Effectiveness of a Prerequisite Histological Course for Eight-year Programme Students in China: A Randomized Controlled Study

Yan Ruan
Army Medical University

Junlei Zhang
Army Medical University

Qiyan Cai
Army Medical University

Jiali Wang
Army Medical University

Gaoke Liu
Army Medical University

Yunlai Liu
Army Medical University

Feng Mei
Army Medical University

Jianqin Niu
Army Medical University

Lan Xiao
Army Medical University

Hongli Li
Army Medical University

Yanping Tian (✉ tianyp1981@163.com)
Army Medical University

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Abstract

Background: Due to their lack of basic medical knowledge and learning strategies different from that of high school, it is more difficult for students of 8-year medical programme to adapt to study in the initial stage of basic medicine. This study was to determine whether a prerequisite course can provide an opportunity to adjust learning strategies and improve basic medicine learning performance in order to adapt to study in medical college earlier for achieving the goals of 8-year programme.

Methods: A prerequisite course of histology was conducted by a two-round modified Delphi study. 74 students of 8-year medical programme were subjected randomized to two groups: the prerequisite course group (PC group) and non-prerequisite course group (NPC group). The PC group take part in the prerequisite course by student-centred blended learning approach. The NPC group, taught by the same teachers, underwent requisite histology teaching activities directly with no prerequisite course. Examination of the prerequisite course and requisite histology course were carried out. Effect of the prerequisite course was evaluated by an empirical method using a questionnaire-based approach.

Results: No significant difference was found in baseline admission characteristics between the two groups (P>0.05). Students' scores of the PC group were significantly higher than those of students of NPC group in both prerequisite course and requisite histology examinations (P < 0.05). The results of questionnaires showed that the PC students reported positive effects of the blended learning (P<0.05). Students were satisfied with the prerequisite course, which was beneficial for the adaptation in learning strategies, the uptake in medical knowledge and cultivation of scientific research ability (P<0.01). Furthermore, our prerequisite course is conducive to the study of subsequent courses, especially for pathology.

Conclusion: Our prerequisite course for students of the long-term medical education model could effectively adapt their learning strategies, enhance their knowledge of basic medicine, and improve their scientific research capacity. These findings suggest that the prerequisite course is useful and should be incorporated into the initial stage of basic medicine in future medicine curriculum reform for Chinese students.

Background

Accompanying economic development and growth, it is still a challenge to provide high quality medical services to Chinese people. A massive reform in medical education has already embarked on by the Chinese government. In 2001, program for the reform and development of medical education was approval to pilot an 8-year medical education programme [1]. In China, 5-year programme are anticipated to be the primary pathway for most medical doctors. In contrast, 8-year programme, which award students the doctor degree at graduation, are designed to train high-quality clinician-scientists with rich clinical skills and scientific research ability [1–3]. Students of the long-term medical education model are
required to learn more in a short period of time compared with common MD students because of the reduced duration of the training [4].

Medical students in North American, who have completed 3-4 years of undergraduate education before medical education, have extensive biomedical knowledge and useful learning strategies for future clinical medicine training. However, medical students in many Europe countries and Japan are generally selected from high school [5]. Similarly, in China, students can go to medical school directly from high school, which may cause them fully accustomed to a fairly traditional, teacher-centered education. However, it is worth mentioning that a significant gap exists between high school education and medical university education with regard to learning objectives and learning approach. The student-centred approach was employed to advance student's learning basic knowledge, more importantly, training critical thinking and learning skills in college[6]. It is more difficult for Chinese medical students, especially for 8-year medical students, to change learning methods and strategies for medical professional curricula at the initial stage of basic medicine.

Eight-year medical students have a long learning process, which includes premedical education in the early stage, basic medicine (pre-clinical education) in the middle stage, and clinical and research training in the later stage[7]. Histology is a core basic medicine component of medical education programs and basis for the use and analysis of medical morphology in scientific research works [8]. Teaching implementation of histology is carried out at the initial phase of basic medical curricula, which is also the beginning of scientific research training. As a result, students usually found early academic difficulty in histology curriculum and required additional biomedical knowledge and didactic support to develop a successful study strategy [9]. A prerequisite course provides an opportunity to present students with a given knowledge or skill used as the starting point to build upon in later courses. Prerequisite courses are embedded in basic medicine curricula, leading to improvements in student learning and performance in future courses. Forester et al reported that the students taken prerequisite histology or anatomy course earned a significantly higher course grade in histology or anatomy course in a medical school [10].

In order to adapt to study earlier in the initial stage of basic medicine, a prerequisite course of histology was conducted based on the cultivation goal of 8-year medical programmeme. Through the implementation of prerequisite course, the students adjusted study strategies from passive teacher-centred learning to active student-centred learning, learned more knowledge of basic medicine, and improved scientific research capacity. These findings suggest that our prerequisite course is useful for students of the long-term medical education model and should be introduced in medical curriculum reform for their quicker learning and adaptation to the early stages of basic medical training.

**Methods**

**Participant sampling**
The participating students were 74 undergraduates of 8-year medical programme at Army Medical University (Chongqing China) and divided into two groups: prerequisite course group (PC group, 39 persons) and non-prerequisite course group (NPC group, 35 persons). Admission data (age, gender, and a pretest score) were collected to establish baseline characteristics between the two groups. All students were tested for their histology knowledge before prerequisite course activities. Details of the paper are shown in supplementary materials. Table 1 shows the basic characteristics of the two groups. No significant differences of mastery of histology knowledge were observed between the two groups (Figure 1A, \( P > 0.05 \)).

The construction of prerequisite course

A two-round modified Delphi study on teaching contents of prerequisite course was performed by cell biology teachers, anatomy teachers, and pre-course medical students using an online survey\[11\]. The final main content of prerequisite course and teaching model are as follows (Table 2).

1. Learning strategies. Teachers systematically introduce the strategies and learning methods of histology. Active learning patterns, student-centred learning, were established to replace the previous passive learning model, teacher-centred learning.

2. Learning resources. The relevant textbooks and materials including relevant scientific research progress in Chinese and English were prepared. Resources such as online examination, online microscopy classes, clinical cases bank and so on were constructed. Massive open online courses (MOOCs) were also used (https://www.icourse163.org, https://www.cnmooc.org or https://www.pmphmooc.com)\[12\]. Nineteen prerequisite concepts were designed for histology learning.

3. Blended learning. 39 students was randomly divided into 13 smaller groups, each composed of 3 participants. Through self-study, students master the relevant basic knowledge online. Teachers provided guidance and communicate with students throughout the whole process by email, WeChat, etc. Online quizzes were used to assess effect of teaching. Team members presented their results and held discussions with the other groups. Teachers also summarized key and difficult points of the course and solved common problems by face to face.

Teaching methods

PC group

The prerequisite course is carried out based on the implementation plan in semester before requisite histology course using blended learning. After the prerequisite course, requisite histology course was undertaken by traditional teaching methods.
NPC group

The 35 students did not participate in prerequisite course, but underwent requisite histology teaching activities directly, provided by the same staff as with the PC group.

Evaluation methods

Three approaches were used to evaluate effect of prerequisite course.

1. Pre-test assessment. A pre-test was carried out to test the grasp of basic knowledge in both the PC and NPC groups before and after prerequisite course.

2. Histology examination. Students in both PC and NPC groups took a final examination after finishing requisite histology teaching activities. The scoring staff were blinded to the identity of the students and their assigned group.

3. Questionnaire survey. After the end of the requisite course, the students’ satisfaction with prerequisite course was evaluated by an empirical method using a questionnaire-based approach. Part of the survey was conducted two years after the prerequisite course. The scopes of the questionnaire included blended learning, histology learning, later courses (pathology) learning and scientific research ability training. Each item of questionnaire was rated on a 4-point Likert scale described as, 1 = “completely insufficient for my opinion” to, 4 = “completely sufficient for my opinion”.

Statistical analyses

The data from the students’ evaluation ratings was summarized using descriptive statistics (means, standard deviation (SD), and response rates). Statistical analysis was conducted using SPSS 20.0 software for Windows (SPSS Inc., Chicago, IL, USA). Data are presented as means ± SD. Statistical analysis between the groups was evaluated using t tests and analysis of variance (ANOVA). We used a P-value < 0.05 as the standard for statistical significance and a P-value < 0.01 as highly significant.

Results

Participation of PC and NPC groups

As evident in Table 1, there was no significant difference between the groups in terms of student numbers, sex and age ($P > 0.05$). The results of a pre-test before prerequisite course was also not different between the two groups (Figure 1A, $P > 0.05$). All the students took the final examination of histology and completed the questionnaire in this study.
Examination results of PC and NPC groups

To determine the impact of the prerequisite course on histology knowledge acquisition, students in both groups completed the test immediately before (pre) and after (post) the prerequisite course. The scores in the pre-test and post-test were included for analysis (Figure 1). We found no difference in the test scores between PC group and NPC group before the course. However, the scores of the PC group after the course (mean ± SD, 74.8 ± 14.9) were significantly higher than those of the NPC group (36.5 ± 12.3; Figure 1A; \( P < 0.01 \)).

In order to observe the effect of the prerequisite course on the requisite histology course, the final exam scores of requisite histology course were statistically analyzed. Results showed that students of PC group scored significantly higher than that of students not participated in the prerequisite course (Figure 1B; \( P < 0.05 \)). Further analysis showed the percentage of high scores (>80) of the PC group was significantly higher than that of the NPC group (Figure 1C, D). Higher achieving students in the PC group scored significantly higher than those in the NPC group on identification of tissue structure (slices observation), ability training (clinical case analysis) (Figure 1E, and G, \( P < 0.05 \)) but not knowledge acquisition (knowledge mastery) (Figure 1F, \( P > 0.05 \)).

Analysis of questionnaire of PC and NPC groups

The students were asked to complete an anonymous questionnaire about the prerequisite course after the requisite course. Table 3 summarizes students’ perceptions of the student-centred blended learning. In the feedback analysis the majority of students considered active learning methods useful for histology learning. 87.2% of the students were satisfied (3 and 4 on the four-point scale) with the blended learning (\( P < 0.01 \)), while 64.1% with face to face teaching and 58.9% with e-learning. The students regarded blended learning as an innovative learning method and agreed that it helps them to learn more efficiently and enhance integration with prerequisite content.

Students were asked about the effect of prerequisite course on requisite histology study in second part of survey questions. The evaluation results showed that students had a high degree of satisfaction with the effect of prerequisite course on histology learning. When asked to compare prerequisite course to those without prerequisite course, 97.5% of the students agreed that the prerequisite course was helpful for their later histology study (\( P < 0.01 \)). The prerequisite course was beneficial to student mastering of learning methods and goal of histology. The prerequisite course is also conducive to their mastery of professional English and learning of other courses. The students of PC group agreed that the prerequisite course helps them to observe the H&E-stained sections and analyze clinical cases efficiently (Table 4).

With respect to the effect of prerequisite course on later courses study (pathology especially), 92.4% of students in PC group stated that the PC was beneficial to pathology study (\( P < 0.05 \)). Knowledge and skills they learned from PC course is helpful for the observation of pathological tissue slices and the analysis
of clinical pathological case (P<0.01). The study strategies of our prerequisite course promote efficiency of learning pathology and are conducive to learn other courses (Table 5).

Our prerequisite course also provided scientific research thinking training (Table 6). The results of questionnaire showed that 84.7% of students of PC group agreed that English learning materials increased their vocabulary and improved writing with professional English (P<0.01). The morphological observation and analysis on slices improved their scientific research ability and are conducive to subsequent scientific research tasks. 97.5% of students of PC group agreed that they would recommend our PC course to their peers (P<0.01).

Discussion

8-year medicine programme in China are designed to train high-quality clinician-scientists. But students of the long-term medical education model are enrolled from high school, which makes it difficult for them to adapt to study due to different learning strategies and high learning standards in the initial stage of basic medicine. In this project, the prerequisite course provide a good opportunity to help students adjust their learning strategies and increase basic medical knowledge to adapt to study in the initial stage of basic medicine.

High-school education in China has been characterized by a style of teacher-centred didactic teaching. Faculty transmit knowledge too much in a too short time, while students are expected to be passive recipients of knowledge, which decreases the time to develop abilities such as critical thinking, problem solving, and clinical decision making\textsuperscript{13}. The student-centred approach is an active learning strategy which focuses on the learners' learning, rather than the teacher's teaching \textsuperscript{14}. The student-centred approach has the potential to advance student not only learning basic knowledge but also training critical thinking and learning skills \textsuperscript{15}. Our prerequisite course activities change a teacher-centred, content driven approach to a student-centred, process-driven approach, which is expected to generate independent, active, and autonomous learners. The results showed that most students found this learning strategy promoted their learning.

Due to rapidly increasing medical knowledge, traditional educational resources cannot meet the needs of teaching. There are more and more online teaching resources with the advancement of IT technology. Massive Open Online Courses (MOOCs) are unlimited web-based courses accessed through computers, smartphones, or other digital devices \textsuperscript{16}. There are thousands of MOOCs from hundreds of universities worldwide, including universities of China. These courses are made accessible online, which are beneficial to learn and use for students\textsuperscript{17}. These online resources benefit the participants to facilitate their learning. The practice of teaching histology is based on theoretical didactic strategies along with practical training. Students can observe the microstructure of the tissue by digital microscopic images. A virtual microscopy programs were introduced in many universities \textsuperscript{18, 19}. We also constructed online microscopy classes and clinical cases bank which ensure knowledge learning and retention. Use of the
online resources can be an effective supplement for developing students' competence, confidence and satisfaction.[20]

Several studies show that online course organization and computer-assisted teaching tools are helpful to improve students’ learning. Despite the advances in online technologies, it is not possible to fully replace traditionally teaching pattern. Fully online based learning provides advantages such as flexibility and variety, but comes with disadvantages such as inhibiting face to face communication with other peers [21]. Students can learn basic knowledge by self but need experts for the higher levels thinking skills such as integration or evaluation of knowledge which are better delivered by tutorials. Blended learning is integrated of face to face learning experiences with online experiences affiliating the strengths of traditional and modern learning settings [22, 23]. The real test of blended learning is the effective integration of the two main components [24, 25]. Blended learning was acceptable and of interest to undergraduate students. Students identified that the blend rather than a purely online learning module was beneficial. They expressed a desire for more blended learning in their courses. Our prerequisite course implementation offer a useful teaching reform for medical students that strengthen their competences in terms of knowledge and skills.

Histology is a visually oriented, foundational anatomical sciences subject, which is learned in early medical school curricula. There are many difficulties for undergraduate students in learning histology, such as a better grasp of the terminology being used with insufficient time[26]. Biology knowledge learned at high school is not sufficient to support histology learning, which creates a gap between high school and college. The prerequisite course may provide more biology knowledge and learning strategies used as the starting point to build upon in a later course [27]. In this example, prerequisite course provide appropriate learning strategies and resources to enhance student learning in later requisite histology course. Appropriate learning strategies help students to better master relevant histology knowledge. Sufficient basic medicine knowledge lay a good foundation for students to develop clinical analysis ability, which is supported by our findings and other reports [8]. These findings showed our prerequisite course is useful resource to support histology learning.

Histology is a discipline that mainly involves analyzing the normal structure and related functions present in a cell, tissue, or organ. As the basis for the study of pathology, the mastery of histological knowledge affect the learning of pathology. Markus etal reported that histological knowledge is a predictor of medical students’ performance in diagnostic pathology [28]. In our course, students’ learning strategies acquired in the prerequisite course accelerate their learning of pathology. The basic knowledge learned in our course supports the study of pathology and other clinical courses. In conclusion, our prerequisite course is beneficial for the study of other courses.

The goal of the 8-year programme is to train high-quality clinician-scientists, who have not only rich clinical skills but also multiple scientific research skills[2]. The cultivation of scientific research ability takes a long time, which makes it necessary to start training as early as possible[3]. Our prerequisite course is implemented at the beginning of basic medicine stage. Therefore, we have added the content of
cultivating students' scientific research ability. Our prerequisite course provides professional English learning materials to train students in professional English learning, which helps students to read and write scientific research papers. Section observation and morphological analysis are important methods of scientific research, which are conducive to the improvement of students' scientific research ability. The basic knowledge of histology and the observation of section can improve students’ clinical reasoning skills and experimental techniques. Therefore, our course not only provide rich basic knowledge but also cultivate academic research ability for students of 8-year medical programme.

However, some participants in this study were negative about the prerequisite course. Our further analysis found that it was more difficult for those students to adapt to a student-centered teaching approach in a short time. It takes longer time for these students to change their learning strategies. Another limitation of this study was that the number of participants was relatively small, and therefore not provides more information about the prerequisite course. This will need to be explored in future studies.

In conclusion, the prerequisite course is a powerful tool for bridging the gap between high school and college, which helps students not only in adjusting their learning strategies but also increasing basic medical knowledge and improving scientific research ability. Our prerequisite course is useful for curriculum development and resources support to achieve the objectives of 8-year medical programme. These findings suggest that our prerequisite course is useful for students of eight-year medical programme and should be added in curriculum reform to help students adapt earlier to the initial stage of basic medicine.

**Conclusions**

Our findings indicate that our prerequisite course, a specific course for 8-year medical programme undergraduate, is a powerful educational strategy, which helps students not only in adjusting their learning strategies but also increasing basic medical knowledge and improving scientific research ability. Our prerequisite course is useful for curriculum development and resources support to objectives of 8-year medical programme. These findings suggest that our prerequisite course should be incorporated into the medicine curriculum reform for Chinese students.

**Declarations**

**Ethics approval and consent to participate**

This study was approved by the Protocol Review Committee of the Undergraduate MD Programme and the Faculty of Health Sciences Research Ethics Board at Army Medical University. We obtained informed consent from all participants before conducting our study. Participants were assured that anything they selected would not influence their current or future learning. There was no potential harm to participants.

**Consent for publication**
Availability of data and materials

No data are shared. If anyone need our data and materials, we are very pleased to provide.

Competing interests

All other authors have no conflict of interests.

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Authors’ contributions

YT, LX and HL conceived and designed the study. YR, JZ, QC, JW, YL, GL, FM, JN, and LX undertook data collection and analysis. YR, YT and HL wrote the paper. All authors reviewed drafts of the paper and approved the final manuscript.

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**Tables**

Table 1

Descriptive statistics of participant characteristics

| Variables       | PC group       | NPC group       | P     |
|-----------------|----------------|-----------------|-------|
| Number          | Number (%)     | Number (%)      |       |
| Number          | 39 (100%)      | 35 (100%)       |       |
| Sex (M/F)       |                |                 | 0.45  |
| Male            | 31 (79.5%)     | 29 (82.9%)      |       |
| Female          | 8 (21.5%)      | 6 (17.1%)       |       |
| Mean age (years)| 21.14±0.87     | 20.56±0.95      | 0.14  |
Table 2

The concepts of prerequisite course of histology learning

| Prerequisite topics          | Detailed objectives                                                                                                                                 |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Learning strategies and resources | Learning strategies: the strategies and learning methods of histology.  |
|                             | Resources: the relevant textbooks and materials including relevant research progress in Chinese and English, massive open online courses (MOOCs) |
| Learning contents           | Cell biology: Cell membrane; mitochondrion; endoplasmic reticulum; ribosome; lysosome; cytoskeleton; nuclear                                               |
|                             | Basic tissues: Epithelial tissue; connective tissue; muscle tissue; nervous tissue                                                                 |
|                             | Systematic anatomy and organ histology: Nervous system; circulatory system; immune system; endocrine system; digestive system; respiratory system; urinary system; reproductive system |
| Teaching model              | Blended learning: students grasp the relevant basic knowledge through self-study. Teachers provided guidance online and summarized key points of the course and solved problems face to face. |

Table 3

Questionnaire results about blended learning in the PC and NPC groups
| Items                                      | PC group | NPC group | t    | P  |
|-------------------------------------------|----------|-----------|------|----|
| I like face-to-face teaching              | 2.80±0.15| 3.54±0.11 | 3.89 | <0.01|
| I like e-learning                         | 2.92±0.15| 2.80±0.16 | 0.57 | 0.57|
| I like blended learning                    | 3.46±0.12| 2.66±0.14 | 4.55 | <0.01|
| E-learning is a replacement for face-to-face teaching | 1.80±0.14| 2.40±0.15 | 2.98 | <0.01|
| Teachers play a better role for guiding   | 3.56±0.9 | 3.63±0.08 | 0.53 | 0.59|
| Blended learning helps me to learn more efficiently | 3.41±0.11| 2.54±0.15 | 4.76 | <0.01|
| Blended learning enables me to learn in a pleasant atmosphere | 3.30±0.13| 2.54±0.11 | 4.38 | <0.01|
| Blended learning enables me to integrate prerequisite content | 3.70±0.11| 2.23±0.14 | 8.42 | <0.01|
| Blended learning enables me to study actively | 3.72±0.09| 2.66±0.14 | 6.65 | <0.01|
| I was generally satisfied with the blended learning | 3.51±0.10| 2.46±0.14 | 6.21 | <0.01|
| I wish more blended learning courses available | 3.44±0.10| 3.00±0.11 | 3.02 | <0.01|

Table 4

Questionnaire results about effect of prerequisite course on histology learning in the PC and NPC groups

| Items                                      | PC group | NPC group | t    | P  |
|-------------------------------------------|----------|-----------|------|----|
| Helpful for histology learning            | 3.56±0.09| 3.09±0.15 | 2.82 | <0.01|
| Increased interest in histology learning  | 3.39±0.10| 3.05±0.13 | 2.01 | 0.04|
| Master learning strategies of histology   | 3.23±0.12| 2.66±0.15 | 3.06 | <0.01|
| Help us to improve our learning efficiency| 3.31±0.11| 2.66±0.15 | 3.45 | <0.01|
| I know the goal of histology learning     | 3.05±0.13| 2.49±0.14 | 2.96 | <0.01|
| Master many basic knowledge of histology  | 3.56±0.10| 2.46±0.12 | 6.89 | <0.01|
| Helpful for slices observation            | 3.46±0.11| 2.54±0.14 | 5.27 | <0.01|
| Helpful for clinical case analysis.       | 3.39±0.12| 2.40±0.12 | 5.70 | <0.01|
| Master professional English of histology  | 3.34±0.15| 2.54±0.14 | 5.24 | <0.01|
Table 5

Questionnaire results about effect of prerequisite course on later courses (Pathology) learning in the PC and NPC groups

| Items                                              | PC group   | NPC group   | t    | P     |
|----------------------------------------------------|------------|-------------|------|-------|
| Helpful for pathology learning                    | 3.39±0.10  | 3.00±0.15   | 2.18 | 0.03  |
| Master learning strategies of pathology            | 3.18±0.12  | 2.60±0.14   | 3.11 | <0.01 |
| Improve learning efficiency of pathology           | 3.23±0.11  | 2.71±0.15   | 2.77 | <0.01 |
| Helpful for pathological slices observation        | 3.39±0.11  | 2.63±0.14   | 4.18 | <0.01 |
| Helpful for clinical pathological case analysis    | 3.21±0.13  | 2.46±0.13   | 4.06 | <0.01 |
| Conducive to learn other courses                   | 3.31±0.11  | 2.31±0.13   | 5.88 | <0.01 |

Table 6

Questionnaire results about effect of prerequisite course on scientific research ability training in the PC and NPC groups

| Items                                               | PC group   | NPC group   | t    | P     |
|-----------------------------------------------------|------------|-------------|------|-------|
| Master professional English of histology            | 3.28±0.13  | 2.83±0.13   | 2.47 | 0.02  |
| Increase my professional English vocabulary         | 3.31±0.12  | 2.66±0.14   | 3.57 | <0.01 |
| Improve my English writing ability                  | 3.23±0.11  | 2.54±0.14   | 3.89 | <0.01 |
| Helpful for slices observation                      | 3.41±0.11  | 3.06±0.12   | 2.23 | 0.03  |
| Helpful for morphological analysis                  | 3.18±0.14  | 2.57±0.12   | 3.26 | <0.01 |
| Improve my clinical analysis ability                | 3.31±0.12  | 2.91±0.12   | 2.36 | 0.02  |
| Improve my scientific research ability              | 3.31±0.14  | 2.74±0.13   | 2.94 | <0.01 |
| Expand my academic field                            | 3.38±0.12  | 2.66±0.14   | 4.04 | <0.01 |
| Conducive to subsequent scientific research tasks   | 3.37±0.12  | 2.63±0.13   | 4.26 | <0.01 |
| I would recommend this course to my peers           | 3.44±0.09  | 2.54±0.17   | 4.78 | <0.01 |

Figures
Figure 1

Results of the Examinations. A. Mean examination scores of pre-test before and after prerequisite course. B. Mean examination scores of final histology course. C. Demographic characteristics of exam results of final histology course in NPC group. D. Demographic characteristics of exam results of final histology course in PC group. E. Average score rate of identification of tissue structure (slices observation). F. Average score rate of knowledge acquisition (knowledge mastery). G. Average score rate of ability training (clinical case analysis).
Average score rate of knowledge acquisition (knowledge mastery). G. Average score rate of ability training (clinical case analysis).*P <0.05, **P <0.01

**Supplementary Files**

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- Supp1.pretest.doc