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Effects of a Free Electronic Book on Systemic Anatomy with Schematics on Student Learning

Efectos de un Libro Electrónico Gratuito sobre Anatomía Sistémica con Esquemas sobre el Aprendizaje de los Estudiantes

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SUMMARY: For students in schools of nursing, health sciences, and premed, a systemic anatomy textbook with minimized contents, schematics, and mnemonics may be helpful for learning an otherwise often unappealing subject. In this study, we assess the educational effect of such a textbook. Schematic drawings, anatomy comics, and easily readable text were generated for the chapters of the book (e.g., skeletal system, articular system). The book was presented without charge via a webpage (anatomy.co.kr). Nursing students who were exposed to the book and those who were not exposed were compared; a survey was administered to those who were exposed. The students who read the presented textbook were more knowledgeable than those who used other textbooks. Hours spent reading the presented textbook and scores of fill-in-the-blank questions were positively correlated. In general, the students replied that the presented textbook was helpful for learning systemic anatomy. The systemic anatomy textbook accompanies preexisting textbooks in regional anatomy, neuroanatomy, and the histology, all of which are written by the same authors. We suggest anatomy instructors generate their own books with unique style to enrich the student learning process.

KEY WORDS: Systemic anatomy; Learning; Illustrated books; Cartoons; Internet; Nursing students.

INTRODUCTION

Two Korean anatomists, one of whom is the author of this report, have written a free electronic book on regional anatomy in English, to help medical students learn the subject more effectively than they would with traditional textbooks. Only anatomical terms essential for routine cadaver dissection are explained along with schematic figures. Learning comics and comic strips that depict mnemonics and anatomy jokes are appended. With the help of student volunteers from Korean medical schools, the book's learning effects were evaluated (Chung *et al*., 2020).

However, the regional anatomy book is not suitable for students who do not dissect cadavers. This includes students not only in nursing, health sciences, and premed, but also those who want to expand their anatomical knowledge (Evans, 2007).

A systemic anatomy book, composed of various chapters (e.g., "skeletal system" and "articular system") was published that includes the aforementioned content: a regional anatomy section (Chung *et al*., 2020), anatomy learning comics (Kim *et al*., 2017), anatomy comic strips (Park *et al*., 2011), and anatomy drawings of a white/black board lecture (Park & Chung, 2006). The illustrations are explained with minimal anatomical terms and short descriptions. The systemic anatomy book is available online at [http://anatomy.co.kr/].

The purpose of this study was to evaluate the effect of the presented systemic anatomy book on students' learning. We compared learning outcomes of nursing students who were exposed to the book and those who were not exposed. Question scores and opinions of the exposed students regarding the book were also obtained and analyzed.

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MATERIAL AND METHOD

The book consists of sixteen chapters, including not only the systems that were officially determined (Federative Committee on Anatomical Terminology, 1998), but also embryology, neuroanatomy (as the nervous system), and histology. Three long chapters introduce individual muscles (i.e., muscular system: 27 pages, 103 figures), individual blood vessels (i.e., cardiovascular system: 22 pages, 110 figures), and individual nerves (i.e., nervous system: 27 pages, 100 figures), akin to a brief edition of a regional anatomy book (Table I) (Chung *et al*., 2020).

The learning comics were arranged in Microsoft Word 2016 (Microsoft Corp., Redmond, WA) to deliver anatomy knowledge in the individual chapters (Kim *et al*., 2017). The comic strips and schematics of the regional anatomy book were allocated appropriately and text from the regional anatomy book was selected and simplified. In particular, the anatomical terms were reduced in number and used repeatedly (Fig. 1**;** Chung *et al*., 2020).

The preexisting content was insufficient for the book in quantity and quality. The insufficiency was addressed by generating new schematics, comic strips, and text. The new schematics were drawn in black and white in Adobe Illustrator CC (Adobe Systems, Inc., San Jose, CA; Fig. 1C). Concurrently, new anatomy comic strips, updated with helpful mnemonics and relevant jokes, were created and inserted (Fig. 1) (Shin *et al*., 2013).

We attempted to make the text logical, successive, and correlated throughout the entire book. Surface anatomy was emphasized to enhance comprehension and increase interest by guiding the readers to touch their bodies to gain hands-on experience. In the illustrations and text, the official anatomical terms were used (Federative Committee on Anatomical Terminology, 1998).

The book was titled "Visually Memorable Systemic Anatomy" to emphasize its useful schematics and mnemonics. The title was analogous to another complimentary book "Visually Memorable Regional Anatomy" (Chung *et al*., 2020) and a commercial version of the book "Visually Memorable Neuroanatomy for Beginners" (Chung *et al*., 2020).

The finalized document (DOCX) file was saved as a portable document format (PDF) file (70 MBytes). The PDF file's security properties were set to the minimum to allow readers to copy the figures and texts freely. The electronic book in pdf format was uploaded to a webpage (anatomy.co.kr), where it was downloadable without charge or registration (Chung & Chung, 2018).

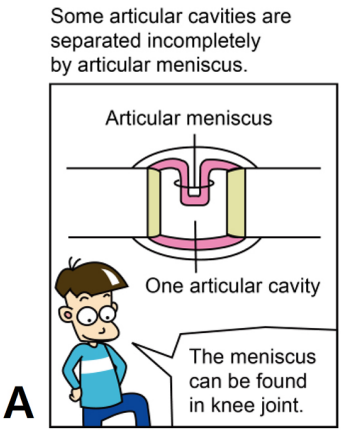

Fig. 2-36.

Unlike the articular disc, the articular meniscus imperfectly divides the articular cavity.

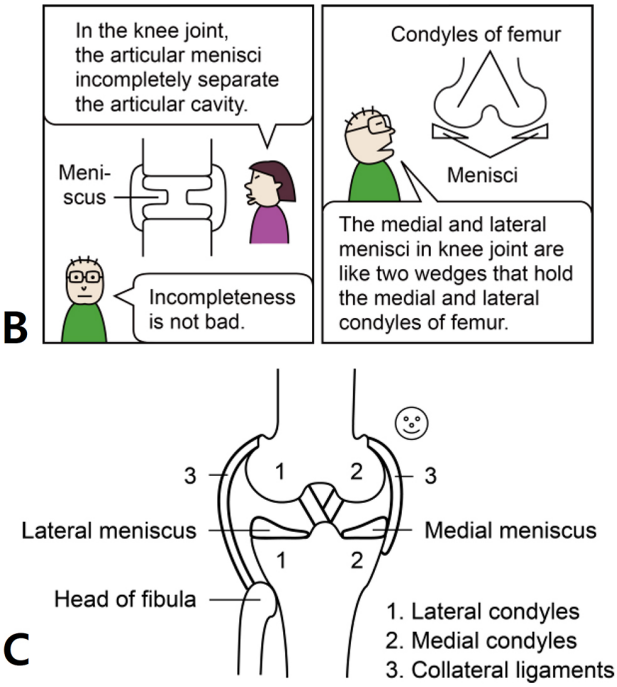

Fig. 2-37. Knee joint.

Fig. 1. Comic illustrations of the knee joint taken from the book. A: Learning comic, B: Comic strip, C: Schematic drawing.

To assess how the presented book helped students, nursing students in a Korean nursing school (College of Nursing, Ajou University) who learned systemic anatomy in 2019 and 2020 were asked to volunteer. We presented students a research outline summarizing the purpose of the study, according to which they were asked to evaluate the book. Table I shows a description of the characteristics of the participating nursing school students.

Table I. Chapters of the systemic anatomy book.

	Pages	Figures
1. Skeletal system	15	68
2. Articular system	13	64
3. Muscular system	27	103
4. Digestive system	15	74
5. Respiratory system	8	40
6. Urinary system	8	37
7. Genital system	12	58
8. Embryology	15	72
9. Endocrine system	7	31
10. Cardiovascular system	22	110
11. Blood	5	29
12. Lymphoid system	6	31
13. Nervous system	27	100
14. Sensory system	11	65
15. Integumentary system	7	41
16. Histology	9	42
Total	207	965

The authors focused on the articular system because this chapter was taught early in the systemic anatomy curriculum (Table I). The lecture on the articular system was received without reference to the presented book in 2019 and on the basis of the presented book in 2020 (Fig. 1). The lecture was presented by an affiliated coauthor in 2019 and by one the book's authors in 2020. The lecture was presented in person in 2019 and on-line using pre-recorded video in 2020, due to COVID-19 (Table II).

In 2020, a test of articular system knowledge was provided, consisting of four fill-in-the-blank questions extracted from the presented book. Four additional multiple-choice questions unrelated to the presented book were also provided. One of the multiple-choice questions had been presented in a counterpart nursing school (Red Cross College of Nursing, Chung-Ang University; Fig. 2, Table II).

In 2019 and 2020, the students, who were finishing the systemic anatomy curriculum, were asked to report how many hours they had dedicated to reading the "articular system" chapter of the book. The reading hours in 2019 and 2020 were compared by independent-samples t test (Table III). In 2020, the students were also asked how many hours they had dedicated to reading the other chapters of the presented book.

Fig. 2. Questions on the articular system, consisting of two fill-in-the-blank questions generated from the presented book (top) and one multiple-choice question, generated independently of the presented book (bottom).

Reversely, [1] refers to a medial motion that pulls a part toward the midsagittal plane. The [2] joint has a concave [2] articular surface on one side and a convex [2] articular surface on the other side. (Correct answers are "adduction" and "ellipsoid" for [1] and [2], respectively.)

Which joint is the below figure? 1. Knee joint 2. Shoulder joint 3. Hip joint 4. Wrist joint 5. Ankle joint (Correct answer is "1.")

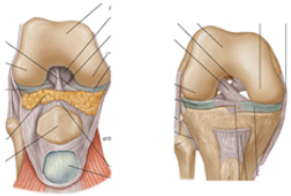

Table II. Description of participating nursing students.

Survey year	2019	2020
Number of participating students	49	62
Sex of participating students	38 females, 11 males	53 females, 9 males
Lecture hours	2	2
Textbook	Another book	Presented book
Lecturer	Affiliated coauthor	Book author
Lecture style	Off-line	On-line (video)
Student testing method	Multiple-choice	Fill-in-the-blank, multiple-choice

Table III. Proportions of students who read the book and their reading hours.

Survey year	2019	2020
Number of participating students	49	62
Proportion who read the "articular system" chapter	40.8%	83.3%
Reading hours of the "articular system" chapter	0.9 ± 1.7***	2.3 ± 1.4***
Proportion who read the other chapters		51.6%
Reading hours of the other chapters		0.5 ± 0.7

Mean ± Standard deviation. ***P < 0.001

In 2020, the reading hours and the test scores (multiple-choice questions and fill-in-the-blank questions) were statistically analyzed by calculating Pearson's correlation coefficients and P-values. The Statistical Package for the Social Sciences (SPSS), version 20 (IBM Corp., Armonk, NY) was employed for all statistical analysis. Individual students' scores were needed for the analysis. Therefore, the students were identifiable, although the authors fully maintained each student's privacy.

In 2020, the students were asked to evaluate the following questions on a 4-point Likert scale: "How much did you learn about the articular system?" "How much did the book help you learn about the articular system?" and "How much did the book help you learn systemic anatomy?".

The students were also asked to provide their positive and negative remarks on the book. Remarks gathered in the Korean language were translated into English by the authors. These remarks were then categorized according to the figures, comics, text, content, and summary.

Ethics statement. This study was approved by the Institutional Review Board (IRB) of Ajou University School of Medicine. The IRB granted an exemption from deliberation (AJIRB-SBR-EXP-15-254).

RESULTS

There were no remarkable gender differences in the results (Table II). In 2019, 40.8 % of students read the "articular system" chapter (reading hours, 0.9 ± 1.7). In 2020, 83.8 % of students read the same chapter (reading hours, 2.3 ± 1.4); 51.6 % of students briefly read the other chapters (reading hours, 0.5 ± 1.7; Table III).

In 2020 (62 students), Pearson's correlation coefficient was 0.239 (P > 0.05) between the hours spent reading the "articular system" chapter and the scores of the fill-in-the-blank questions; that between the hours spent reading and the scores of the multiple-choice questions was 0.056 (P > 0.05). The proportion correct for the multiple-choice questions (97.1 %) was higher than that for the same question in the counterpart school (81.5 %).

By the 2020 school year, most students had good knowledge of the articular system ("much" or "very much") and all students replied that the book helped them understand the subject. Many students replied that the book was also helpful for learning systemic anatomy (Fig. 3).

The students replied that the strengths of the book were the simple figures, the familiar and helpful comics, and the comprehensible text (Table IV).

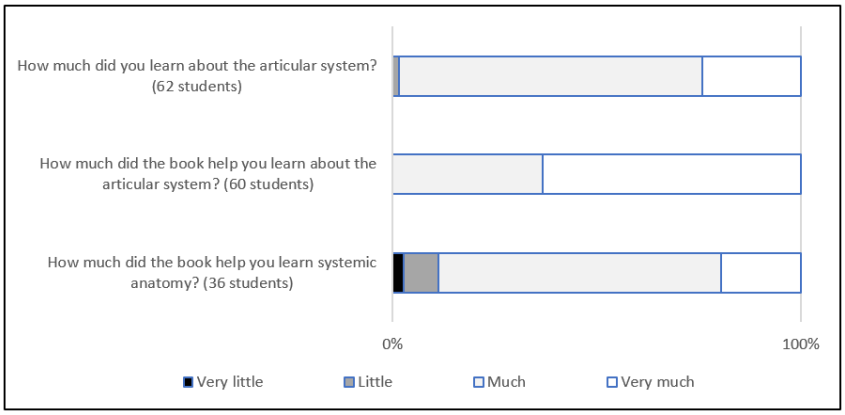

Fig. 3. Responses of students regarding knowledge of the articular system and the book's contribution to their knowledge of the articular system and systemic anatomy in 2020.

Samples of positive remarks were as follows: "It was nice for the authors to have the complex anatomy simply and clearly separated. So, the book helped me understand the differences in joint types at a glance, "The familiar and intuitive comics improved accessibility," and "The contents were organized well and elaborated enough; there was no unnecessary information." The students also replied that the weaknesses of the book were the unrealistic figures, the lack of a summary, and discomfort with the English language in which the book was presented (Table IV).

Table IV. Narrative remarks from 62 students who were exposed to the presented book in 2020.

Themes	Strengths of the book	Weaknesses of the book
Figures	Figures are simple and easily understood (37) Figures are easy to trace (1) Figures are like the lab practice (1)	Figures are unrealistic (3)
Comics	Comics are familiar (8) Comics help understanding (8)	Comics require rearrangement by students (1)
Text	Text is easy to understand (17) Text is simple (2) Text is logical. (1)	Contents are not easy to memorize (1) Contents are not so interesting (1) Contents are extensive for students (1)
Content*	Content is easy to understand (3) Content is interesting (1) Content includes good examples (1) Only essential content is included (1)	Subchapters are insufficient (1)
Summary		Summary of each chapter is absent (3) Table of contents is absent (1)
English		English text is uncomfortable for Korean students (16)

Number of persons expressing the opinion is shown in parentheses. *Content refers to the collection of figures, comics, and text.

DISCUSSION

The current study examined how a reader-friendly systemic anatomy e-book might enhance the student learning experience. The results of our study clearly show that students spent more time reading the presented book than the prior book and the students preferred the new book over traditional textbooks (Table III).

The first stated reason for this preference was that the fill-in-the-blank questions could be correctly answered only after reading the book (Fig. 2). As anticipated, Pearson's correlation coefficient between the hours spent reading the "articular system" chapter and the scores of the fill-in-the-blank questions (0.239) was higher than that (0.056) between the hours spent reading the "articular system" chapter and the scores of the multiple-choice questions. Nonetheless, proportion correct ratio (97.1 %) for the multiple-choice-questions was higher than that (81.5 %) for the same questions in the counterpart school where the students were not exposed to the presented book.

The second stated reason for the preference was the helpfulness of the presented book. Many students replied that the book helped them understand not only the articular system, but also the whole systemic anatomy (Fig. 3). This is why approximately half (51.6 %) of the students read the other chapters of the book even though the questions were not taken from those parts of the book (Table III).

According to the students' narrative remarks, the helpfulness of the book was attributed to its simple figures, the familiar and helpful comics (Fig. 1), and the comprehensible writing (Table IV).

The students also regarded the simple figures as a weakness (Table IV). The schematics can and must be complemented by detailed figures drawn by professionals or pictures of dissected cadavers. An example is the digital learning tools that include on-line atlases and videos, which are frequently utilized by current students (Saxena *et al*., 2008; Jaffar, 2012; Al-Khalili & Coppoc, 2014; Lewis *et al*., 2014; Topping, 2014; Oberoi *et al*., 2018; Mustafa *et al*., 2021). Moreover, students who read the presented book could complement their knowledge via practice with a plastic model and cadaver (Chung *et al*., 2020).

The students complained that there was no summary or table in each chapter of the book (Table IV). It is suggested that students summarize chapters themselves or obtain a summary from another existing book, including other electronic books.

The students also indicated discomfort with the English language in which the book was presented (Table IV); other chapters they read were in Korean. It would be beneficial for the book authors or other anatomists to translate the presented book into Korean or other languages.

Referring to the narrative remarks from the students, the book will be continuously upgraded. Because the book does not involve a publishing company, it may be conveniently upgraded.

The next challenge for the book authors is to write "Visually Memorable Histology." To do so, parts of "Visually Memorable Systemic Anatomy" will be recycled.

Conversely, the histology book will facilitate upgrading the systemic anatomy book. In total, four serial books on regional anatomy, systemic anatomy, neuroanatomy, and histology will interact and produce a synergistic effect because the books have a similar structure and some degree of overlap.

Concurrently, the book authors are recording lecture movies on the basis of their books. They have videoed and edited white/black board lectures (Park & Chung, 2006), which have been distributed through YouTube (channel name: Visually Memorable Neuroanatomy). The lecture videos (white/black board lecture or slide lecture) and the serial books are closely linked and their use is expected to also result in a synergistic effect (Azer, 2012a,b; El-Sayed & El-Sayed, 2013; Raikos & Waidyasekara, 2014).

The presented book containing schematics could be a paradigm-shifting material to help students learn systemic anatomy. Simultaneously, this book could motivate other anatomists to devise their own unique books.

SHIN, D. S.; SEO, E.; KIM, K. Y. & CHUNG, B. S. Efectos de un libro electrónico gratuito sobre anatomía sistémica con esquemas sobre el aprendizaje de los estudiantes. *Int. J. Morphol., 41(6)*:1909-1914, 2023.

RESUMEN: Para los estudiantes de las escuelas de enfermería, ciencias de la salud y premedicina, un libro de texto de anatomía sistémica con contenidos, esquemas y mnemónicos minimizados puede ser útil para aprender un tema que de otro modo sería poco atractivo. En este estudio, evaluamos el efecto educativo de dicho libro de texto. Se generaron dibujos esquemáticos, cómics de anatomía y texto de fácil lectura para los capítulos del libro (por ejemplo, sistema esquelético, sistema articular). El libro se presentó sin costo a través de una página web (anatomy.co.kr). Se compararon los estudiantes de enfermería que estuvieron expuestos al libro y los que no estuvieron expuestos. Se administró una encuesta a quienes estuvieron expuestos. Los estudiantes que leyeron el libro de texto presentado tenían más conocimientos que aquellos que usaron otros libros de texto. Las horas dedicadas a leer el libro de texto presentado y las decenas de preguntas para completar espacios en blanco se correlacionaron positivamente. En general, los estudiantes respondieron que el libro de texto presentado fue útil para aprender anatomía sistémica. El libro de texto de anatomía sistémica acompaña a los libros de texto preexistentes de anatomía regional, neuroanatomía e histología, todos escritos por los mismos autores. Sugerimos que los instructores de anatomía generen sus propios libros con un estilo único para enriquecer el proceso de aprendizaje de los estudiantes.

PALABRAS CLAVE: Anatomía sistémica; Aprendiendo; Libros ilustrados; Dibujos animados; Internet; Estudiantes de enfermería.

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