Using Case Study Approach to Teach Argumentation in Natural History Museum

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Abstract

Most science learning in schools has long been criticized for being passive and fragmented, with students leaving schools without knowing much of the nature of science. On the other hand, natural history museums possess rich and diverse collections of the natural world, could play a more active role in helping schools to alleviate this situation. In this report, we documented the development and execution of a lesson plan based on the evolution of human bipedalism as a case study in our museum to promote the scientific literacy skill of argumentation for high school teachers, and hopefully, they will adopt this lesson plan in their teaching.

The lesson plan began with the introduction of two conflict ideas of the evolution of bipedalism, namely locomotion-first route or brain-first route. The lesson then provided teachers with casts of the skulls and pelvis of a chimpanzee, *Australopithecus afarensis* and modern human. In order to assess the two competing ideas, teachers proceeded to measure the position of the foramen magnum, size and shape of the three pelves and brain volume by filling the brain cavities with seeds. Finally, teachers used these measurements as evidence and related to the evolutionary timeline of these species and concluded that at 3.6 million years ago, early hominids have already developed features for walking on two legs, while the brain volume was not much larger than the chimpanzee.

At the end of the session, we conducted a survey to evaluate teachers' perception of importance and teaching feasibility or adaptability of this lesson plan in the school setting. The response of the teachers are very positive and encouraging. Finally, the advantages of using a scientific case study in teaching science are discussed.

Background

Traditional school science teaching has been criticized for filling students' head with myriad scientific facts and word associating (Alberts, 2000). Current science education reform calls for inquiry-based teaching and emphasized more on science literacy (Llewellyn, 2006). One interesting question is whether Natural History Museums can help in this reform? In fact, a quick scan of the recent science education landscape may discover an interesting trend, that more and more studies showed that informal learning environment such as museums, zoos, botanical gardens, aquariums and planetariums can play an important role in science learning. The CAISE Inquiry Group Report also reports that the 21st century science and technology is too complex that no single K-12 school can do it all. And fortunately, schools can work with the many informal science learning institutions to bring the rich and diverse resources to classroom, and engaging students in learning science (CAISE, 2010). The Journal of Museum Education published a thematic issue on "Common Goals, Common Core: Museums and Schools Work Together" in October 2015. In this issue, many authors review the various way museums collaborate with schools and report some successful case studies (Ng-He, 2015).

In the past, the best-known museum-school collaboration is through curriculum-related field trips, after-school, summer and weekend programs. But the collaboration can be extended to teacher professional development programs for practicing teachers. Teachers are usually

occupied by the constant class progress in order to meet the requirement of an examination-oriented curriculum and possible additional administrative works. Teachers constantly complain about the lack of time to develop interesting and stimulating lesson plans for students. This is where a natural history museum can offer their contributions. Natural history museums have rich and diverse collections and strong research foundation. These strong collections offer object-oriented learning which is the core-value of museum education and is very distinguishable from text-based school learning. Museum collection offers a very an excellent starting point for inquiry learning since many questions could be raised for any specimen. Accordingly, we believe that it should be of little effort for the museum's researchers to convert their research findings into real life case study lesson plans that teachers can use in their teaching. Case studies had been widely adopted to help students learn science (Herreid et al., 2012). Another advantage of using case studies in teaching science is that it promotes learners' problem solving and decision making skills by using real event.

In this article, we will report how The National Museum of Natural Science in Taiwan adopted a case-study approach to develop a science literacy based lesson plans. We then organized a teacher workshop to promote the lesson plan. After the completion of the workshops, we collected teachers' response on the perception of the importance and teaching feasibility of this lesson plan, and their intention to adopt this lesson plan in their future teaching.

The Dimensions of Science Literacy

Any qualified science teacher is well aware of the fact that teaching science is more than the presentation of scientific facts and the emphasis on knowledge acquisition. This type of teaching has a negative effect on science learning as students find the class boring and irrelevant to everyday lives. In addition, an overemphasis of knowledge (or just information) also affects student performance in international evaluation such as PISA (e.g. Choi et al., 2011). In response to this, policymakers call for a revitalization of science teaching and putting efforts to incorporate skills-based learning such as science literacy into the future science curriculum.

As a major informal science learning institution, the National Museum of Natural Science responded to this call in late 2013 by working on a new dimension of science literacy through extensive literature review, numerous consulting meetings with science teachers, school principals, and parents. The resulting science literacy consists of three abilities with the aims to improve students' ability to 1) uncover the meaning beneath the scientific facts, 2) convert their knowledge into arguments, and 3) conduct an inquiry study. However, the present study only focuses on the literacy skill of argumentation.

Our rationale behind the literacy skill of argumentation is that our lives have a close association with science and technology and many of these science-related issues are controversial. In addition, our information overloaded cyberspace flooded with many contradictory claims, which make the discussion of these issues even harder. Thus, as claimed by a scholar that knowing a lot won't do you much good unless you have the ability to convert the information into your own argument and to identify and reject a false claim. Equally important, when faced with numerous evidence, we need additional skills to sort out and evaluate the order of the evidences (Hillock, 2010). With this ability in mind, our students will become more critical in engaging the discussion of science related issues. In fact, this importance of this skill cannot be overstated, as NSTA published a special issue on argument in the summer of 2013 (NSTA, 2013).

The Lesson Plan: The Evolution of Bipedalism in Human

In the field of paleoanthropology, there has long been a debate on how human evolve the ability of walking on two legs or bipedalism. So the lesson plan began with the introduction of two conflict ideas of the evolution of bipedalism, namely locomotion-first route or brain-first route. The objective of the lesson plan is to allow the teachers to confront this scientific problem and attempt to resolve this issue by evaluating the evidence themselves rather than just passively accepting the conclusion from the textbook. We then delivered a 30 minutes presentation on the major anatomical features used in this inquiry, including the location of foramen magnum at the base of the skulls and the size and shape of the pelvis. In order to conduct this inquiry learning activity, the museum presented the casts of the following: a 3.6 million years ago skull and a pelvis of one of the best known early human *Australopithecus afarensis* or Lucy, and the skulls and pelvis of modern day human and chimpanzee. Teachers were then allowed to work in groups and start to make their measurements of these casts. In addition, rape oil seeds were poured into the skulls from the base opening to measure brain capacity. There were no strict requirements for the types of measurements made, as long as these measurements can provide replicable data and comparison could be made among groups. At the end of these activities, teachers used the information and reference to the evolutionary timelines of the three species to draw their conclusion and make up their mind which of the two ideas offer a better explanation of the evolution of walking on two legs.

The Study

This study was conducted in the summer of 2018 during a two-day workshop. At the beginning and the end of the workshop, all participants were asked to complete a survey instrument to examine their viewpoints or perceptions about the lesson plan. The reason for this pre- and post-survey comparison was to compare the change of perceptions before and after the introduction to this lesson plan. The survey instrument contained many items related to the lesson plan *per se*, but for the present study, only two major indicators, the importance of the science literacy skills and the teaching feasibility of these skills in school, were used in the analysis. For each question of the instrument, a 10-point Likert scale was used to collect participants' responses, with a higher score represent the higher perception of importance and teaching feasibility. We used SPSS to analyze the data, particularly pair t-test analysis to examine the differences of change in perception of the two major indicators. We also used descriptive statistics to show teachers' rating of their response in including the literacy skills in future teaching.

Result and Discussion

At the end of the measurements, teachers found out that the location of the foramen magnum of Lucy and modern day human are located toward the center at the base of the skulls. This center-located opening indicates that the backbone connects perpendicularly to the skull and is a first requirement for walking upright. On the other hand, the chimpanzee' skull opening is located more toward the back of the skull, and consequently, the backbone connects to the chimp's skull in a slant manner. Secondly, the measurement of Lucy and modern day human's pelvis show that they are short and wide whereas the pelvis of the chimpanzee is long and narrow. The difference in the shape of these pelves may affect how the major muscles attached to the hip, with the wider hip bones of Lucy and modern human provide more powerful support of the upper body and balancing walking than the chimp. When these findings were put along the evolutionary timelines of the three species and the conclusion is very obvious. At 3.6 million years ago, when Lucy's brain capacity was no

larger than 500 cc, had a skull base opening that supports an erect backbone and a short and wide pelvis that together support an upright walking posture. These findings provide more robust evidences supporting the locomotion-first route of the evolution of human bipedalism.

Statistical analysis of the survey data revealed that there are significant changes of perception of the importance of the argumentation skills and teaching feasibility at the school, with the mean post-survey scores significantly greater than the pre-survey scores (Table 1). These results indicated that the design of these lesson plan did have an influence on teachers' perception of changes.

Table 1. Comparison of the mean pre-survey and post-survey scores for the two measured indicators

	Mean Pre-Survey Score (1-10)	Mean Post-Survey Score (1-10)	*t*-value	df	*p*
Indicators					
Importance of Argumentation Skill	7.41	9.03	-5.58	36	0.000
Teaching Feasibility	7.08	9.16	-6.75	36	0.000

A secondary analysis of the survey data also found that more than 95% of the teachers show the intention of adopting this lesson plan in their future teaching. Overall, these analyses of teachers' response are very positive and encouraging. Finally, we also aware that our survey was conducted shortly after the workshop when there are still fresh memories of new thing learned, we cannot be certain how long these enthusiasms be sustained by the teachers. A long-term follow-up on site observational study and in-depth interview to explore the reasons to adopt or not to adopt these skills in teaching will be necessary in order to answer this question. This study also demonstrates that natural history museums have a lot to contribute on the teaching of science literacy.

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