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Effects of prompting critical reading of science news on seventh graders' cognitive achievement

Pei-Ying Tsai • Sufen Chen • Huey-Por Chang • Wen-Hua Chang

Science teachers frequently select science news articles as supplementary teaching materials; however, the literature indicates that students encounter difficulties in examining and evaluating the news content and textual elements. This paper reports an instructional strategy of utilizing science news articles and investigates its effectiveness in enhancing students' cognitive learning outcomes. In this quasi-experimental study, 118 seventh graders from four classes in one secondary school in Taiwan took part in the Science News Instruction (SNI). After eight weeks of instruction about Genetics and Reproduction, all students were requested to present their written arguments to the selected science news article. Two of the classes were prompted to link to their science content knowledge (the CK-SNI group, n=56), whereas their counterpart peers were not instructed to link to their science content knowledge (the SNI group, n=62). The analysis of students' written artifacts revealed that the CK-SNI group performed significantly better on examining the data and claims made in the science news, producing warrants of higher quality to support their reasoning about the relationship between data and claims, and providing better reasons to refute the identified causal textual elements. Furthermore, the results of ANCOVA indicate that the CK-SNI group outperformed the SNI group on the cognitive test, with the largest improvement at Apply level (η_p^2 = .10). We conclude that prompting students to examine news content based on the content knowledge they learned is effective in fostering students to evaluate the science news critically, and thus make a positive impact on students' cognitive learning.

Keywords: argumentation, content knowledge, critical reading, science learning, science news

Introduction

The official curriculum documents of many countries show a trend to promote understanding of science presented in the mass media (Cross & Price, 1999; De Vos & Reiding, 1999; Elliott, 2006; Halkia & Mantzouridis, 2005; Jarman & McClune, 2007a; Ministry of Education, 2006; National Research Council (NRC), 1996). These documents recognize that learning science is not only aimed at knowing science facts and building conceptual understanding, but also at comprehending and evaluating science related information in the mass media. Science related news that reports medical or scientific developments, computer technology, as well as environmental events has become the main source of science information outside classroom. Science news influences the

public's science knowledge, attitudes toward science, and their decision-making about health or lifestyle. Science news of good quality can enhance the public's evaluation capacity about science policy (Pellechia, 1997). School science teachers often select science news articles relating to the teaching units to assist students in making connections between school science and science in everyday life (Jarman & McClune, 2002; Marks & Eiks, 2009). Science educators suggest that reading science news helps students to understand how science influences and shapes the world, and to construct important scientific knowledge and relationships between science and society (Murcia, 2005). Reading science news can also promote an interest in science learning and help connecting the abstract theories with the real world (Glaser & Carson, 2005). However, the literature indicates that many people are not able to apply the related science knowledge to make judgments, and students are generally not educated to read science news critically (Pellechia, 1997). Developing an instructional approach to bridge the school science curriculum and science in the mass media is challenging for science education today (McClune & Jarman, 2010).

One of the challenges comes from the text structure of science news. Journalists produce science news as one portrayal of the progress of science research. Owing to limitations of time and space or of the reporters and editors' backgrounds, science news tends to present incomplete and fragmentary scientific knowledge and inquiry processes. It might overemphasize the importance of partial results and omit details about different viewpoints, important issues and research limitations (Jarman & McClune, 2007b). Science news transmits scientific information based on non-neutral, particular viewpoints in order to attract, influence and shape readers' ideas, and makes them focus on what the media is stressing (Gardner, Jones, & Ferzli, 2009). Moreover, when scientific knowledge is applied to complex and authentic societies, exact scientific analysis disappears and the same data might lead to different reasoning and conclusions (Glaser & Carson, 2005).

People with scientific literacy should not only be able to read and interpret, but also to criticize science reported in mass media (NRC, 1996; Wellington, 1991). Critical reading of science news needs argumentative reasoning (Glaser & Carson, 2005; Norris & Phillips, 1994; Norris, Phillips, & Korpan, 2003; Ratcliffe, 1999). An argument uses evidence and reasons to support conclusions, and the public needs it to understand science news and make decisions about science-related issues. Science in authentic life is seldom simple and certain because of the different viewpoints of socio-scientific issues. Through argument, indeed, the public can think about scientific investigation, understand the uncertainty of scientific knowledge, and improve their understanding of science and the process of scientific knowledge construction. Ignoring argument will lose an opportunity to face and criticize scientific issues in our everyday life (Driver, Newton, & Osborne, 2000). Specifically, previous studies found that students tend to uncritically accept positions of science news and reason with a single argumentation element (Tsai, Chang, Lin, & Chang, 2010; Dawson & Venville, 2009; Ratcliffe, 1999). There is a need to build up their ability to refute or argue about science news, and to differentiate between claims, evidences and scientific knowledge in science news (Kolstø, 2001). With quality instruction in argumentative reasoning (that is, argumentation-based approach for reasoning), students may be able to form the own standpoints about an issue in reading science news.

Our goal is to propose an instructional approach to connect school science and science in the mass media. The purposes of this paper are to present an example that guiding students to identify arguable points while reading science media reports, and to examine its impacts on middle school students' cognitive learning outcomes. According to the purposes, in the following section we review the literature related to argumentation about science news and argumentation based on content knowledge.

Argumentation about Science News

The advance of the information technology makes science news easily accessible to science teachers. However, effective usage of science news articles in the classroom is subject to several factors. The literature concerned with argumentation about science news presents that argumentative quality is influenced by background knowledge, awareness of text structure, and teaching methods.

In terms of background knowledge, Ratcliffe (1999) compared abilities of middle school students (11-14 years old; 7th and 9th graders), high school students (17 years old) and science graduates (22-35 years old) in interpreting media reports of scientific research. The results showed that background knowledge played a crucial role for the students to reason logically. Unlike the other two groups of students, the middle students could not reason logically until the technical vocabularies were explained to them. An analysis of the quality of their reasoning, it was found that they tended to quote media reports directly, rather than refer to content knowledge, to support their arguments. In addition to the help with terminology, further guidance is required for middle school students to apply science knowledge in argumentative reasoning. Korpan, Bisanz, Bisanz and Henderson (1997) examined the types of requests for information made by university students when the students evaluated science news briefs. The results also show that the types of requests for information were influenced by many factors, including students' content knowledge, plausibility of the conclusions, typicality, and personal familiarity with the phenomena. It would be worthwhile to investigate whether with some instructional intervention after teaching a unit, early adolescents could apply content knowledge of that unit to evaluate media reports.

The aspect of text structure of science news includes science knowledge structure and argumentative structure. Interpreting science news needs a certain level of awareness about both structures. In Norris and Phillips' (1994) study, most senior high school students were not good at interpreting and reasoning text structure in popular reports of science chosen from a popular science magazine, a non-science magazine, and a newspaper. They recognized the major conclusions in the reports of science and many of them could state a specific standpoint supported by personal beliefs. However, they failed to observe in the reports the other two elements in the argumentative structure, i.e., justifications and evidences, as well as their relation to the conclusions (Phillips & Norris, 1999). The students had poor performance in justifying their standpoints. Some students liked to use beliefs, rather than scientific justification or evidence, to support their positions. Other students relied on the information written in the reports. They would cite the news content to justify and understand causal relationships, but could not succeed in interpreting the cause and justification of the reasoning or in integrating the information in the texts. Moreover, they tended to overestimate the degree of certainty expressed in the media reports and ignored alternative viewpoints. They often irrationally trusted the articles, especially when the articles adopted the same standpoint with them. It is hard to learn from reading popular reports of science in a situation in which the readers are unable to understand the relationship between justifications, evidence and conclusions (Norris & Phillips, 1994). It demands a repertoire of knowledge and metacognitive strategies to interpret science news and make judgments about the presented relationship among evidence, justifications, and conclusions (Phillips & Norris, 1999). Similar results were found among university students (Norris, Phillips, & Korpan, 2003). They tended to over-estimate the degree of certainty, and trusted their decisions or accepted information in media reports of science to produce correct or incorrect single claims due to misunderstanding the reported information.

Past research has investigated the relationship between science knowledge and science learning from text structure, and has explored the ability of assessing the relationship among evidence and conclusions (Norris & Phillips, 1994). Future research should focus on how to

promote students' ability of interpreting text of science news for students. A few instructional approaches have been carried out to facilitate students' application of content knowledge in the critical reading of science news (McClune & Jarman, 2010).

In the Chemistry Is in the News project (Glaser & Carson, 2005), university or upper-level high school students created a news portfolio in order to connect between the course content and real world issues and problems for facilitating learning. They used chemistry concepts to produce interpretive comments and questions about authentic chemistry news. Then students in different areas and countries exchanged ideas and feedback via the Internet. Glaser and Carson's research suggested that, selecting appropriate science news articles that match the science curriculum can facilitate students' science learning.

Elliott (2006) investigated a somewhat different approach to guide student-teachers. In the study, science student-teachers applied a structured review technique to evaluate biotechnology news and then discussed with peers in order to examine a range of evidence. Student-teachers could recognize the values of the news, evaluate its accuracy, and comment on bias through analyzing science news. Questionnaire responses indicated that these student-teachers considered that this technique was interesting and that it promoted intellectual development. Moreover, they felt that it had potential to transfer effectively to their future science classrooms, in which the school-age students would benefit. However, student-teachers rarely commented on the accuracy of the science content. Lacking confidence in or judgment of science knowledge, the student teachers could not examine the accuracy of the biotechnology news. Elliott suggested that analyzing and commenting on science news provided a structure to think about science content and the nature of the issues, awareness of issues and the ways in which issues were presented. It made the student-teachers furnish the science news with additional information when they analyzed and commented on it. They were confident and had a capacity for argument which was supported by the structure and which made them develop science literacy. Elliott's research implied that in order to develop the ability to evaluate science news, science news instruction should focus on linking science content knowledge to the critical reading of science news articles in structured situations. Past research has suggested that the students from different school levels use a single opinion to read science news, and it is difficult for students of different age to understand science knowledge structure and argumentation structure (Norris, Phillips & Korpan, 2003; Phillips & Norris, 1999; Ratcliffe, 1999). In this study we developed an instructional approach to assist learners to link science content knowledge and to support their critical reading of science news articles. This approach was expected to foster students in connecting news text and their science knowledge for the sake of evaluating science news.

Factors Influencing Argumentation Based On Content Knowledge

The literature on argument based on science content knowledge mainly focuses on two aspects. The first is the influence of science content knowledge on argumentation. The other is the effect of learning by argumentation on science content knowledge. The Effects have been reciprocal.
An understanding of the science content is a prerequisite for good argumentation. According to Sadler and Fowler's (2006) knowledge threshold model, university students without a certain level of knowledge could not produce better informal reasoning and judgment claims about socio-scientific issues related to genetic engineering. On the contrary, learners with advanced genetics knowledge, could base on their understanding of investigation methods, implementation, and research restrictions to justify their claims.

An explicit teaching of argumentation in science class has a positive effect on students' learning of science concepts. In Zohar and Nemet (2002), prior to the argumentation instruction,

most of the ninth graders produced uncertain conclusions. They could not offer more than one justification for their conclusions and fewer justifications appeared in their discussion. After the argumentation instruction, by repeated use of genetic concepts, the students in the explicit teaching group produced more complex arguments, brought up definite conclusions and justifications, used more justifications to support their conclusions, and were more careful about recognizing and justifying their conclusions. The explicit teaching group gained higher scores for genetic concepts than the control group. Zohar and Nemet's study demonstrated that, the practice of higher-order cognitive operations gives students a crucial opportunity to develop new understandings utilizing genetics knowledge. Furthermore, arguing based on correctly considered genetic concepts could foster students' learning about both argumentation quality and genetics knowledge.

Engagement in argumentation by content knowledge enhances understanding of science knowledge. In von Aufschnaiter, Erduran, Osborne, and Simon's study (2008), eighth graders were engaged in oral argumentation based on their primary experiences and knowledge in the context of socio-science issues or solving problems with science theory. It consolidated their existing knowledge and elaborated their science understanding at high levels of abstraction. Only when students consider their content-specific knowledge before argumentation, they can acquire a high quality of argumentation.

Cross, Taasoobshirazi, Hendricks, and Hickey (2008) suggested to developing strategies for students to connect content knowledge with argumentation patterns to improve student achievement by using software program. Cross et al. pointed out that the way the teacher organizes the classroom activity is one of the influencing factors on student engagement in argumentation learning activities. In Venville and Dawson's (2010) study, teachers demonstrated rational and complex argumentation and encouraged the students to discuss socio-scientific issues based on genetic knowledge, so that it influenced the tenth grade students' genetic knowledge, while also improving their ability to connect separate facts with concepts. In Venville and Dawson's study, it only took one lesson of argumentation skills and two lessons of whole class discussion concerned with socio-scientific issues, indicating that genetic understanding can be improved with only a short time of argumentation instruction.

From the literature reviews, it is clear that no matter whether evaluating science news or providing argumentation instruction, science content knowledge plays a critical role. Science content knowledge can help learners gain new knowledge, offer high quality of argumentation, and evaluate evidence, reasons, rebuttals and claims of science news. But it has been considered less in research which enhances learning by linking science content knowledge to the critical reading of science related news. Many people rely on science news as one of the major sources of new science knowledge. However, science news frequently presents incomplete science knowledge and inquiry methods. People with science literacy should use text information and their own background knowledge to critically read science news articles (Yore, Bisanz, & Hand, 2003). To achieve this goal, school science learning and science news should support each other. Science news enriches school science learning, and linking science concepts enhances understanding science news and making personal or political decisions (Jenkins, 1999).

Many students encounter difficulties in evaluating the credibility of conclusions of science reports due to a lack of understanding of the relevant content knowledge (Brem, 2000). Science news presents new research discoveries, scientific issues, and social situations that science knowledge could be applied to. But most of the time a science news article presents a singular viewpoint. Students have to use argument ability to manage science news. This current study integrates argumentation about science news into the genetic-reproduction unit, proposes a teaching method of utilizing science news articles, and examines the effects of prompting students to link their science content knowledge to read science related news critically. It not only provides

argumentation instruction with a new orientation, but also fills in the omissions and details of the past research on argumentation. The research question of this study is- to what extend prompting students to link their science content knowledge while reading science related news can enhance seventh graders' cognitive outcomes on the Reproduction-Genetics Unit?

Method

According to the research purpose, a case study in a junior high school in Taiwan with an embedded quasi-experimental design was conducted. This junior high school is located on the seashore area in western Taiwan. About 10 percent of students in each grade level were qualified for free lunch. The students achieved slightly below average on the nationwide Basic Competence Test. Almost all students entered the senior high schools, vocational schools, and technology colleges after graduation, however, only about one percent of the students enter academic-oriented senior school. In general, most of the students seldom selected science as their specialized area after graduating from the junior high school.

Before the school year started, the Academic Office of the school assigned students into different classes based on students' test scores of teacher-made mathematics and literature tests. The average test scores among classes are maintained to be about equal. The participant students were 118 seventh graders (56 boys and 62 girls) from four 7th grade classes. Two classes (n = 56, 24 boys and 32 girls) were assigned to be the CK-SNI group, in which group the students were prompted to link to their learned science content knowledge. The other two classes (n = 62, 32 boys and 30 girls) were assigned to the SNI group, in which the students were not instructed to link to their science content knowledge. A t-test on the achievement pretest scores of these two groups of students did not show significant difference (t = 1.15, df = 116, p = .25). The achievement pre-test was on the unit related to reproduction-genetics. This present study took the Reproduction-Genetic Unit as an example to demonstrate the intervention and student learning outcomes. Both groups of students attended the Reproduction-Genetic Unit and a 45-minute Science News Instruction session taught by the same biology teacher.

To plan the 45-minute instruction, the researchers analyzed and built a concept map of the core concepts in the Reproduction-Genetics unit. The concept map was constructed in order to choose science news which is related to science concept in curriculum and matched students' ability. The concept map also was helpful in analyzing the distribution of related concept knowledge with different level. We searched for science news articles that addressed issues related to the unit. In order to determine the news article, we followed the advices of literature. Due to researchers of this study were interested in developing tasks to encourage students applying learned science concepts to develop a critical understanding of science news articles, the science knowledge structure and argumentation structure of the news articles will play a key role in determining the quality and legitimacy of the tasks. All the identified news items were analyzed and mapped to represent their knowledge structure and argumentation structure. Then we selected one news article that best related to the structure of the core content knowledge and had more elements of argumentation. The title of the science news article was "Sixteen million people are descendants of Genghis Khan." This news article was posted in 2004 and found from one of the most popular Taiwanese newspapers. It has four paragraphs including 376 Chinese words in total, and does not state rebuttals. The students were not familiar with the news content and did not have opportunities to discuss the content before they encounter the article in this study.

Figure 1 is Toulmin's argument pattern (TAP) of science news with five kinds of argument elements which include data warrants, backings, qualifiers, and claims. The first author followed the definition of argumentation elements to identify the elements in the news article.

Data:
1. Gene scientists analyzed the gene sample of 200 men in Central Asian; there are a large group of persons whose Y chromosomes are almost the same in these samples.
2. Gene scientists proceeded with geography analysis for these samples. They discovered that its distribution closely matched the boundaries of the Mongol Empire, Genghis Khan's territory, and it extended from China to the Middle East.

so

Qualifier:
… the inference's possibility raises highly.

Claims:
1. Today at least sixteen million people in the world carry Genghis Khan's genes.
2. In other words, 1 in 200 men in the world are direct line descendants of Genghis Khan.

since

Warrants:
1. The researchers showed Y chromosome which decided the sex of men only passed from father to son.
2. The men have almost the same Y chromosomes. It represented that these men have the same ancestor.
3. During the reign of Genghis Khan he conquered from North to South and expanded his empire territory and he fell in love everywhere.

unless

Rebuttals:
(Rebuttals do not exist in the article and need to be offered by the reader)

On account of

Backings:
1. Because of Genghis Khan's high social advantage, it makes chromosomes transmit continually.
2. Y chromosome of Genghis Khan had super physiology advantage.
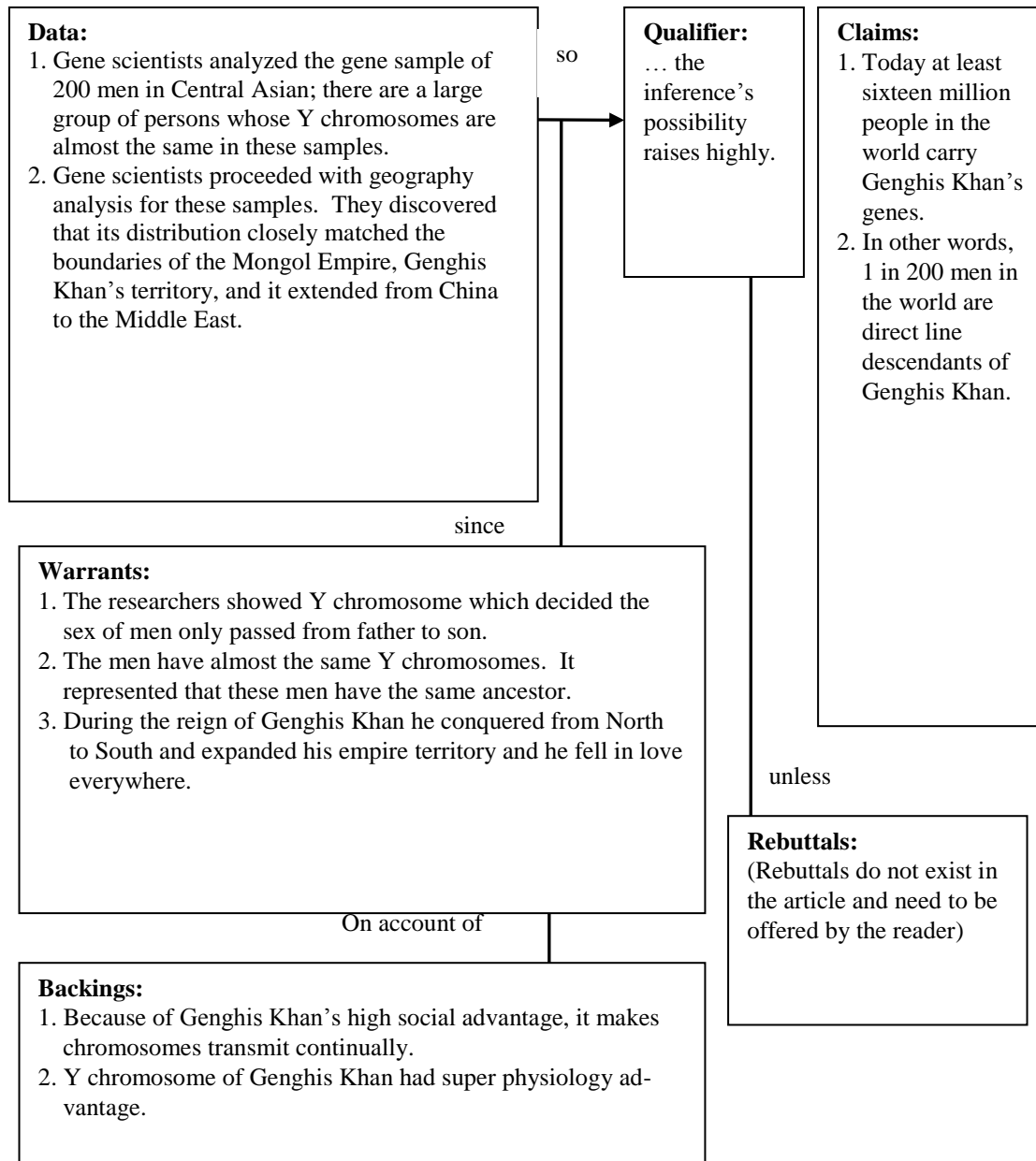
Figure 1. TAP of science news with five kinds of argument elements including data warrants, backings, qualifier, and claims

Another author crosschecked the coding of each element, as well as the interpretation of the news article author's intention. Figure 2 illustrates the structure of the content in the science news and the text book chapter, and the relationship between these two texts. The science textbook adopted by the school presents science facts including fundamental theories and principles that

address structure and function of gene and chromosome in meiosis and mitosis, the role of sperms and eggs in reproduction, and inheritance of traits, sex and blood types. In addition, the application of the principles of reproduction and inheritance in medical consultation and agriculture was also addressed.
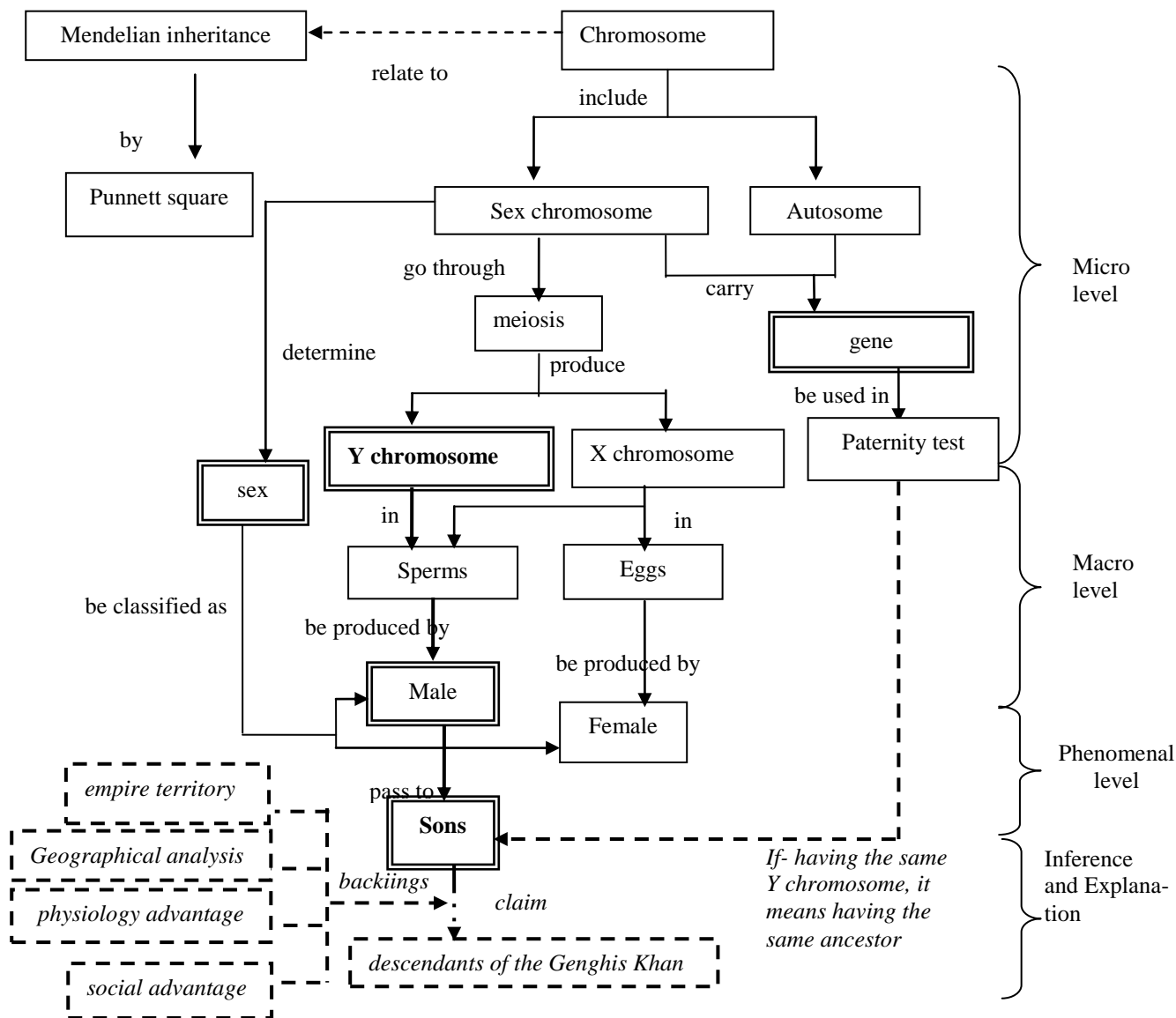
Note: blocked words indicate closely related concepts; double frames words indicate concepts referred to in both the science news and science curriculum; italics indicate concepts only referred to in the science news.

Figure 2. An analysis of the concepts in the science news and in the science curriculum concerning the science news.

From Figure 2, it is clear that the students' textbook covered micro level concepts that addressing chromosomes, genes, meiosis, Principles of Mendelian Inheritance and other related concepts; macro level concepts that addressing sperms and eggs; and phenomenal level concepts that explaining sex determination, and reproduction of male and female. Unlike the textbook, the science news reported frontier science findings and focused on narrating inference and explanation. The selected science news article reported work of the gene scientists on analyzing gene sample of 200 Central Asian men and how the gene scientists combined findings from geographical analysis to develop explanation.

After completing the Reproduction-Genetics Unit, both groups of students were requested to read the selected news article, analyze the argumentation structure of the news text, and decide their position. The CK-SNI group was given a writing frame that required them to apply the science knowledge they had learned from the biology lessons to give approval or refuting reasons to the news. The SNI group used a writing frame that did not cue the students to refer to the science knowledge in the textbook. In other words, the instruction time duration and content of both groups was identical except that the prompt for argumentation writing frame was different. We would like to investigate the effect of the prompt on the quality of their argumentation, and the effect of their ability of argumentation on science achievement. The instrument of the study included the worksheet of argumentation about science news and the achievement test of the Reproduction-Genetics unit which are illustrated below.

The Intervention

Awareness of text structure is one strategy of reading comprehension, and text structure of causal relationship is the most difficult in terms of memory and awareness (Richgels, Mcgee, Lomax, & Sheard, 1987). Awareness of text structure helps students comprehend text and foster learning science content (Christensen, 2008). If students cannot understand text structure, it is not easy to comprehend the text. Teachers can diagram the text structure to promote students' awareness of the text structure and to help them understand the learning content in a positive manner (Dymock, 2005). Furthermore, it is essential to help students get familiar with argumentation structure. If students could comprehend claims, evidence, and their relationship as well as being able to evaluate evidence, science knowledge, the relationship between claims and evidence, sources of evidence, and alternative viewpoints, they develop a capacity of argumentation and create high quality of argumentation (Kolstø, 2001). As a result, in the 45-minute session, the science news article accompanied a diagram of argumentation as a writing frame designed based on TAP was provided to help students recognize and evaluate the argument elements of the article.

TAP could include six argument elements of science argument structure: claims, data, warrants, backings, qualifiers, and rebuttals. Among them, data, claims, and warrants are the basic elements. Claims are assertions which are established by argument. Data are facts which support claims. Warrants are used to judge how to explain claims using data. Backings consolidate warrants and illustrate the overall relationship among the data, warrants and claims. Rebuttals explain additional situations that the claims could not establish. Qualifiers are the extent to which claims could be established (Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Toulmin, 2003). In the context of present study, science news seldom reports all details of science research or covers all the above-mentioned elements. Moreover, the writing frame must take into account the participant seventh graders' argumentation ability and time constraint in a regular science class. As a result, we combined some elements to simplify the structure based on previous studies. In past relevant research using the TAP analyzing scheme, warrants, backings, and qualifiers were hard to distinguish (Dawson & Venville, 2009). Hence, McNeill and Pimentel (2010) combined

warrants and backings into reasoning, and took data as evidence including both data and information. Accordingly, the argument structure of our writing frame focused on the similar four elements. The elements were diagramed by grids and links. One question in accordance with each element's characteristic was provided to guide students writing. The diagram of the argument elements and questions related to the argument elements mainly offers scaffolding of argument structure which helps the students focus on and organize the argument structure (Chin & Osborne, 2010). It also helps the students understand the relationship among the elements in the argument structure. The CK-SNI group, but not the SNI group, was asked to produce approval and refuting reasons using science content knowledge.

1. Claims: As usually defined in TAP, claims refer to the conclusions in the article which might be assertions, opinions, or positions. The capacity of evaluation of conclusions in scientific media reporting is an important form of scientific literacy (Korpan, Bisanz, Bisanz, & Henderson, 1997). In other words, people with scientific literacy should be able to recognize claims in science news and the arguments for or against them. In the writing frame for both the CK-SNI and the SNI groups, the question for the element of claims is "Please write down the content which this science news article presents."

2. Evidence/Data: This refers to data in typical TAP to help illustrate the claims with data or facts. Two phenomena are often found regarding this argumentation element. First, students are likely to ignore, eliminate or completely refuse to accept abnormal data. They might consider it as insufficient or unsure evidence (Erduran, Simon, & Osborne, 2004). Secondly, data usually include two forms, firsthand data and secondhand data. Secondhand data are commonly used in newspapers, magazines, or on televisions. Firsthand data and secondhand data make a difference to discussions and interpretations. It has been found that, rather than using firsthand data, students more often use content knowledge, and there is a higher level of accuracy in the context of their discussion of secondhand data, but they think less about the source of secondhand data or errors of measures (Hug & McNeill, 2008). In the writing frame for both the CK-SNI and the SNI groups, the question for this element of is "Please write down the data and information which this science news article provides."

3. Approval reasons: This combines warrants and backings of TAP, i.e., reasons which agree with the presented claims. Based on the purpose of the study, there were two kinds of designed questions. One is "Please write down approval reasons based on the content you have learned from your science textbook." This encouraged the CK-SNI group to link their arguments about the science news to science content knowledge. The prompt in the writing frame for the SNI group is "Please write down approval reasons." The SNI group was not instructed to apply science content.

4. Refuting reasons: This is the rebuttals of TAP, a special element, for which additional situation claims are not established. Rebuttals make thinking more precise and promote discussion. Emergence of abnormal data and opposite reasons offer an opportunity for changing the arguers' ideas and beliefs as well as having strength to destroy arguments (Bricker & Bell, 2008). Therefore, rebuttals are especially considered as an important element for evaluating the quality of argumentation. Arguments with rebuttals are considered as having better quality, and being more challenging, and more persuasive. The prompt in the writing frame for the CK-SNI group is "Please write down refuting reasons based on the content you have learned from your science textbook," which makes explicit a link to science subject matter knowledge. The SNI group was asked: "Please write down refuting reasons."

Students' written responses on the argumentation worksheet were analyzed to understand their argumentation capacity. The procedure was as following:

1. Two of the researchers clarified the definition of each argumentation element, and negotiate about example(s) in the news article for each element.
2. One researcher coded categories of argumentation elements in student written artifacts as D (data), W (warrant), B (backing), C (claim), and R (rebuttal).
3. One researcher segmented student writing into meaningful propositions, then constantly compared among students' writing segments for each argumentation element, and identified and enumerated acceptable sub-items of each element in order to elaborate the coding scheme.
4. Another trained researcher cross-checked the coding scheme.
5. One researcher applied the revised coding scheme to code student writing segments. If students correctly referred to science knowledge not mentioned in the news article, an additional sub-item was added. In case the sub-items were not-science content related, misplaced or conceptual incorrect, the score was not granted.
6. Another trained researcher randomly selected twenty-five percents of student writing segments and coded independently.
7. Researchers cross-checked coding results, and negotiated about the inconsistent items until reached a consensus.
8. Two researchers scored student written artifacts. Each sensible proposition placed in correct column granted one point. Sum of points from each column represented the student's argumentation score.

Table 1 presents the science news coding scheme and scoring for "Sixteen million people are descendants of Genghis Khan." Students' total scores of all the argument elements were used to investigate their argument ability. In Table 1, the first letter presents the argument elements where D means data, C means claims, W means warrants, B means backings, and R means rebuttals. The second number presents the number of examples for the argument elements. One correct response of argument structure gets one point. Because there is no element of rebuttal in the selected science news, students' rebuttals in their written artifacts are categorized according to the correctness and appropriateness. If there is relevant science content knowledge in approval and refuting reasons that appears in the science news text, it also gets points. After the two coders reach agreement about each code, one coder graded the written artifacts of the CK-SNI group and the SNI group, after which another coder graded twenty-five percent of the CK-SNI group and the SNI group. The coders discussed and negotiated any disagreements until they reached agreement.

The Achievement Test of the Reproduction and Genetics Units

The researchers developed an achievement test composed of 50 multiple-choice items covering the concepts in the teaching unit, including cell division, meiosis, reproduction behavior, genes, chromosomes, Mendelian Inheritance, sex determination, mutation, human disorders, and biotechnology. After a pilot test on two equivalent classes of students to examine the level of difficulty and discrimination index of each item, the statement of the items was revised before administering it to the two target classes. The test was administered before and after the teaching unit. It took about 40 minutes for the students to finish the test. The time interval between the pre- and post- test was about 8 weeks.

According to Bloom's taxonomy of educational objectives, the achievement test ($\alpha = .94$) focused on the levels of Remember ($\alpha = .69$), Understand ($\alpha = .84$), and Apply ($\alpha = .89$) in the Cognitive Process Dimension and on Factual Knowledge ($\alpha = .87$), Conceptual Knowledge ($\alpha = .86$), and Procedural Knowledge ($\alpha = .68$) in the Knowledge Dimension (Anderson & Krathwohl,

2001). Argumentation about science news may help students learn scientific facts and concepts. It also offers the context of applying science knowledge as well as helping them understand inquiry methods (Jarman & McClune, 2007a). Therefore the achievement test was designed to focus on these levels or dimensions.

Table 1. Coding Scheme of the Argument Structure and Scoring for "Sixteen million people are descendants of Genghis Khan"

Code	Type	Examples of students responses	Score
D-1	Data	The Y chromosomes of 200 men in Central Asian were almost the same.	1
D-2		Through geographical analysis, they found that its distribution closely matched the boundaries of Genghis Khan's territory.	1
C-1	Claim	Sixteen million people are descendants of Genghis Khan. Today at least sixteen million men worldwide carry his genes.	1
C-2		1 in 200 men in the world are direct line descendants of Genghis Khan.	1
W-1	Approval reason	The Y chromosome can only be passed to the son by the father.	1
W-2		If they had the same Y chromosome, and it means that they had the same ancestor.	1
		It might be that he had descendants in every place that he occupied. If there were no accident, it might be transmitted continually.	1
B-1	Approval reason	The Y chromosome of Genghis Khan had super physiological advantage; hence, later generations had his genes.	1
B-2		Genghis Khan had high social advantage.	1
R-1	Refuting reason	Because no true gene of Genghis Khan was compared.	1
R-2		These genes evolved through many years, and it was impossible that there was no mutation at all! Moreover, even if it was, it could not present that their Y chromosomes are from Genghis Khan.	1
R-3		Maybe the Y chromosome of those people is only like Genghis Khan's.	1
R-4		It seems that sixteen million people are too few, because his descendants, no matter whether they are males or females, all have his genes. If it was transmitted continually, there could not just be these people.	1
R-5		Because there were only two hundred samples, it might be fortuitous to get similar samples.	1
R-6		The article did not report if the genes are Genghis Khan's. By that, the experiment was incorrect to some extent. Moreover, they only found the places that Genghis Khan occupied, and did not find other places.	1

In terms of Bloom's knowledge dimension, the test was comprised of 21 factual items, 24 conceptual items, and 5 procedural items. In terms of Bloom's cognitive process dimension, the test was comprised of 8 items at the remember level, 18 items at the understand level, and 24 items at the apply level. Each correct answer scored 2 points. The data from the pre- and post- test were statistically analyzed by SPSS software. An ANCOVA was conducted with the pre-test as the covariate and the post-test as the dependent variable.

Results

In order to investigate the effect on cognitive achievement by linking science content knowledge to the critical reading of science related news, the study examines the quality of argumentation and presents and compares the achievement test for both the CK-SNI group and the SNI group.

The Quality of Argumentation

In all, 118 copies of written artifacts were collected. Table 2 shows the t-tests of the argumentation totals and element scores for the two independent groups.

Table 2. Results of T-Tests on Elements of Argumentation Structure

Elements of Argument	CK-SNI group (n = 56)		SNI group (n = 62)		df	t	Cohen's d
	M	*SD*	*M*	*SD*	*df*	*t*	*Cohen's d*
Data	.61	.56	.35	.52	116	2.55*	0.48
Claim	1.07	.78	.26	.51	92.94	6.61**	1.23
Warrant	.71	.68	.39	.55	116	2.88*	0.52
Backing	.29	.56	.23	.53	116	0.60	—
Rebuttal	1.38	.96	.55	.69	98.95	5.38**	0.99
Argumentation score	4.05	1.95	1.77	1.38	116	7.26**	1.35

*p<.05

Table 2 briefly presents the results of t-tests on the Data, Claim, Warrant, Backing and Rebuttal elements of the argumentation structure. In four of the five elements as well as the total scores, the CK-SNI group (n = 56) scored significantly higher than the SNI group (n = 62). The CK-SNI group scored significantly higher than the SNI group on the TAP elements of Data (t[116] = 2.55, p < .05, d = .48), Claim (t[92.94] = 6.61, p < .001, d = 1.23), Warrant (t[116] = 2.88, p < .05, d = .52), Rebuttal (t[98.95] = 5.38, p < .001, d = .99), and total Argumentation scores (t[116] = 7.26, p < .001, d = 1.35). Nevertheless, there were not significant differences between the two groups on Backing (t[116] = 0.60, p = .55). It is important to notice that the strength of the association between linking science content knowledge to the news on the student performance on generating claim, rebuttals and on overall argumentation score was strong (Cohen's d > .8).

Table 3 presents numbers and percentages of every argumentation element score. It should be noted that, in the news, data and claims were more explicit than warrants and backings, and rebuttals were absent. Table 4 presents numbers and percentage of argumentation elements scores. Tables 3 and 4 show that in all aspects, the CK-SNI group gained more points. More students in the CK-SNI group recognized the data and claims in the article. In terms of the data, students referred to the D-1 data, that is, the Y chromosomes of 200 men in Central Asian were almost the same, but less reference was made to the D-2 data. In terms of claims, more students in the CK-SNI group cited C-1, sixteen million people are descendants of Genghis Khan, and C-2, 1 in 200 men in the world are direct line descendants of Genghis Khan.. Compared with data and claims, fewer students were able to point out warrants and backings. Nevertheless, more than half (58.9%) of the CK-SNI group provided at least one warrant. However, only one third (35.5%) of the SNI group had warrants. Moreover, the types of warrants provided by these groups were different. The CK-SNI students preferred W-1, the Y chromosome only can be passed to son by father. On the other hand, the SNI students focused on W-2, which were socio-politically related and mentioned

in the news article but not referred to biological knowledge. Although there were no rebuttals in the selected science news article, 83.9% of the students in the CK-SNI group could produce scientifically correct rebuttals. Those students who used science content knowledge were better at producing rebuttals and different ideas, and at raising quality argumentation.

Table 3. Numbers and Percentages of Written Argumentation Elements

Element	Code	Type	CK-SNI group ($n = 56$)		SNI group ($n = 62$)	
			N	*%*	*N*	*%*
Data	D-1	Data	29	51.8	20	32.3
	D-2		5	8.9	2	3.2
Claim	C-1	Claim	33	58.9	9	14.5
	C-2		27	48.2	7	11.3
Warrant	W-1	Approval reason	22	39.3	7	11.3
	W-2		18	32.1	17	27.4
Backing	B-1	Approval reason	9	16.1	6	9.7
	B-2		7	12.5	8	12.9
Rebuttal	R-1	Refuting reason	13	23.2	14	22.6
	R-2		14	25.0	1	6.7
	R-3		22	39.3	15	24.2
	R-4		9	16.1	0	0.0
	R-5		15	26.8	0	0.0
	R-6		4	7.1	4	6.5

Achievement in the Reproduction-Genetics Unit

Table 5 briefly presents the results of the 50-item cognitive test. After adjustment by the covariate, the main effect of linking to science content knowledge was also significant ($F[1,115] = 8.18$, $p < .05$). The CK-SNI group ($M = 69.23$, $SD = 2.51$, $n = 56$) scored significantly higher than the SNI group ($M = 59.31$, $SD = 2.38$, $n = 62$) on the total scores, with a moderate effect size $\eta_p^2 = .07$.

The results of the ANCOVAs reveal that the CK-SNI group achieved significantly higher than the SNI group on the concept tests. The results suggested that while the students argued through linking content knowledge in the textbook, their process of cognitive operation was not only focusing on retrieving science knowledge directly related to the science news article. Combining with the data and findings from the Table 2 ~ Table 4, it is reasonable to explain that the students in the CK-SNI group utilized the core concepts they previously learned to approve or refute the claim statements in the news article. Furthermore, generating refuting reasons was the more active cognitive operation the CK-SNI group students adopted.

Effects of Connecting Content Knowledge to Argumentation on Learning Achievement

Comparisons of the groups' achievement in the reproduction-genetics unit for Bloom's cognitive domain were carried out by ANCOVAs. The data indicate that, after adjustment by the pretest as the covariate, the experimental group was significantly higher in both cognitive process and knowledge dimensions except for Remember. In the cognitive process dimension, the strength of the association between linking science content knowledge to the news argumentation structure

was low and moderate (η_p^2 =.04, .10) on the Understand and Apply levels. Regarding the knowledge dimension, the effect sizes of the writing intervention highlighting the connection to science content knowledge were low for Factual with η_p^2 = .04, and were moderate for Conceptual and Procedural levels, with η_p^2 =.07, and .09, respectively.

Table 4. Numbers and Percentage of Scores for Elements of Argumentation Structure

Elements of argument	Score	CK-SNI group ($n = 56$)		SNI group ($n = 62$)	
		N	%	*N*	%
Data	0	24	42.9	41	66.1
	1	30	53.6	20	32.3
	2	2	3.6	1	1.6
Claim	0	15	26.8	48	77.4
	1	22	39.3	12	19.4
	2	19	33.9	2	3.2
Warrant	0	23	41.5	40	64.5
	1	26	46.4	20	32.3
	2	7	12.5	2	3.2
Backing	0	43	76.8	51	82.3
	1	10	17.9	8	12.9
	2	3	5.4	3	4.8
Rebuttal	0	9	16.1	35	56.5
	1	26	46.4	20	32.3
	2	13	23.2	7	11.3
	3	7	12.5	0	0.0
	4	1	1.8	0	0.0

The results indicate that linking science content knowledge to the news argumentation structure can foster students' learning achievements at the understand and apply levels of the cognitive process as well as at the factual, conceptual, and procedural levels of knowledge.

Discussion

This study presents an instructional approach emphasizing linking science content knowledge to the critical reading of science related news and reports its effects on enhancing cognitive outcomes. The results indicate that linking science content knowledge to argumentation about science news enhances learning better than simple argumentation about science news. The literature indicates that argumentation based on science content knowledge produces better science concept understanding related to argumentation content. The results of the present study show that argumentation about science news based on content knowledge not only enhanced the students' achievement on directly related concepts but also on all core concepts of the Reproduction-Genetics Unit. Students in the CK-SNI group thought about refuting or approval reasons for the identified causal textual elements by linking to science content knowledge; consequently, they incorporated scientific knowledge into argumentation by generating connection relationships between warrants and data, and they also produced refutations which seldom appear in media reports of science research findings.

Table 5. Adjusted Means, Standard Deviations, and Analysis of Covariance (ANCOVA) Results on the Cognitive Test

Taxonomy of Educational Objective: Cognitive domain	CK-SNI group ($n = 56$)		SNI group ($n = 62$)		ANCOVA	
	Pretest *Mean (SD)*	Posttest *Mean (SD)*	Pretest *Mean (SD)*	Posttest *Mean (SD)*	F	η_p^2
Test (50 items)	35.54 (8.17)	69.23 (2.51)	33.68 (9.21)	59.31 (2.38)	8.18[*]	.07
Cognitive Process Dimension						
Remember (8 items)	7.46 (2.52)	12.42 (3.87)	7.81 (2.48)	11.56 (2.58)	1.65	—
Understand (18 items)	13.46 (5.24)	23.70 (8.96)	12.52 (5.46)	20.66 (8.39)	4.53[*]	.04
Apply (24 items)	14.61 (4.09)	33.54 (10.21)	13.35 (5.34)	26.71 (11.95)	12.23[*]	.10
Knowledge Dimension						
Factual (21 items)	16.93 (3.91)	31.06 (9.76)	16.32 (4.85)	27.59 (9.20)	4.80[*]	.04
Conceptual (24 items)	15.61 (5.32)	31.37 (10.62)	14.42 (5.60)	25.99 (10.98)	8.71[*]	.07
Procedural (5 items)	3.00 (2.19)	7.24 (2.92)	2.93 (2.07)	5.33 (3.14)	11.81[**]	.09

[*]$p < .05$, [**]$p < .001$

The findings of the present study confirm the literature that linking science content knowledge to argumentation does indeed assist learners in organizing and elaborating the existing science concepts. The proposed instructional approach helped the students in this present study perform better on the achievement test of the Reproduction-Genetics Unit. We suggest that science news instruction should be designed to guide students think over approval and refuting reasons. Furthermore, linking to science content knowledge can achieve this goal by helping learners organize and elaborate their content knowledge through generating more rebuttals.

The present study also analyzes learning outcomes at the levels of remember, understand, and apply in the Cognitive Process Dimension, as well as at the levels of factual, conceptual, and procedural knowledge in the Knowledge Dimension. The study found better learning outcomes in the CK-SNI group than in the SNI group. In this aspect, past research has indicated that conceptual confusion, such as heredity abstraction, probabilistic reasoning, or the lack of connections between production and genetics, create obstacles to students' thinking (Jiménez-Aleixandre, Rodríguez, & Duschl, 2000). Reading and criticizing organic chemistry news can help connect the abstract scientific theories with the authentic world. However, when applying science concepts to complicated authentic society, people seldom apply rigorous scientific analysis. Moreover, different reasoning produces different conclusions, even though it is based on the same data. As a result, students hardly construct connections between science concepts and the authentic world. Glaser and Carson (2005) suggested teachers should develop strategies to help them see the connections. This present study shows that selecting news articles based on the core teaching content and providing learners with a visualized writing frame to link science content knowledge to their reading of science-related news can not only enhance students' application ability, but can also improve their understanding. Our results lead to the educational implication that school teachers should carefully consider using science news articles related to core content knowledge as supplementary materials.

Past research has indicated that background knowledge is the crucial factor, only students with a certain level of scientific knowledge can produce better argumentation (Sadler & Fowler, 2006). Lewis and Wood-Robinson (2000) argued that a lack of understanding of the knowledge

structure of genetics makes it difficult for students to clarify the relationships between core genetics concepts such as chromosomes or genes. The results of their study illustrated that facilitating students to link learned science content knowledge to argumentation structure can promote students' science concept learning and the quality of their argumentation. Past research has also indicated that when students combine inherent knowledge and argumentation discussion through complex argumentation demonstration by teachers, students can connect discrete facts and concepts to produce more integrated scientific knowledge in a short learning time (Venville & Dawson, 2010). The present study further shows that the CK-SNI group had learning outcomes for science knowledge and argumentation quality better than the SNI group after only one class session. The results confirm that it is promising to link science content knowledge to the written argumentation for evaluating science news articles. Eventually it will promote learning at the levels of understand, and apply in the cognitive process dimension and help learning at the levels of factual, conceptual, and procedural knowledge in the knowledge dimension.

Argumentation based on content knowledge assists in elaborating existing knowledge and achieving a higher level of scientific understanding (von Aufschnaiter et al., 2008). The results of this current study further present detailed concept learning outcomes at different levels. In reality, science news does not present all of the relevant science knowledge that is necessary for evaluating science news. From a comparison of covered knowledge in the news text and the relevant knowledge structure, it is notable that science news presents incomplete and fragmented scientific knowledge. This study suggests that science educators should select science news related to core content knowledge and big ideas in the science curriculum as materials of argumentation about science news. Moreover, this study also suggests that further research can apply the instructional approach and investigate its effectiveness on different curricular topics to gain a more complete picture about to make connections between science in the textbook and new science findings in science news articles.

Maloney and Simon (2006) pointed out that students have to develop argumentation skills to judge claims of articles and to use evidence systematically to produce complex argumentation. Hence, it can enhance their reasoning skills and their understanding of science concepts. Moreover, it can clarify and develop their thinking. With regard to science news instruction, this present study further suggests that students should be offered opportunities to link science content knowledge to deliberate approval and refuting reasons, to recognize argument elements, and to connect the relationships among elements. It can help students understand the content of science news, clarify relevant scientific concepts, promote students' evaluation of science news, and lead student to apply the science knowledge they have learned, and to connect the science news and science content knowledge they have learned. Linking science content knowledge to interpret science news helps students elaborate their conceptual understanding. Besides, it also promotes students' expansion of their knowledge structure and argumentation structure.

Conclusion and Implications

This study proposes an instructional approach to connecting science content knowledge to the critical reading of science news articles in authentic classroom situations. The purpose of the study was to explore if learning is enhanced by linking science content knowledge to the critical reading of science related news. The results demonstrate that linking science content knowledge to critical reading of science news enhances the seventh graders' cognitive learning. Moreover, from the aspect of cognitive processes, linking science content knowledge to critical reading of science news articles can enhance the capacity of understanding, and applying. From the aspect of the knowledge dimension, it also enhances learning of factual, conceptual, and procedural knowledge.

Combined with the analysis of student artifacts, we conclude that linking science content knowledge to the critical reading of science news articles can guide students in making quality argumentation, especially for rebuttal production which often does not appear in science news.

　　　Science news usually carries incomplete science information. Due to the space limitation, science news articles often do not present extend relationship in related concepts, therefore students need to connect related concepts for offering approval and rebuttal reasons, understanding meaning of data authentically, and judging claims. Especially for concepts related to genetics, such as cell division and genetic inheritance, the subordinate concepts, principles and process are closely interrelated and as a whole (Williams, Debarger, Montgomery, Zhou, & Tate, 2011). Therefore, it is critical for readers to take into accounts of the specific function of each argument element in order to form quality argumentation and to argue against the viewpoints in the news.

It is suggested that when planning a science news instruction, the teachers could choose science news related to core science content in the science curriculum, and assist students to deliberate their approval and refuting reasons by linking science content knowledge to the critical reading of science related news. Hence, students can judge science news rationally, and think deeply about the scientific knowledge they have learned. Furthermore, students can practice elaborating and expanding their knowledge structure, and nurture habits of mind by linking science content knowledge to make judgments about science related issues and events (Taber & Taylor, 2009), and scientific discoveries in media.

　　　In terms of linking theory to teaching practice, this study reveals a rather straightforward process for instruction. First of all, two main criteria can be applied to select appropriate science news. The first criterion is the news addresses core science content that covered in the text of the teaching unit. The other is the news content comprises argument elements. Teachers who are novice at argumentative reasoning may follow Figure 1 to analyze the text structure of science news and develop connections between the news and the teaching unit. Secondly, the suggested approach is complementary. It does not require teachers to alter their original instructional plan and teaching style while they try to extend their teaching goals to cover higher order thinking skills and updated science knowledge. Finally, the suggested approach focusing on building students' science subject knowledge and then facilitating the students to base on their science subject knowledge to develop argumentation ability. In a nutshell, the approach carefully considers teachers' comfort zone and supports teachers to enrich their classroom teaching content and thus succeeds in moving them toward cultivating future scientific literate citizens. Future research may further investigate the effectiveness of this approach on students' learning, such as in higher cognitive level and changes in attitudes (Glaser & Carson, 2005). The effects on different topics in the science curriculum and other science news with different knowledge structure and argument structure (for examples, Gardner, Jones, & Ferzli, 2009; Elliott, 2006) also need further empirical research.

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Authors

Pei-Ying Tsai is a doctoral student in the Graduate Institute of Science Education at the National Changhua University of Education, Taiwan.

Sufen Chen is an Associate Professor in the Graduate Institute of Digital Learning and Education at the National Taiwan University of Science and Technology, Taiwan.

Huey-Por Chang is a Professor and President at the Open University of Kaohsiung, Taiwan.

Wen-Hua Chang is an Associate Professor in the Graduate Institute of Science Education at the National Taiwan Normal University, Taiwan. **Correspondence:** Graduate Institute of Science Education at the National Taiwan Normal University, Taiwan. E-mail: sujudy@ntnu.edu.tw

Appendix

Sixteen Million People Are Descendants of Genghis Khan

Although Mongolia Empire established by Genghis Khan had been disappeared, the descendants of Genghis Khan are still seen everywhere. Through a group of gene scientists' sampling and analysis, the inference's possibility raises highly. The researchers showed Y chromosome which decided the sex of men only passed from father to son. And after analyzing the gene sample of 200 men in Central Asian men, they discovered that there are a large group of persons whose Y chromosomes are almost the same. It represented that these men have the same ancestor. The researchers proceeded with geography analysis for these samples again. They discovered that its distribution closely matched the boundaries of the Mongol Empire, Genghis Khan's territory that very year, and it extended from China to the Middle East. Gene scientists showed that during the reign of Genghis Khan he conquered from North to South and expanded his empire territory and he fell in love everywhere at the same time. The result of passion is that today at least sixteen million people in the world carry his genes; in other words, 1 in 200 men in the world are direct line descendants of Genghis Khan. For the result of having descendants everywhere, gene scientists offer two kinds of explanations, one is that Y chromosome of Genghis Khan had super physiology advantage, but scholars considered pervasively that because of Genghis Khan's high social advantage, it makes chromosomes transmit continually.