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Active learning strategies, such as analogical models, aid in student learning of spinal anatomy and biomechanics

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Objective: This study aimed to examine the effect of active learning strategies using analogical models versus didactic lectures on student learning of spinal anatomy and biomechanics.
Methods: Students enrolled into year 1 of a chiropractic program in 2014 and 2015 were eligible to participate. The 2014 cohort received didactic lectures. Active learning approaches using analogical models were incorporated into the 2015 cohort. Both groups received an identical written assessment at the end of the 3rd lecture. Between-group differences in age and written assessment percentages were analyzed using independent *t* tests.
Results: Fifty-nine students from the 2014 cohort and 62 students from the 2015 cohort took part. There were no significant differences in age or gender between the cohorts. The differences in the mean of the written assessment percentages between the didactic group and the analogical models group were significant ($p = .00$), with a mean difference of 22.6% (95% CI, 17.4–27.9). The didactic group mean percentage was 37.9% (SD 15.8) and was within a fail percentage bracket. The analogical models group mean percentage was 60.6% (SD 13.1) and within a pass percentage bracket.
Conclusion: The analogical models group performed significantly better than the didactic lecture group, particularly with regard to content delivered using literal or surface analogies.

Key Indexing Terms: Teaching Methods; Active Learning; Anatomy; Biomechanics; Chiropractic

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INTRODUCTION

Traditionally, the pedagogical approach to teaching in higher education has been didactic and lecture focused. The didactic approach assumes the teacher has the information and will transmit this information to the students. This teaching style can make it difficult for students to integrate new information with preexisting knowledge.[1] In contrast, active learning strategies can broadly be defined as "instructional activities involving students doing things and thinking about what they are doing."[2] They are based on the constructivist learning theory of building new knowledge from prior learning.[3] Students become active participants in their learning process, constructing their understanding of concepts. This helps them to integrate new information with prior knowledge.[4] Active learning strategies allow the student to develop better cognitive skills and gain a deeper understanding of a concept, which could impact student learning.[1] As a result, it has been suggested that active learning strategies can increase student performance when compared to didactic lectures.[5] In addition to this, it is suggested that active learning strategies improve student engagement.[6,7]

A vast array of potential active learning activities can be used to submerge students more deeply into the learning experience.[8] Visual aids are one of the most common techniques used.[9,10] However, when teaching anatomy and biomechanics, 2-dimensional pictures can be difficult for students to visualize and understand as a moving 3-dimensional (3D) structure. Although anatomical models are 3D, they are expensive and difficult to supply to a large class of students. Analogical models may provide a tangible structure for exploring anatomy and biomechanics: they are inexpensive and provide a 3D representation of anatomy and biomechanics for students.

The definition of an "analogy" is a comparison between things that have similar characteristics.[11] The use of analogy in teaching involves taking something that is familiar to the student and using it to explain something more complex or to help the student understand something that is new. The familiar is called the "analog," and the new is called the "target." An analogy explicitly compares and highlights similarities between the analogy and the target.

Structure-mapping theory outlines 3 types of analogies based on the level of link complexity between the analogy and the target being used[12]: Simple analogies (type 1) are those that are easy for students to understand as the jump from analogy to target is short. Simple analogies can be further divided into literal analogies (based on attributes of objects, such as shape, size, and color) and surface analogies (map of 1 or 2 simple parts of the target). Deep analogies (type 2) are more complex and challenge the relationship between analogy and target.[12] They are the most valuable in terms of inferential power, and they map substantial parts of the target, not merely a single characteristic or aspect. Salient analogies (type 3) are the most complex analogies and require the largest jump from analogy to target.[13] However, if the jump between the analogy and the target is too big, there is a danger that the students will become confused and lost. To prevent this, a bridging analogy model can be included within the salient analogy that suggests the use of multiple, smaller analogies to bridge the gap between analogy and target.[14] Salient analogies are rarely used in education, possibly due to the risk of confusion from an elaborate analogy outweighing the potential benefit.

The teaching-with-analogy (TWA) model is a practical and usable model.[14] It begins by introducing students to the target concept, then presenting the analogy. The teacher then leads the students through comparative features of the target and analogy. The final step is to indicate where the analogy breaks down. These steps help to ensure that the students see the same similarities that the teacher has in mind to aid reaching the same target.

There are mixed reviews on the use of analogies in teaching. However, literature supporting the benefits of their use suggests that analogies help students to construct their own knowledge.[15–19] In addition, understanding relationships between analogies and targets improves problem solving.[16,17] It is suggested that students with lower cognitive abilities find teacher-lead analogies more beneficial to their learning as the teacher presents the analogy and relates it to the target for the student.[18] In 1 study, up to 75% of students were found to be able to problem solve better following teacher-lead instruction through analogy.[19]

There are some pitfalls when using analogies in teaching.[20,21] Primarily, the analogy will always be different from the target. The differences, even if small, may be misleading to students and create misconceptions of the target. These misunderstandings of the analogy may then be transferred to the target. Thus, for students to engage with the analogy appropriately, it must be both familiar and relatable to the target. It is also possible that the teacher and the students interpret the analogy differently; therefore, presentation of the analogy is very important for teachers.[20] Finding the right relational analogy is crucial, thus teachers need a well-prepared repertoire of tried and tested analogies.[14] Lastly, the use of analogies (particularly when using deep analogies) require considerable guidance from the teacher. These pitfalls may constitute barriers to incorporating analogies into the teaching practice of many educators.[21]

Students in year 1 of the chiropractic program require a basic subject area knowledge and understanding of spinal anatomy and biomechanics. In the past, this was taught using a series of didactic lectures. The final lecture included a formative assessment that had the objective of assessing the student's subject area knowledge (factual recall) and understanding (comprehension) as outlined in Bloom's taxonomy of the cognitive domain.[22] The results of the formative assessment caused concern as students were unable to adequately demonstrate subject area knowledge and understanding. As such, a different approach to teaching and student learning was explored. Anatomic models are expensive, and it is not possible to provide a large number of students with access to the models during a 50-minute lecture. Equally, it is difficult to find the exact model that illustrates a particular area sufficiently. However, the hands-on approach plays a crucial role in learning.[23] As such, the creative use of analogical models, which are inexpensive, widely available, and familiar to the students, may transfer into anatomical and biomechanical learning. Currently, there is a paucity of literature pertaining to the use of analogical models in health care education. Therefore, this study may provide some insight into this area.

To investigate this topic, we wanted to know if there is a difference in subject area knowledge and understanding of spinal anatomy and biomechanics when using an active learning strategy (analogical models) compared to a didactic lecture approach.

METHODS

Ethics approval was gained from the AECC University College (AECC) ethics committee (ethics number: E16/09/11). Year 1 students enrolled into the chiropractic program in 2014 and 2015 were eligible to take part in this study. In the UK, students enrolling in a higher education program may do so immediately after leaving school or later as mature students. All students enrolled into a year 1 chiropractic program are required to have biology as well as science or math in their final year of school. Of the mature students in the study, none had experience of biological science at a higher education level.

Students were given a participant information sheet with details of the study and an opportunity to ask questions. Participants signed a fully informed participant agreement form before starting the study. Demographic data of gender and age were collected with the written assessment. Fifty-nine students from the 2014 cohort volunteered to take part in the study. One year later, 62 students from the 2015 cohort volunteered to take part.

As there were only 2 groups, a coin toss determined that the 2014 group would receive didactic lectures and the 2015 group would receive analogical models. The study was carried out in the first 2 weeks of semester 1 for both cohorts. The chiropractic program consists of compulsory units; there are no optional units, and as such the first 2 weeks were consistent between cohorts. Both groups received three 50-minute lessons on basic spinal anatomy and biomechanics delivered in a lecture theatre. The

Figure 1 - The use of an onion to explain the lamellae of the annulus fibrosus (layers of collagen fibers arranged obliquely approximately 30 degrees in reverse contiguous layers).

lessons presented subject area knowledge of the spinal curves and functional spinal unit, as well as an understanding of the biomechanics of the functional spinal unit and spine.

For the didactic lecture group, information was conveyed verbally and supported by Microsoft PowerPoint (Microsoft Corp, Redmond, WA). Slides contained diagrams of spinal anatomy in addition to an explanation of the biomechanics of the functional spinal unit.

The students in the analogical model cohort were sent an e-mail a few days before a lecture session requesting them to bring common objects (eg, large bath sponge; Figs. 1–5) to the lecture. This information was also posted on the virtual learning environment. During the session, the TWA model was adopted by using PowerPoint diagrams to introduce the target to the students. The teacher then demonstrated the analogy using the objects before instructing the students to interact with their own analogical models. A class discussion of the similarities and differences of the analogy to the target took place during this interactive period. Table 1 outlines the type of analogy, the object, and their relationship to either subject area knowledge or understanding.

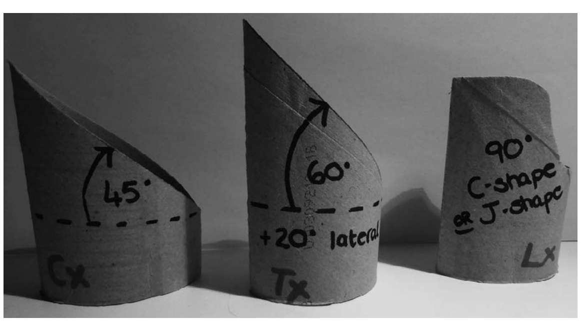

Figure 2 - The use of cardboard tubes to explain the orientation of the superior vertebral facets. Shown left to right. Typical cervical spine facets are elevated 45 degrees in the coronal plane; typical thoracic spine facets are elevated 60 degrees in the coronal plane and 20 degrees in the frontal plane; typical lumbar spine facets are elevated 90 degrees in the coronal plane. From L1 through to L5, the facets change orientation from more sagittal (medial/lateral) to more coronal (anterior/posterior).

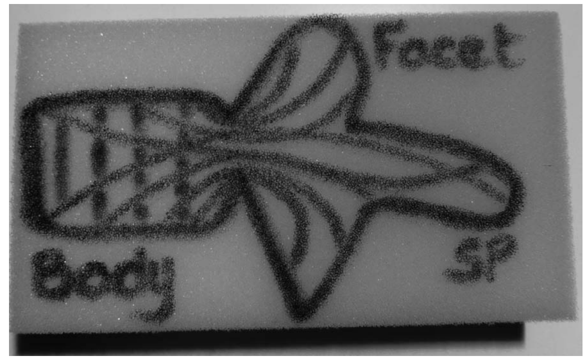

Figure 3 - The use of a large bath sponge to draw and identify trabecular patterns of the vertebrae. Shown as (left to right) vertebral body, superior and inferior facets, spinous process.

Both groups received an identical written formative assessment at the end of the 3rd lecture. Every effort was made to decrease the potential for leaked assessment papers between cohorts (paper scripts were numbered to ensure collection of all copies; assessment was not made available on the following the session). The assessment comprised short answer questions (up to 9 marks) and assessed each of the subject areas listed in Table 1. The assessment and the rubric were reviewed by a subject area specialist for accuracy and question ambiguity. Assessments were graded by a teaching assistant according to a rigorous scoring rubric. Example questions and scoring rubric can be seen in Table 2.

Analyses were performed using SPSS statistical software (version 24; IBM Corp, Armonk, NY). Normal distribution of the data was determined using the 1-sample Kolmogorov-Smirnov test. Between-group differences in age and written assessment percentages were analyzed using independent t tests.

RESULTS

Fifty-nine students from the 2014 cohort volunteered to participate; all students completed the study. Sixty-one of the 62 volunteers from the 2015 cohort completed the study. The remaining student did not complete the study due to absence from the final lecture and therefore did not sit the assessment. Age data were normally distributed. There was no significant difference ($p = .156$) between the age of the didactic group (mean = 21.1 years; SD = 3.4) or the analogical models group (mean = 22.1; SD = 4.2). A small difference in gender ratio between the didactic group (24 males, 35 females) and the analogical models group (26 males, 35 females) was noted.

The passing score for assessments is 50%. The written assessment mean percentage for the didactic group fell below this at 37.9% (SD: 15.8). The mean for the written assessment in the analogical models group was 60.6% (SD: 13.1). The difference between the 2 groups was significant ($p = 0.00$), with a mean difference of 22.6% (95% CI, 17.4–27.9).

The subject areas were marked as individual sections. As can be seen from Table 3, the analogical group gained higher

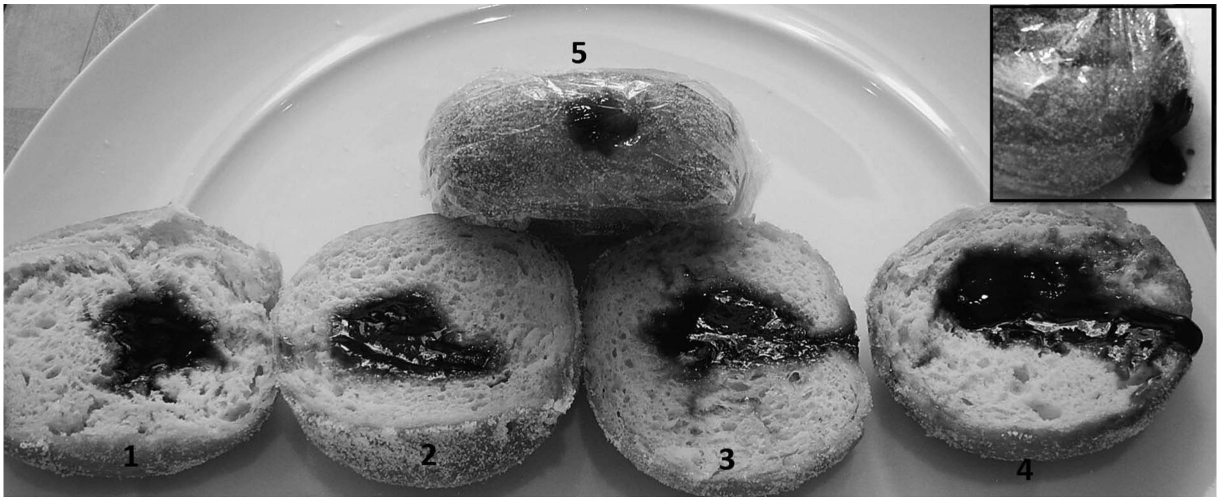

Figure 4 - The use of jam doughnuts to demonstrate disk lesions. Shown left to right: (1) degeneration of disk showing the start of annular fissuring; (2) disk herniation (protrusion); (3, 4) disk herniation (extrusion) in varying degrees; (5) disk herniation (contained or covered by the posterior longitudinal ligament [PLL]). Insert: Disk herniation (uncontained or broken through the PLL).

Table 1 - Type of Analogy and Object (Analogy) Used in Teaching Subject Area Knowledge and Understanding in Basic Anatomy and Biomechanics of the Spine

Cognitive Process	Subject Area	Object (Analog)	Type of Analogy
Subject area knowledge	Vertebral anatomy (cortical and spongy bone)	Bath sponge	Literal analogy
	Intervertebral disc anatomy	Onion (see Fig. 1)	Literal analogy
	Spinal facet orientation	Cardboard tubes, protractor and white board marker (see Fig. 2)	Surface analogy
Subject area understanding	Vertebral trabeculae patterns and stress lines	Bath sponge and whiteboard marker (see Fig. 3)	Surface analogy
	Understanding of disc lesions (disc prolapse)	Jam doughnut (see Fig. 4)	Deep analogy
	Understanding creep and hysteresis	Liquorice Allsorts (see Fig. 5)	Deep analogy
	Understanding of coupled motion in the spine	Cardboard tubes (see Fig. 2)	Surface analogy

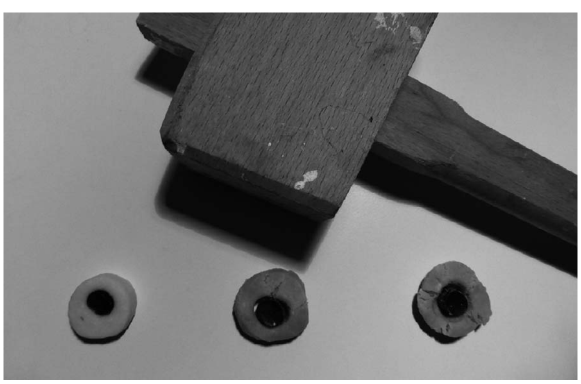

Figure 5 - The use of a wooden mallet and a Liquorice Allsort to demonstrate creep and hysteresis. Left to right: A normal Liquorice Allsort; a Liquorice Allsort that the students had been sitting on since the beginning of class to demonstrate creep; a Liquorice Allsort that had been hit with a hammer or textbook to demonstrate hysteresis.

marks for each of the subject areas with regard to recall of knowledge. Although understanding of "vertebral trabeculae patterns and stress lines" and "coupled motion" was significantly better in the analogical model than in the didactic group, this was not the case for the other subject areas. The mean mark for both groups failed to reach 50% for comprehension of "disc lesions" and "creep and hysteresis."

DISCUSSION

The results suggest that the use of active learning strategies had a greater impact on student learning than a didactic lecture. The analogical models group not only obtained better results, but the results obtained meant that majority of participants passed the formative written assessment, achieving more than 50%. In previous years, this was not the case, which was a cause for concern. There was a need to find a way to increase student learning in this subject area, as this forms the grounding knowledge to build on in practical classes.

Table 2 - Formative Assessment Example Questions Related to the Subject Area Being Assessed

Cognitive Process	Subject Area	Assessment Questions and Model Answers (Mark Allocation in Brackets)
Subject area knowledge	Vertebral anatomy (cortical and spongy bone)	• Question: In the diagram of a lumbar vertebrae below, label where you would find cortical bone and where you would find spongy bone (1 mark for each label). 
	Intervertebral disc anatomy	• Question: Draw and label an intervertebral disc. Describe the anatomy of the layers. Please include what they are comprised of. Nucleus pulposus (1 mark): inner "jelly-like" part of the disc (1 mark); approximately 80% water (1 mark) and 20% collagen (1 mark) in young adults. Annulus fibrosus (mark 1): outer layers of the disc (1 mark); approximately 30% water (1 mark) and 70% collagen (1 mark) in young adults. 7–15 concentric bands; bands alternate in direction of fibers (1 mark).
	Spinal facet orientation	• Question: What are the orientations of the superior facets of a typical cervical vertebra, mid-thoracic vertebrae, and typical lumbar vertebrae? Typical cervical spine facets are elevated 45 degrees in the coronal plane (1 mark); typical thoracic spine facets are elevated 60 degrees in the coronal plane (1 mark) and 20 degrees in the frontal plane (1 mark); typical lumbar spine facets are elevated 90 degrees in the coronal plane (1 mark). From L1 through to L5, the facets change orientation from more sagittal (medial/lateral) to more coronal (anterior/posterior) (1 mark).
Subject area understanding	Vertebral trabeculae patterns and stress lines	
	Understanding of disc lesions (disc prolapse)	• Question: Name the stages of disc prolapse from a normal disc to an uncontained disc herniation. You may use annotated diagrams (1 mark for each stage up to a total of 4 marks). Normal disc–degeneration of disk showing the start of annular fissuring–disk herniation (protrusion)–disk herniation (extrusion)–Disk herniation (contained or covered by the PLL)–Disk herniation (uncontained or broken through the PLL).
	Understanding creep and hysteresis	• Question: Define creep and hysteresis. Creep–progressive deformation (1 mark) of a structure under constant load (1 mark) Hysteresis–loss of energy (deformation) (1 mark) when the discs are subjected to repetitive cycles of loading and unloading (1 mark).
	Understanding of coupled motion in the spine	

The results of the written assessment show that there is a significant difference between the didactic group and the analogical models group in subject area knowledge. This relates to the literal and surface analogies received by the analogical models group. There is a significant difference between the groups in understanding vertebral trabecular patterns and stress lines. This relates to the surface analogies received by the analogical models group. As such, students from the analogical models group scored higher on questions that related to simple analogies, for example, spongy bone is named spongy bone because it looks like a sponge (literal analogy), and an onion has layers and an annulus fibrosis has layers, and each layer's fibers have a different orientation to withstand stress and force (surface analogy).

It is suggested that educators are fearful of using analogies in teaching as they suggest that students will remember the analogy and not the target.[21] The results suggest that this is somewhat true, but only in the use of deep analogies. With regard to creep and hysteresis, students in the analogical models group were able to describe what was done with the Liquorice Allsorts;

Table 3 - Question by Question Comparison Between Didactic ($n = 59$) and Analogical Model ($n = 61$) Groups

Cognitive Process	Subject Area	Didactic (% Mean Mark For Section) (SD)	Analogical Models (% Mean Mark for Section) (SD)	Significance, *p*
Subject area knowledge	Vertebral anatomy (cortical and spongy bone) and trabeculae anatomy	58.7 (8.8)	65.0 (6.1)	.021
	Intervertebral disc anatomy	37.8 (6.6)	70.9 (11.1)	.001
	Spinal facet orientation	36.8 (4.4)	68.8 (3.3)	.008
Subject area understanding	Vertebral trabeculae patterns and stress lines	32.5 (6.3)	52.7 (8.3)	.003
	Understanding of disc lesions (disc prolapse)	25.3 (3.9)	42.6 (5.6)	.078
	Understanding creep and hysteresis	20.6 (7.7)	40.0 (9.9)	.069
	Understanding of coupled motion in the spine	50.6 (6.6)	60.0 (5.6)	.032

however, they were unable to demonstrate understanding of each. For disc lesions, students were able to describe what was done to the jam doughnut, but unable to demonstrate understanding of disc lesions using anatomical language. It is possible that the relationship between the analogy and the target was not well understood. These similarities were not just about the subject knowledge, but they underpinned the understanding of the behavior of the anatomical structures. Perhaps the difference between the analogy and the target was too big, and as such the understanding of the target was not achieved. An additional consideration is the use of anatomical and medical language. Thus, it is not only the analogy students needed to relate to the target, but also the relationship and target needed to be understood in an entirely new language. While the students were able to explain a concept by describing the analogy, it is possible that they did have the understanding of the target but are as yet unable to express it in the anatomical language desired. As such, the breakdown in the process may not be with the analogy and target relationship, but rather with the descriptive anatomical language required.

The research suggests that teachers need a well-prepared repertoire of validated analogies.[14] The simple analogies used in this trial seemed successful and therefore suitable for use in the future with other students. The deeper analogies may require more thought and preparation before using them with future students. It may be that the same analogy is used, but more time is spent on the use of the anatomical and medical language before introducing the analogy. If there still appears to be an ongoing issue with this analogy, a change of analogy should be considered.

If the analogical models that were most successful were simple analogies, the question must be asked, why go through the process at all? What did the student learn that they could not have learned in a didactic presentation, including diagrams? Although the diagrams presented the same material as the simple analogy models, students in the analogical models group were able to correctly label spongy bone within the picture of a vertebral body, unlike those in the didactic group. The students in the analogical models group were able to touch and see the sponge in front of them. This is an everyday object that they are familiar with, and through the TWA model the student was able to link it to the target of the spongy bone in the vertebral body. The orientation of the vertebral facet joints was slightly more complicated, and the students were able to see the cardboard cut outs, physically measure the angles, and dynamically move the cardboard tubes to see the concept of combined movements in the spine. This was demonstrated and discussed among the students, creating more scaffolding to construct knowledge. The analogical models group were given an opportunity to see the visual 2D-anatomical structure on the diagram. In addition to this, they were given the opportunity to be tactile and hands-on with a 3D analogical model that represented the target anatomical structure and discuss it with their peers. This seems to be a powerful combination and mirrors the principle of active learning strategies.

A limitation of this study is that prior knowledge was not assessed before the study began. However, there were no students with previous higher education degree experience in biological science. It should be noted that, although not significant, there is a 1-year age difference between cohorts.

CONCLUSION

This study supports the use of active learning in health care education. Students in the analogies learning group significantly outperformed students in the didactic lecture group. The use of literal and surface analogies significantly increased student learning in both subject area knowledge and understanding of spinal anatomy and biomechanics. The use of deep analogies increased student learning, but not significantly.

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Author Contributions

Concept development: JR. Design: JR. Supervision: JR. Data collection/processing: JR. Analysis/interpretation: JR. Literature search: JR. Writing: JR. Critical review: JR.

REFERENCES

1. Kim AM, Speed CJ, Macaulay JO. Barriers and strategies: implementing active learning in biomedical science lectures. *Biochem Mol Biol Educ*. 2019;47(1): 29–40.
2. Bonwell CC, Eison JA. *Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports*. Washington, DC: ERIC Clearinghouse on Higher Education, The George Washington University; 1991:3.
3. Rumelhart DE, Normann DA. Analogical processes in learning. In: Anderson JR, ed. *Cognitive Skills and Their Acquisition*. Hillsdale, NJ: Erlbaum; 1981:335–359.
4. Mozzer NB, Justi R. Science teachers' analogical reasoning. *Res Sci Educ*. 2013;43:1689–1713.
5. Freeman S, Eddya S, McDonough M, et al. Active learning increases student performance in science, engineering, and mathematics. *Proc Natl Acad Sci U S A*. 2014;111:8410–8415.
6. Efstathiou N, Bailey C. Promoting active learning using audience response system in large bioscience classes. *Nurse Educ Today*. 2012;32:91–95.
7. Habel C, Stubbs M. Mobile phone voting for participation and engagement in a large compulsory law course. *Res Learn Technol*. 2014;22:19537.
8. Warren D. Improving student retention: a team approach. *Annual Conference of the Institute for Learning and Teaching in HE*. Coventry, UK: University of Warwick; 2003.
9. Velasco MS, Sanchez Martinez MT, Ferrero NR. Developing generic competences in the European higher education area: a proposal for teaching the principles of economics. *Eur J Educ*. 2012;47(3):462–476.
10. Watts M, Christopher C. Using art (paintings, drawings, and engravings) to teach economics. *J Econ Educ*. 2012;43(4):408–422.
11. Cambridge University Press. Analogy. 2018. http://dictionary.cambridge.org/dictionary/english/analogy. Accessed February 9, 2018.
12. Gentner D. Structure-mapping: a theoretical framework for analogy. *Cogn Sci*. 1983;7:155–170.
13. Vosniadou S. Capturing and modelling the process of conceptual change. *Learn Instr*. 1994;4:45–69.
14. Duit R. On the role of analogies and metaphors in learning science. *Sci Educ*. 1991;75(6):649–672.
15. Black D, Solomon J. Can pupils use taught analogies for electric current? *Sch Sci Rev*. 1987;69(247):249–254.
16. Gentner D, Genter DR. Flowing waters or teaming crowd: mental models of electricity. In: Gentner D, Stevens AL, eds. *Mental Models*. Hillsdale, NJ: Erlbaum; 1983:99–129.
17. Glynn SM. The teaching with analogies model: explaining concepts in expository texts. In: Muth KD, ed. *Children's Comprehension of Narrative and Expository Text: Research into Practice*. Neward, DE: International Reading Association; 1989:185–204.
18. Sutala V, Krajcik JS. The effective use of analogies for solving mole problems in high school chemistry. In: *Proceedings of the 61st Annual Meeting of the National Association of Research in Science Teaching*. Cincinnati, OH: National Association of Research in Science Teaching; 1988:22.
19. Holyoak KJ. The pragmatics of analogical transfer. In: Bower GH. *The Psychology of Learning and Motivation*. Vol 19. Orlando, FL: Academic Press; 1985.
20. Dagher ZR. Review of studies on the effectiveness of instructional analogies in science education. *Sci Educ*. 1995;79:295–312.
21. Thiele RB, Treagust DF. An interpretive examination of high school chemistry teachers' analogical explanations. *J Res Sci Teach*. 1994;31:227–242.
22. Anderson LW, Krathwohl DR. *A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Addison Wesley Longman, Inc; 2001.
23. Fink LD. *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses*. Hoboken: John Wiley & Sons; 2013.