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ORIGINAL RESEARCH

Integrated pathology and radiology learning for a musculoskeletal system module: an example of interdisciplinary integrated form

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Introduction: Many curricula integrate radiology with anatomy courses but none of these curricula adopt integration of pathology with radiology as interdisciplinary form at the undergraduate level. The aim of the current study was to identify the outcome of interdisciplinary integrated course of pathology and radiology in musculoskeletal system module (MSK).

Methods: A comparative interventional study was conducted on 60 students representing a whole class of the third year of level V. MSK and gastrointestinal module (GIT) were selected as study and control module, respectively, as being adopted for the same level/allocated hours, enriched with many subject areas for both fields, and availability of learning resources for both. A planned interdisciplinary integrated course for MSK pathology and radiology was implemented in the pathology lab. The subject area was selected and taught for both fields in consecutive ways by pathology and radiology experts. After teaching, gross/histopathologic specimens and radiology imaging/reports were distributed over benches and the students investigated the same. Conversely, in GIT control module, both fields were delivered separately, and no interdisciplinary form of integration occurred. Students' scores for both fields were filtered from the objective structured practical exam, quiz, and final exam. Students' marks and satisfaction were subjected to multiple comparisons using independent student's *t*-test. SPSS version 17 was used.

Results: Significances were obtained between total marks of students for both modules and between radiology courses for both with P=0.0152 and 0.0199, respectively. Number of students who achieved >80% in MSK was 20 and 26 compared to 15 and 17 in GIT for pathology and radiology, respectively. Student satisfaction was high for interdisciplinary integration in MSK with significant difference obtained between MSK and GIT.

Conclusion: The integration of both fields augments student performance for both. This experience must encourage curriculum committee to globalize it over all other modules.

Keywords: pathology teaching, radiology teaching, high level of integration, curriculum reform, Harden' interdisciplinary level

Introduction

Periodic curriculum reform was implemented in both pathology and radiology teaching. Recent curriculum analysis revealed points of strength and weakness that might be subjected to minor reforms.[1] Despite integrated curriculum being fully adopted in Albaha School of Medicine (ABSM) in 2008,[2] there has been no adoption for interdisciplinary step in the curriculum contents. A series of questions were asked: when and how can interdisciplinary step be implemented and on what module would it be started?

To adopt the interdisciplinary integrated step, investigation of commonalities among disciplines was the first step in designing the course. Interdisciplinary step

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is, by definition, the shift of emphasis to the commonalties across the disciplines or subject areas.[3,4] Jarvis[5] describes the interdisciplinary step as an investigation of an event that comprises the application of more than one didactic discipline in coincident manner. The interdisciplinary teaching denotes an advanced stage of integration, in which the subject contents are combined into a newly developed course[6] with loss of the disciplines' perspectives.[7]

On what module can the interdisciplinary step be implemented? In an attempt to respond to the question, holistic investigatory approach for all modules was done and it was found that the musculoskeletal system module (MSK) is the most suitable one to group the MSK pathology and radiology into entity course within the module. Each academic year is divided into two levels arranged as follows: levels 1 and 2 form the first year, levels 3 and 4 form the second year, levels 5 and 6 form the third year, and so on. The 6-year-curriculum is divided into 3 phases; phase I; preparatory phase, phase II: preclinical phase, and phase III: clinical phase. The MSK is adopted for the third year, of level V mapped in phase II. The learning outcomes applied for the module were designed according to SMART criteria, which denote that these objectives are highly Specific, can be Measured and Attained, are Relevant, and are Time bounded.

The allocated time required for module execution is five credit hours over five weeks. The initial framework of the module implies 45 lectures, two self-directed learning sittings, two problem-based learning meetings, four practical pathology sessions of two hours' duration each, four practical anatomy sessions, four radiology sessions of two hours' duration each, and three seminars. Student achievement was assessed by multiple diverse tools, including an objective structured clinical examination, a quiz, a clinical and final exam.

While interdisciplinary courses formed by two disciplines as pathology and radiology are being processed in the current study, the use of imaging in teaching anatomy is well established and considerable improvements in students' radiology understanding has been reported,[8] especially in schools where formal radiology courses have been established and integrated.[2,9,10] In USA, 80% medical schools integrate radiology in their anatomy courses.[10,11] Schober et al[12] surveyed 557 students who adopted a formal radiology program in their preclinical year and revealed that 80% appreciated the introduction of such courses as an element of the anatomy programs.

Aim of the work

The aim is to introduce minor curricular reforms in the form of adoption of interdisciplinary integration step through a well-designed interdisciplinary course that implies pathology and radiology teaching/learning. Also, to investigate the outcome of interdisciplinary integrated form on the student achievement and satisfaction in an attempt to enhance both pathology and radiology learning across the MSK system module as a part of continuous reform of the pathology and radiology learning.

Methods

This study was implemented after obtaining ethical approval from the Scientific Research Ethical Committee guided by the College Agency for Scientific Research of Faculty of Medicine, Albaha University, Saudi Arabia. In addition, a written consent from all participants was obtained.

As a component of curriculum reform, a comparative interventional study was conducted on 60 medical students representing the whole class of third year, level V, and phase II. So, all students of that class were included in the current study.

The curriculum of the third year is divided into two levels: levels 5 and 6; each phase comprises several consecutive modules or blocks arranged in vertical integrated manner. The phase 5 consisted of MSK, gastrointestinal module (GIT), genitourinary modules. From this schematic representation, both MSK and GIT were selected as study and control module, respectively, to be represented in the study for many reasons: first; both modules are applied for the same phase and the same students, second; both modules are enriched with many subject areas for both pathology and radiology, third; the number of credit hours applied for both fields are the same, fourth; availability of teaching/learning resources in the form of histopathological and gross specimens as well as diverse imaging modalities for both modules.

In the MSK study module, a planned course of MSK pathology and radiology was designed to be taught in pathology lab as an interdisciplinary form of radiopathologic integration. The subject area in pathology was selected and taught in parallel with its radiologic findings. Both aspects were implemented through pathology and radiology experts. The subject areas are addressed in Table 1. Each practical session consists of two successive stations; the first one was concerned with radiologic findings with different imaging modalities and introduced by radiology staff member, the second station was concerned with study of morphology, either gross specimens or microscopic, and introduced by pathology staff member. After teaching the subject area from both radiology and pathology aspects, the gross specimens and histopathologic slides in addition to radiology imaging and reports were distributed in the class and the students were encouraged to investigate it separately. On the other hand, in GIT control module, both fields were delivered separately, and no interdisciplinary form of integration occurred.

Table 1 Summary of selected subject areas for interdisciplinary pathology and radiology learning course in pathology lab sessions

Theme	Subject area
Muscles	Inflammatory lesions (pathology and radiological findings)
	Tumors of skeletal muscles (pathology and radiological findings)
	Other soft tissue tumors (pathology and radiological findings)
Bones and cartilage	Congenital anomalies of bone (pathology and radiological findings)
	Inflammatory lesions of bone (pathology and radiological findings)
	Metabolic lesions of bone (pathology and radiological findings)
	Bone and cartilaginous tumors (pathology and radiological findings)
Joints	Inflammatory lesions including different types of arthritis (pathology and radiological findings)
	Joint tumors (pathology and radiological findings)

For both study and control modules, the student mark for both pathology and radiology was filtered and selected from all modes of assessment applied for both MSK and GIT, which comprises the objective structured practical exam (OSPE), quiz, and final exam. The student mark for both fields in MSK was subjected to multiple comparisons, comparison with their counterpart in GIT, comparison with each other in the same module, comparison between total marks of both fields in MSK with that of GIT.

At the end of the MSK course, the degree of student satisfactions was investigated. A well-designed, applicable, prepared questionnaire was planned by a board collected from associates of the pathology, radiology, and medical education. Questions were prepared and adjusted methodically by the didactic professionals to grant the validity for questionnaire. A pilot study was performed on two disconnected clusters: one cluster represented junior staff elements and the second cluster represented level IV students. Results obtained from both clusters were alike, verified that the questionnaire was consistent. The questionnaire was disseminated to 60 students and was intended to determine the intensity of satisfaction among students concerning the interdisciplinary form of integration in pathology and radiology teaching. The questionnaire operated has a five-heading Likert scale, [13–16] which calculated the extent of satisfaction in the main domains of the course among students. The scale varied from 5 to 1 started from strongly satisfied and ended by strongly dissatisfied. All students plotted their satisfaction level through rotating a dot on the level. Qualitatively, student observations were also allowed.

The core of statistical study was carried out via the independent *t*-test. A one-way variance study for comprehensive comparisons of all areas was also performed. SPSS of version 17 (SPSS Inc., Chicago, IL, USA) was utilized in the current study. *P*-values were statistically significant if ≤0.05.

Results

Six stations for pathology and radiology in MSK module were applied; three for each, each station had 2 marks. The total questions in quiz and final exam applied for both were 40; 20 for each, each question had one mark. The counterpart GIT had the same conditions. The results obtained revealed that there is better improvement in the total marks of pathology and radiology in the OSPE, quiz, and final exam of MSK than of GIT with much improvement in radiology mark than the pathology mark in MSK.

In MSK, the number of students attaining ≥90% for pathology and radiology is 6 and 8 (10%, 13.3%), 80%–89% is 14 and 18 (23.3%, 30%), 70%–79% is 21 and 25 (35%, 41.6%), 60%–69% is 15 and 8 (25%, 13.3%), and <60% is 4 and 1 (6.6%, 1.6%), respectively. In GIT, the number of students attaining ≥90% for pathology and radiology is 4 and 3 (6.6%, 5%), 80%–89% is 11 and 14 (18.3%, 21.3%), 70%–79% is 25 and 32 (41.6%, 53.3%), 60%–69% is 11 and 4 (18.3%, 6.6%), and <60% is 9 and 7 (15%, 11.6%), respectively. There is significance obtained in the total marks of students between MSK and GIT with P=0.0152 (Table 2 and Figure 1). Also, there is significance between pathology and radiology mark in MSK with P=0.03052. No significance was obtained between pathology and radiology mark in GIT with P=0.1496. While no significant difference between pathology courses of both modules were present (P=0.140) (Table 2), there was a significant difference between radiology courses for both modules (P=0.019). Differential analysis among mark scales in between both courses does not give rise to any statistical differences among those scales. Also, differential analysis among mark scales in pathology between both courses does not give rise to any statistical differences among those scales (Figure 2). Also, differential analysis among mark scales in radiology between both courses does not give rise to any statistical differences among those scales (Figure 3).

Regarding Likert scale for student satisfaction, the number of students who showed satisfaction (strongly satisfied and satisfied) regarding the interdisciplinary form in MSK was 49 out of 60 (81.6%) opposite to 36 (59.6%) for GIT. Conversely, the number of students who showed dissatisfaction (dissatisfied and strongly satisfied) for MSK was nine out of 60 (15%), opposite to 16 (26.6%) for GIT. A global comparison between the satisfaction scales for both modules gives a highly significant difference, P=0.007.

Table 2 Results of student assessments for both pathology and radiology in MSK and GIT after implementation of integrated interdisciplinary form in MSK

Module	Degree (%)	n (%) of students		*P*-value using independent *t*-test
		Pathology	Radiology	
MSK	≥90	6 (10)	8 (13.3)	Significance obtained in total marks of students between MSK and GIT module with *P*=0.0152. Also, there is significance between pathology and radiology mark in MSK module with *P*=0.03052. No significance was obtained between pathology and radiology mark in GIT module with *P*=0.1496.
	80–90	14 (23.3)	18 (30)	
	70–79	21 (35)	25 (41.6)	
	60–69	15 (25)	8 (13.3)	
	<60	4 (6.6)	1 (1.6)	
GIT	≥90	4 (6.6)	3 (5)	
	80–89	11 (18.3)	14 (23.3)	
	70–79	25 (41.6)	32 (53.3)	
	60–69	11 (18.3)	4 (6.6)	
	<60	9 (15)	7 (11.6)	
P-value using *t*-test between pathology of MSK and that of GIT, radiology marks in MSK and GIT		0.140	0.01999	

Abbreviations: GIT, gastrointestinal module; MSK, musculoskeletal system module.

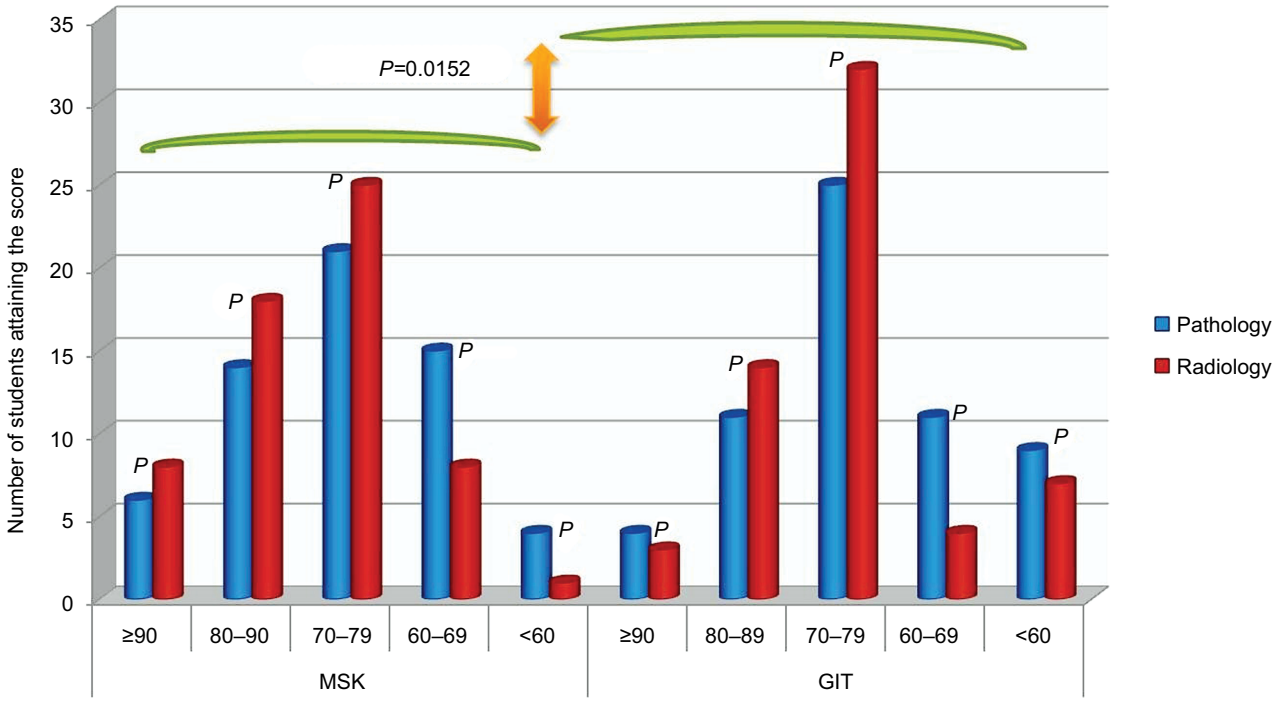

Figure 1 Results of student marks in both MSK and GIT modules.
Notes: The global comparison between all mark scales for both MSK and that of GIT modules gave significant results with *P*=0.0152, while differential analysis among mark scales in between both courses as marked by *P* does not give rise to any statistical differences among those scales.
Abbreviations: GIT, gastrointestinal module; MSK, musculoskeletal system module.

The student satisfaction was high for interdisciplinary integration in MSK; the result of student satisfaction using Likert scale is expressed in Table 3 and represented in Figure 4.

Discussion

Since ABSM adopted integrated curriculum for all teaching courses in 2008, the level of integration is rising and, in some

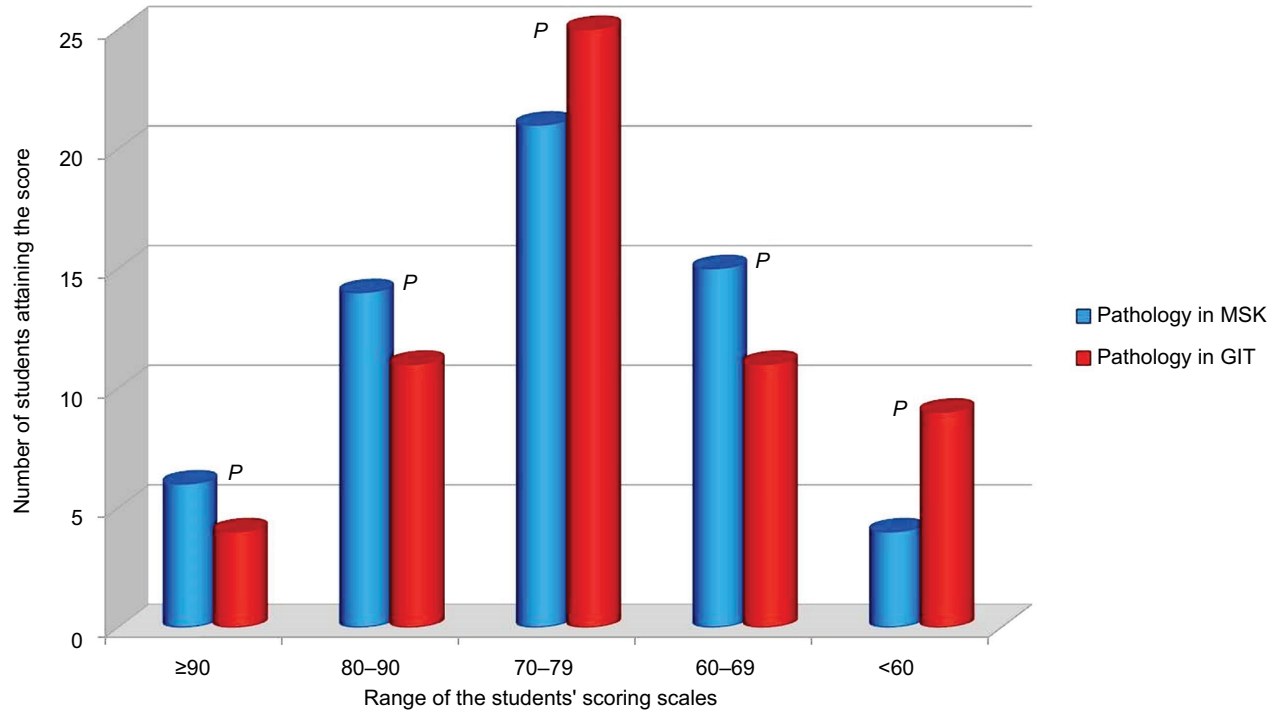

Figure 2 Results of student marks in pathology for both MSK and GIT modules.
Notes: Regarding the pathology mark scales, the comparison between both modules does not give significant results. Also, differential analysis among mark scales of pathology between both courses as marked by *P* does not give rise to any statistical differences among those scales.
Abbreviations: GIT, gastrointestinal module; MSK, musculoskeletal system module.

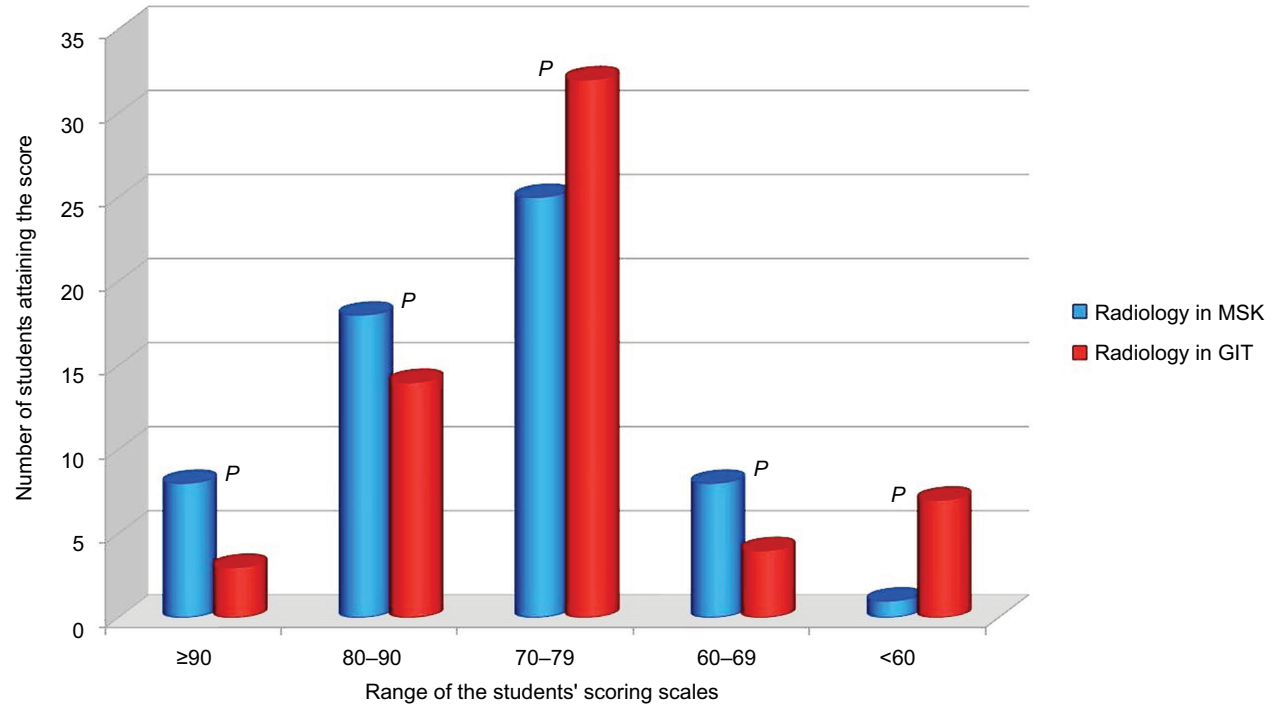

Figure 3 Results of student marks in radiology for both MSK and GIT modules.
Notes: Regarding the radiology mark scales, the comparison between both modules gives a significant result, *P*=0.0199; on the other hand, differential analysis among mark scales of radiology between both courses as marked by *P* does not give rise to any statistical differences among those scales.
Abbreviations: GIT, gastrointestinal module; MSK, musculoskeletal system module.

courses, has reached multidisciplinary step of Harden's ladder.[3,4] In addition, periodic evaluation of curriculum revealed that there are some points of concern when doing curriculum reform. Of these, delivery of pathology and radiology must be in interdisciplinary form. Furthermore, evaluation of basic imaging module revealed low student achievement

Table 3 Results of student satisfaction for MSK module using Likert scale

	Strongly satisfied	Satisfied	Neutral	Dissatisfied	Strongly dissatisfied	*P*-value using independent *t*-test
MSK	34 (56.6%)	15 (25%)	2 (3.3%)	6 (10%)	3 (5%)	0.0077
GIT	22 (36.6%)	14 (23.3%)	8 (13.3%)	10 (16.6%)	6 (10%)	

Abbreviations: GIT, gastrointestinal module; MSK, musculoskeletal system module.

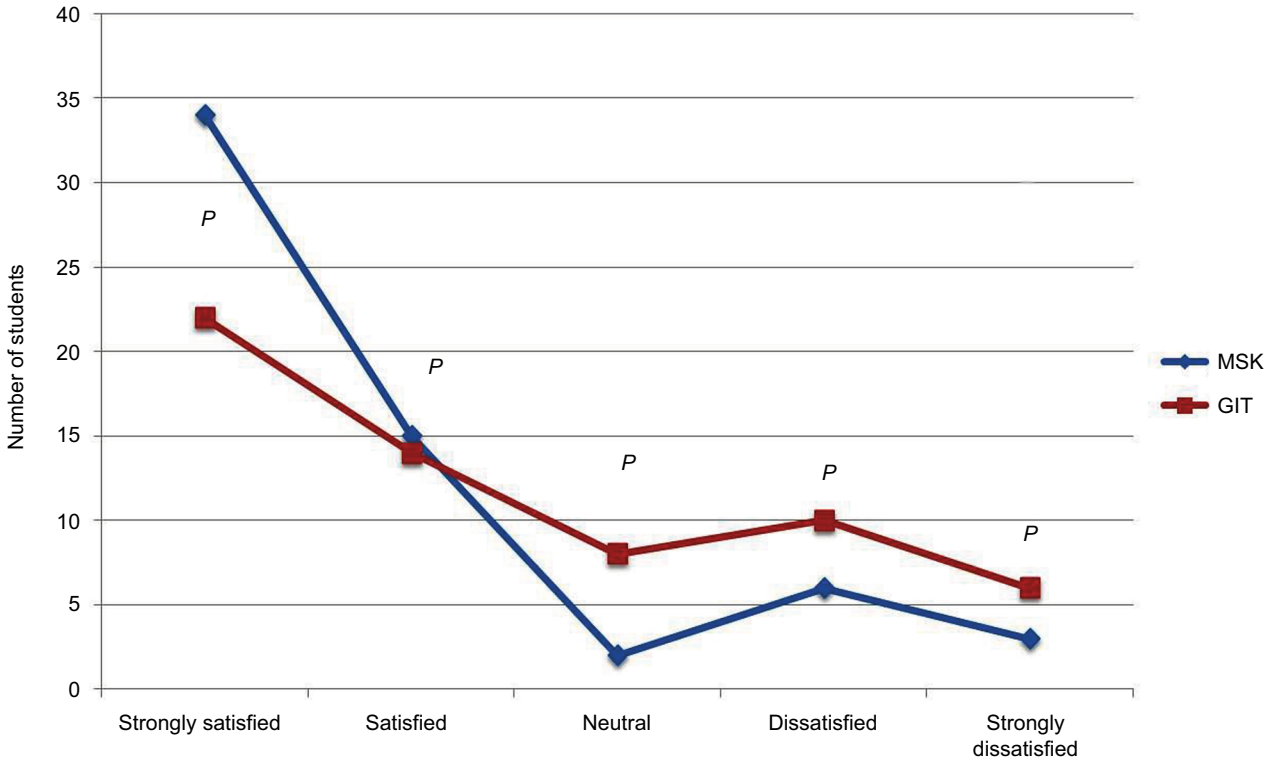

Figure 4 Results of students' satisfaction for the two modules.
Notes: A global comparison between the satisfaction scales for both modules gives a highly significant difference with *P*=0.007, but on the other hand, differential analysis among satisfaction scales in between both courses as marked by *P* does not give rise to any statistical differences among those scales.

compared with other courses,[1] this finding augmented the inevitable need for curriculum reform. Accordingly, pathology and radiology teaching has been reformed in horizontal and vertical manner.[1] In vertical reforms, the MSK was the first module in which the radiology and pathology subject areas were grouped together across the interdisciplinary step of integration.

In the present study, there is significance obtained in the total marks of students between MSK and GIT with *P*=0.0152. The number of students who achieved >80% in MSK was 20 and 26 compared to 15 and 17 in GIT for pathology and radiology, respectively. While significant difference was obtained in radiology courses between MSK and GIT (*P*=0.0199), there is no significance in pathology courses between both modules (*P*=0.140) despite much improvement in the student marks in MSK. Student satisfaction was high for interdisciplinary integration in MSK with significant difference obtained between MSK and GIT. All these findings advocate the importance of interdisciplinary-based integration. The interpretation of these results with others is being difficult as there are no previous studies that have been done to support this current study. From psychological aspect, these results support and match with the results obtained by Atta et al, who studied the learning style of Albaha medical students and found that majority of the students (>90%) have a visual learning style.[17,18]

Despite many studies investigating the integration of radiology and pathology, these studies are mainly concentrated in clinical care and not focused on radiology and pathology teaching for undergraduates. Miller et al[19] studied the effect

of integrated radiology and systemic pathology tutorials on student performance and stated that student assessment was optimistic, signifying the tutorials were believed relevant, valuable, and an incentive for thoughts. Both students and facilitators authorized the advantages of incorporation of pathology and radiology in one integral form. Results obtained through assessments have confirmed the efficacy of pathology and radiology learning in the tutorials. Miller recommended that the reform of pathology tutorials with incorporation of radiology brings forth several benefits reflecting on the learning of both pathology and radiology. In the clinical care, the integrated pathology and radiology was applied for some instances, as in diagnosis of benign breast lesions,[20] breast cancer, [21] pneumonias, [22] and lung fibrosis.[23]

Sorace et al[24] stated that radiologists' and pathologists' data are necessary for reaching accurate diagnoses and proper patient management, and separation of pathology and radiology will affect the outcomes and quality of patient care. With the vast technological approaches in both disciplines, the chance has developed to build up a complementary diagnostic reporting scheme that enhances the serve of both disciplines and, consequently, optimizes the quality care of patients.

Conclusion

The integration of pathology course with radiology as interdisciplinary step of integration augments student performance for both courses. This experience in MSK must encourage the curriculum committee to study and integrate radiology and pathology courses in other modules to enhance student performance in both sciences.

Disclosure

The authors report no conflicts of interest for this work.

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