Enhancing Students’ NOS Views and Science Knowledge Using Facebook-based Scientific News

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ABSTRACT

This study investigated how the different discussion approaches in Facebook influenced students’ scientific knowledge acquisition and the nature of science (NOS) views. Two eighth- and two ninth-grade classes in a Taiwanese junior high school participated in the study. In two of the classes students engaged in synchronous discussion, and in the other two classes they engaged in asynchronous discussion. The 83 participating students discussed scientific news that had been posted on Facebook, with a total of seven news stories. Three instruments – a general NOS views questionnaire, a content-related NOS views questionnaire, and a science knowledge test – were administered before, immediately after, and three weeks after the intervention. In addition, student responses to each news story were collected and analyzed. The results demonstrated that regardless of which online discussion group they participated in, students improved their science content knowledge, general NOS views, and NOS analyses of scientific news. Especially, synchronous discussion proved more effective than asynchronous discussion at helping students to develop science content knowledge and increase their view of community aspects of content-related NOS. These findings demonstrated the advantages of quick feedback and responses in synchronous discussion facilitated communication and cognitive development about subject and subject-related nature of science.

Keywords

Nature of science views, Science knowledge, Facebook, Scientific news

Introduction

Studies have consistently found that students usually lack an adequate understanding of the nature of science (NOS) (Lederman, 1992; Ryan & Aikenhead, 1992). The nature of science is defined as the epistemology of science, characteristics of scientific knowledge, and the values and beliefs inherent to scientific knowledge and its development (Lederman, 1992). Many of these intrinsic ideas are not emphasized in traditional science classroom instruction, resulting in students learning skewed notions about how science is conducted (Abd-El-Khalick & Lederman, 2000). Exploring ways to help students acquire an adequate understanding of NOS is important for educators, since this is among the desired outcomes of science instruction (Lederman, 1992; Abd-El-Khalick & Lederman, 2000). The mass media tend to cover contemporary socio-scientific issues which address the public’s attention and interests as they are related to daily life (Halkia & Mantzouridis, 2005). The values of media news stories in science instruction seem promising given that the use of scientific news stories in education prepares individuals to learn about science and to build essential knowledge of NOS (Christensen, 2011; McClune and Jarman, 2012). In sum, NOS and news stories about science are interrelated and have an effect on one another. One particular media form has gained prominence recently as a means of conveying relevant information throughout society: social networking. Popular social networking sites such as Facebook can facilitate collaborative science learning because they are user-friendly and support flexible communication (Baatarjav, Phithakkitnukoon, & Dantu, 2008), thus providing ideal spaces for users to engage intellectually and form networked learning communities. Although researchers generally agree that explicit instruction improved students’ NOS learning, few have examined how different online communication formats influence students’ understanding of NOS. Knowledge remains limited regarding how reading and discussing scientific news in online contexts affects students’ NOS comprehension. This study compared how students’ NOS views changed when they analyzed scientific news stories in synchronous and asynchronous online discussions. The findings of the current study reiterate the value of scientific news stories in informal science education and broaden our knowledge about how news media influences individuals’ awareness of NOS.
Literature review

The rising influence of Facebook in instruction

Social networking sites, such as Facebook and MySpace, are currently among the most popular online communication methods. The number of Facebook users has grown exponentially from 1 million in 2004 to over 1 billion in 2012 (Smith, Segall, & Cowley, 2012), compelling some researchers to explore the potential educational benefits of using such sites. One advantage of using Facebook was that it offered learners “a dynamic and unintimidating environment” in which to communicate (Schroeder & Greenbowe, 2009, p. 5), and social networking has the potential to support diverse instructional strategies, dynamic learning materials, and learning communities (Arnold & Paulus, 2010). Scholars thus have new opportunities to explore how social networking sites can be used to influence instructional design and learning outcomes.

Synchronous and asynchronous online discussion

Online discussion has been shown to benefit student learning by fostering high-level cognitive skills such as reasoning, argumentation (Pilkington & Walker, 2003; Yeh & She, 2010), and subject comprehension (Comeaux & McKenna-Buyington, 2003; Chen & She, 2012). Researchers continue to explore the educational advantages and disadvantages of different online communication approaches, particularly synchronous and asynchronous discussion.

Synchronous discussion involves online interaction in real time, establishing urgent and immediate feelings among students that foster a sense of community and that works well for content that stimulates debate (Schwier & Balbar, 2002). Learners enjoyed synchronous online discussions because it provided more social interaction (Hrastinski, 2008). It also fostered both cognitive and social activities (Oztok, Zingaro, Brett, & Hewitt, 2013). Despite receiving quick feedback (Davidson-Shivers, Muilenburg & Tanner, 2001), students had difficulty keeping up with long threads of discussion (Khine, Yeap, & Lok, 2003) and engaging in in-depth thinking (Hrastinski, 2008) when using synchronous online discussion within a short period of time.

While synchronous online discussion promotes the “social” aspect of education, asynchronous communication supports “academic” aspects of learning (Motteram, 2001). It is more appropriate for learners to engage in asynchronous online discussions when engaged with complex ideas because they have sufficient time to respond to posted messages (Hrastinski, 2008; Mandernach, Dailey-Hebert, & Donnelli-Sallee, 2007, Schrire, 2006).

The nature of science

The nature of science (NOS) is an all-encompassing concept that includes the process of forming scientific knowledge, and concerns “how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors” (McComas, 2008, p. 250). It contains one’s “conceptions about scientific knowledge and knowing, values and beliefs incorporated in gaining scientific knowledge, as well as the influences of society, culture, and technology on science” (Urhahne, Kremer, & Mayer, 2011).

While scholars have no consensus concerning the aspects of NOS, they often note three important issues. First, science derives from the collection of accumulated knowledge. New scientific claims emerge when scholars reinterpret old evidence, explain existing theories differently, or engage in new research directions. As such, scientific knowledge never remains absolute and certain (Lederman, 2007). Second, science involves creativity and imagination. Scientists need much creativity to explain science (Lederman, 2007). One science education standard, Benchmarks for Scientific Literacy (AAAS, 1993), indicated that learners should apply their imaginations to devise hypotheses and explanations while attempting to make sense of collected evidence and construct evidence-based explanations. Finally, scientific endeavors are characterized by continuous discussion, communication, and criticism among scientists. Within a society, scholars often encounter situations in which their scientific claims are questioned, especially when they use inappropriate, insufficient, or misinterpreted evidence. Individuals must negotiate and communicate their ideas with others in order to reach consensus. When scientific communities have internal agreement, their conclusions are likely to be accepted by the public.
International science education organizations, such as the American Association for the Advancement of Science (1993) and the National Research Council (1996), recognize that an adequate understanding of NOS would help students in scientific literacy. In this regard, learner understandings of NOS continuously constitute an area of intense academic interest. However, studies show that science teachers and students do not always possess adequate conceptions of NOS (Halai & McNicholl, 2004; McComas, Clough, & Almazroa, 1998).

**Implicit and explicit NOS instruction**

The differences between implicit and explicit approaches lie in the extent to which learners think about and reflect on the specific aspects of NOS (Abd-El-Khalick & Lederman, 2000). Implicit instruction supports students to experience “what science is and how it works” but providing no direct content to understand NOS (Clough, 2006, p. 467). However, several studies argued that implicit NOS instructions were generally not successful (Sandoval & Morrison, 2003; Schwartz, Lederman, & Thompson, 2001).

Considering the limitations of implicit NOS instruction, researchers suggest teaching NOS with explicit strategies to promote student reflection and discussion. Explicit NOS instruction deliberately designs science lessons to draw student attention to important NOS issues without lecturing or imposing NOS perspectives (Clough, 2006). In addition, prior studies widely reported that explicit NOS instruction supported student learning better than implicit instruction. Creswell and Clark’s (2007) study also demonstrated explicit and reflective instruction that helped students to achieve better NOS views and content knowledge than implicit instruction produced. Similarly, Peters (2012) found that students in the explicit instructional group significantly outperformed those in the implicit group on NOS. Thus, this study employed explicit instruction for NOS instruction.

**Learning science through news stories**

Recognizing the limitations of formal science education curriculum tend to teach straightforward but isolated scientific facts, scholars assert the significance of using real-world sources to bridge the gap between school curriculum and science in everyday life. The experiences individuals have in various learning contexts, such as watching television, visiting museums, and reading newspapers and magazines, influence the ways “individuals construct scientific knowledge, attitudes, behaviors, and understanding” (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003, p. 109). Thus, real-world experiences shape individual’s understanding of scientific knowledge and perceptions about the process of science. In addition, real-world learning experiences prepares students “to engage with science in the contexts they will encounter in later life.”(McClune & Jarman, 2010, p. 728). To achieve this, DeBoer (2000) suggests science education should prepare individuals to critically understand “reports and discussions of science that appear in the popular media” (p. 592).

For over a decade, instructors have recognized the potential value of utilizing media reports of scientific research in instruction to foster scientific literacy (Korpan, Bisanz, Bisanz & Henderson, 1997). According to McClune and Jarman (2010), almost any secondary school in the UK used newspapers as a resource to support science instruction to some extent. Given the fact that public media usually reports socio-scientific issues that are related to daily life, using newspapers in science education not only communicates important science information with individuals but also keeps learners informed about cutting-edge science issues. In this respect, news stories offer a great opportunity to stimulate learning interests, which facilitates further research and lifelong learning (McClune & Jarman, 2012). Especially, scholars (Korpan, Bisanz, Bisanz & Henderson, 1997; Zimmerman, Bisanz, Bisanz, Klein, & Klein, 2001) emphasized that media-based scientific research reports serve as an important source of new science knowledge in an age of information. Korpan and colleague’s (1997) study demonstrated the benefits of science-based news stories, finding that through reading, evaluation, and discussion about scientific research and news, readers not only learned the news content but also realized what the scientific community worked for and how scientific knowledge is formed.

**Purposes of the study**

The present study aims to investigate how synchronous and asynchronous online discussions via Facebook influence student informal science learning, especially on content-related NOS and science content knowledge. Three research questions guided the present study:
• Do synchronous and asynchronous discussions of scientific news stories influence student learning differently, particularly as regards the students’ general NOS views, content-related NOS views, and science content knowledge?
• How do different online discussion approaches (synchronous and asynchronous) influence students’ accumulative, creative, and community aspects in NOS when they analyzed scientific news stories?
• How do general NOS views and science content knowledge contribute to the development of content-related NOS views?

Methods

Participants

The current study took place in a junior high school in Northwestern Taiwan. Two 8th-grade and two 9th-grade science classes, all of which were taught by the same instructor, participated in this study. In total, 49 male and 34 female students joined the online discussion activities. The t-test gained from three science examinations in the first semester of the 8th grade year indicated that the participating students in both synchronous (N = 42) and asynchronous (N = 41) groups had no significant difference in their prior knowledge (t(83) = 0.18, p = 0.86).

Procedure

The current study encompassed eight class periods lasting 45 minutes each and occurring over the course of three weeks. Following the completion of three pretests (general NOS views questionnaire, content-related NOS views questionnaire, and science knowledge test), the instructor explained to the students the content of learning activities as well as features of NOS and the significance of understanding it. To help students understand NOS, this study posted seven scientific news stories on Facebook which allowed students to analyze the accumulative, creative, and community of NOS in each designated scientific news story (see Figure 1). The stories consisted of two themes: heat (calorie, exercise, green house) and elements (environmental change, gold, proton, high temperature superconducting material). The day after the students finished the online learning activities, they were given three multiple-choice posttests (general NOS views questionnaire, content-related NOS views questionnaire, and science knowledge test). In addition, in order to test whether students retained their knowledge, the same three tests were administered again three weeks later.

Figure 1. Scientific news story on Facebook.
Research design

This study adopted a quasi-experimental design which randomly assigned the four science classes to synchronous or asynchronous groups. One class in each grade level engaged in synchronous discussion, and the other engaged in asynchronous discussion. Each class was divided into five groups, with each group consisting of four to five students. While students in the synchronous groups spent 45 minutes (one class) analyzing a scientific news story on Facebook (see Figure 2), students in the asynchronous group had three days to finish their discussion of one news story.

![Figure 2. Students’ discussion on Facebook: Scientific news story.](image)

The participating students logged-in to Facebook and navigated to the page devoted to this study. For each discussion topic, the instructor posted the text of a scientific news story and a video clip related to the story. Following these, students were provided with three questions that required them to analyze the NOS features (accumulated knowledge, creativity, and scientific community) in each story. For example, students were asked “Which descriptions explained the creativity of science knowledge?” in the news story. In addition, each news story included one question encouraging students to discuss the content of the story, such as “Why isn’t it appropriate for patients with kidney problems to drink tea?”

Data collection

General NOS views questionnaire

Based on the important features of NOS identified in prior studies (Chen, 2006; Kao, 2006; Tsai, 2007), a questionnaire was designed to explore student general views of three features of NOS: accumulative, creative, and community. Fifteen content-independent multiple choice items, five for each NOS feature, investigated general NOS views. One of the items was, “A new scientific theory must be recognized by the majority of scientists in order to achieve the validity.” The instrument was measured by a 5-point Likert scale, ranging from strongly agree (5 points) to strongly disagree (1 point). The validity of the questionnaire was established by the input of four science education doctoral students and two scholars. The overall reliability of the questionnaire items was 0.86. Each of the three NOS features were represented on the questionnaire by five items each, with satisfied reliability (accumulative = 0.83, creative = 0.69, community = 0.82).
Content knowledge test

The content knowledge test consisted of fifteen multiple choice questions. The test measured students’ comprehension of the science content they discussed in the online interactions. This test required students to understand each discussion topic (2 items for each) and the practice topic before the intervention (1 item). In addition to the established expert validity, a Cronbach’s alpha showed adequate reliability scores for the comprehension measure (0.76).

Content-related NOS views

Two measurement methods were applied in the current study for analyzing students’ understanding of content-related NOS while analyzing scientific news stories. First, this study implemented a newly-designed instrument (Content-related Nature of Science View Questionnaire) that was based on scientific news stories. These stories were discussed in class, and were used to assess the changes in students’ content-related NOS views. Unlike the general NOS views questionnaire, this one measured how students analyzed the NOS in each scientific news story, specifically regarding the features of accumulated knowledge, creativity, and scientific community. Within each scientific news story, the three major NOS features were measured individually using two multiple-choice questions. First, students justified which description in the selected paragraph best explained the accumulated knowledge, creativity, or community aspects of NOS. Second, students explained their reasons by answering the multiple-choice question. For instance, a question asked,

Why do you think your choice best describes the feature of NOS? Please explain. (A) They designed an unprecedented biological experiment because they used monkeys as subjects. (B) The experiment lasted for more than twenty years. (C) The cause of the monkeys having different appearances was their diet. (D) The research team pointed out an innovative theory: longevity comes from a low calorie diet.

Students received full credit (one point) only if they answered both questions accurately. If not, they gained no points. The questionnaire contained 42 questions with an average reliability of 0.83.

Second, the discussions in the Facebook forum were measured to evaluate the level of student understanding about NOS in each aspect. During the discussion, students analyzed each scientific news story by identifying its NOS features in terms of three major aspects of accumulated knowledge, creativity, and community. A science educator and a middle school science teacher developed a coding system to analyze student NOS views for each scientific news story. Two middle school science teachers used this coding system to categorize students’ responses into three levels for each aspect of accumulated knowledge, creativity, and community – complete (2 points), partially complete (1 point), and unrelated (0 point) – with an inter-rater reliability of 0.93.

Results

This study investigated how different discussion approaches in Facebook influenced students’ scientific knowledge acquisition and the nature of science (NOS) views both in general and content-related views. A multivariate analysis of the questionnaires given before the intervention showed that the performance of students in both the synchronous and asynchronous groups showed no statistically significant difference in terms of content knowledge, and general and content related NOS views ($F(3, 79) = 0.65$, $p = 0.59$, Wilk’s $\lambda = 0.98$, partial $\eta^2 = 0.02$).

General NOS views

The pretest, posttest, and retention test scores were collected to measure whether students’ general NOS views have changed significantly after they engaged in synchronous or asynchronous online discussions. A paired samples $t$ test in Table 1 indicated that after participating in online discussions, students on average achieved significantly better understanding of NOS as indicated by the different posttest and pretest scores, regardless of whether they were assigned to a synchronous ($t (41) = 2.14$, $p = 0.04$, Cohen’s $d = 0.33$) or asynchronous ($t (40) = 2.12$, $p = 0.04$, $d = 0.32$).
Cohen’s $d = 0.33$) group. However, only synchronous online discussion groups showed a significant difference between the pretest and retention test scores ($t(41) = 2.88, p = 0.01$, Cohen’s $d = 0.44$).

**Table 1. Descriptive statistics and paired t-test**

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Retention</th>
<th>Posttest-Pretest</th>
<th>Retention-Pretest</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M(SD)</td>
<td>$t$ test $(p)$</td>
<td>$t$ test $(p)$</td>
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<tr>
<td><strong>Views of NOS</strong></td>
<td></td>
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<tr>
<td>Synchronous (N = 42)</td>
<td>56.55</td>
<td>59.05</td>
<td>59.33</td>
<td>2.14</td>
<td>2.88</td>
</tr>
<tr>
<td>(N = 41)</td>
<td>(6.45)</td>
<td>(5.99)</td>
<td>(6.25)</td>
<td>(0.04)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Asynchronous (N = 41)</td>
<td>56.51</td>
<td>59.41</td>
<td>57.49</td>
<td>2.12</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>(6.34)</td>
<td>(7.23)</td>
<td>(6.71)</td>
<td>(0.04)</td>
<td>(0.44)</td>
</tr>
<tr>
<td><strong>Science knowledge</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Synchronous (N = 42)</td>
<td>4.52</td>
<td>10.05</td>
<td>10.17</td>
<td>12.24</td>
<td>11.22</td>
</tr>
<tr>
<td>(N = 41)</td>
<td>(2.64)</td>
<td>(2.52)</td>
<td>(2.77)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Asynchronous (N = 41)</td>
<td>3.88</td>
<td>8.39</td>
<td>8.27</td>
<td>7.88</td>
<td>8.19</td>
</tr>
<tr>
<td></td>
<td>(1.81)</td>
<td>(3.81)</td>
<td>(3.46)</td>
<td>(0.00)</td>
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<tr>
<td><strong>Content-dependent NOS</strong></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Synchronous (N = 42)</td>
<td>2.10</td>
<td>7.95</td>
<td>7.83</td>
<td>8.81</td>
<td>7.67</td>
</tr>
<tr>
<td>(N = 41)</td>
<td>(2.12)</td>
<td>(4.59)</td>
<td>(5.45)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Asynchronous (N = 41)</td>
<td>1.85</td>
<td>7.49</td>
<td>7.05</td>
<td>7.58</td>
<td>6.45</td>
</tr>
<tr>
<td></td>
<td>(1.74)</td>
<td>(4.92)</td>
<td>(5.16)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
</tbody>
</table>

**Note.** Views of NOS posttest scores: high = 75; low = 36. Retention scores: high = 73; low = 44. Science knowledge posttest scores: high = 15; low = 1. Retention scores: high = 15; low = 2. Content-dependent NOS posttest scores: high = 19; low = 1. Retention score: high = 19; low = 1.

Multivariate analyses of covariance (MANCOVA) were conducted to investigate whether instructional strategies (synchronous vs. asynchronous discussion) influenced students’ overall general NOS views on both the posttest and retention test, with the pretest as the covariate in each analysis model. Instructional strategies were entered as the independent variable and the general NOS views questionnaire as the dependent variable. The preliminary data screening indicated no violation of the assumptions of linearity, homogeneity of variance-covariance matrices, and equality of variance. The result showed that there was no statistically significant difference between synchronous and asynchronous discussion groups on the combined dependent variables after adjusting the pretest score, $F(2, 79) = 1.98, p = 0.15$, Wilk’s $\lambda = 0.95$, partial $\eta^2 = 0.05$ (see Table 2). In short, students in the two discussion groups did not have significantly different general NOS views in either the posttest or retention test, after adjusting the pretest scores.

**Table 2. Multivariate analysis of covariance in views of NOS, content-related NOS view, and science knowledge tests**

<table>
<thead>
<tr>
<th></th>
<th>Wilk’s $\Lambda$ (Partial $\eta^2$)</th>
<th>$A$</th>
<th>Multivariate $F$ ($p$)</th>
<th>Univariate $F$ Posttest ($p$)</th>
<th>Univariate $F$ Retention ($p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Views of NOS</strong></td>
<td></td>
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</tr>
<tr>
<td>Pretest</td>
<td>0.85 (0.15)</td>
<td>6.80 (0.00)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.95 (0.05)</td>
<td>1.98 (0.15)</td>
<td>0.07 (0.79)</td>
<td>1.92 (0.17)</td>
<td></td>
</tr>
<tr>
<td><strong>Science knowledge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.91 (0.09)</td>
<td>3.84 (0.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.93 (0.07)</td>
<td>3.13 (0.05)</td>
<td>5.45 (0.02)</td>
<td>7.60* (0.01)</td>
<td></td>
</tr>
<tr>
<td><strong>Content-related NOS views</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>0.89 (0.12)</td>
<td>5.11 (0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>1.00 (0.00)</td>
<td>0.17 (0.84)</td>
<td>0.08 (0.78)</td>
<td>0.26 (0.61)</td>
<td></td>
</tr>
</tbody>
</table>

**Content knowledge**

As the pretest/posttest scores in Table 1 show, students improved their science content knowledge significantly after participating in this study, regardless of whether engaged in synchronous ($t(41) = 12.24, p = 0.00$) or asynchronous
A MANCOVA analysis tested whether students in different discussion groups achieved significantly different levels of science knowledge comprehension in the posttest and retention test when students’ prior test was controlled as the covariate. The assumption of the homogeneity of variance was met. The analysis revealed that instructional strategies had a significant effect on the combined dependent variables, $F(2, 79) = 3.13, p = 0.049$; Wilk’s $\lambda = 0.93$; partial $\eta^2 = 0.07$. Follow-up univariate ANCOVAs continued to showed that instructional strategies in online discussion groups significantly affected students’ science comprehension immediately after learning (Welch’s $F(1, 69.15) = 5.45, p = 0.02$). Students in the synchronous discussion group achieved higher content knowledge than those in the asynchronous discussion group in the posttest. The positive effects of synchronous discussion over asynchronous discussion on science knowledge development were also reflected in the retention science content knowledge test, Welch’s $F(1, 76.49) = 7.61, p = 0.01$.

**Content related NOS views**

*Content-related NOS Views Questionnaire*

Paired sample $t$ tests were conducted to evaluate the impact of online discussion on student scores on the Content-related NOS Views Questionnaire. There was a statistically significant increase between the pretest and posttest questionnaire scores in both the synchronous ($t(41) = 8.81, p = 0.00$, Cohen’s $d = 1.36$) and asynchronous ($t(40) = 7.58, p = 0.00$, Cohen’s $d = 1.18$) groups. Comparing pretest and retention test scores also indicated that student overall content-related NOS views improved after they participated in this study, regardless of to which group they were assigned ($p = 0.00$).

A MANCOVA was performed to investigate whether different instructional strategies utilized in online discussion groups influenced students’ content-related NOS views. The MANCOVA test revealed that there was no statistically significant difference between synchronous and asynchronous discussion groups on the combined dependent variables, controlling for the pretest ($F(2, 79) = 0.17, p = 0.84$; Wilk’s $\lambda = 1.00$; partial $\eta^2 = 0.00$).

**Scientific news stories analysis in Facebook**

The student discussions in Facebook were collected and analyzed to determine the extent of student understanding about each aspect of content-related NOS views. To determine whether online discussion strategies influenced student understanding of each aspect, three separate one-way ANOVA were conducted. The dependent variable in each statistical analysis model was student responses to scientific news stories in Facebook in terms of each aspect of NOS (accumulative, creative, or community aspects). Statistics found that different online discussion approaches influenced student comprehension of scientific community significantly, $F(1, 81) = 8.64, p = 0.00$ (see Table 3). When students participated in synchronous online discussion, they were more likely to gain a better understanding of scientific community concepts in content-related NOS than those in asynchronous online discussion groups ($M_{Synchronous} = 1.19, SD = .08; M_{Asynchronous} = .88, SD = .08$).

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Synchronous</th>
<th>Asynchronous</th>
<th>$F$</th>
<th>$P$</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accumulation</td>
<td></td>
<td>0.64 (0.06)</td>
<td>0.68 (0.06)</td>
<td>0.24</td>
<td>0.63</td>
<td>0.00</td>
</tr>
<tr>
<td>Creativity</td>
<td>1.11 (0.72)</td>
<td>1.10 (0.07)</td>
<td></td>
<td>0.01</td>
<td>0.94</td>
<td>0.00</td>
</tr>
<tr>
<td>Community</td>
<td>1.19 (0.75)</td>
<td>0.88 (0.08)</td>
<td>8.64</td>
<td>0.00</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>

To understanding better the differences between synchronous and asynchronous discussion groups vis-à-vis the community aspect of content-related NOS, student responses to each scientific news story in Facebook were analyzed qualitatively.
At the beginning of the intervention, students in both groups tended to simply define scientific community as a teamwork system which encouraged scientists to discuss and conduct research cooperatively. Students in the asynchronous group continued this belief by defining scientific community as a group of people working together. For example, one student simply defined scientific community as “research teams.” This indicated that students who engaged in asynchronous groups failed to define scientific community completely even after several discussions. In contrast, the majority of students in the synchronous group noted that one component of scientific community is the public. That is, other scientists had to comment on researchers’ ideas and the public must acknowledge these ideas and incorporate them into a public discourse. For example, student L described the community aspect in a scientific news story in the following way:

Professor Maw - Kuen Wu discovered a new research on the superconductor. His research had been recognized and accepted by other scientists and published to the famous journal in order to acquire the acknowledgement of scientific community. This is what scientific community means.

The benefits of a scientific community were also noted. Students in the synchronous groups stressed that researchers needed to record their studies carefully in order to allow scientists to examine and test their research outcomes.

Dr. Kennett's research results were published in Science, the prestigious academic journal. Russian American scientist George Gamow re-examined Kennett's theory with different scientific methods and reached similar conclusions. (Student H)

Thus, student view of community were close to what researchers (Lederman, 1992; McComas, 2008) emphasize; that is, that new knowledge had to be reported clearly and openly in order to establish community in NOS.

Predictions on content-related NOS views

In order to investigate how general NOS views and science content knowledge contributed to students’ development in content-related NOS views, three multiple linear regression models were carried out to determine the effects these variables had on the pretest, posttest, and retention test.

The first linear regression was performed to observe how pretests, which measured both science content knowledge and general NOS views, explained student content-related NOS views which were also measured before the intervention. Preliminary data checking showed that multicollinearity did not seem to be a problem for this model. The analysis found that the combination of independent variables significantly predicted students’ content-related NOS views, $F(2, 80) = 5.12, p < .01$. The R-square value indicated that about 12% of the variance in the dependent variable was explained by both independent variables. While the science knowledge pretest significantly predicted the students’ content-related NOS views as shown through their pretest scores (standardized beta = 0.35, $p = 0.00$), NOS views alone did not appear to have a significant contribution to predicting students’ prior content-related NOS views ($p = 0.27$).

<table>
<thead>
<tr>
<th>Model</th>
<th>Outcome variable</th>
<th>Predictor variable</th>
<th>B</th>
<th>β</th>
<th>SE</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression 1: Pretest</td>
<td>Content-related NOS</td>
<td>Science knowledge</td>
<td>0.31</td>
<td>0.35</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Views of NOS</td>
<td>-0.04</td>
<td>-0.12</td>
<td>0.03</td>
<td>0.27</td>
</tr>
<tr>
<td>Regression 2: Posttest</td>
<td>Content-related NOS</td>
<td>Science knowledge</td>
<td>0.78</td>
<td>0.55</td>
<td>0.13</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Views of NOS</td>
<td>0.13</td>
<td>0.19</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>Regression 3: Retention</td>
<td>Content-related NOS</td>
<td>Science knowledge</td>
<td>0.81</td>
<td>0.50</td>
<td>0.16</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Views of NOS</td>
<td>0.14</td>
<td>0.17</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Using two posttests on science knowledge and general NOS views as the independent variables, the second multiple regression analysis investigated to what extent these variables predicted students’ content-related NOS views as represented by the posttest scores. Preliminary data checking also showed no violation of assumptions in conducting multiple regression analysis. The analysis revealed that the two independent variables accounted for a significant amount of variability in the dependent variable, $F(2, 80) = 25.37, p < .001$. The value of 0.388 for R square
indicated that the two predictor variables together accounted for 39% of the variability on content-related NOS posttest scores. In addition, both posttest scores for science knowledge and general NOS views had unique contribution in predicting how well students developed their content-related NOS views as measured in the posttest. The beta weights, presented in Table 4, suggest that science knowledge achievement contributed most to predicting students’ content-related NOS views, followed by general NOS views.

The final multiple regression analysis of the retention test was conducted to assess the simultaneous effects of students’ science knowledge and NOS views on content-related NOS views. Data analysis revealed no serious threats to the assumptions of linearity and normal distribution of residuals of the dependent variable. The result of the multiple regression model found an R of 0.57 and an R square of 0.33. When both science knowledge and general NOS views were treated as predictors, about 33% of the variance in content-related NOS views could be predicted. The overall regression was statistically significant, $F (2, 80) = 19.687, p = 0.00$. Only the science knowledge retention test scores accounted for a significant amount of unique variance in the dependent variable ($p = 0.00$), and general NOS views did not appear to significantly contribute to predicting student content-related NOS views ($p = 0.08$) (see Table 4).

**Discussions and implications**

This research explored how discussing scientific news using different communication approaches influenced student learning, especially the effects that this had on students’ scientific content knowledge, and general and content-related NOS views. Students engaged in either asynchronous or synchronous online discussion analyzed news stories in terms of the accumulative, creative, and community aspects of NOS. Recognizing the potential educational benefits of using scientific news in informal science instruction, the current study combined scientific news with popular social networking tools.

Results showed that all students improved their science content knowledge, and general and content-related NOS views regardless of which group they were assigned. While Johnson (2008) claimed that communication in synchronous and asynchronous approaches had no significant impact on student learning, this study found that students in synchronous groups acquired better understanding of science content knowledge than those in asynchronous groups. The ability to receive quick feedback and responses (Davidson-Shivers, Muilenburg & Tanner, 2001) in synchronous discussion benefited student learning. By providing students with a sense of community (Schwier & Balbar, 2002), synchronous discussion in this study helped students to communicate cognitively and socially.

This study also examined how different types of online discussion approaches influenced student content-related NOS views when they analyzed scientific news in Facebook. When students engaged in online synchronous discussion to analyze the NOS features of scientific news, they understood community aspects of content-related NOS better than those in asynchronous discussion groups. But different communication approaches showed no significant difference in terms of how students analyzed the accumulative and creative features of NOS in scientific news. Like the findings of prior studies (Khishfe, 2008), students in the current study did not show consistent improvement in all aspects of NOS when they received explicit instruction. One reason for this might be the nature of synchronous communication. Schwier and Balbar (2002) emphasized that synchronous strategies such as real time chat experiences created a strong sense of community compared to asynchronous strategies. Therefore, prompting individuals to discuss scientific news synchronously is likely to enhance their scientific community aspect of NOS views as well.

A regression analysis revealed the improvement of students’ general NOS views as well as the significance of science knowledge to foster content-related NOS. As shown in the pretest regression model, students’ general NOS views did not account for their development of content-related NOS views. But the posttest regression showed that general NOS views significantly predicted development of content-related NOS views. Therefore, analyzing scientific news, as presented in the current study, significantly enhanced the development of students’ general NOS views. Moreover, all regression tests revealed that science knowledge significantly predicts student content-related NOS. This finding highlights the value of explicit NOS instruction, strengthening the connection between science knowledge and content-related NOS understanding (Clough, 2006).
We conclude that synchronous online discussion facilitates the development of content knowledge, which fosters understanding of content-related NOS. While scholars believed that asynchronous discussion benefited complex thinking and discussions (Mandernach, Dailey-Hebert, & Donnelly-Sallee, 2007; Romiszowski & Mason, 2004; Schrire, 2006), the findings of this study favored synchronous communication to teach content-related NOS. Such results further indicate that learning NOS, especially when it is embedded within explicit instruction, is not a difficult task for middle school students.

Moreover, consistent with prior studies (Khishf & Abd-El-Khalick, 2002; Southerland, Gess-Newsome, & Johnston, 2003), the current study highlights how explicit instruction supports NOS learning. The positive learning outcomes reiterate the educational value of engaging individuals in critically reading scientific news in order to learn NOS. While the current research only investigated three aspects of NOS, future studies should continue exploring whether synchronous discussion also benefits other aspects of NOS learning. In addition, it also would be beneficial to explore why synchronous communication can effectively develop students’ science content knowledge and views of community aspects of content-related NOS, but not accumulated knowledge and creativity. Also, this study only analyzed each student’s response to scientific news without considering the context of student conversation from a holistic viewpoint. Future studies should analyze the content of threaded discussion, such as how the process of student interaction with peers influenced student learning.

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References


