A Conceptual Framework for Scientific Writing in Nursing

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ABSTRACT

Formal scientific writing is the central mode of communication used across disciplines to disseminate ideas and persuade others of the validity of scientific arguments. Dissemination of knowledge is important because it provides evidence for nursing practices and plays a critical part in defining the boundaries of the discipline. Despite its relevance to nursing, education about this essential skill is not currently evidence based and relies on a combination of mentorship and trial and error. This is problematic because considerable time is required to become proficient using that method, which slows down the dissemination of knowledge and creates a barrier for many skilled individuals who aspire to a career in academics. This article's aim is to present a conceptual framework for scientific writing that has been used in medical education and to demonstrate how it could be used to structure educational programs to teach novice nursing scholars about scientific writing.

Received: November 2, 2008

Accepted: November 19, 2009

Posted: April 30, 2010

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The authors have no financial or proprietary interest in the materials presented herein.

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doi:10.3928/01484834-20100430-02

For nursing scholars, effective scientific writing skills are essential to disseminate their research findings and ideas. By *scientific writing*, we mean written scholarly articles, aimed at building knowledge about a particular subject, that are published in a variety of professional venues, such as journals. Dissemination of scientific ideas is necessary to provide an evidence basis for practice and also to establish a functional definition of nursing. Shumway and Messer-Davidow (1991) demonstrated how over time the content of articles published in a discipline's professional journals promote understanding about the discipline. That understanding acts to establish the defining boundaries of the discipline (Gieryn, 1999). This is evident in nursing, where successful publication of scholarly papers in professional journals over the past several decades has contributed to establishing the status of nursing as a bona fide discipline (Donalson & Crowley, 1978; Fawcett, Watson, Neuman, Walker, & Fitzpatrick, 2001; Newman, Sime, & Corcoran-Perry, 1991).

However, despite the importance of scientific writing, to date in nursing the majority of programs aimed at teaching novice researchers this essential skill have taken a mechanical approach. By this, we mean they provide general rules of thumb and broad basic instructions, but they lack a conceptual or theoretical basis and consequently fail to provide a scientific justification for the type of writing style or structure that is being recommended. This is demonstrated in the nursing literature, where a recent review of the related literature conducted in preparation for writing this article failed to identify a single source aimed at providing instruction devoted to scientific writing based on a conceptual or theoretical model or framework. This notion is further supported by anecdotal evidence that suggests that most often, junior researchers learn how to write scientifically through a combination of mentorship and trial and error. Although it would seem that this approach has been relatively effective in the past, it takes a

considerable amount of time and effort to achieve proficiency in this manner. It also slows down the dissemination of scientific knowledge and creates an unnecessary barrier for many highly skilled individuals who aspire to a career in academics. However, the lack of an evidence-based framework that could be used to teach this skill is not warranted because there is a notable body of literature about scientific writing, and the topic has attracted a significant amount of attention in other disciplines such as sociology and psychology.

The purpose of this article is to fill that gap. We present a theoretically based model that can be used for teaching and analyzing scientific writing in nursing. The model is taken from psychology, sociology, and rhetoric and is rooted in the view that human communication is a cognitive phenomenon. We also demonstrate how the model could be used in nursing to structure educational programming aimed at teaching novice researchers how to write effectively. A similar framework is currently being used in a problem-based certificate course about outcomes research in medical education. The course has proven to be an effective method to expedite knowledge development necessary to increase the conduct and dissemination of clinical research. Although it has been used in medical education, to our knowledge it has not been used in nursing.

HISTORICAL DEVELOPMENT OF SCIENTIFIC WRITING

Robert Boyle is credited with formalizing the structure of the scientific manuscript (Sharpin, 1984). Boyle was a seventeenth-century scientist whose experiments covered a wide range of phenomenon from mechanics to alchemy (Newman & Principe, 2002). He was troubled that the conduct of research was not uniform across scientists and by the limited availability of historical data that could be used to compare findings. To remedy this problem, he proposed a systematic and objective approach to conduct research and report experimental findings. The method he developed for conducting his own research included witness observation and meticulously detailed descriptions for the experiments that he used to demonstrate rigor and build credibility for his own experiments. His efforts established a reproducible, nonmystical way to describe research that differentiated science from other areas of investigation, such as alchemy. Boyle applied the same precise principles to his written reports, a practice that was soon emulated by other scientists and that over time generated a formalized structure for scientific manuscripts.

Boyle's original rules are still identifiable in modern-day scientific articles (Knorr-Cetina, 1999), providing tangible evidence for the idea that certain text structures and writing styles are adopted across disciplines over time. This occurrence is congruent with selection theory that was initially articulated by Toumlin (1972) and later extended by Campbell (1990) and Heyes and Hull (2001). Selection theory asserts that in many domains, including science, standardization results from the cumulative process of privileging certain styles (Bickhard, & Campbell, 2003). The theory challenges the notion that the practice of science is purely objective, and it demonstrates how social constructions of science have evolved over time. As the process of selection unfolds, variation is systematically eradicated, leaving only styles that conform to the preferred standard for the group (Giere, 1987).

Selection theory was further refined by Gross, Harmon, and Reidy (2002), who demonstrated how groups develop preferred standards for scientific writing tailored to their specific preferences through social pressure in the form of collegial expectations. These expectations result in the development of a set of rules for scientific writing that define the preferred standard for a particular group. Generally, the rules guiding development of preferred standards across disciplines include unity of purpose; stylistic and presentational simplification; model-based studies, using mechanical and mathematical explanations; and the use of visual illustrations such as figures, graphics, and models. These commonalities across publications foster "more efficient communication, and produce stronger, more flexible argumentative strategies" (Swale, 1990, p. 43).

Preferred standards vary widely between disciplines, due to the process of speciation (Swale, 1990). *Speciation* refers to the refinement of a group's preferred standard for scientific writing that evolves among subspecialized groups within a discipline. It results from increasing specialization, which causes like cohorts to cluster into groups, each requiring their own particular writing standard. Speciation is a relatively new occurrence in the field of biomedical research; until recently, biomedical articles largely converged to a single standard, but the increasing volume of research, as well as the emergence of new fields of specialization, has prompted the rise of speciation. Slight initial differences in preferred standards for the various subspecialties ultimately result in a unique rhetorical style specifically suited to each of the subspecialty's particular needs. By *rhetoric*, we mean the use of formal arguments to persuade readers about the validity of a finding or viewpoint. Therefore, rhetorical standards are styles of structuring a formal argument that are privileged by a discipline (e.g., Boyle's rules).

In scientific articles, the progress of speciation is seen most clearly in the Introduction section, where multiple studies have shown a progression toward what is commonly called the three-step formalism (Swale, 1990). In this rhetorical style, the author first identifies the study's area of significance, which Swale (1990) termed "claiming centrality" (p. 141). Then a critical gap is isolated in the existing body of knowledge, so the author can present a hypothesis that closes the gap or simply state the research aim and questions that logically achieve the same goal. This strategy is effective because it presents the argument logically, first establishing the topic's importance and then situating it within the context of the field of research. In this way, the reader is led naturally toward the research aim and questions. The strategy is also effective because it emphasizes the value of progressively building on pre-

vious studies. An example of the three-step formalization is provided in the **Table**, dissecting the introduction of a published research report (Hodnett, 2002) to demonstrate the rhetorical standard in contemporary scientific writing in nursing.

TABLE

Dissection of the Introduction of a Published Report (Hodnett, 2002)

Text	Structural Role
"In recent decades, the importance of measuring satisfaction with health care has been recognized. Patients' views are being used by health care managers in assessing the quality of care, and by policy makers in making decisions about the organization and provision of health services. Since childbearing is the most common reason for accessing health services, assessments of women's satisfaction with their care during labor and birth are relevant to health care providers, administrators, and policy makers" (Hodnett, 2002, p. 160).	Step 1: Significance Women's satisfaction with the birth experience is important because (1) "childbearing is the most common reason for accessing health" and (2) measures of satisfaction drive health policy and the administration of care.
"Reviews of patient satisfaction studies indicate that patient demographics are among the most important determinants of satisfaction. However, it was unclear whether the findings of general patient satisfaction studies were applicable to satisfaction with the childbirth experience. Particularly controversial were questions about the influences of labor pain and pain relief methods on satisfaction with their childbirth" (Hodnett, 2002, p. 161).	Step 2: Critical information gap The gap is that it is "unclear whether the findings of general patient satisfaction studies were applicable to satisfaction with the childbirth experience."
"Through a systematic review of the childbirth satisfaction literature, I addressed the following questions: What has been measured, and how and when has it been measured? What roles do pain, pain relief, the use of specific pain relief methods, and other factors play in determining how satisfied a woman will be? How is satisfaction with childbirth related to other childbirth outcomes?" (Hodnett, 2002, p. 161).	Step 3: Hypothesis

Although the mechanism of speciation is clearly understood, it is not clear why one rhetorical standard (e.g., three-step formalism) is selected over another. We speculate that the particular writing styles of key researchers may influence that process. It is likely that researchers who use easy-to-read language and a clear writing style would be emulated by others and their style could become a preferred standard over time. In addition, researchers who work with many students or associates are likely to be perceived as leaders in their fields and subsequently, their style could be judged as influential or advantageous, which would prompt others to duplicate it, thereby propagating the writing style. Finally, decision makers such as journal editors are also likely to privilege rhetorical styles that they find effective, increasing the likelihood that it will be replicated. Ultimately, whatever the forces driving speciation in nursing, more than a century of scientific publication and the recent explosion of available information have set the stage for the powerful, cumulative effects of selective forces.

Research about reader expectations (Gopen & Swan, 1990) provide another important factor related to preferred rhetorical styles. Gopen and Swan (1990) demonstrated that certain rhetorical or writing structures can actually improve reader understanding. They showed that when reading a scientific text, readers must divide their attention between understanding the content and parsing the structure. Because an individual's cognitive energy (e.g., memory, attention) is more or less fixed, when a reader spends more energy navigating the structure, less remains to understand the content. Consequently, the more that an article is structured using a common format, the more cognitive energy is available for the reader to comprehend what the content means.

There are many examples of rhetorical strategies that are used to manage the cognitive burden imposed by text structure. As previously described, the one that is particularly common in western industrialized cultures is the three-step formalism. Use of that form allows readers to anticipate what will come next, which in turn frees cognitive energy so that they can concentrate on the content. The application of similar principles can be found in other mediums. For example, television advertisements use a similar standard structure that is aimed at showing how a product is relevant to us, why we need it, and how happy we will be once we have it. What is important to note is that strategies such as these may not be truly universal, as other cultures may have different messaging structures. However, they are effective in Western industrialized societies and are well represented in the preferred standards across the health science disciplines, including nursing.

Reader expectations and preferred standards also relate to scientific writing on a much more basic level and are pivotal factors that influence the publication success that novice researchers achieve. This is because reader expectations play such a key role in comprehension, and preferred standards establish the structure to which manuscripts must conform. The relevance of this is demonstrated in anecdotal evidence that shows that even when novice researchers include all the relevant facts in their first manuscripts, peer reviewers often report a perception that something is wrong with the manuscript. The perception is generally subliminal; reviewers simply report feeling tired, bored, or bothered, although the underly-

ing cause is not clear to them. This so-called "doesn't look right" phenomenon occurs because the structure is unfamiliar, which forces the reviewer to focus more intently to grasp the content (Gopen & Swan, 1990). This phenomenon is not evident when the writing style conforms to the standard preferred by that discipline.

When considering a theoretical framework for scientific writing, it is important to remember that because text structures are socially determined, they are specific to certain types of research and historical moments. Subsequently, educational programs about scientific writing must be tailored to meet current preferred standards for the specific discipline. Biomedical computational ontology is one method that has been used to identify the preferred standards for a specific discipline or target journal or audience (Pietrobon et al., 2007). The process breaks down the structure of various types of scientific studies (e.g., random controlled trials) into discrete, interrelated informational units, revealing the underlying structure organizing the content. In this way, the text structures that comprise the preferred standards can be made readily apparent.

A CONCEPTUAL FRAMEWORK TO TEACH NOVICE RESEARCHERS SCIENTIFIC WRITING

The conceptual framework that we are proposing to teach novice nursing researchers scientific writing has been used to structure the scientific writing components in a problem-based certificate course in outcomes research. The international program targets medical education and is hosted by Duke University Medical Center. It is composed of a total of 14 modules, 4 of which directly relate to scientific writing. Although the program has not been empirically tested, its effectiveness has been demonstrated by the impressive volume of publications in multiple fields produced by participants who have completed the program (Pietrobon et al., 2007).

The framework we are proposing comprises four principles that direct distinct learning activities in sequential phases. The first is the Rhetoric Principle, which concerns the relationship between structure and content. Although the content of a text is immediately apparent, the structure is a latent characteristic that may not be evident until it is deliberately identified. Furthermore, each discipline's preferred standards favor specific structures; for example, in the biomedical sciences, the most commonly used sequence for the introduction is a statement of significance, followed by the identification of an information gap and a review of the pertinent literature. The format may vary somewhat in different journals, but in general, potential authors need to conform to that standard structure. Identifying the preferred standard and teaching novice researchers how to use it in their writing increases the likelihood that their manuscripts will be accepted for publication.

Learning activities in this phase are intended to help students clarify the difference between content and structure. This is a complex task, given that the two can be hard to tease apart; however, it is fundamental to teach novice researchers about scientific writing. For example, when a manuscript begins by stating that "Social determinants and intractable health disparities among different populations rank at the top of challenges for health care leaders" (Lucey & Maurana, 2007, p. 179), the authors are commenting on health disparities (content) while also stating the significance of their topic (structure). Structure differs from content in that a given structural framework can be made to fit any type of content. Similarly, the sentence "Pressure ulcers are complex chronic wounds and a frequent cause of morbidity in elderly subjects in hospitals and nursing homes" (Barrois et al., 2007, p. 267), like the previous example, is also a statement about the significance of the topic, but in this case the content is completely different. Understanding the difference between content and structure is the first step toward effective scientific writing. It is important for students to learn that fundamental distinction before moving on to the second principle.

The second principle is called the Ethnographic Principle because its methodology is derived from ethnographic studies. It is related to computational ontology in that its purpose is to identify the best way to construct a formal argument within a specific discipline (Pietrobon et al., 2007). This principle focuses on the identification of a given field's preferred standard text structure. As stated previously, the development of preferred standards is a social, rather than objective, process; researchers conducting similar analyses in different fields might present their findings in completely different ways. It is for this reason that universal guidelines are not applicable to scientific writing because although general rules for effective writing can provide useful advice for scientific writing in general (Alley, 1996; Matthews, 2007), they are insufficient for the particulars of each discipline. Instead, in order to make apparent the specific structures and standard that are preferred, it is necessary to analyze a series of texts from target journals to identify their underlying structure.

In this phase, students analyze a report that is similar, in terms of structure and target journal, to the paper they intend to write, although it can be different in terms of content. For example, a student preparing a qualitative study for publication in the *Journal of Nursing Education* would examine a previously published qualitative article from that journal, without regard to its content. The analysis is aimed at dissecting the manuscript in a linear fashion to identify the structure. This process starts by first identifying discrete informational components, or text blocks. *Text blocks* are defined as groups of words or sentences that play a single rhetorical role or purpose within a manuscript (Hoey, 2001). For example, most scientific articles will contain text blocks related to the significance of the topic, background to the problem, research method, and so on. Identification of the text blocks provides important insights about the structure that helps build an understanding about the underlying structure. In particular,

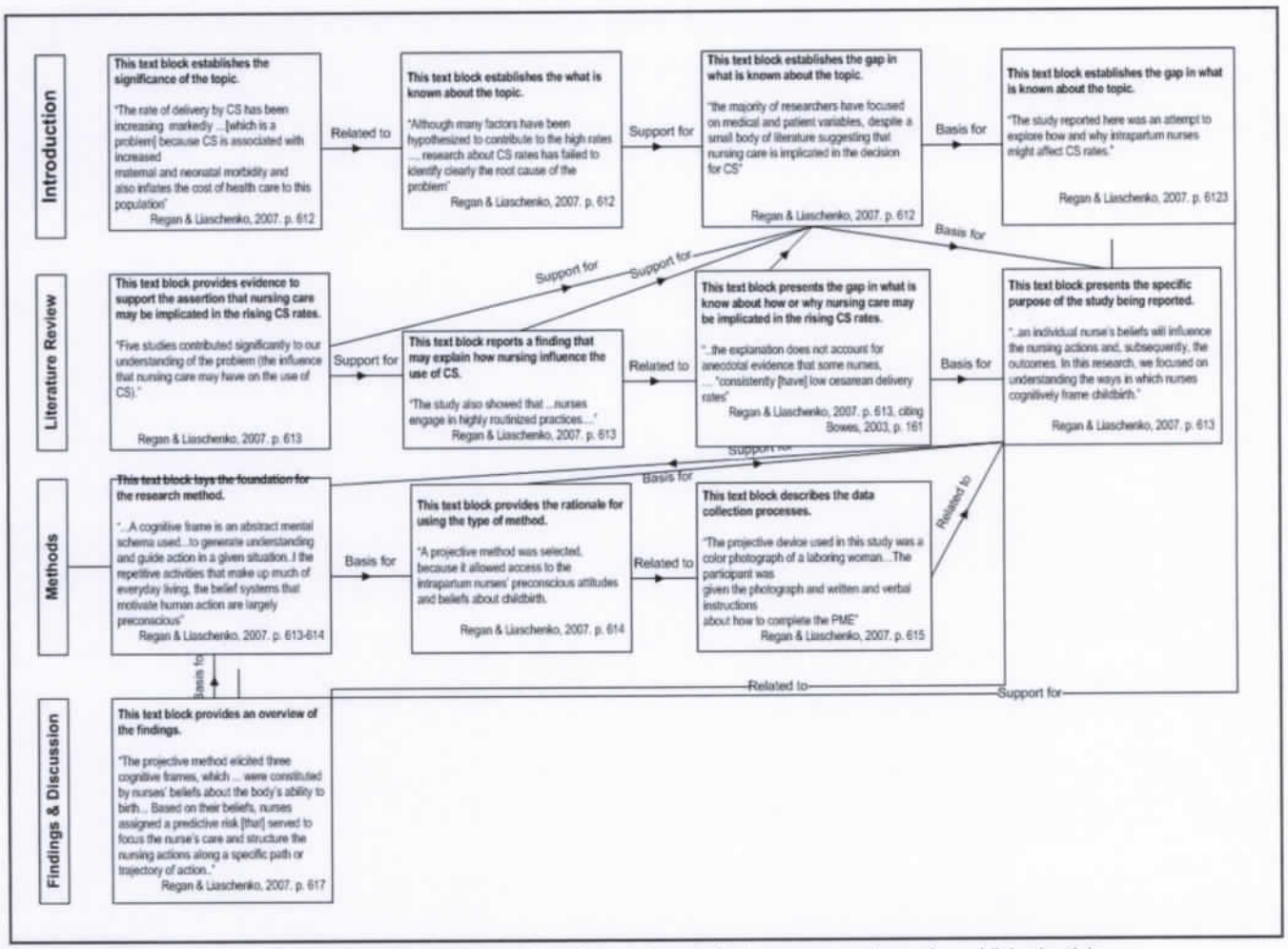

Figure. Examples of rhetorical purpose and their relationships of the main text blocks across sections of a published article.

this analytic step will make apparent the relationships between text blocks. The relationships between text blocks include descriptions that provide the basis for a claim or compliment it, report a result, or provide additional support for an argument. For example, text blocks that define the information gap also lay the groundwork for the block dedicated to presentation of the research question. An example of rhetorical purpose of text blocks and their relational nature across a manuscript is presented in the **Figure**.

Cross-checking students' coding of text blocks is time-intensive—a commodity that few instructors have in abundance. One way to speed up this process is to use papers that have been precoded. The students then code a blank version of the article and then compare their findings against an answer key. There will always be small discrepancies across coders, given that the exact boundaries and purposes of text blocks are somewhat subjective; however, the strategy helps manage the workload for the instructor, which is an equally important consideration for any educational framework. The point of the exercise is not to achieve complete agreement, but rather that the students learn the general principles about structuring written content by actually identifying text blocks in published work and then comparing their findings. In this way, they will be guided to review the rationale behind the answers that will promote a better understanding about text structure.

Although it may seem on the surface that the first two principles are similar, the second principle builds essential knowledge for several reasons. First, students may appear to understand the differences between structure and content, but the analytic process provides tangible evidence of their application of that knowledge. Commonly, students do not succeed in their initial attempts to analyze manuscripts for structure. This may be because it is normal to read for understanding, rather than performing a meta-reading to understand why we understand. Students may require several sessions to learn this technique. Second, students are typically surprised by how much they can learn about text structure by formally coding each portion of text. This type of analysis uncovers the nuts and bolts of various rhetorical strategies, as well as common flaws in their application. Past practice has made us realize that

is helpful if the analyzed texts are similar to the student's target texts in terms of structure, the target journal, and if possible, content because preferred structures do vary among journals and even fields of research.

The third principle is the Recognition Principle. It is focused on the fact that effective writing requires the ability to distinguish between optimal and suboptimal writing styles. Given that what is considered an "optimal style" will vary over time and in response to social developments, it is vital to use contemporary publications. In this phase, students are taught how to distinguish between good and below average text blocks by analyzing each section of a manuscript (Introduction, Methods, Results, and Discussion). The Introduction and Discussion sections can be analyzed in a fairly standard fashion because they tend to be similar across research fields, but the Methods and Results sections are highly specialized for each field and research method. For those sections, it is necessary to provide specific examples for each type of report, such as qualitative research, randomized clinical trial, or cohort study.

Exercises aimed at teaching students about the Recognition principle involve asking questions such as:

> A randomized controlled trial is focusing on the comparison between two prevention strategies for falls in the elderly, and you are writing the Introduction section focusing on the significance of your topic. Based on the following examples, please select the one that would best fit the purpose of the significance section within the manuscript.

Students then choose from a set of paragraphs that all pertain to the same content but that serve different structural roles describing, for example, the study's objective or a literature review in support of the information gap.

Although it would be ideal if students write their own sentences, reviewing them would require a vast amount of instructor time. Therefore, strategies such as standardized answers and computer grading allow this type of activity to be scalable. An example of a program aimed at achieving this purpose was developed by a group of researchers at Duke University. WriteSim TCExam is an "open source text simulation environment for training novice researchers in scientific writing" (R. Pietrobon, personal communication, July 6, 2009). It is a Web-based program that provides participants with a set of examples from published manuscripts and requires them to select the best answer. The program provides the students with feedback on the answer they selected and a test result summary. The program is being implemented as part of certificate course in outcomes research at Duke-NUS Graduate Medical School in Singapore. In a preliminary evaluation of WriteSim, 70% of the participants (n = 14) reported that they thought their understanding of the rhetorical purpose of the types of sections in scientific manuscript was improved, and that overall completion of the program improved their understanding of scientific writing (Shah, Shah, & Pietrobon, 2009).

The fourth principle is called the Practice Principle. It is focused on recognition of the difference between learning to recognize text structure patterns and actively using those models in our own writing. In this phase, students write a scholarly article. It is only in this final phase that mentors are required to provide guidance. The role of mentor requires a large commitment of time and energy that greatly increases the cost of a program such as this. The program that we are proposing here purposively stages the first three phases to serve as a screening mechanism, as less dedicated students tend to drop out earlier and therefore the instructor is unlikely to waste time in the final phase. In addition, the initial phases introduce students to essential new knowledge, saving the mentor the need to teach expository material.

Mentor critique of the students' written work helps students to recognize optimal and suboptimal text structures as they work to conform to their field's preferred standards. As they write, they need to break their project down into discrete text blocks, which they title with appropriate subheadings. The subheadings serve two purposes: they ensure that students adhere to the prescribed sequence and they expedite the mentors' assistance, helping them judge whether the student's text conforms to the proper structure. The discrete text blocks should relate to the basic structural elements of the manuscript and include subheadings specific to the section. For example, in the Introduction text block section, the student should include the significance of the topic and what is currently known about it, and identify the gap. Similarly, in the Literature Review section, students should report the literature supporting the topic and information lag or gap. The same principle should be applied for the Methods, Results, and Discussion sections of their article. To further facilitate the student-mentor exchange, texts can be written in virtual environments, which are accessible simultaneously by both parties at times that work best within their schedules.

We would suggest a Web-based platform for this program. It could consist of four stages, each representing the principles discussed above. These are not the only valid principles on which to form the basis of such a program, nor do the steps outlined above represent the single best means of teaching them. Rather, we consider this lesson plan to be one of many possible teaching strategies, each of which should be empirically tested to determine its suitability for a given set of educational goals.

CONCLUSION

The four-phase educational program that we propose here is an attempt to formalize, and proportionately scale, an effective training regimen for novice researchers. It is intended to establish a conceptual foundation for education about scientific writing using an evidence-based approach, rather than traditional methods that rely on subjective rules of thumb. Systematic study of the underlying text structure allows us to better understand the writing process and may explain outstanding questions. For example, in the problem-based certificate course used in

medical education, we found that participants often fully grasp the difference between structure and content, yet they often could not demonstrate that in practice. Research is needed to understand the discrepancy between understanding and doing. Research about this topic may also help explain how it is that expert scientific writers can apply these concepts unconsciously, with little awareness of their underlying thought processes. We propose this conceptual framework as a starting point to begin the process of rigorously evaluating the topic in order to determine the most effective way to teach nursing researchers this fundamental skill.

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Record: 1

Title: A conceptual framework for scientific writing in nursing.

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Source: Journal of Nursing Education (J NURS EDUC), 2010 Aug; 49 (8): 437-43. (26 ref)

Publication Type: journal article - tables/charts

Language: English

Major Subjects: Conceptual Framework
Research Personnel -- Education
Scholarship
Writing -- Methods
Writing -- Standards

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Journal Subset: Core Nursing; Editorial Board Reviewed; Expert Peer Reviewed; Nursing; Peer Reviewed; USA

Special Interest: Nursing Education

ISSN: 0148-4834

MEDLINE Info: *PMID:* 20438033 *NLM UID:* 7705432

Entry Date: 20101105

Revision Date: 20101105

DOI: http://dx.doi.org/10.3928/01484834-20100430-02

Accession Number: 2010732044

Database: CINAHL Plus with Full Text