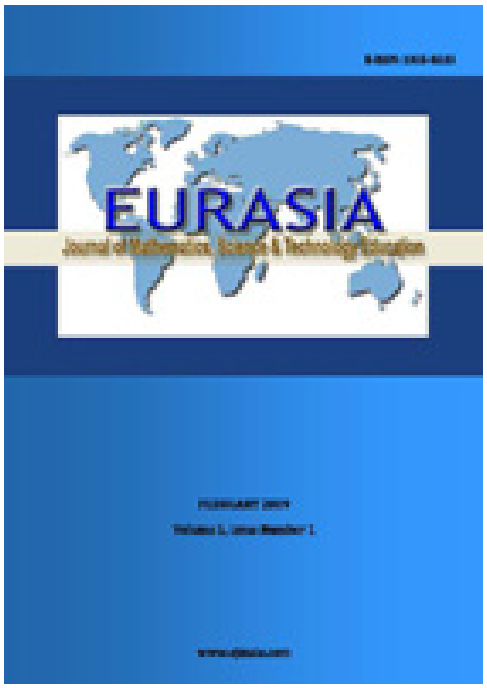
Eurasia Journal of Mathematics, Science & Technology Education
www.ejmste.com



Analysis of Teaching Resources for Implementing an Interdisciplinary Approach in the K-12 Classroom

Morgan B. Yarker and Soonhye Park
The University of Iowa, USA

Received 15 September 2010; accepted 15 December 2011
Published on 28 October 2012

APA style referencing for this article: Yarker, M. B. & Park, S. (2012) Analysis of Teaching Resources for Implementing an Interdisciplinary Approach in the K-12 Classroom. *Eurasia Journal of Mathematics, Science & Technology Education*, *8*(4), 223-232.

Linking to this article: DOI: 10.12973/eurasia.2012.841a

URL: http://dx.doi.org/10.12973/eurasia.2012.841a

ISSN: 1305-8223 (electronic) 1305-8215 (paper)

The article starts with the next page.

Eurasia Journal of Mathematics, Science & Technology Education, 2012, **8**(4), 223-232

Analysis of Teaching Resources for Implementing an Interdisciplinary Approach in the K-12 Classroom

Morgan B. Yarker and Soonhye Park
The University of Iowa, USA

Received 15 September 2010; accepted 15 December 2011

Articles from the National Science Teacher Association (NSTA) publications were analyzed to investigate resources available for teachers who want to implement interdisciplinary approaches into the science classroom. All articles in each journal from 2004 through 2008 were read an analyzed; approximately 13% of Science & Children (elementary), 21% of Science Scope (middle), and 17% of The Science Teacher (high school) articles met the interdisciplinary approach criteria. Results show that overall, reading, writing, art, and technology are the subjects most commonly integrated into science. Surprisingly, math is rarely discussed across all school levels. Comparing the articles across different school levels, Science Scope articles have the highest number of integrated articles, whereas The Science Teacher had the fewest number of integrated articles.

Keywords: interdisciplinary, cross-curriculum, mathematics, teacher resources

INTRODUCTION

Science process skills are transferable intellectual skills, appropriate to all scientific endeavors (NSTA, 2000). Science process skills are in two categories which are basic and integrated skills. Basic process skills include observing, inferring, measuring, communicating, classifying, predicting, using time space relations and Many reform documents (e.g., National Science Education Standards, NRC, 1996; 2012; Benchmarks for Scientific Literacy, AAAS, 1993) represent the broad vision of scientific literacy as the desired endpoint of science education. Scientific literacy is the knowledge and understanding of scientific concepts and processes required for a person to ask, find, or determine answers to questions derived from curiosity about everyday experiences (NRC, 1996; 2012).

To raise scientifically literate citizens, science teachers need to organize experiences to allow students to relate scientific knowledge to their real life. However our real world experiences have never been segmented into disciplines. In this regard, science should be taught in a way that makes connections among different disciplines and, thus, with the real world of the student. Interdisciplinary approaches to teaching science have been suggested to be an effective way to increase scientific literacy in our students (Bybee, 1997) in that they reflect real world problems in which various disciplines and perspectives may be brought to resolve (Beane, 1997).

Teachers often find it difficult to incorporate interdisciplinary approaches in their science curriculum (Newell, 1994; Applebee, Adler, & Flihan, 2007). A major reason for this is that interdisciplinary approaches require time and resources for teachers that are not usually available (Adler & Flihan, 1997). To address this issue, we analyzed every article published in National Science Teacher Association (NSTA) journals, Science & Children (elementary school journal), Science Scope (middle school journal), and The Science Teacher (high school journal), published from 2004 through 2008 to investigate the characteristics of resources available for teachers who want to implement such approach.Then, this study examined two research questions:

Correspondence to: Morgan B. Yarker, Professor of Science Education, Science Education Program, College of Education, The University of Iowa, N259 Lindquist Center, Iowa City, IA 52242, USA
E-mail: *morgan-e-brown@uiowa.edu*

ISSN: 1305-8223

State of the literature

- Many reform documents suggest that the desired goal of K-12 science education is for students to have a broad vision of scienctific literacy. Interdisciplinary approaches can be an effective way to increase scientific literacy in our students.
- Teachers often find it difficult to incorporate interdisciplinary approaches in their science curriculum because it requires time and resources for teachers that are not usually available.
- Recent research in science education has been advocating the need to incorporate skills, such as reading and writing, into the science classroom.

Contribution of this paper to the literature

- With appropriate support for teachers, incorporating other disciplines into the science classroom can be relatively easy to do. However, teacher journals are lacking in true interdisciplinary resources, which makes implementation of interdisciplinary approaches very difficult for teachers to achieve.
- The NSES suggest that mathematical understanding is critical to all aspects of scientific inquiry. Given this emphasis, it is surprising that only 41 of the total 276 interdisciplinary articles identified (out of a total of 1,614 articles analyzed) incorporated math.
- Many researchers argue the importance of developing interdisciplinary curriculum within a teaching team, particularly for extensive, yearlong curriculum development. Of the 276 articles identified in this study, there were only 5 that suggest extensive, yearlong development of curriculum.

1) *How many resources for interdisciplinary approaches exist in practical publications that provide teachers with direction for future endeavors in this area?*

2) What types of interdisciplinary approaches exist in these practical publications? This includes both the disciplines incorporated into science as well as the resources provided to teachers to help them implement the approach effectively.

Literature Review

What is an interdisciplinary approach?

Much of the literature about interdisciplinary approaches describes approaches across a continuum, ranging from true disciplinary teaching (traditional methods) to pure interdisciplinary approaches (Adler & Flihan, 1997; Applebee, Adler, & Flihan, 2007; McComas, 2009). The most blended interdisciplinary curriculum source is, perhaps, the most difficult to orchestrate, however it does allow for individual teachers to experiment with their curriculum and can lend to a more positive learning experience for both the teacher and students (Adler & Flihan, 1997). Applebee, Adler, & Flihan, (2007) define this most blended approach as reconstructed curriculum, in which the concepts from different disciplines are completely merged so that students approach learning content across more than one discipline simultaneously (Adler & Flihan, 1997; Applebee, Adler, & Flihan, 2007). In this case, one specific discipline is no longer the focus of the course; rather instruction is based on exploration of a common theme or problem. The goal of this approach is for the students to learn real world concepts that are broad and convey multiple aspects of more than one discipline at a time (Newell, 1994; Applebee, Adler, & Flihan, 2007; McComas, 2009).

Less blended interdisciplinary approaches can be labeled as intradisciplinary approaches (McComas, 2009). For example, Applebee, Adler, & Flihan, (2007) observed teachers who worked in interdisciplinary teams often used a type of correlated curriculum, which involves two or more teachers from two or more disciplines working together to correlate their curriculum with each other. Generally, teachers will develop coordinated or integrated lesson plans between two classrooms so that major themes are discussed at the same time (Adler & Flihan, 1997; Applebee, Adler, & Flihan, 2007). A slightly more interdisciplinary approach than the correlated curriculum is a shared curriculum, where a course is designed that focuses on broad, thematic, and integrated concepts. An example of such a course is a general science course that covers topics in biology, chemistry and physics simultaneously (McComas, 2009).

From a theoretical perspective, using an interdisciplinary approach can be described as a crossing between different ways of knowing (McComas, 2009). Teaching a common theme without restricting student thinking to a specific discipline of knowledge provides opportunity for development of problem-solving skills (Beane, 1997; Bybee, 1997); which is not a discipline-specific process. Since most social problems require knowledge from multiple disciplines to solve, teaching through discipline segregation could hinder student critical thinking skills (Cohen & Staley, 1982; McComas, 2009). In other words, allowing students to think about a problem without discipline restrictions can help them be better able to see connections in content between two different disciplines.

Interdisciplinary approaches in science

Recent research in science education has been advocating the need to incorporate skills, such as reading and writing, into the science classroom because these skills are necessary in the process of doing science (e.g., Alexander et al., 2008; Fang et al., 2008; Prain & Hand, 1996). Simple lesson-based reading and writing assignments give students the opportunity to learn how to write and enjoy reading while simultaneously learning science. In addition, the writing assignments can easily be used to assess student learning, which is a key element in inquiry learning (NRC, 1996; 2012; AAAS, 1993).

Integrating science into other disciplines brings about meaning to science, helps students understand the role science plays in society, and makes science more realistic (Cohen & Staley, 1982; McComas, 2009). For example, a study by Fang et al. (2008) found that students who infused reading into their science content showed a statistically significant increase in science literacy. Additionally, students who wrote creatively about science (rather than writing a typical report) felt that they had learned about both English and science during the course of the project (Alexander et al., 2008). This process of "writing-to-learn" has been discussed in recent science education literature and is shown to help students increase their understanding of science content as well as critical thinking skills (Prain & Hand, 1996).

Not only does teaching across multiple disciplines enhance student learning, students may be able to learn through a context that has personal meaning to them, which can empower students to learn on their own (McComas, 2009). Specifically, science topics can be introduced in terms of social issues that are relevant and important to students. This approach can be a better method to teach science in a way that allows learning for everyone, even those not interested in science careers (Schwartz 1999; McComas, 2009).

Difficulties in implementing interdisciplinary approaches

Studies suggest that it can be very difficult for teachers to develop their own interdisciplinary curriculum (Newell, 1994; Applebee, Adler, & Flihan,2007). As a result, it is highly recommended that teachers use teaching teams as an approach to design and practice the types of intradisciplinary approaches discussed earlier. However, simply forming teacher teams within a traditional science classroom is not sufficient for effective implementation of interdisciplinary practices. It takes dedication to design a curriculum that fully integrates two disciplines into a broad, real-world concept (Newell 1994), while still allowing teachers to have independent exploration in their teaching and assessing methods (Applebee, Adler, & Flihan, 2007). In addition, traditional science classrooms must undergo restructuring to focus on broad topics rather than individual facts (Newell 1994; Richards & Shea, 2006) because each discipline requires a different set of procedures to teach content-specific knowledge effectively (Colomb, 1999).

Few teachers experience interdisciplinary approaches as learners therefore teachers generally find it easier to link two similar disciplines (such as biology and chemistry) than two drastically different disciplines, like biology and literature. Additionally, student performance on required examinations and curriculum standards may cause resistance to change from methods that provide high scores. Therefore, it is expected that for students to successfully learn using interdisciplinary approaches, both them and the teacher need to see the advantages of such a practice (McComas, 2009). To accomplish this, there needs to be explicit education for teachers so that they are more easily able to connect other disciplines to science content. The goal of this paper is to explore resources available in practical journal articles that provide teachers with explicit ideas on how to incorporate truly interdisciplinary techniques into their science classrooms.

METHODS

Data Collection

For the purpose of this study, articles that discuss interdisciplinary approaches to teaching science were identified for all articles in all issues of Science & Children, Science Scope, and The Science Teacher from 2004 through 2008. The types of articles identified as interdisciplinary approaches to teaching science only included articles that emphasized both a science and a non-science discipline equally throughout the lesson. For example, lessons that incorporate writing-to-learn techniques use the writing to help students understand the science content, hence writing plays a central role in the science lesson. In contrast, simply including basic math equations into a science lesson does not adequately emphasize the math discipline into the science classroom, thus it is not included in this study.

Additionally, this study only considers articles that include disciplines outside of science. Therefore, an article that provides a teaching approach that blends physics and biology is not considered, but in contrast an article that blends biology and art is considered.

Data Analysis

Once all relevant articles were identified, they were coded to identify 1) the discipline that was integrated into science as well as 2) the teaching tools provided in

the article. Disciplines identified in articles that met the interdisciplinary criteria were math, art, reading, social studies, engineering, writing, language arts, environment, culture, statistics, technology, music, history, crime, and architecture. Teaching tools identified included resources, lesson plans, general strategies, real-classroom examples, assessment, and general information. Table 1 provides a complete list of the disciplines and teaching tools discussed in the identified articles.

Resources include books, Internet sites, teacher workshops, and other types of information for teachers, either as a source for content or as something they can bring into their classrooms for students to use. Assessments include rubrics, suggested assignments for grading, and assessment examples. Lesson plans are any formal procedures provided in the article, which may include (among other things) a material list, step-by-step process, intended learning outcome, or an assignment. Real-classroom examples were articles where the author documented his or her experiences while implementing an interdisciplinary approach in their class, generally providing documentation of student assignments and photographs of student experiences Informative articles were very general, providing readers with interesting facts, interviews with professional scientists, food-for-thought, or the authors opinion about a concept. Similarly, general strategies were relatively broad (as compared to the other teaching tools) in that they provided general ideas on how teachers could incorporate other disciplines into the science classroom; such as having students write lab reports in the form of a comic book rather than a traditional report, to strengthen creative writing and art skills with the science content.

In order to analyze patterns across the journals, a correlation coefficient and student's t-test are used. The correlation coefficient quantifies the linear relationship between two data sets and the student's t-test determines the probability that the relationship between two variables is statistically significant (Vardeman & Jobe, 2001). For this study, the paired student's t-test determines if the relationship identified by the correlation coefficient between specific disciplines for each of the three NSTA journals is statistically significant. For example, a paired student's t-test will tell us the probability that the correlation between articles that discuss writing in Science & Children and in Science Scope is significant. Determining the statistical significance is important because it provides us with an idea of how a discipline is linked across all three different school- level journals.

RESULTS

The total number of articles published in Science & Children from 2004 through 2008 was 554. Of these, 72 (approximately 13%) fit the interdisciplinary criteria. The total number of articles published in Science Scope from 2004 through 2008 was 532. Of these, 112 (approximately 21%) fit the interdisciplinary criteria. Finally, of the 528 articles in The Science Teacher printed from 2004 through 2008, 92 were interdisciplinary (approximately 17%). The journal with the most interdisciplinary articles was Science Scope, the middle school journal.

Figure 1 indicates the total number of interdisciplinary articles found, listed by the discipline incorporated into the science content. The total for all journals combined indicates that reading is the most commonly discussed discipline, followed by art, writing, and history, respectively. Additionally, the total for each journal is identified. The most common discipline incorporated into Science & Children is reading, writing for Science Scope, and technology for The Science Teacher.

Table 1. provides a complete list of the disciplines and teaching tools discussed in the identified articles.

Discipline	Teaching Tools
Math	Lesson plans
Art	Strategies
Reading	Real classroom examples
Social studies	Informative
Engineering	Assessment (e.g., rubrics, assignments, examples, etc.)
Writing	Resources (e.g., books, Internet, teacher workshops, etc.)
Language arts	
Environmental studies	
Culture	
Statistics	
Technology	
Music	
History	
Crime	
Architecture	

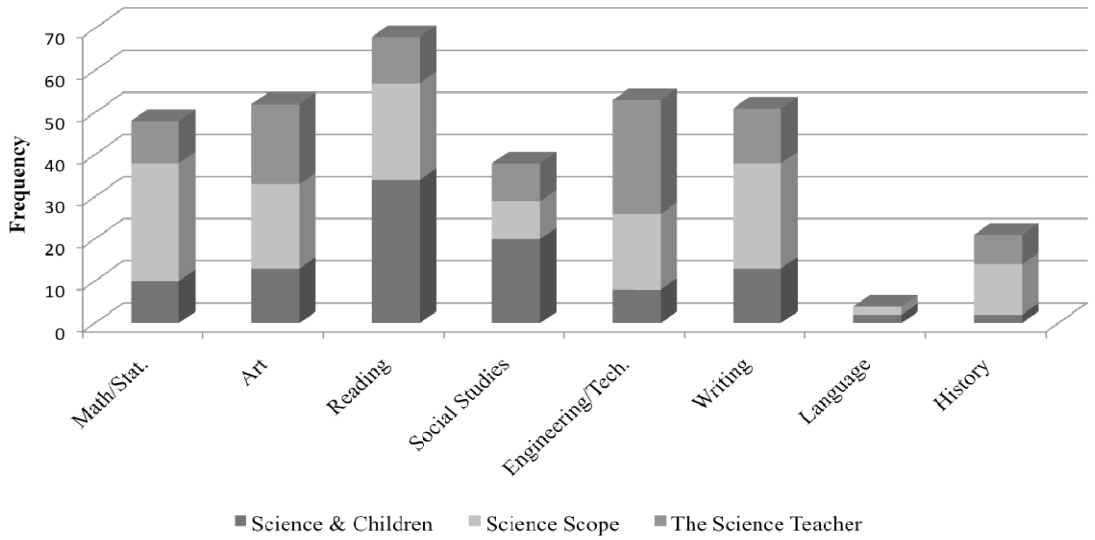


Figure 1. Frequency chart of disciplines discussed in *The Science Teacher*, *Science Scope*, and *Science & Children* articles.

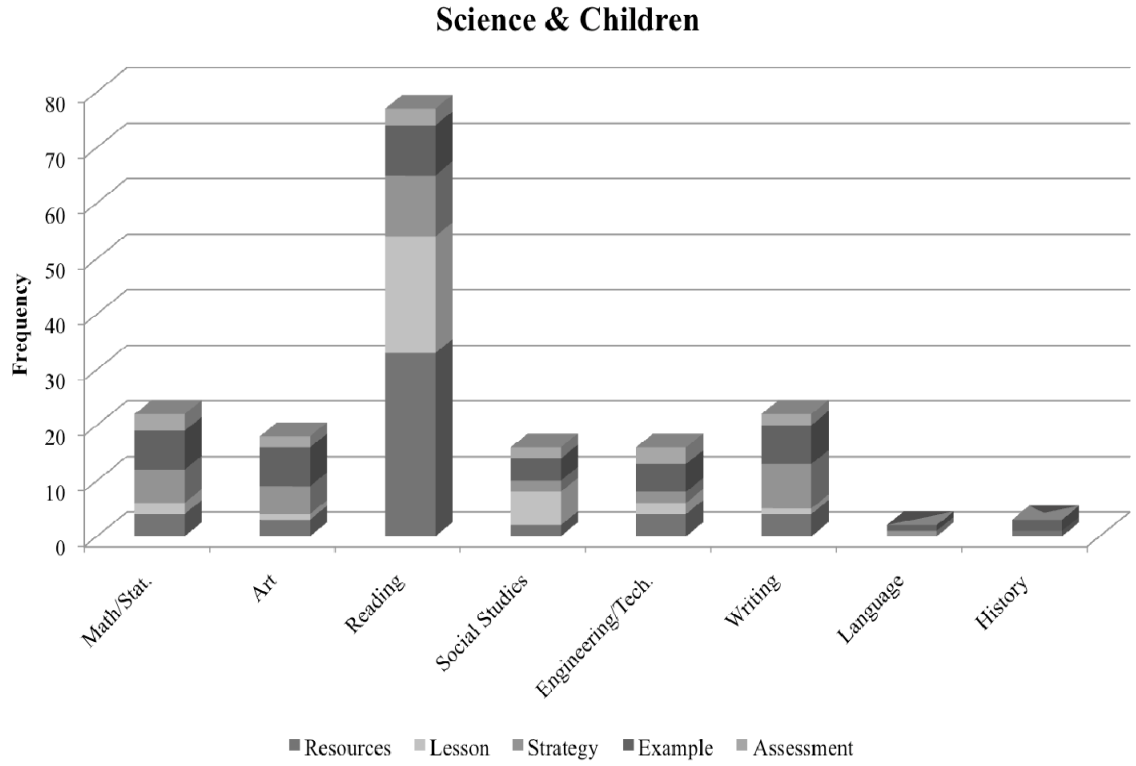


Figure 2. Frequency chart showing the types of teacher resources provided in each discipline for elementary school, *Science & Children* articles

Results from the student's t-test indicate statistically significant (at the 90% level) correlations between Science Scope and The Science Teacher for math (0.76) and history (0.76), Science & Children and Science Scope for technology (0.48) and history (0.82), and Science & Children and The Science Teacher for reading (0.64). These correlation values indicate that there is a statistically significant pattern between two journals within each discipline. For example, the trend in articles incorporating math in Science Scope (that peaks in 2007) is also evident in The Science Teacher. Though this is visible in Figure 1, Figure 5 provides a clearer illustration of the trend comparisons.

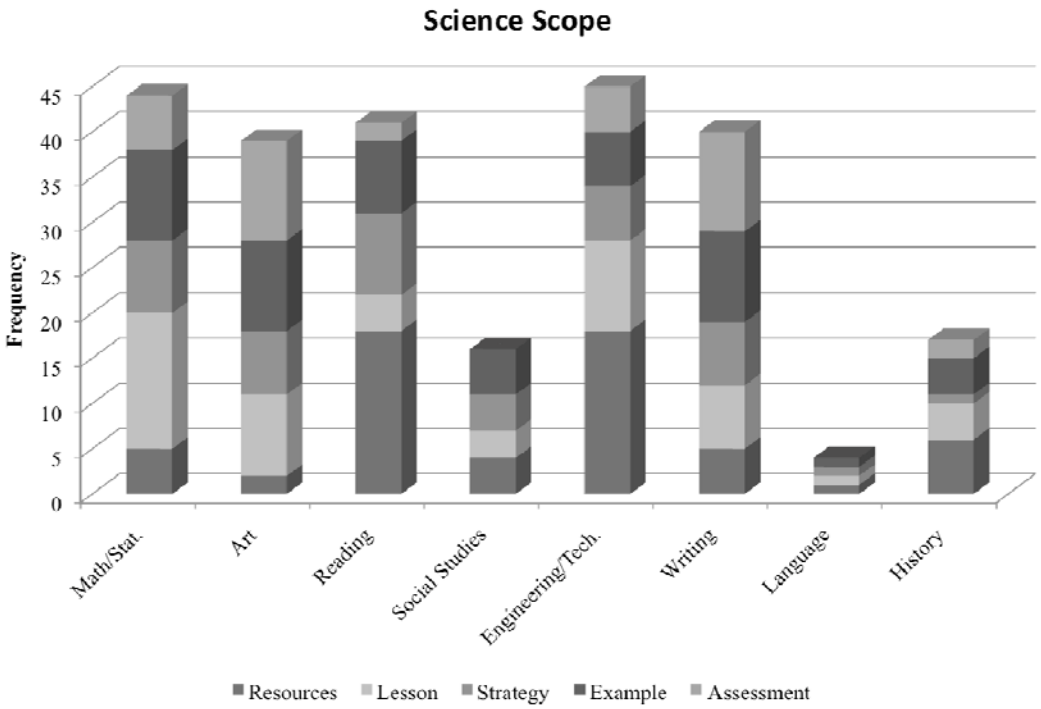


Figure 3. Frequency chart showing the types of teacher resources provided in each discipline for middle school, *Science Scope* articles

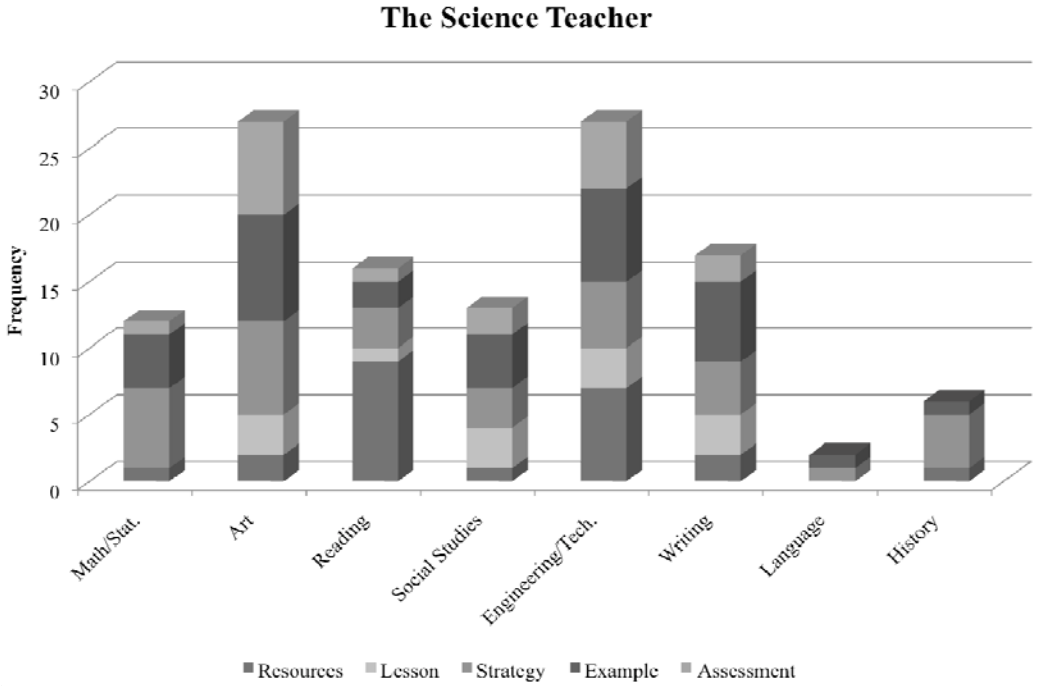


Figure 4. Frequency chart showing the types of teacher resources provided in each discipline for high school, *The Science Teacher* articles

According to Figures 2, 3, and 4, Science & Children articles frequently incorporate reading into the science curriculum. Often, reading is also incorporated with writing, art, and social studies. The most frequently used teaching tool is assessment, followed closely by real-classroom examples and general strategies.

In Science Scope, reading is also the most commonly incorporated discipline in the science curriculum; articles that incorporate reading also often include writing. Commonly used teaching tools are evenly spread between strategies, real-classroom examples, assessment, and informative articles.

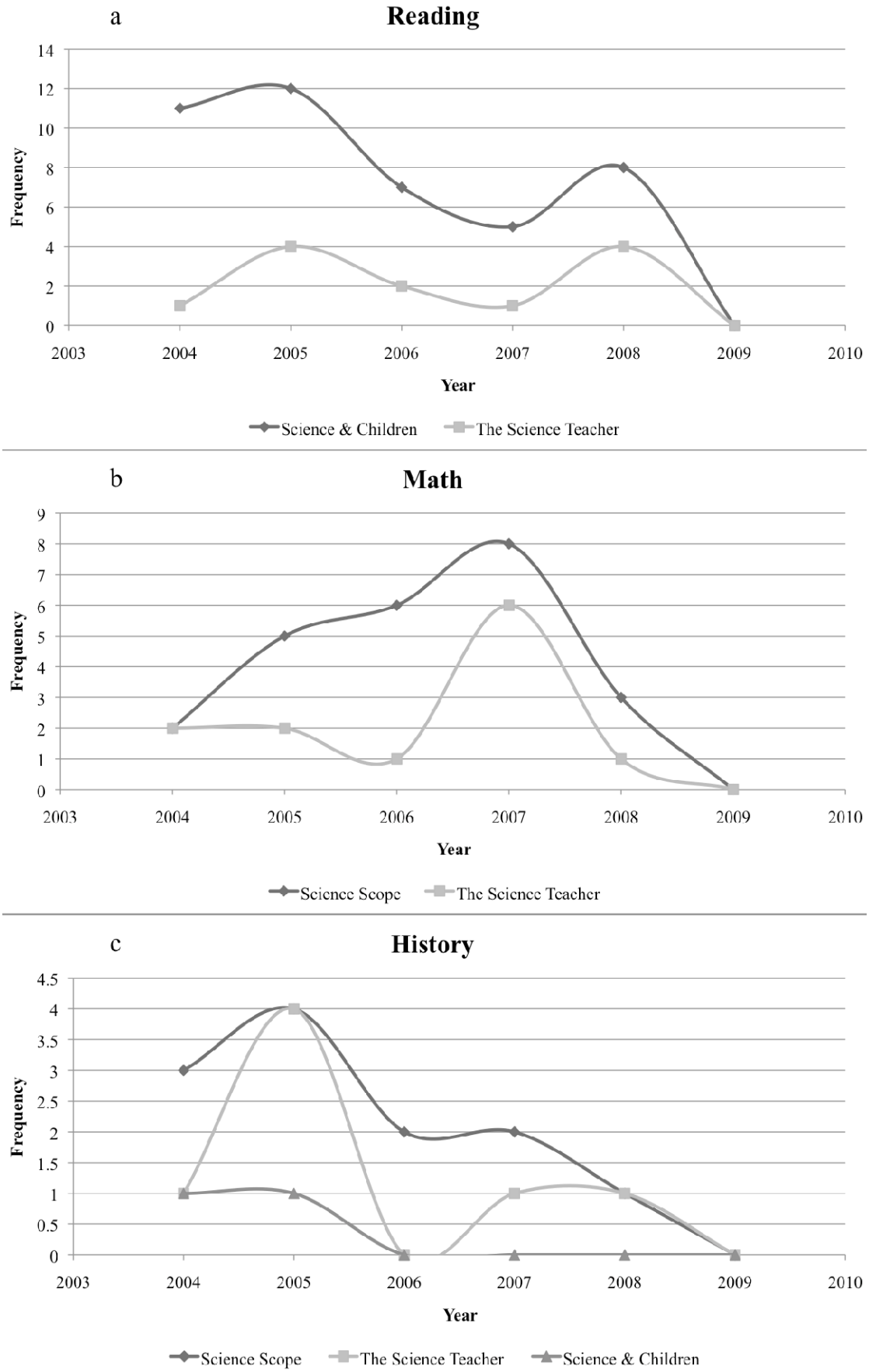


Figure 5. Frequency charts showing article trends across publication year for statistically significant disciplines, a) reading, b) math, and c) history. Each journal is represented individually: *Science & Children*, *Science Scope*, and *The Science Teacher*.

Finally, The Science Teacher most commonly incorporates technology; while often pairing writing and engineering with other disciplines, which are usually social studies, reading, math and art. Tools used in The Science Teacher articles are most often general strategies, lesson plans and real classroom examples.

DISCUSSION

Interdisciplinary approaches to learning science are an important part of raising a scientifically literate society. Students should be expected to evaluate and think critically about claims regarding real-world problems, which are rarely confined to science-based knowledge only. As a result, we should expect students to learn science using interdisciplinary approaches in order to prepare them to be critical thinkers. With appropriate support for teachers, incorporating other disciplines into the science classroom can be relatively easy to do. However, teacher journals are lacking in true interdisciplinary resources, which makes implementation of interdisciplinary approaches very difficult for teachers to achieve.

Comparison of NSTA journals

When comparing the total number of articles that discuss more than one subject into the science classroom, it is clear that Science Scope (middle school journal; 74 articles) includes more disciplines per article than both The Science Teacher (high school journal; 36 articles) and Science & Children (elementary school journal; 46 articles) articles. Hence, articles at the middle school level not only have the most number of interdisciplinary approach articles; they also tend to be the most integrated because Science Scope has the highest number of articles that combine two or more disciplines into the science content. Further analysis must be done in this area to determine why middle school teachers tend to report using more interdisciplinary approaches to teaching science than other disciplines, especially since middle schools generally segregate disciplines.

From the Science & Children results, reading is the most commonly suggested discipline to incorporate into the elementary science classroom. Science & Children frequently discusses NSTA's list of Trade Books by through their recurring articles, "Teaching Through Trade Books." In these articles, science topics are discussed using appropriate storybooks as well as age-appropriate lesson plans. As a result of their Trade Book emphasis, lesson plans and resources are two of the most often used teaching tools discussed in the journal.

In Science Scope, writing is the most commonly included subject in interdisciplinary articles. Many of these articles focused on incorporating the use of creative science journals in the science classroom because it provided an easy way to incorporate language arts and creativity. Teaching tools most commonly used in Science Scope articles are lesson plans and real-classroom examples; most examples were showcases of creative journals students developed in the authors' classrooms.

For The Science Teacher, the most common subject incorporated in the science content is technology, followed closely by art. The majority of the technology articles provide resources for Internet software. Art is incorporated into the science classroom as a method of teaching students how to make detailed observations using artistic methodology. Articles in The Science Teacher most commonly used resources, strategies, and real-classroom examples as teaching tools. Similarly to the other NSTA journals, The Science Teacher published editions that focused on a specific topic, which were most commonly about using art in the science classroom.

Looking at the similarities across all three journals, the underlying concept between the most commonly integrated subjects appears to be creativity. For example, Science & Children most frequently included reading into the science content, which seemed to emphasize helping students to link stories to science concepts. Additionally, the most frequently used interdisciplinary subject for Science Scope (writing) and The Science Teacher (art) serve a similar purpose. Not only does using creativity appear to help teach science content, it could begin a shift from teacher-centered to student-centered learning environment (Prain & Hand 1996), it also moves the classroom towards a focus on the big ideas in science rather than individual facts (Richards & Shea 2006). Further research on this topic can explore how effectively adding creativity elements to the science classroom can move the class towards a student-centered, big-idea focused learning environment.

Integrating mathematics

The National Science Education Standards (NRC, 1996; 2012) emphasize the importance of integrating math and science in preparing students to be scientifically literate. The NSES suggest that mathematical understanding is critical to all aspects of scientific inquiry; such as asking questions, gathering, organizing, and presenting data, and structuring plausible claims. Given this emphasis, it is surprising that math is not incorporated into the science classroom more often. Only 41 of the total 276 interdisciplinary articles identified incorporated math. According to a

historical analysis of publications between 1901 and 2001 (Berlin & Lee, 2005), a substantial amount of publications (more than 900 articles) concern the integration of math and science. Furthermore, several studies indicate that the integration of the two disciplines positively impacts on students' achievement scores (Hurley, 2001; Stevenson & Carr, 1993). This implies that the math and science integration has been widely supported by research, but its practical support is still not well explored (Czerniak et al., 1999).

Length of curriculum

Many researchers argue the importance of developing interdisciplinary curriculum within a teaching team, particularly for extensive, yearlong curriculum development (Newell, 1994; Applebee et al., 2007). Of all the articles in Science & Children, Science Scope, and The Science Teacher, there were five articles that suggest extensive, yearlong development of curriculum and of those articles only two reported the use of teaching teams. As suggested by Newell (1994), refocusing curriculum to broad topics rather than specific facts can lead to effective implementation of interdisciplinary approaches; however this is a difficult process that requires a shift in the classroom environment and cannot be done on a lesson-by-lesson basis. Therefore, it can be expected that yearlong curriculum development is an important part of preparing teachers to use interdisciplinary approaches in the science classroom.

Applebee et al. (2007) suggested that working in teaching teams could be a lengthy, potentially difficult process. However, three of the five articles that incorporated extensive, yearlong interdisciplinary curriculum did so without the use of teaching teams; therefore it is conceivable that teachers are able to incorporate other disciplines into the science classroom without having to take time to work with a team. However, there is little research in the area of developing extensive interdisciplinary curricula in the classroom without the use of teaching teams. To get a better idea of how this approach can be utilized in the science classroom, there is a lot of work yet to be done.

REFERENCES

Adler, M., & Flihan, S. (1997). *The interdisciplinary continuum: Reconciling theory, research, and practice* (Report Series No. 2.36). Albany, NY: Center on English Learning and Achievement.

Alexander, J., Walsh, P., Jarman, R., McClune, B. (2008).From rhetoric to reality: Advancing literacy by cross-curricular means. *The Curriculum Journal*, 19 (1), 23-35.

American Association for the Advancement of Science (AAAS). (1993). Benchmarks for scientific literacy. Washington D.C.: AAAS.

Applebee, A., Adler, M., Flihan, S. (2007). Interdisciplinary curricula in middle and high school classrooms: case studies of approaches to curriculum and instruction. *American Educational Research Journal*, 44 (4), 1002-1039.

Beane, J. (1997). *Curriculum integration: Designing the core of democratic education*. New York: Teachers College Press.

Berlin, D.F., Lee, H. (2005). Integrating Science and Mathematics Education: Historical Analysis. Retrieved from http://www.redorbit.com/news/science/ 119259 /integrating_science_and_mathematics_education_historical_analysis/index.html.

Bybee, R. (1997). Achieving science literacy: from purposes to practices. Portsmouth, N.H.: Heinemann publishers.

Cohen, H. and Staley, F. (1982). Integrating with science: One way to bring science back into the elementary school day. *School Science and Mathematics*, 82 (7), 565-572.

Colomb, J. (1999). School knowledge and didactic analysis: A research perspective in comparative didactics. *Instructional Science*, 27, 53-71.

Czerniak, C.M., Weber, W.B., Sandmann, A., Ahern, J., (1999). A literature review of science and mathematics integration. Science and Mathematics, 99 (8), 421-430.

Fang, Z., Lamme, L., Pringle, R., Patrick, J., Sanders, J., Zmach, C., Charbonnet, S., Henkel, M. (2008). Integrating reading into middle school science: What we did, found, and learned. *International Journal of Science Education*, 30 (15), 2067-2089.

Hurley, M. M. (2001). Reviewing integrated science and mathematics: The search for evidence and definitions from new perspectives. *School Science & Mathematics, 101*(5), 259-270.

Jacob, S. (2008). Cross-Disciplinarization: A new talisman for evaluation? *American Journal of Evaluation*, 29 (2), 175-194.

McComas, W. (2009). Thinking, teaching, and learning science outside the boxes. *The Science Teacher*, 76 (2), 24-28.

National Research Council. (1996). National Science Education Standards. Washington, D.C.: National Academy Press.

National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Newell, W. (1994). Designing interdisciplinary courses. *New Directions for Teaching and Learning*, 1994 (58), 35–51.

Prain, V. & Hand, B. (1996). Writing for learning in secondary science: Rethinking practices. *Teaching and Teacher Education*, 12 (6), 609-626.

Richards, J. & Shea, K. (2006). Moving from separate subject to interdisciplinary teaching: The complexity of change in a preservice teacher K-1 early field experience. *Qualitative Report*, 11 (1), 1-19.

Schwartz, A. (1999). Creating a context for chemistry. *Science and Education*, 8, 605-618.

Stevenson, C., & Carr, J. (Eds.). (1993). *Integrative studies in the middle grades: Dancing through walls*. New York: Teachers College Press.

Vardeman, S. & Jobe, J. (2001), Basic Engineering Data Collection and Analysis, Pacific Grove, CA: Duxbury.