern Description	2.66±1.5	2.6±1.17	0.91
	Approach selection	2.55±1.66	1.10±1.59	0.06
	Diagnosis	3.55±1.03	2.9±1.44	0.27
Contrast radiography	Pattern recognition	2.77±1.39	3.00±1.49	0.74
	Pattern Description	3.11±0.92	3.2±0.78	0. 82
	Approach selection	3.77±0.66	2.2±1.98	0.03
	Diagnosis	3.8±0.75	2.80±0.91	0.1
CT scan	Pattern recognition	3.00±1.41	3.6±0.51	0.22
	Pattern Description	2.44±1.66	3±1.15	0.4
	Approach selection	2.77±1.39	1±1.69	0.02
	Diagnosis	2.77±1.09	2.3±1.25	0.39

Comparison of pre- and post-test OSCE scores in the intervention group:

For all the residents, recognition of the radiologic pattern was significantly improved in plain X-ray modality (P=0.01); however, there was no significant difference between the two groups in terms of the variables of pattern description, selection of the appropriate diagnostic approach, and presentation of correct diagnosis.

In contrast, for radiography modality, each three variables of pattern recognition, choice of appropriate diagnostic approach, and expression of correct diagnosis were significantly improved (P<0.05). In CT scan modality, only the choice of appropriate diagnostic approach was improved as negligible value (P=0.056); however, there was no significant difference in pattern recognition and description, nor in the expression of the final diagnosis.

Comparison of two groups in the standard university exams

For first-year residents, no changes in the OSCE exam scores were found, but the scores of formative (qualitative) and the multiple-choice question exams were inversely one or two scores less than the control group, although it was not significant (P=0.33 and P= 0.86, respectively). For the second-year residents, the scores of OSCE, formative (qualitative), and the multiple-choice question exams were significantly better in the intervention group than the control group (P=0.002, P=0.048, and 0.043, respectively). For the third-year residents, the score of the OSCE test of the intervention group was significantly better than the control group with some overlook; however, there was no significant difference between the two groups in scores of formative (qualitative) and the multiple-choice question exams (P=0.05, P= 0.18 and P= 0.78, respectively) (Table 3)

In sum, for all residents, the OSCE test scores of the intervention group were significantly better than the control group (P=0.02), but no significant difference was found between the two groups in the formative (qualitative) exam and multi-choice exams in the mid-term and the final of term.

DISCUSSION

Nowadays, major educational strategies and models (including SPICES and PRISMS), as well as new educational approaches such as problem-solving methods, collaborative methods (group discussion, and questions and answers (QA)), meta-cognitive packages, and conceptual mapping methods have urged the researchers to make significant changes in instructing and training methods of various medical disciplines (1, 6) among which the radiology field is not an exception.

Medical imaging and similar disciplines such as pathology and dermatology, in which images play a key role in teaching and learning, are different from other medical disciplines (4). Since visual diagnosis in radiology is a complex and difficult skill, it is necessary to pay attention to research in relation to the preferred educational model for this discipline (7). Unfortunately, in the present literature review, few studies have been found concerning this subject, the radiology residency.

Up to now, a number of specialized teaching methods for instructing radiological imaging have been studied, including problem-based learning, group discussions, collaborative learning and taking students' feedback (QA), e-learning, technological supplements (5, 8, 9, 10), case comparison learning, case-based, and team-based learning (7, 11, 12).

In case comparison-learning methods, comparing the relevant case with a normal image or image of a similar case is considered as a teaching method of radiological findings to students; anyway, both are effective learning methods (7, 12).

E-learning and technological supplement methods have some benefits for fostering critical thinking, collaboration, interactive, simulation, and self-testing as important sources of teaching and learning. Consideration of accuracy and usefulness of these materials, and sometimes excessive time loss are the disadvantages of this method (4, 5, 9, 13-15).

Table 3. The comparison of results after the intervention; the scores of control and intervention groups in three types of standard university exams

	Exam type	Number (control#intervention)	Control group	Intervention group	P value
First year	OSCE	9#11	119.33±3.9	119.18±5.3	0.94
	Formative (qualitative)	9#11	50.33±5.36	48.09±4.06	0.33
	Multiple-choice question	9#11	46.00±3.6	45.3±5.48	0.86
Second year	OSCE	10#11	122.1±4.7	127.72±2.32	0.002
	Formative (qualitative)	10#11	38.1±6.5	43.36±4.84	0.048
	Multiple-choice question	10#11	48.9±4.35	55.09±8.01	0.043
Third year	OSCE	10#9	122.9±4.7	128.2±3.6	0.05
	Formative (qualitative)	10#9	39.1±2.99	41.8±5.5	0.18
	Multiple-choice question	10#9	53.9±9.2	55.00±7.85	0.78

In the collaborative or small-group discussion, members of a group present their group discussion and search results to other students, and the instructor has a facilitator role. This method will improve the communication and leadership skills of residents (5).

In most medical schools in the world, the problem-based learning approach has replaced the traditional sequential method of medical education from normal structure and function to pathologic processes (16). In this approach, students discuss a scenario or problem in a small group in which the teacher plays the role of the facilitator. This method is based on four key principles of learning as follows: constructive learning, student-centered and self-directed, social and collaborative, and clinical context-based. Although this method has been fully applied in another discipline of medical sciences, the possibility of its use in radiology is not approved by all radiologists due to its numerous disadvantages. The implementation of this method has been proposed in two formats: 1) as a source for interpretation of the final stages of a number of problem-solving scenarios, and 2) problem design based on imaging findings (16-18).

The results of this study also showed that radiological education in pattern-based learning format can increase the clinical skills of students. The pattern-based learning process has three steps: PAF, which can be taught by two methods of lecture, and guided discovery learning. The student must be actively informed of the final diagnosis through the patient's follow-up, asking from colleagues, or scientific search for the final diagnosis. In this study, "Pattern-based learning" was selected because the word of 'pattern' in radiology means "appearance" of the lesion, and in education is a synonym of "models".

New approaches of radiology researchers and associations were suggested to introduce different lexicons for lesions of various organs such as ACR-Reporting and Data Systems (RADS) in the breast, thyroid/head and neck/liver/prostate/ovarian adnexal/lung/. Moreover, introduction to guidelines or some protocols have been proposed precisely by considering the application of science and improvement of clinical skills of physicians in providing better services to patients (19). All these have been presented in the last decade and the applied pattern in the present study has a similar structure, but in the medical education field and format.

It seems that this educational model, leading to increased clinical competency of radiology residents, has the following strategic educational features: High satisfaction of residents (in the survey), active learning (in the approach and feedback stage), problem-based approach (in the abnormal pattern stage of medical images), student-centered path (at the feedback stage), integration of radiology with clinical medicine (at the feedback stage), applied or product-focused, relation with students and community needs (in all three stages), inter-professional or symbiotic multi-modality (at the approach stage), continuation (in all three stages from observation of abnormal findings to reaching the diagnosis), algorithmic or process-based (in all three stages), and being concise and brief. This proposed educational model may be the most practical proposal for teaching radiology concepts in a problem-based learning format.

Nonetheless, many upgrading tests at different universities are based on students' scores of multiple-choice question exams and formative (qualitative) exams which mainly determine the level of residents' knowledge.

Based on the results of this study, the lack of improvement in scores of residents in written tests showed that this educational method does not affect the level of residents' knowledge. So, paying attention to this type of education may be detrimental to students by its own. Moreover, most major medical reference textbooks still provide content in the subject-based format, which of course, needs to be corrected.

Anyway, the greatest benefit of learning through using this method of education was observed in the second and somewhat third-year residents. For the second-year residents, even the scores of written examinations showed some progresses. Although no significant 1-2-point drop in written test scores was observed among the first-year residents, the results showed that, fortunately, this method of instruction does not lead to a decline in knowledge scores of students, especially at high levels.

As no similar study was found in the literature review section,

therefore, this study has some limitations as follows: Impossibility of fully dividing the residents into two distinct groups with respect to a few overlaps in some collateral rotations and consultation of students with each other, limitation of sample number, the probability of presenting the contents in pattern-based learning format by other faculty members for both groups, lack of a pre-test exam for control group's residents, and spontaneous effect of educational sessions regardless of the learning pattern. Further studies are required to codify and rectify these defects in the radiology discipline, as well as in other similar fields.

The training and application of the PAF educational model led to the increased clinical competency of radiology residents, especially in the second and third years. Therefore, it is recommended to use this approach to educate radiology residents, and it seems necessary to study the residents of similar fields.

Ethical considerations: Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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