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The Use of Educational Comics in Learning Anatomy Among Multiple Student Groups

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Understanding basic human anatomy can be beneficial for all students, regardless of when, or if, they will later undertake a formal course in the subject. For students who are preparing to undertake a formal anatomy course, educational comics on basic anatomy can serve as a concise and approachable review of the material. For other students, these comics can serve as a helpful and fun introduction to the human body. The objective of the comics in this study was to promote an understanding of fundamental human anatomy through self-learning among students. Based on the authors' previous teaching experience, these anatomy comics were produced in a simple, direct style. The comics were titled after the two main characters, "Anna" (a girl) and "Tommy" (a boy). These comics were then presented to groups of elementary school students, high school students, premedical students, and medical students to assess the comics' ability to enhance student interest and comprehension of basic anatomy. Quiz scores among high school students and premedical students were significantly higher among participants who read the educational comics, indicating a deeper comprehension of the subject. Among medical students, close reading of the comics was associated with improved course grades. These educational anatomy comics may be helpful tools to enrich a broad spectrum of different students in learning basic human anatomy. Anat Sci Educ 00: 000–000. © 2016 American Association of Anatomists.

Key words: gross anatomy education; anatomy cartoons; comics in education; science education; nonprofessional education; undergraduate education; medical education

INTRODUCTION

Students planning on enrolling in a formal anatomy course can significantly improve their learning potential by reviewing the subject material before the course begins (Bohn et al., 2014). Many premedical students are encouraged to do so to maximize their learning potential, especially considering the recent trend of decreasing the time spent on anatomy coursework in medical schools (Drake et al., 2009). In addition, medical, veterinary, or allied health students may also find it helpful to review basic human anatomy before enrolling in a formal course (Cantwell et al., 2015; McNulty et al., 2016).

Beyond these considerations, however, a basic knowledge of human anatomy is also beneficial to many others who never plan to enroll in an anatomy course. By learning essential human anatomy, these members of the lay public may not only satisfy their latent curiosity about the human body (Weigold, 2001), but as patients they may additionally benefit from improved communication with physicians and health care staff, which may also result in higher compliance (Arksey, 1994; Evans, 2007, 2013). Indeed, public health is closely related to medical literacy and knowledge of fundamental medical information (Williams et al., 1998; Williams, 2012). Finally, for younger students in high school, knowledge of basic human anatomy may be an influential factor in choosing a future career in the health sciences.

For students setting out to study anatomy for the first time, comics consisting of simple and concise illustrations may be superior learning tools over others. Anatomy is a

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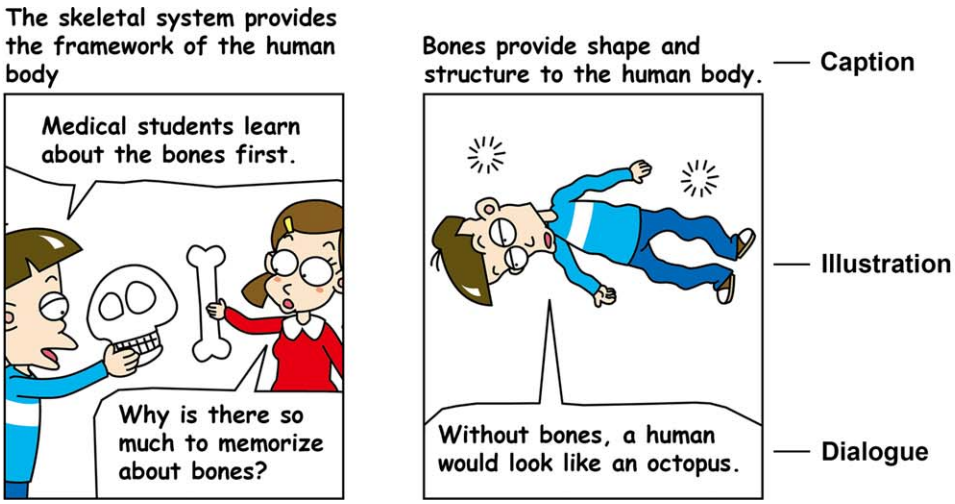

Figure 1.

The first and second panels of the skeletal system. The caption above the illustration conveys anatomical knowledge, while the dialog accompanying the illustration complements the caption.

highly visual branch of study, relating to the morphology and spatial relationships of body structures (Reid and Beveridge, 1986; Reid, 1990a,b). To properly study human anatomy, visual representations of the necessary human structures are essential (Seifert, 2009). However, highly detailed illustrations in anatomy atlases or textbooks may not be helpful to students who are setting out to study anatomy for the first time since they will be unfamiliar with the subject matter and easily disoriented (Alesandrini, 1984; Seifert, 2009; Williams, 2012). In contrast, simple, concise illustrations, such as line drawings, have been shown to be beneficial to students learning new and complex science concepts (Mathewson, 1999; Weigold, 2001; Kim et al., 2012).

While there are several existing educational anatomy comics, many suffer from several limitations. For example, most of these comics were produced by cartoonists rather than professional anatomists. Since these cartoonists typically lack formal anatomical training, their comics may contain flaws in anatomical knowledge. In addition, the anatomy facts that are provided in the prevalent comics are not organized around a general comprehension of anatomy. Moreover, professional cartoonists often focus on other aspects of graphical storytelling, such as the unique characteristics of the protagonist and an exciting plot to grab the interest of readers. While entertaining, these features may come at the expense of the comics' educational objective, as an excessively character-driven story may divert the reader's attention from the acquisition of knowledge (Tatalovic, 2009).

The purpose of producing and presenting educational anatomy comics was to enhance the interest and comprehension of anatomy among both students planning to enroll in a formal anatomy course, and those who do not plan on learning any further anatomy in their educational careers. The authors' previous experience of creating anatomy comic strips ("*Dr. Anatophil*") was utilized when developing "*Anna & Tommy*" (Park et al., 2011; Chung, 2013, 2015). The comics, available on the authors' homepage free of charge (Anatomy, 2015), are intended to provide concise and logical anatomical knowledge so that readers may study anatomy for the first time with ease. In this study, the educational value of these comics was investigated through an analysis of the comics' effects on various types of students' learning, as well as their ability to foster an interest in anatomy.

METHODS

Producing the Educational Anatomy Comics, "*Anna & Tommy*"

The educational anatomy comics revolve around the two title characters, "Anna" (a girl) and "Tommy" (a boy). These two characters were not given unique traits or personalities. Each panel consisted of a caption, dialogue, and an illustration. The caption, located at the top of each panel, delivered the main anatomical facts. The dialog between the characters provided additional information that supplemented the caption (Fig. 1). A simple style of illustration was employed to explain the anatomical features in a comprehensive manner. The comics were produced using Adobe Illustrator (Adobe Systems, Inc., San Jose, CA).

After the introduction chapter, all the systems of the human body were arranged into successive chapters: skeletal, articular, muscular, digestive, respiratory, urinary, genital, endocrine, cardiovascular, lymphoid, nervous, sensory, and integumentary systems. The chapter order corresponded to that of the Terminologia Anatomica (FCAT, 1998). In addition, the comics strictly employed formal anatomic terms rather than colloquial or lay language (FCAT, 1998). Additional chapters included general embryology, blood, and general histology chapters. The general embryology chapter was placed after the genital system; the blood chapter was placed after the cardiovascular system; and the general histology

Table 1.

Participant Demographics

Participants	Male	Female	Total	Average age (range)
Elementary school students	17	18	35	9.8 (6–13)
High school students	35	40	75	16.4 (15–17)
Premedical students	40	16	56	19.9 (18–22)
Medical students	30	19	49	22.9 (20–27)

chapter was placed as the last chapter. Since there is no overarching plot to the comics, the chapters may be read in any order.

Each chapter was composed of panels ranging from 14 to 59 in number. In total, the 17 chapters consist of 853 panels. Due to the restrictive nature of the comic format, overly detailed information was excluded, in keeping with the comics' objective of focusing only on basic anatomy. Two panels were typically saved together as a single Adobe Illustrator (.ai) file (Adobe Systems Inc., San José, CA). The resulting 430 (.ai) files of the comics were 178 megabytes in total. These (.ai) files were then exported in portable network graphics (.png) file format to achieve a small file size without image quality loss. The (.png) files were arranged by chapters and embedded into hypertext markup language (html) webpages, which could then be accessed directly on the authors' website (Anatomy, 2015) by both personal computer and smart phone. Moreover, the comics were put into Microsoft Word (.docx) and portable document format (.pdf) file formats. The final (.docx) file and the (.pdf) file were 73 megabytes and 29 megabytes, respectively, and these were uploaded onto the same homepage.

Evaluating the Utility of the Educational Anatomy Comics Across Four Groups

For the assessment of learning utility of the comics, four groups of students were evaluated. These groups consisted of elementary school students ($n = 35$), high school students ($n = 75$), premedical students ($n = 56$), and medical students ($n = 49$) (Table 1). The elementary and high school students voluntarily attended workshops convened by the authors of this article. The students were first requested to attend the lectures that were aimed at the general public, and then they were asked to read the comics and take the survey. The premedical and medical students were given the option to participate in the study. With the exception of two premedical students, a total of 54 premedical students and 49 medical students chose to read the comics and participate in the study voluntarily. It was assumed that these students believed that reading the anatomy comics would help them familiarize themselves with anatomy.

All participants were native Korean-speaking, so all materials presented and collected were written in the Korean language. The materials were then translated into English for the purposes of this report. Prior to subject participation, the proposed study was examined by the institutional review board (IRB) in Ajou University School of Medicine. The IRB granted an exemption of deliberation (AJIRB-SBR-EXP-15-254).

Quiz

The elementary students did not undertake any written assessment of their knowledge after viewing the educational anatomy comics.

The high school and premedical students were divided into two groups. These consisted of a control group that did not read the "*Anna & Tommy*" comics, while an experimental group was given 20 minutes to read the digestive system chapter within the comics. Then the control and experimental groups undertook a descriptive quiz which asked two questions on the digestive system: "Describe the digestive tract" and "Describe the function of liver." The descriptive quiz format was chosen to assess if the comics aided the students in organizing and comprehending anatomical knowledge, not merely memorizing anatomical terms. The high school and premedical students' answers were blinded and scored by an anatomist. The scores of the control group and that of the

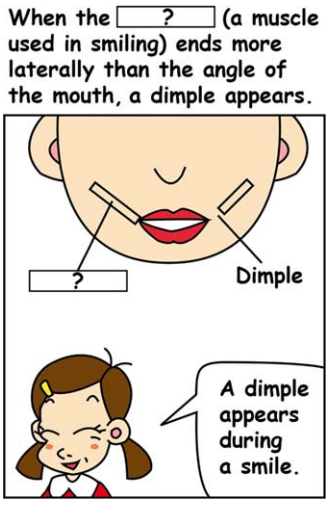

Figure 2.

A sample of the fill-in-the-blank quiz for medical students. The correct answer is zygomatic major muscle.

Table 2.

Survey Results Regarding Learner Interest in, Difficulty of Understanding, and Helpfulness "*Anna & Tommy*" Among Various Groups of All Students

	Elementary school students, *n* (%)	High school students, *n* (%)	Premedical students, *n* (%)	Medical students, *n* (%)
1. How much attention did you pay while reading the comics?				
Greatly	26 (74. 3)	66 (88.0)	50 (89.3)	42 (85.7)
Somewhat	9 (25.7)	8 (10.7)	5 (8.9)	6 (12.2)
Barely	0 (0.0)	1 (1.3)	1 (1.8)	1 (2.0)
2. How difficult are the comics?				
Easy	24 (68.6)	24 (32.0)	20 (5.7)	7 (14.3)
Moderate	2 (5.7)	47 (62.7)	33 (58.9)	29 (59.2)
Hard	9 (25.7)	4 (5.3)	3 (5.4)	13 (26.5)
3. Do the comics help in understanding the digestive system?				
Greatly	20 (57.1)	46 (61.3)	29 (51.8)	NA
Somewhat	15 (42.9)	28 (37.3)	27 (48.2)	NA
Barely	0 (0.0)	1 (1.3)	0 (0.0)	NA
4. Will you read the rest of comics?				
Yes	20 (57.1)	56 (74.7)	30 (53.6)	NA
Maybe	15 (42.9)	19 (25.3)	26 (46.4)	NA
No	0 (0.0)	0 (0.0)	0 (0.0)	NA
5. Were the comics helpful in your anatomy course?				
Greatly	NA	NA	NA	11 (22.4)
Somewhat	NA	NA	NA	37 (75.5)
Barely	NA	NA	NA	1 (2.0)
6. Will you recommend the comics to future anatomy course students?				
Yes	NA	NA	NA	36 (73.5)
Maybe	NA	NA	NA	11 (22.4)
No	NA	NA	NA	2 (4.1)

NA, not applicable/question not asked; cohort size: elementary school students ($n = 35$); high school students ($n = 75$); premedical students ($n = 56$); and medical students ($n = 49$).

experimental group were compared using independent samples *t* test (Table 3).

The medical student cohort was asked to thoroughly read the entire "*Anna & Tommy*" comics (Chung, 2015). Two months before undertaking a formal anatomy course. At the beginning of the semester, the medical students were given several fill-in-the-blank comics quizzes. A fill-in-the-blank quiz was used rather than a descriptive quiz to examine the medical students' level of concentration on the comics' contents (Fig. 2). A lower score would potentially indicate that a student did not concentrate very much on the content of the comics, while a higher score would indicate that a student read the comics more thoroughly.

After the course, the comics quiz scores and the final anatomy grades of the medical students were statistically analyzed using a paired *t* test to evaluate their relationship. The data was also analyzed through calculating the *P*-value and Pearson's correlation coefficient. Statistical Package for the Social Sciences (SPSS), version 20 (IBM Corp., Armonk, NY) was employed in the analyses.

Satisfaction Survey

Three short questionnaires were developed to evaluate the students' satisfaction with the comics. The first survey was designed for all elementary, high school, premedical, and medical students (Table 2, Questions 1 and 2). The purpose of this survey was to examine the students' different levels of perceived interest and accessibility of "*Anna & Tommy*" across different education levels. The second survey was designed specifically for elementary, high school, and premedical students (Table 2, Questions 3 and 4). Its purpose was to examine the comics' perceived effect on students' comprehension of anatomy. The third survey was developed only for medical students (Table 2, Questions 5 and 6). This survey

Table 3.

Comparison of Anatomy Quiz Scores on the Digestive System Between Participants who Read the Comics (Experimental Group) and Those who did not (Control Group)

Participants	Control, mean % (±SD),	Experimental, mean % (±SD)	*P*-value
High school students	44.9 (±17.5)[a]	63.3 (± 19.7)[b]	<0.001
Premedical students	52.8 (± 19.0)[c]	69.4 (± 14.5)[d]	<0.001

Data are reported as mean % of correct answers ± standard deviation; Sample size: a = 42; b = 33, c = 27; d = 29.

was intended to examine the comics' perceived helpfulness on their academic performance in an anatomy course.

Prior to the survey, the elementary school students were given 20 minutes to read the digestive system chapter. With regards to the high school and premedical students, the control groups were then allowed to read the same chapter as well. The elementary, high school, and premedical students were then requested to answer the four questions (Table 2, Questions 1–4). The medical students were requested to answer also four questions, (Table 2, Questions 1, 2, 5, and 6).

Free Comments

In addition to completing the survey, all participants were asked to provide free comments of their overall opinion for the sake of improving the educational anatomy comics. This feedback was used to identify the strengths and weaknesses of the comics.

RESULTS

The effectiveness of the educational "*Anna & Tommy*" comics (Chung, 2015) was evaluated through statistical analysis of quiz grades and questionnaire replies. There was no notable difference based on gender.

Quiz

The response rate of the quiz was 100% in all four groups. In both the high school and premedical student cohorts, the anatomy quiz scores were significantly higher among the experimental group that read the comics than the control group that did not read the comics. This observed tendency was stronger in the high school group. The *P*-value was < 0.001, both for the high school and premedical students (Table 3).

The medical students who acquired higher fill-in-the-blank quiz scores also earned significantly higher anatomy course grades. Paired samples *t* test indicated a significant relationship between the scores ($P < 0.001$). Pearson's correlation coefficient was 0.305, thereby demonstrating a positive correlation (95% confidence interval: 0.049–0.518; $P = 0.033$) (Kendall's tau $b = 0.216$; $P = 0.045$).

Satisfaction Survey

The response rate of the survey was 100% in all four groups. Most of the elementary students (74.3%), high school students (88.0%), premedical students (89.3%), and medical students (85.7%) replied that they paid close attention when reading "*Anna & Tommy.*" Interestingly, the majority (68.6%) of elementary school students answered that the comics were easy, while only a minority (14.3%) of medical students regarded the comics as being easy (Table 2).

After reading the digestive system chapter, almost all (98.7–100.0%) elementary, high school, and premedical students answered that "*Anna & Tommy*" was greatly or somewhat helpful in understanding that chapter. This result corresponded with that of the quiz scores between control and experimental groups (Table 3). Consequently, all students responded that they would read the rest of "*Anna & Tommy*" (Table 2).

Table 4.

Examples of Free Comments from the Satisfaction Survey

Participants	Quotes
Elementary school students	"The simplicity of both the art and narrative styles makes it easy to approach anatomy"; "There are not enough jokes to help the reader keep up with reading the comics."
High school students	"The comics are easier to read than lengthy texts, so I am less pressured and more willing to take the time to learn anatomy"; "I wish there were definitions for the various anatomical terms that I was not familiar with"; "More comprehensive explanations for the diseases related to various organs might be helpful."
Premedical students	"It would be nicer if images of the actual organs or additional visual anatomy contents were provided along with the comics"; "More connections between the anatomical concepts and everyday life would help the readers relate anatomy with their lives."
Medical students	"The comics are appropriate for those who are going to take an anatomy course because the comics provide prior knowledge on what anatomy comprises of"; "Because actual cadaver dissection and lecture during the course are arranged by region, the anatomy comics arranged by system were helpful in understanding functional relationships between the body organs."

After finishing the anatomy curriculum, nearly all (98.0%) the medical students replied that the "*Anna & Tommy*" comics greatly or somewhat helped them in their anatomy course. This may be attributed to why most (95.9%) medical students said they would recommend the comics to other medical students who were going to take the anatomy course next year (Tables 2, 4).

Free Comments

Five elementary students agreed on the simplicity and ease of reading "*Anna & Tommy.*" However, another five elementary students claimed that there were not enough jokes in the comics. Eleven high school students preferred "*Anna & Tommy*" to lengthy texts. Many high school students wished that there were definitions for the anatomical terms and explanations for diseases. Over 20 premedical students wanted to see additional pictures with the comics. Seven premedical students wished that there were more connections between anatomical concepts and everyday life to make the content easier to comprehend. Twelve medical students said that the comics were appropriate in reviewing anatomy. Five medical students said that the structure of "*Anna & Tommy*" organized by anatomical systems was useful because it was helpful for understanding the overall structure and function of the human body (Table 4).

DISCUSSION

Evaluation of "*Anna & Tommy*"

The student groups in this study were divided into two categories: elementary, high school, and premedical students who were not obligated to study anatomy at that time, and medical students for whom anatomy is a required course. For the first category of students, "*Anna & Tommy*" effectively provided them with a basic understanding of anatomy compared to a previous lack thereof, which was indicated by the results of the quiz (Table 3) and questionnaire (Table 2). For the second category of students (medical students), there was a positive correlation between the fill-in-the-blank comics quiz score prior to undertaking their anatomy course, and the anatomy course grade at the end. In general, these results agree with those of previous studies which have indicated a positive effect of comics in education (Rota and Izquierdo, 2003; Liu, 2004; Tatalovic, 2009; Green and Myers, 2010).

However, these results do not prove the absolute educational value of these comics. The greater strength of comics such as these is to nurture a favorable attitude toward the topic, rather than to simply deliver knowledge (Shin et al., 2013). Instilling curiosity about anatomy may drive students to further study the subject by themselves (Table 2).

In addition, "*Anna & Tommy*" can be read casually or in depth according to the reader's desire. The survey results illustrate an interesting tendency among the four groups of students: that is, an inverse relationship was determined between the age of participants and the perceived ease of the material (Table 2). One of the causes behind this tendency may be that different learning attitudes could be found in each age group. For example, elementary students may have read the comics lightly and understood the contents only roughly. In contrast, the medical students may have put more effort to memorize and understand the provided anatomical knowledge while reading the comics.

Comics as a Medium for Distribution of Anatomical Knowledge

Comics have often been used for the distribution of health information and have been evaluated to be effective in multiple studies (Houts et al., 2006; Williams, 2012; Glazer, 2015). Patients provided with instructional comics on wound care have also been shown to comprehend, recall, and comply with the instructions more than those who received text-only instructions (Delp and Jones, 1996). Comics on specific diseases, known as "pathographies," have also been produced, such as "*Cancer Vixen*: *A True Story*" (Marchetto, 2006), which describes how breast cancer impacts an individual both physically and mentally. Such comics have become a popular medium for distribution of disease information (e.g., adolescent cancer procedures) (Barnes, 2006). Comics that provide not only information but also personal accounts of the diseases can be helpful for those who are affected by the same disease (Green and Myers, 2010). Comics are believed to be especially helpful for younger patients, as comics are effective in making complex scientific knowledge enjoyable and easy to understand for younger audiences (Rota and Izquierdo, 2003).

As a morphologic-based medical science, anatomy is a natural subject for illustration and would appear to be well-suited to graphical representation in comic form. Educational anatomy comics may be read along with other clinical educational comics to produce a synergistic effect (Table 4). Through learning basic human anatomy, patients who understand the reasons behind clinical treatments could be more likely to comply with professional instructions (Evans, 2007). While clinical comics provide in-depth knowledge that is exclusively beneficial to patients with specific diseases, educational anatomy comics provide broad, general anatomical knowledge that is beneficial to anyone interested in health and the human body.

With regards to learning basic human anatomy, comics may be particularly effective. While anatomy atlases provide photographs or realistic illustrations, readers unfamiliar with anatomy may be unable to extract essential information from complex images (Levie and Lentz, 1982). Unlike anatomy atlases, educational anatomy comics provide simple pictures which aid comprehension through minimizing distracting details (Houts et al., 2006). For novices, comics are also superior to anatomy textbooks in learning basic human anatomy, since textbooks may contain a superfluous amount of information. Without proper help from a tutor, such long texts can discourage self-learning students. In contrast, comics have little text, simple pictures, and are clearly guided by captions which help readers comprehend the essential information (Fig. 1) (Houts et al., 2006; Williams, 2012). Comics utilize two streams of information—visual and verbal—to effectively produce a synergistic effect in learning (Liu, 2004).

Comparison of "*Anna & Tommy*" to Other Anatomy Comics

There is a variety of other anatomy comics that are already published, such as the five-book series entitled *First Graphics: Body Systems* (Ballen, 2013; Clark, 2013; Kolpin, 2013a,b; Reina, 2013), along with *Human Body Theater* (Wicks, 2015), and *A Journey Through the Digestive System with Max Axiom, Super Scientist* (Sohn, 2009). Such comics share the common characteristics of having an exciting plot, a protagonist with unique traits, and vivid, descriptive pictures of

the body structures. Through the use of dramatic storytelling, such comics are generally more enjoyable and appealing to readers, much in the same manner as DC comics (DC Entertainment Inc., Burbank, CA) or Marvel comics (The Walt Disney Comp., Burbank, CA). However, these features are deleterious to learning anatomy because the reader's attention may become diverted from essential anatomical facts (Tatalovic, 2009). In addition, the distortion of anatomical facts for the sake of dramatic storytelling frequently occurs. For example, during neural transmission, a neuron, who is the main character, excitedly glides on another neuron as seen in *A Tour of Your Nervous System* (Kolpin, 2013a).

In contrast to other comics, "*Anna & Tommy*" has a narrative without a plot, an undefined setting, and two simple protagonists to achieve the concise delivery of anatomical knowledge (Figure 1). Without an interfering storyline, the reader may start from any chapter of interest. Such characteristics might encourage the reader not only to merely passively glide through the information, but also to actively participate in learning anatomy. By not being distracted by the aesthetic appeal of bright colors and shapes, readers of "*Anna & Tommy*" can focus solely on the anatomical information at hand. Furthermore, thanks to the lack of cultural context, "*Anna & Tommy*" is more approachable by the readers of various demographics.

"*Anna & Tommy*" contains redundant illustrations to aid in learning and memorization (Levie and Lenz, 1982). The redundant images between nearby panels, accompanied by the repeated texts, reinforce the necessary information for the reader's comprehension, especially the core anatomical concept of the section. The contextual images and texts relate the knowledge to everyday life to make complex anatomical concepts sensible and familiar to the reader (Table 4). Connecting the reader's prior experiences to the subject at hand is recognized to help improve comprehension and memorization of new material (Alesandrini, 1984).

Applications of "*Anna & Tommy*"

In summary, such educational anatomy comics might be utilized effectively in any anatomy course. Anatomy teachers can insert appropriate panels of "*Anna & Tommy*" into their lecture slides to stimulate student interest and learning. Additionally, fill-in-the-blank quizzes for students can be easily generated by deleting the words from the comics, as the authors of this study did (Fig. 2).

"*Anna & Tommy*" similar to other comics related to health care issues, might also be used to improve patient–physician communication (Williams, 2012; Glazer, 2015). A physician can employ comics such as these when explaining an essential concept of anatomy to his or her patients. For instance, a clinician explaining gastroesophageal reflux disease to a patient may show the simple drawing of the digestive system in "*Anna & Tommy*" (Fig. 3). Panels from these comics can also be inserted into leaflets to explain the anatomical basis behind various diseases.

The readers of "*Anna & Tommy*" can also compare the comics to anatomy textbooks or atlases. In this study, many students expressed that they would like to view actual images of organs and tissues while reading "*Anna & Tommy*" (Table 4). Making such meaningful connections between the comic's simplified pictures and actual photographs would likely help students understand and retain basic human anatomical knowledge. Such comics could interest the reader in anatomy and encourage him or her to find additional anatomy resources.

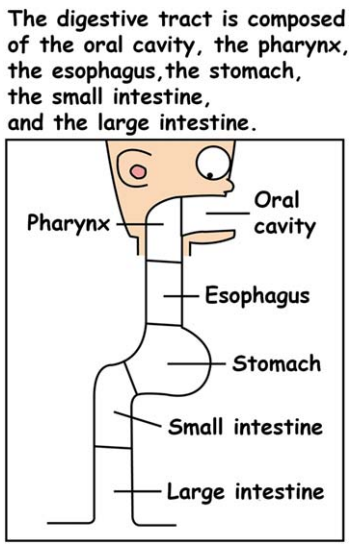

Figure 3.

A panel from the digestive system chapter from "*Anna & Tommy*" comic book (Chung, 2015).

"*Anna & Tommy*" has a great deal of potential. For students who will later undertake a formal anatomy course, these comics can serve as a concise review of basic human anatomy. For those who do not necessarily plan on undertaking the formal study of anatomy, such comics can satisfy their curiosity on human body, as well as provide helpful information for a member of the lay public. Anatomists and educators inspired by such comics are recommended to produce other anatomy comics. Future directions for similar anatomy comics may include more clinical aspects to appeal to new target readers (Table 4).

Study Limitations

The greatest drawback of this study was the lack of proper control groups. For example, in the assessment of the effects of the comics among high school students, the experimental group of students that read the comics was compared only to the control group of students that had not read the comics. For a fuller evaluation of the effects of the comics, another control group that consisted of students that had read conventional anatomy textbooks or atlases should have been included in the study. An additional control group such as this could have offered an insight into whether the comics enhanced student learning over traditional materials.

Moreover, among the medical students, there was an absence of a control group of students who had not read the comics. This absence was due to the authors' efforts to maintain fairness among medical students in terms of the resources available to them and the grades they received in their course. Another obstacle in establishing a control group was the small number of eligible students in the medical school at the time of the study.

Participation in the study was purely voluntary. Therefore, participating students may already have had an interest in anatomy or in comics, which would have led to a response bias. In addition, the sample size of elementary school students (16) was insufficient. The reliability of the questionnaires was low (Cronbach's alpha = 0.393 for elementary school, high school, and premedical students; Cronbach's alpha = 0.505 for medical students). To produce more generalized conclusions, further study with improved testing among larger sample sizes and a revised study design are needed.

CONCLUSIONS

The educational anatomy comics, "*Anna & Tommy*," can be effective educational tools across multiple education levels. While comics have been used in various fields of educational research, the present results indicate that comics can also be effective in anatomy, which is, after all, a highly visual study of the human body. In addition, students who read the comics indicated an increased level of interest in anatomy. The comics are expected to motivate other anatomists and educators to produce other anatomy comics.

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