



Development of an Internet-delivered Communication Curriculum for Graduate Women in STEM

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Abstract

This paper details the process and development of the second major phase of the *CareerWISE* intervention: communication training aimed at strengthening the knowledge and skills helpful to women as they navigate the varied interactions that may arise in mostly male environments. The *CareerWISE* communication training modules are organized in a hierarchical structure with three overarching categories: (1) *Communication Elements*, (2) *Essential Skills*, and (3) *Advanced Strategies*. The design protocol for module development employed a cyclical loop whereby content material was developed, piloted, and revised based on participant feedback. All of the *CareerWISE* communication training materials are interconnected, but also function as stand-alone pieces; this provides visitors to the site with a unique opportunity to engage the material for quick answers to vexing questions or to learn essential and advanced skills that may be used now and throughout the entirety of their careers.

Introduction

Projects in the interdisciplinary *CareerWISE* research program, supported by the National Science Foundation, have two goals: (1) to better understand and explain the interplay between the person and environmental conditions that affects attrition amongst students enrolled in engineering and sciences graduate programs, and (2) to strengthen personal and interpersonal skills identified as significant in assisting women in these disciplines to persist toward degree completion and career attainment. Past research has illustrated that women are underrepresented at every level of science and engineering, including in graduate school. For example, women made up 53 percent of all doctoral degree earners in 2011. But only 22% of 2011 engineering PhDs were women¹. Women made up a large percentage of all first-time enrollments in fields such as education and health sciences. But women were only 31 percent of the graduate enrollments in mathematics and computer science and 24 percent of all first-time enrollments in engineering graduate programs². Notably, the academic community now acknowledges that across all fields, 1 out of 2 new doctoral students does not finish the program, and when isolating variables that contribute to this outcome, gender has been shown to be the strongest predictor³.

One of the major goals of the *CareerWISE* research program is to investigate whether an online psychological course in personal resilience can help women in STEM persist toward degree completion and professional career attainment. The first phase of the *CareerWISE* intervention was developed based on findings from two strategies: an extensive review of the literature that cataloged the challenges women face in the male-dominated STEM environments and a series of focus groups and interviews to better understand the experiences of women in STEM. A singularly unique feature of the *CareerWISE* approach is its grounding in a foundation of empirical theory and research of the individual psychological processes, the environmental contexts, and the behaviors that predict risk factors for attrition⁴.

Solving technical problems is a fundamental skill for engineers and scientists; hence we selected the familiar strategy of problem solving as a framework for instruction in how to manage and resolve personal and interpersonal problems we found common among women in STEM doctoral programs: managing relationships with advisors (Advisors), balancing work commitments with personal lives (Balance), advancing in climates unfriendly to women (Climate), and coping with unexpected delays and setbacks (Delays). The initial curriculum for the online coping skills training was centered on a four-step problem-solving model and offers a wide range of instructional materials and self-tests to better understand oneself, understand others and the situation, and learn skills. *Herstories*, video clips of interviews with successful women scientists and engineers, are included to normalize challenges that are commonly encountered by women in STEM environments and model approaches for navigating them successfully. A randomized controlled trial (RCT) with a national sample of women in engineering and science doctoral programs provided strong support for the effectiveness of the *CareerWISE* resilience training. Compared to a wait-list control group, women who spent at least five hours exploring the site showed significant improvements on all targeted outcomes⁵.

Subsequent to establishing the effectiveness of the first phase of the *CareerWISE* online training (<http://careerwise.asu.edu/>), we focused on a second phase of curriculum development: communication training aimed at strengthening the knowledge and skills helpful to women as

they navigate the varied communication interactions that may arise in mostly male environments. The development and formative evaluation of the communication curriculum are the subjects of this paper.

Online Communication Training As An Intervention Modality

Communication skills are essential to all facets of work and personal lives and continue to be emphasized among the “21st century skills” as key targets for education⁶. In engineering and science, the importance of advanced technical communication skills is well recognized^{7,8,9} although the incorporation of technical communication training is lagging¹⁰ and instruction in interpersonal communication and problem solving is notably absent. A goal of the second phase of *CareerWISE* is to provide an online platform^{11,12,13,14} for building effective interpersonal skills to assist in improving team communication, solving interpersonal problems, and strengthening professional relationships. Because of the additional challenges many women face in the predominately male environments of engineering and the sciences, enhancing the interpersonal skills of women may provide new strategies for addressing common issues.

We set out to develop instructional modules for online delivery (on the *CareerWISE* website) using recommended practices in the educational psychology, pedagogical theory and virtual environment¹⁵ literatures. Our approach employs interventions to bolster coping skills^{16,17}, provide instruction in systematic problem-solving¹⁸, and offer a form of e-mentoring¹⁹, and is based on recent internet-based psychosocial training efforts that have shown promise in increasing knowledge, attitudes, and skills in circumscribed settings^{20,21,22}. This approach was chosen to ensure we were providing the most relevant information in an optimal way.

As an initial step, our interdisciplinary team of faculty and students engaged in an extensive process of conceptualization and scoping. We sought to clarify the parameters of communication relevant to the target audience of women in STEM, identify the communication elements to be included in the intervention, agree on the structure of the communication curriculum, and envision interactive materials to be included in the communication intervention (i.e., interactive simulations not discussed in this paper). Team members conducted and presented literature reviews for individual content areas (e.g., Active Listening) so that the applicability of research findings could be discussed and decisions made about which and how findings would be incorporated into the future content of the curriculum for maximum effectiveness. The varying disciplinary perspectives of faculty and graduate students from fields that included counseling psychology, engineering, communication, and educational technology were invaluable in crafting an outline of content and structure that would best meet the needs of our target users.

A primary task related to instructional design was to consult the education technology and pedagogical theory literatures to ensure we were developing the learning environment to maximal effect. We applied educational technology design approaches for effective teaching with technology in higher education²³ and principles for instructional message design from the behavioral and cognitive sciences^{24,25}. Careful consideration was taken to outline a set of systematic procedures for the development of instructional materials^{26,27} using best practices from the web-based instruction literatures^{28,29,30,31}. Similarly, best practices from the pedagogical theory literatures were adopted^{32,33}, especially as they pertained to the convergence of traditional

instructional design and web-based instruction^{34,35}. Using the knowledge from this process, we incorporated strategic tools for learning, such as: learning objectives, self-tests, graphics and tables, quotes, tips, etc. The instructional design elements incorporated into our materials are outlined in greater detail in the next section of this paper

Early in the process, we decided that an effective approach to increasing applicability was to employ real-life communication interaction scenarios—included for practice, reflection, and modeling^{36, 37, 38, 39, 40}. These scenarios were drawn from composites identified in *CareerWISE* focus groups⁴¹, described earlier, which found the four major themes that affect attrition and persistence decisions for graduate women in STEM: (1) advisor issues, (2) balance issues between work and non-work life, (3) climate issues related to the STEM environment, and (4) delays and setbacks. These four major themes were then incorporated into the content and presented as multidimensional (i.e., pertaining to more than one theme) self-tests and/or real-life communication interaction scenarios. An example of a communication interaction scenario, selected from the *CareerWISE* content, is presented here:

Monique wants to talk with her advisor, Dr. Hernandez, about taking the lead on an upcoming project in their lab. She is not sure how supportive Dr. Hernandez will be since she is already committed to a number of other projects, so she is trying to proceed cautiously and deliberately to convince him that she is capable of handling the extra work. In order to broach the topic with him, she uses the following plan to devise her approach...

This particular communication interaction scenario pertains to multiple themes. Monique is carefully planning the best strategy for negotiating with her advisor to secure a lead role on an important project that will advance her career. Monique's situation also highlights the potential climate issues that may exist around perceptions of women's competence and a conflict of commitments.

Next, skills and sub-skills were identified from the communication and psychology literatures and learning objectives were identified for each area of content using educational design approaches found to be empirically valid and effective. From this process, the overarching structure of the communication-training curriculum was identified. The *CareerWISE* communication training is organized in a hierarchy of three overarching categories of module types: (1) *Communication Elements*, (2) *Essential Skills*, and (3) *Advanced Strategies*.

Similar to introductory material, Communication Elements orient visitors to the intervention website in general and to the *CareerWISE* communication model specifically. The Communication Elements are presented in Table 1. An example of the language and content of the Communication elements is provided next. This particular section is entitled, *How the Context Affects You* and it is taken from the Communication Element entitled, *The Context*:

In higher education, the environmental contexts in which you interact with others range from formal (e.g., a classroom) to informal (e.g., the common area outside of your building), academic (e.g., a research conference) to social (e.g., a party at a professor's home), or any combination thereof (e.g., your office at any given moment). The extent to

which you experience these contexts as supportive or challenging to your sense of belonging, both academically and socially, directly affects your comfort and motivation to continue. Further, if you belong to a minority group, you might find it even more difficult to feel integrated in the academic or social life of your department.

Essential Skills provide comprehensive instruction in four critical interpersonal communication skills: (1) *Planning The Message*, (2) *Active Listening*, (3) *Expressing Yourself*, and (4) *Receiving and Responding to Feedback*. The *Essential Skills* modules and associated skills are presented in Table 2. Example text is provided here from the *Listening For Content* portion of the *Active Listening* module:

Listening in its most basic form is paying attention to and understanding the words being said by the person in the conversation; however, listening deeply and honing in on messages that are less than obvious are skills that are different altogether. Listening for content involves a focus on hearing and understanding the other person rather than on getting our own messages across. You can't fully absorb or understand what someone is trying to say if you are busy thinking about what you are going to say next, or if you are listening only for what you want to hear.

The *Advanced Strategies* modules engage visitors in learning to express their needs assertively, negotiate effectively when interests and positions may diverge, and manage conflict as it arises in their environment(s). The *Advanced Strategies* rely on the mastery of the *Essential Skills* and understanding of *Communication Elements*. The *Advanced Strategies* modules and associated skills are presented in Table 3. The following is a sample of text taken from the *Introduction* section of the *Advanced Strategy* entitled, *Negotiation*:

Negotiation is a discussion between two or more people that involves two main functions: identifying a common ground and reaching an explicit agreement regarding a matter of mutual concern. It's an advanced strategy that relies on the mastery of basic communication skills. However, although negotiation is thought to be an experience, like being at the "negotiating table," it is actually an active process, it happens almost every day in the school environment and the workplace—we just may not always recognize it. In fact, we negotiate lots of things in our work and research, including asking for expanded roles and opportunities, seeking support to move ahead, asking for resources (e.g., time, funding, assistance) to get work done, agreeing on goals and objectives, and claiming credit for our work.

Structurally, all *Essential Skills* and *Advanced Skills* modules begin with a comic that helps orient the visitor to the construct and skill being addressed. Similarly, quotes from a wide range of sources are provided as an orienting tool and to help normalize difficulties in a given subject area. For example, a Turkish proverb is included in the *Active Listening* module: *"If speaking is silver, then listening is gold."* Learning objectives are presented in bulleted form at the beginning of each module to help visitors identify the goal of the module and also to allow them to self-select sections based on their area(s) of need and interest. Self-tests are provided throughout the modules to check for comprehension and to provide practice opportunities. The mode of self-tests is two per module—one is usually included about halfway through a module

and another is included toward the end. Each module contains a summary section called the *CareerWISE* Point, which recaps the major take-home message(s) in a paragraph or two. A section entitled *CareerWISE* Tips provides bulleted tips drawn from the module in order to recap and also to give visitors quick access to strategies should they return to review. Lastly, scholarly references and resources are provided to enhance the expert base for the information and to allow visitors to directly consult the sources cited. References range from studies that examine the efficacy of specific strategies to studies that report findings on a particular subject of interest. In total, we referenced 129 scholarly works in the communication curriculum alone.

We took careful measures to tailor our materials to our unique target population—accomplished women from diverse backgrounds in a wide-range of program environments and disciplinary traditions. For example, we watched out for overgeneralization of experience(s); psychology and discipline-specific jargon; international and cultural differences; adequate representation of STEM disciplines, subdisciplines and subfields; the varying environments that exist in STEM (e.g., lab environments versus field environments); and creating plausible situations that are relevant and familiar to the visitors to the *CareerWISE* website. External content evaluations, described next, helped us make revisions that optimized the content for our audience.

Content Evaluation

The design protocol for module development employed a cyclical loop whereby content material was developed, piloted, and revised based on participant feedback. This process followed three rounds of internal review by our team and drafts were not reviewed externally until they were found by the team to be sufficient in quality for external evaluation.

External content evaluations were conducted with 56 undergraduate and graduate student reviewers from STEM, education, educational technology, counseling, and counseling psychology. The number of reviewers per evaluation ranged from 4 to 7 and each reviewer provided feedback on at least two modules. Participant reviewers were selected based on their knowledge and expertise in the content area, mode of delivery, or the disciplines of our target population.

We utilized external reviews as formative evaluations. The content created in the module development stage was initially reviewed by external participant reviewers and then was revised based on feedback and recommendations gleaned from each subsequent review. First an initial review was conducted, which was next followed by a round of revisions based on feedback. Next, a second content evaluation was conducted with a new participant group and, similarly, revisions were made based on feedback and recommendations made by the participant reviewers. Most often, two external rounds of review provided the *CareerWISE* team with sufficient information to address any questions or concerns that arose in the evaluation process; there were, however, a few modules that required further evaluation and, in those cases, a third external evaluation was conducted to solicit feedback about newly added content (i.e., based on feedback obtained in the prior rounds) or to ensure the clarity of revised material. The final stages were to upload approved modules to the *CareerWISE* site for inclusion in a randomized controlled trial that is currently underway. This process is illustrated in Figure 1.

Reviews were conducted in a lab setting or in classrooms where reviewers were presented with survey questions measured on a Likert-type scale and open-ended qualitative questions that were subsequently analyzed by our team. All responses were compiled by our research team and then discussed by the broader writing and design teams. All reviewers were asked to complete a questionnaire pertaining to their experience with the material. In total, all reviewers responded to 30 survey questions using a five-point Likert-type scale (e.g., 1 = *Strongly Disagree*, 3 = *Neither Agree Nor Disagree*, 5 = *Strongly Agree*). The survey questions solicited reviewer perceptions about topics ranging from the relevance of the material (e.g., *How relevant is the material to your personal situation?*), the likelihood of referral and endorsement (e.g., *I would encourage other students to read this material*), the effects on coping efficacy (e.g., *Reading the material increased my confidence in my ability to deal with problems I encounter in school*) and feedback about their subjective experience with the material (e.g., *The material was engaging*). The survey items are included in Table 4. Review comments were also solicited and the most common responses addressed subjects such as the depth, breadth, and length of the material. Often participants provided detailed comments about the ways in which the material pertained to their experiences and how they had learned a new approach or strategy for addressing communication issues in their personal and professional lives. Similarly, comments were provided about particular elements of the modules. For example, the following comment expounds on the instructional value of the self-tests: “The self-tests were a good way to assess my own thought process and the discussion beneath them corrected my way of thinking.” Additional types of feedback that were common in these evaluations included: (1) corrective feedback pertaining to some issue with the discipline-specific content, (2) design structure (i.e., from experts in educational technology), and (3) suggestions for additional strategies, techniques, or approaches (i.e., these were most often suggested by participants with expertise in the content area, such as communication, counseling, and counseling psychology graduate students).

Conclusion and Discussion

In this paper, we have outlined the development and evaluation of the second major phase of the *CareerWISE* intervention: online communication training designed to strengthen women’s knowledge and skills for interpersonal communication in STEM fields, particularly those interactions that occur in gendered environments. We have explained the processes by which general and specific communication topics were chosen for inclusion in the intervention. We have illustrated the ways in which we employed best practices from an interdisciplinary compendium of literature (including educational psychology, pedagogical theory, communication and counseling psychology) to create a comprehensive curriculum tailored to common areas of difficulty experienced by women in STEM.

The *CareerWISE* intervention projects are unique in that all material is empirically evaluated prior to being uploaded on the site and the effectiveness of components of the intervention is rigorously tested. Currently, the effectiveness of the communication training modules in enhancing knowledge and skills is being evaluated in a national randomized controlled trial (RCT).

CareerWISE was designed as a one-stop, free resource for women in STEM. In the instance of the *CareerWISE* communication training, all materials are interconnected, but also function as

stand-alone pieces; this provides visitors to the site with a unique opportunity to engage the material for quick answers to vexing questions or to learn essential and advanced skills that may be used now and throughout the entirety of their careers. An important objective of the *CareerWISE* project is to provide women in STEM with practical solutions, meaningful examples, and ample practice opportunities for positively affecting their graduate experience. Ultimately, we hope to increase the satisfaction, coping efficacy, and progression of women in science and engineering doctoral programs.

Acknowledgments

This study was supported by the National Science Foundation (NSF) grant 0910384. Any opinions, findings, and conclusions and recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the NSF.

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Table 1

Communication Elements: The Seven Components of the CareerWISE Communication Process

Elements	Concepts Introduced
<i>You</i>	The intrapersonal nature of communication and the parts of the self that all individuals bring to communication interactions.
<i>Other</i>	The personal characteristics the <i>Other</i> individual brings to the communication interaction.
<i>The Message</i>	The ways in which communication involves more than the actual content of what is said; it involves when and how the message is delivered, the possible interferences that may arise from different perceptions, and other possible external factors that often contribute to the ways in which a message is received.
<i>Gender</i>	The importance of awareness of social expectations for women and men and the ways in which these expectations can affect individual communication interactions.
<i>The Context</i>	The environment in which communication occurs. All contexts have associated norms and cultures and this module is designed to draw attention to the influence that context may have on the ways in which women in STEM are perceived and understood.
<i>The Outcome</i>	Refers to the end-point of an interpersonal exchange. This module addresses the need to identify in advance the desired objective of the communication interaction and best practices for influencing a positive outcome.
<i>The Relationship</i>	The ongoing nature of communication in personal and professional spheres and the importance of building and maintaining a relationship with your colleagues and others. In <i>The Relationship</i> , interpersonal styles and power dynamics are highlighted and strategies for tailoring approaches for specific relationships are offered.

Table 2

Essential Skills: Comprehensive Instruction in the Four Critical Interpersonal Communication Skills

Modules	Skills
<i>Planning the Message</i>	Teaches women in STEM how to: <ul style="list-style-type: none"> • Identify the goal(s) of their message. • Gather useful information to plan their message, to choose a channel and mode of delivery (e.g., face-to-face versus email). • Prepare for instances of unplanned or unexpected communication.
<i>Active Listening</i>	Teaches women in STEM how to: <ul style="list-style-type: none"> • Develop strategies for attending to the other person(s) with whom they are interacting. • Listen for the content of the message, how to notice nonverbal communication in others. • Identify the critical information within a larger message. • Ask open-ended questions to ensure that they are fully understanding what the other person(s) is trying to communicate. • Check for the other person's perceptions.
<i>Expressing Yourself</i>	Teaches women in STEM how to: <ul style="list-style-type: none"> • Express themselves in a way that helps them to get what they want. • Avoid common problems with verbal communication in professional settings. • Use non-verbal communication to help convey their message. • Avoid common problems with non-verbal communication. • Bring attention to their needs. • Manage their professional image.
<i>Receiving and Responding to Feedback</i>	Teaches women in STEM how to: <ul style="list-style-type: none"> • Demonstrate receptiveness when getting feedback. • Recognize the role of choice when interpreting feedback as positive or negative. • Identify the benefits of feedback. • Employ helpful reframing statements against self-defeating thoughts. • Decipher when feedback fits or doesn't fit. • Increase awareness about how responses to feedback may come across.

Table 3

Advanced Strategies: Mastery of the CareerWISE Communication Training

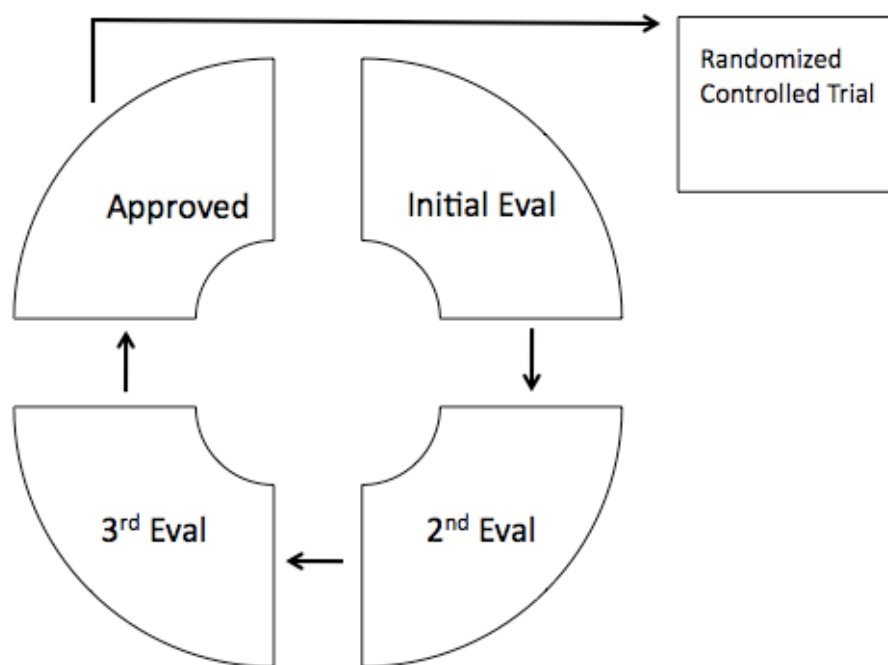
Modules	Skills
<i>Assertiveness</i>	<p>Teaches women in STEM how to:</p> <ul style="list-style-type: none"> • Recognize different types of communication styles in themselves and others. • Avoid common problems associated with ineffective communication styles. • Assertive techniques in their interactions with others. • Appropriate boundaries and limits • Understand and navigate situations in which gender can be a barrier to assertiveness. • Promote assertiveness in themselves and others.
<i>Negotiation</i>	<p>Teaches women in STEM how to:</p> <ul style="list-style-type: none"> • Understand the components of an effective negotiation plan. • Approach negotiation in an effective and confident manner. • Engage effectively in negotiation. • Avoid common pitfalls to negotiation. • Understand and navigate situations in which gender plays a role in negotiations.
<i>Managing Conflict</i>	<p>Teaches women in STEM how to:</p> <ul style="list-style-type: none"> • Recognize the origins of any particular conflict. • Identify different strategies for managing conflict. • Avoid common pitfalls in conflict management. • Manage both anticipated and unexpected conflict situations effectively.

Table 4
CareerWISE Content Evaluation Items: Survey Items Used to Inform Content Revisions

Item Type	Items
<i>Relevance to Experience</i>	<p><i>How relevant is the material to your personal situation?</i></p> <p><i>How relevant is the material to students in general?</i></p> <p><i>The material contained practical information that could be applied to problems experienced by students.</i></p> <p><i>I could identify with the experiences presented in the material.</i></p> <p><i>The material contained practical information that could be applied to problems experienced by students.</i></p> <p><i>The material realistically illustrates problems faced by students today.</i></p> <p><i>The material was relevant to the problems experienced by my fellow students.</i></p> <p><i>The material helped me consider solutions to the problems experienced by other students.</i></p>
<i>Likelihood of Endorsement</i>	<p><i>How likely are you to apply this material to your personal situation?</i></p> <p><i>How likely are you to recommend this material to other students?</i></p> <p><i>How likely are you to visit a website with similar material?</i></p> <p><i>I would encourage other students to read this material.</i></p>
<i>Effect on Coping Efficacy</i>	<p><i>Reading the material increased my confidence in my ability to deal with problems I encounter in school.</i></p> <p><i>After working with this material I believe I am better able to deal with the problems faced in school.</i></p> <p><i>After working with this material I feel overwhelmed by the problems students face in school.</i></p> <p><i>Learning that others share similar experiences increases my motivation.</i></p>
<i>Subjective Experience</i>	<p><i>The material was interesting.</i></p> <p><i>The material was engaging.</i></p> <p><i>The material was helpful.</i></p> <p><i>The materials presented inspired me.</i></p> <p><i>The material met the learning objectives specified at the start of this section.</i></p> <p><i>The material in this section was unclear.</i></p> <p><i>I would like to see more material like this.</i></p> <p><i>The material in this section was unclear.</i></p> <p><i>I was familiar with the vocabulary used in this material.</i></p> <p><i>How would you describe the clarity of the material?</i></p> <p><i>In terms of length, the material presented here was too long, just right...</i></p> <p><i>How much of the information presented in the material was new?</i></p>

*Items were measured using five point Likert-type scales (e.g., 1 = *Strongly Disagree*, 3 = *Neither Agree Nor Disagree*, 5 = *Strongly Agree*)

Figure 1: *CareerWISE* Content Evaluation Cycle



*With Revisions Based on Expert Feedback Occurring Between Each Evaluation