Growing Undergraduate Student Mentoring Skills Using a Reflective Practice Guided by Peer Feedback

Steven C. Zemke, Donald F. Elger
University of Idaho

Abstract

Our university is facing increasing enrollment as well as decreasing funding. Class sizes and faculty workloads are rising. As a result, the students' personal connection with the faculty is decreasing. To cost effectively augment the faculty effort and simultaneously increase connection with students we are utilizing undergraduate student mentors. Since excellent mentoring skills are rare in undergraduates, we need to grow them in our mentors. Additionally, we need to grow these skills as students graduate. We need a low cost, but highly effective means to grow mentoring skills. Furthermore, since mentoring happens in the dynamics of a conversation, the skills growth process needs a "real-time" component.

We believe that mentors can grow their skills quickly by reflecting on their performance immediately following a mentoring session and "scripting" more effective practices. The "scripts" are pre-planned responses the mentor will use in future mentoring situations. The mentor also relies on peer observer feedback recorded during the mentoring session to guide the writing of the scripts. The scripts are then reviewed before the next mentoring session. This skills growth process incorporates parts of an employee development method used by the author at Hewlett-Packard several years ago. Our question is:

"What underlying principles emerge as we train undergraduate mentors?"

To evaluate the skills growth process we employed several instruments during a four-week pilot study. "Snapshot" instruments used during each mentoring session gathered data from the mentors, mentees, and observers. Following the study, the mentors and mentees wrote comments concerning growth in the mentor's skills. Three underlying principles appeared to emerge from the data:

1. The simple formula of exploring what a mentee knows and then collaboratively enabling the mentee to refine his or her understanding appears to be fundamental to mentee learning.
2. Collecting, processing, and incorporating self and observer feedback appears to enable our mentors to quickly and effectively develop their skills.
3. Maintaining the level of challenge and the development of healthy rapport appear to be synergistic with exploring what a mentee knows and enabling the mentee to refine his or her understanding.

1. Introduction

Our university is facing increasing student enrollment at the same time as decreasing funding. These two pressures are increasing class sizes as well as the faculty workload. As a result the students' personal connection with the faculty is decreasing. We are utilizing undergraduate students as mentors within classrooms to cost effectively augment the faculty effort and simultaneously increase connection with students.

Excellent mentoring skills are uncommon among students. Though a student may be academically well developed, there is no guarantee that the same student will be an excellent mentor. Consequently, we must train mentors. However since the mentors leave upon graduation, the training process must work well and be cost effective.

Another consideration in training mentors is that the skill of mentoring is a "real-time" skill. Mentoring is done in the dynamics of a conversation between the mentor and mentee. To be of maximum efficacy, the flow needs to be natural and uninterrupted. In the engineering sciences we are not accustomed to training "real-time" skills. Analysis of stress, strain, fluid flow, etc. is done "off-line" rather than as part of dynamic interpersonal interaction. Consequently, we have little experience and training to rely on when training students to mentor.

We believe that we can grow mentoring skills quickly and inexpensively using a reflective skills improvement process based on peer feedback. Personal experience with an organizational revitalization process implemented at Hewlett-Packard several years ago has led us to develop our analogous mentoring skills development process. Our question is:

> "What underlying principles emerge as we train undergraduate mentors?"

At University of Idaho we are studying ways to train classroom mentors, iterating to improve our training methods, and incorporated our best new practices into our standard methods.

2. Literature Review

2.1. Traditional Mentoring

Mentoring programs have proliferated in the past two decades in the United States. Initial seed programs and ideas have been spread in several venues (Johnson & Sullivan [1]). The goal of the mentoring programs is to enable a young person or professional to successfully develop into the next stage of his or her life. Frequently these mentoring programs are intended to help people within at-risk populations. The conventional wisdom is that mentors, by means of their senior status and mature experience, can aid mentees' growth.

Though mentoring programs are spreading quickly, a common and precise working definition of mentoring does not exist. Jocobi [2] states, "…Although many researchers have attempted to provide concise definitions of mentoring or mentors, definitional diversity continues to characterize the literature." However, some common definitional "themes" run through much of the literature. "…Mentoring is a process within a contextual setting; involves a relationship of a more knowledgeable individual with a less experienced individual; provides professional

networking, counseling, guiding, instructing, modeling, and sponsoring; is a developmental mechanism, is a socialization and reciprocal relationship; and provides an identity transformation for both mentor and mentee." (Galbraith and Cohen [3]) Development of rapport between the mentor and mentee is fundamental to success in these programs.

2.2 Supplemental Instruction

Many universities are using near-peers in instructional settings. The Supplemental Instruction (SI) program, originated at University of Missouri-Kansas City [4], is perhaps the best known. This program has been introduced at many universities in the United States and several foreign countries. In the SI structure, model students who have completed a course serve as SI leaders of small groups of students (typically about 25) currently enrolled in the course. The SI leader's main function is to facilitate students' learning by fostering collaboration. Rather than being an expert who fills the role of a lecturer, the SI leader facilitates discussion and refers student questions back to the group of students to answer. The SI leader also redirects the group back to the main subject if the discussion is heading off on a tangent. These programs have a well-documented rate of improvement of educational outcomes [4].

Queensland University of Technology in Australia has effectively incorporated the SI program into a freshman engineering statics class. Student performance has dramatically improved since the introduction of the program. At the same time program costs have dropped due to larger lecture class size [5]. Murray [6] describes the important roles the SI leaders embody: "SI leaders are trained to run their sessions … as opportunities for participants to work cooperatively and to learn from each other, with only guidance from the leader," "They are trained to redirect students' question back to the group…," "It is made very clear … that (SI) leaders are not experts."

2.3. Individual Tutoring

Individual tutoring is also known to provide an excellent learning environment. Graesser, Person, and Magliano [7] report, "It is well documented that one-to-one tutoring is superior to normal learning experiences in traditional classroom settings. The effect size of the advantage of tutoring over classroom has ranged from 0.4 to 2.3 standard deviation units…." In studying one-on-one tutoring Graesser, et al. uncovered some common dialogue patterns that may account for the greater learning in tutoring.

In their study Graesser, et al. videotaped, transcribed, and analyzed typical one-on-one tutoring sessions. The tutors were untrained. Forty-four one-hour sessions were recorded of graduate students tutoring undergraduates in research methods. Twenty-two one-hour sessions were recorded of high school students tutoring junior high school students in algebra. One central finding of the analysis was a five-step dialogue pattern, shown in Table 1, which commonly appeared in many tutoring sessions.

Graesser, et al. describe the dialogue between the tutor and student as collaborative. The tutor begins by asking a question, the student responds and the tutor gives some sort of feedback on the student's response. The feedback is not necessarily even correct. For example the student may give a vague or incorrect response and the tutor may say something like, "good." Following this point in the tutoring, the tutor and student will collaboratively refine or improve the student's

answer to the point where the answer is correct. The tutor doesn't merely toss out the student's answer and begin "with a fresh sheet of paper," but rather the tutor starts correcting the problems within the student's answer.

Step 1: Tutor asks question.
Step 2: Student answers question.
Step 3: Tutor gives short feedback on the quality of the answer.
Step 4: Tutor and student collaboratively improve the quality of the answer.
Step 5: Tutor assesses student's understanding of the answer.

Table 1. Five-step dialogue pattern in tutoring, Graesser, et al.

2.4. Cognitive Sciences—effect of prior knowledge on new knowledge

Findings in cognitive psychology reinforce the soundness of step 4 in Graesser et al.'s dialogue pattern: collaboratively improving the quality of a student's answer. Pellegrino, Chudowsky, & Glaser [8] report, "One major tenet of cognitive theory is that learners actively construct their understanding by trying to connect new information with their prior knowledge." Not only is knowledge constructed, it is individualized. Since each student has different starting knowledge, each student's construction of knowledge will differ from other students. When the tutor and student collaboratively improve the student's answer (as in Graesser et al.'s step 4), they are constructing knowledge from the student's current knowledge.

Since new knowledge is constructed upon old knowledge, it is important to begin the learning from the old knowledge. "Drawing out and working with existing understandings is important for learners of all ages. Numerous experiments have demonstrated the persistence of a preexisting naïve understanding even after a new model that contradicts it has been taught." (Pellegrino, et al. [8]) Incorrect understanding of old knowledge can prevent the new knowledge from being learned. Thus when the tutor and student collaboratively improve the student's knowledge, "preexisting naïve understandings" can be surfaced and improved.

When prior knowledge prevents new learning the prior knowledge is called a *cognitive obstacle.* Herscovics [9] discusses specific examples of cognitive obstacles in the learning of algebra. He notes two important aspects of learning that cognitive obstacles can interfere with: assimilation and accommodation. "This process of equilibration (balancing the new knowledge with old) involves not only *assimilation*—the integration of the things to be known into some existing cognitive structure—but also *accommodation*—changes in the learner's cognitive structure necessitated by the acquisition of the new knowledge. However, the learner's existing cognitive structures are difficult to change significantly, their very existence becoming cognitive obstacles in the construction of new structures." (Herscovics [9]). Effective learning must address cognitive obstacles associated with both assimilation and accommodation.

When a tutor collaboratively works with a student to improve the student's answer, the tutor is helping the student to overcome cognitive obstacles of both assimilation and accommodation. Refining the student's answer anchors the learning firmly in the student's present cognitive framework and deals directly with the student's individual cognitive obstacles. Thus the fourth

step in Graesser, et al.'s analysis directly deals with the fundamental needs of learning as formulated in cognitive science.

2.5. Cognitive Sciences—Metacognition and learning new skills

Cognitive sciences also inform methods for mentoring skill development. Early psychologists studied learning by using introspection (Nelson [10]). In this approach the experimenter varied external stimulus and subjects described what they thought or felt. This approach was abandoned in the 1920's because the subjects' introspection was not a completely reliable source of information. During the subsequent 50 years psychological experiments collected only externally observable evidence. Recently, both external observations and introspections have been incorporated into studies with success. Nelson [10] states, "…The individual participant can be treated as an imperfect measuring device of his or her own cognitions, in which the individual's metacognitive monitoring is assumed to sometimes contain errors or distortions."

Though people's metacognition of their performance of a skill contains errors and distortions, their insights are necessary for them to improve their performance. Based on their introspective insights people can modify and improve their skills. "Metacognition is crucial to effective thinking and competent performance." (Nelson [10]) Furthermore, people who consciously engage in metacognition show better learning. "Studies of metacognition have shown that people who monitor their own understanding during the learning phases of an experiment show better recall performance when their memories are tested." (Pellegrino, et al. [8])

Present day experimental techniques in cognitive psychology rely on the combination of introspection with external observations. Using both sources of data increases the depth of possible inquiry. "Introspective reports…can be related to other empirical observations and thereby can help investigators draw inferences about the participants' psychological processing." (Nelson [10]) In the same way, learning skills based solely on one's metacognition may be improved by adding external observations as well. The external observations add insight, correction, and calibration for the person's metacognition.

The usefulness of feedback to improve skills has been known for a long time. In addition, the skills will be learned much more quickly if the feedback is accurate. "Individuals acquire a skill much more rapidly if they receive feedback about the correctness of what they have done. If incorrect, they need to know the nature of their mistake. It was demonstrated long ago that practice without feedback produces little learning." (Thorndike [11]) Accurate feedback leads not only to learning, but to rapid learning.

The most rapid improvement to a skill happens when the skill is first being learned. After the initial learning of the skill the rate of improvement decreases. "This pattern is characterized by an initial rapid improvement in performance, followed by subsequent and continuous improvements that accrue at a slower and slower rate. (Pellegrino [9])

2.6. Summary

Traditional mentoring emphasizes development of rapport between senior persons and mentees to enable success. Since our mentors are near-peer, traditional mentoring does not directly

inform our work. However, SI programs have effectively utilized peer leaders and also defined excellent working roles for the peer leaders.

On a different front, studies in tutoring have revealed that tutors and tutees iteratively collaborate to improve the tutee's knowledge. This tutoring dynamic is supported by findings in cognitive sciences that people learn new knowledge in terms of what they already know. Collaboratively improving knowledge is applicable to both how mentors interact with mentees and also how mentors improve their mentoring skills.

Feedback on performance has been shown to be vital when one attempts to improve skills. In cognitive science experiments, both internal (metacognitive) and external sources (observations) have been useful data. Therefore it seems using both internal and external feedback should help mentors develop their skills. Finally, studies have shown that there is rapid skill improvement when a skill is first learned.

3. Model of Mentoring

3.1. Conceptual Framework

Our model of mentoring rests on four basic elements: (1) the mentee's representation of knowledge, (2) knowledge is constructed, (3) mentoring must be consistent with the way people learn, and (4) new knowledge must be both assimilated and accommodated.

Mentee's Representation of Knowledge: When people learn, they typically build on what they already know. Prior knowledge is used to interpret new knowledge. We call this prior knowledge, both in content and organization, the mentee's representation of knowledge. Since mentees are learning a new subject, their representations of knowledge include many errors and inconsistencies in content, procedures and explanations. Faulty as their representation may be, it is the starting point and working area of our mentoring.

Knowledge is Constructed: Current theories of cognition indicate that knowledge is constructed. As knowledge is constructed, it is always constructed relative to some context; it cannot simply be "free-floating." The anchor for the new knowledge is inevitably prior knowledge. People construct new knowledge by adding to and/or modifying what they already know. The mentor seeks to enable the mentee to construct knowledge within the mentee's representation.

Mentoring must be consistent with the way people learn. Effective mentoring must be aligned with the way people naturally learn. Since people learn by constructing new knowledge on old, effective mentoring must follow this pattern. Yet, the model of presenting "the right way to understand something" and simultaneously ignoring prior incorrect knowledge persists in educational settings today. To ask mentees to wholesale abandon their representations of knowledge in order to adopt a correct representation is ineffective. Rather, the mentee's representation of prior knowledge must be directly addressed in the learning of new knowledge.

New knowledge must be both assimilated and accommodated. Learners evaluate the validity of new knowledge based on what they already "know." If their preexisting representations of

knowledge conflict with the new knowledge, they will find the new knowledge very difficult to learn. The learner may well even reject the new knowledge as false. This difficulty or rejection is not a matter of will, but rather a natural outworking of how the mind learns. Consequently, effective mentoring must address not only assimilation, but also integration of new with prior knowledge. The prior knowledge must typically be modified to accommodate the new.

3.2. Process of Mentoring

Our process of mentoring contains two basic elements: (1) exploring mentee's representation and, (2) enabling mentees to refine their representation. These two elements, exploring and enabling, are iterative and flow naturally from the dynamics of a conversation. Figure 1 diagrams our process of mentoring.

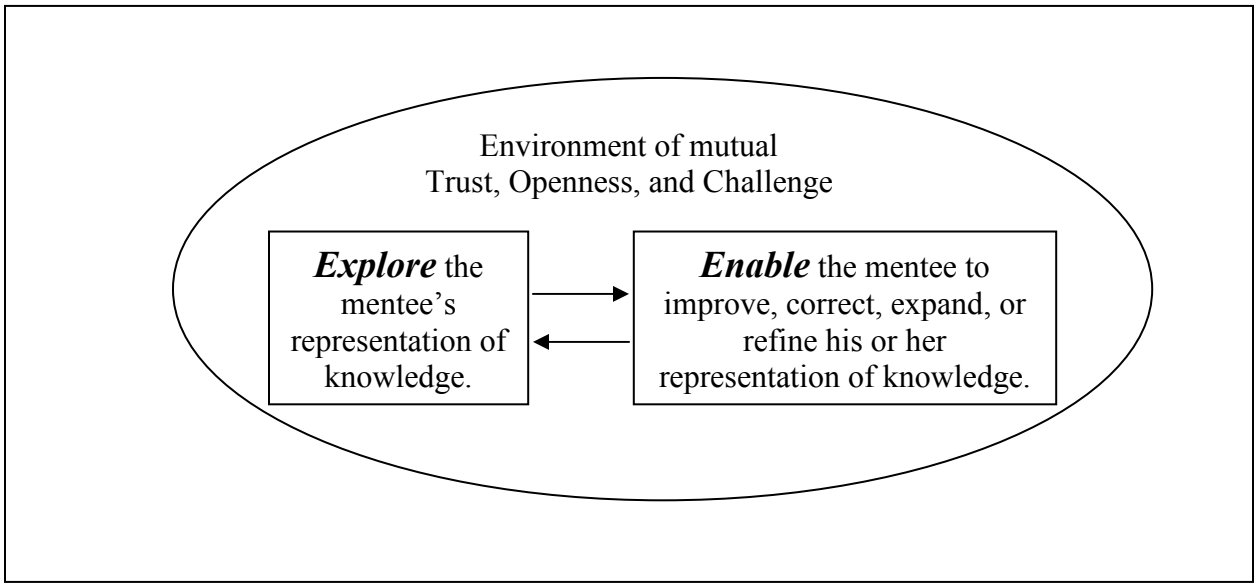

Figure 1. Model of mentoring.

Exploring the mentee's representation of knowledge: The first element of mentoring involves exploration. Through the use of questions and active listening the mentor explores the mentee's representation. The primary goal of this activity is to surface and clarify how the mentee has organized and understands the subject matter. As the mentee explains what he or she knows or doesn't know, the mentee's representation can become obvious to both the mentor and mentee.

This exploration sets the stage for constructing new knowledge on prior. Since prior knowledge has been surfaced, it can be addressed. Errors or inadequacies in prior knowledge can be discussed and refined. This simple step of exploring the mentee's representation insures that the mentor actually addresses the real impediments to the mentee's learning.

Enabling the mentee to refine his or her representation. For the new knowledge to take firm root in the mentee, the mentee, not the mentor, must construct it. It is not sufficient for the mentor to simply "give" the new knowledge to the mentee—even when the mentor has a clear picture of what the mentee needs. Mentees cannot "own" the knowledge until they have

constructed it into their representations. Thus the mentor needs to enable the mentee to construct the knowledge.

Using simple questions the mentor can assist the mentee in distinguishing what they know from what they don't know. Other questions can be used to help a mentee connect correct concepts that he or she has not yet connected. Simple affirming statements help the mentee to remember with more certainty things they already understand. The mentor can give simple specific hints of how the new knowledge fits with the prior. The mentor can even simply state the new knowledge and have the mentee explain what it means or how it is used. This simple course of action centers the discussion on the mentee's representation and how the mentee can refine it.

Refining the mentee's representation becomes a natural dialogue between the mentor and the mentee. Questions that explore the mentee's representation naturally lead to discussion of ways to improve the representation. Improvements in the mentee's representation naturally lead to exploring related aspects of the mentee's representation. This natural flow between exploring and enabling is simply an iterative process of improving the mentee's representation. "Solving" the mentee's problems is not done in one heroic leap, but rather through small incremental steps.

3.3. Environment of Mentoring

Our mentoring environment has two fundamental characteristics: (1) high educational challenge and, (2) strong respect for the individual.

High educational challenge: The mentoring environment must provide a high level of challenge in order for the mentee to experience significant growth. The mentoring cannot create growth that is higher than level of challenge. The difficulty of the learning task innately sets the level of challenge. The mentor then maintains this level of challenge by focusing on the task. No effort is made by the mentor to reduce the overall challenge of the task the mentee is facing. The mentor is not to simply do the work for the mentee. However, the mentor can enable the mentee to divide the task into several smaller tasks, each of which has a smaller amount of challenge. In this way the mentee can achieve the overall challenge.

Strong respect for the individual: The mentoring environment must also be grounded in respect for the individual. The mentor initiates the respect by intentionally developing rapport with the mentee. The mentor continues to build the respect by asking the mentee if he or she wants help and/or feedback. Asking permission also creates an environment of collaboration between the mentee and mentor. The environment of collaboration now turns the learning task into a challenge to be mastered by the mentee with the help of the mentor. The collaborating also prevents the task from becoming one that the mentor forces upon the mentee.

When the mentor explores the mentee's representation of knowledge, the mentee's intelligence and value are directly acknowledged. Acknowledging the mentee further builds trust and openness in the interactions. Enabling the mentee to build on and refine his or her representation further reinforces trust. All of these ways of showing respect for the mentee's intelligence are conducive to high-level achievement against difficult challenges.

4. Practice of Improving Mentoring Skills

Mentors within our community follow a three-step process to improve their mentoring skills. The three steps form a complete cycle that is repeated regularly. Figure 2 diagrams our process for skills improvement.

Step 1: The mentor actively mentors students.
Step 2: The mentor reflects on his or her mentoring performance using both internal and external feedback.
Step 3: The mentor writes new "scripts" to improve their future performance.

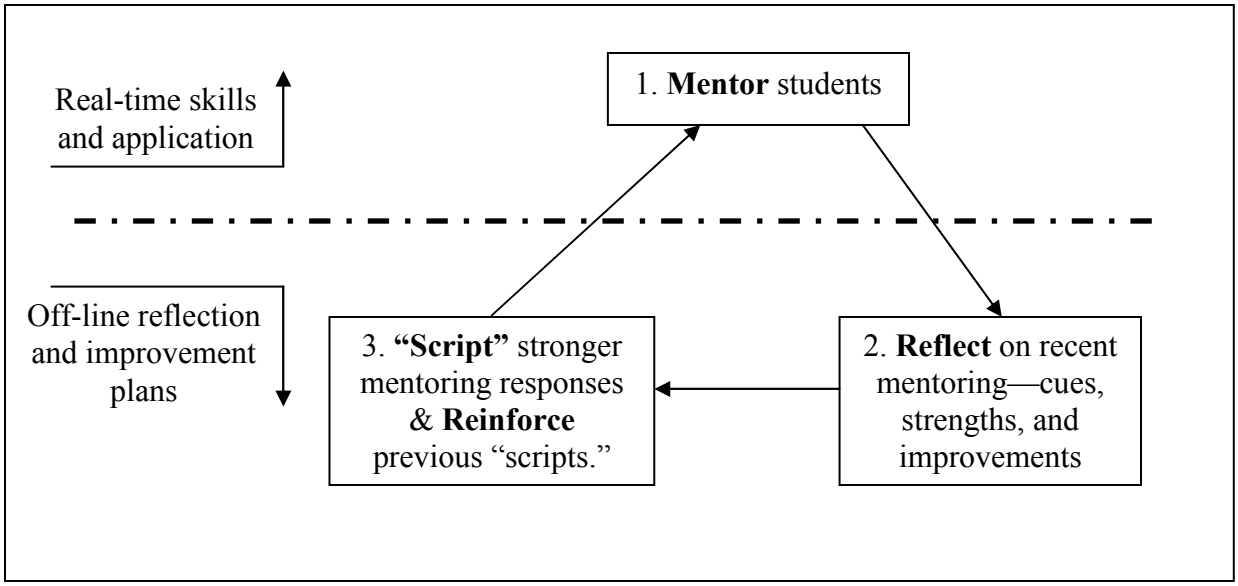

Figure 2. Mentoring skills improvement process.

Step 1—Active mentoring: The first step of improving mentoring skills is simply for mentors to employ whatever skills they already have. We coach our mentors on our particular model of mentoring and then ask them to mentor accordingly. The act of mentoring then provides two necessary ingredients for skill improvement: reinforcement of skills and insights for improvement. As mentors strive to mentor at the peak of their performance, skills are being reinforced. This active mentoring also brings to light areas where the mentors can improve their performance.

Step 2—Mentor reflection: Though mentoring skills are practiced and applied "real-time," the planning to improve the skills is done "off-line." Immediately following a mentoring session, mentors write down their insights from the session. The goal of this reflection is twofold. First, mentors identify their response to verbal and non-verbal communication of the mentee. Secondly, mentors identify why each key item was significant. In this way, mentors recall the session and gain insight into their role in the interactions. This insight becomes the foundation for the skills improvement plans.

For example, after a very positive mentoring situation, mentors may recognize what approach they used and how it helped enable excellent learning in the mentee. Mentors may take note of how a mentee phrased a question and how effective their response to the question was. Conversely, mentors may reflect on a mentoring situation that did not go well and also pull out useful insights. In all situations we ask our mentors to identify not only the "what" of what worked or didn't work, but also the corresponding "why" or "how."

During training sessions, we also augment the mentors' insights with the insights of an observer. Another mentor, serving as an observer, records highlights of the mentoring session. The observers then review their comments with the mentors following the mentoring session.

Step 3—Writing cue/response scripts: Mentors then convert their insights into simple practical responses to use in subsequent mentoring. We call these written responses "scripts." In this way mentors prepare themselves for common situations that arise in mentoring. The scripts allow the mentors to "package" off-line insights for "real-time" use. Since the scripts are individualized, they address the individual needs of the mentor.

The mentor ties each script to an appropriate contextual cue. Contextual cues are situational or verbal indicators that the mentor notices during the mentoring. Cues can be as simple as the mentee sighing, over-focusing on an unimportant point, or asking a question such as, "How do I do this?" Body language can also be a cue. Anchoring the script to a cue helps the mentor to recall a possible response during "real-time" mentoring.

Writing these scripts is a natural extension of the insights gained during reflection. During reflection a mentor may recognize a powerful approach to use in the future. The idea may come as the result of finishing a statement such as, "I wish I had done *this* instead of *that*," or, "I am glad that I did *this* or *that*." In either case both responses can be rewritten in future terms—"next time I will do…". To tie the script to a cue the mentor simply completes the following statements: "The next time I notice…*(the mentor writes the cue here)*, I will respond with…*(the mentor writes the scripted response here)*. For example the mentor may write, "The next time a mentor asks, 'What equation do I use?' I will respond with, 'What equations do you think may be applicable?'"

5. Methods

5.1. Structure of the Pilot Study

We conducted a pilot study to gain insights into how well mentors could improve their skills by reflection and scripted responses. During the four-week study we paired each mentor with a mentee and an additional mentor to observe. The mentor-mentee- observer trios remained intact for the duration of the study.

In the first session, the mentor-mentee pairs worked on routine homework problems for thirty minutes while their observer took notes. Following the mentoring session, the mentee completed a short survey and questionnaire characterizing the quality of the mentoring. Upon completing the survey, the mentee was excused. At the same time, the mentor began making his or her own reflective notes. The mentor and observer then reviewed together the insights from the mentor,

mentee, and observer. Following this review, the mentor wrote scripted responses to improve his or her mentoring skill for the next session.

The mentor began each successive session by reviewing all previously written scripts. After reviewing the scripts, the session proceeded identically to the first session. The mentee again completed a survey and was excused. The mentor and observer reviewed all the insights from the session. The mentor then wrote new scripted responses.

The final session was similar to the previous three sessions. The mentor reviewed all previously written scripts and began working with the mentee on homework problems. The observer recorded observations during the mentoring. Following the session the mentor and mentee both completed exit surveys. Figure 3 diagrams the structure of the pilot study.

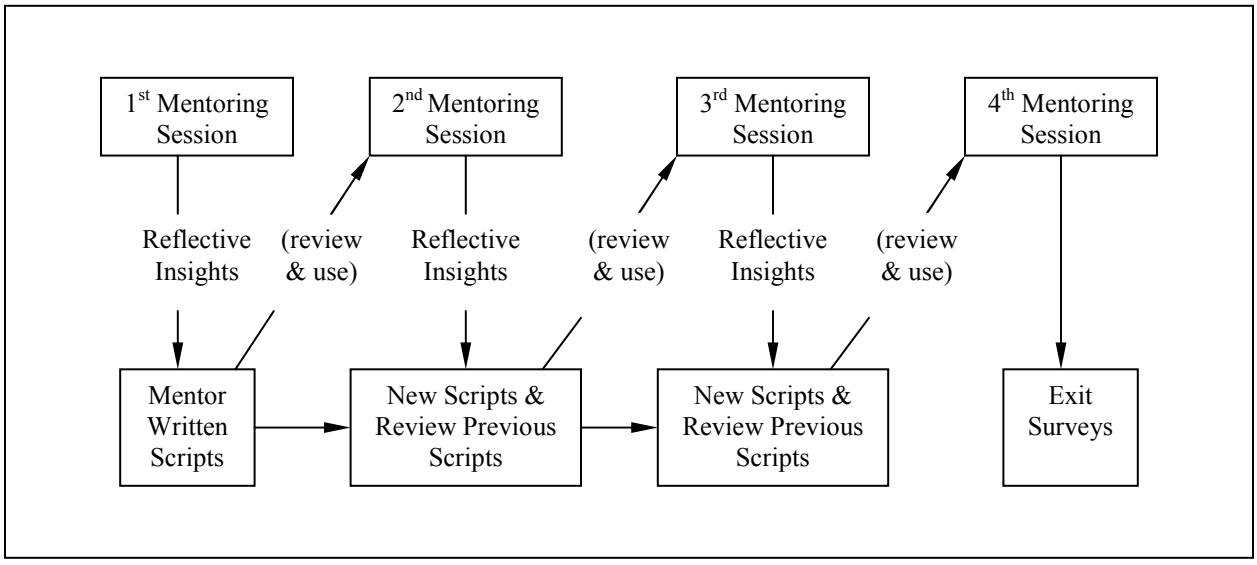

Figure 3. Structure of the pilot study.

5.2. Artifacts and Instruments

The mentor, mentee, and observer feedback forms provide a snapshot of the mentoring each week. The corresponding scripting form provides a record of the specific ways the mentor planned to improve his or her performance. Table 2 gives a brief description of the information collected at each mentoring session.

Snapshot instrument	Information collected
Mentor script form	List of cues and responses written by each mentor.
	Rating of how often the cue was followed.
Mentor self-feedback form	Specific key events and reasons they were important as recorded by the mentor.
	Assignment of whether each interaction was strong mentoring or something to change.
Observer feedback form	Specific key events and reasons they were important recorded by the observer during the mentoring session.
	Assignment of whether each interaction was strong mentoring or something to change.
Mentee feedback form	List of specific actions the mentor took to: a) Understand the problem from the mentee's perspective b) Help the mentee understand the problem c) Build rapport with the mentee
	Rating the mentor's performance on a) through c) above.

Table 2. Description of information collected each mentoring session.

Mentors and mentees completed exit surveys. Table 3 gives a brief description of the data gathered at the end of the study.

End of Study Instruments	Information collected
Mentor exit survey	Rank the relative usefulness of the feedback from self-reflection, mentee, and observer.
	Rate the usefulness of writing and reviewing scripts.
	Rate how long it would take to improve mentoring skills if: a) Observer feedback was eliminated b) Mentee feedback was eliminated c) Self reflection was eliminated d) Writing of scripts was eliminated
	Identify which script was a) easiest to follow, b) hardest to follow, c) most useful and explain why for each.
	Identify which cue was a) easiest to notice, b) hardest to notice, c) most useful and explain why for each.
	List areas of skills growth and what caused the growth.
Mentee exit survey	List of what the mentor did that was helpful and why each item was helpful.
	List noticeable changes in the mentor's approach and give specific examples.

Table 3. Description of information collected at the end of the study.

6. Results

The key events recorded in the weekly mentor and observer feedback forms are categorized and tallied in Table 4.

Feedback Source	Total Responses	Exploring		Enabling		Rapport		Other
		Strength	Weakness	Strength	Weakness	Strength	Weakness	
Mentors	116	25%	7%	29%	17%	8%	4%	10%
Observers	301	25%	4%	34%	7%	13%	3%	14%

Table 4. Mentor and observer weekly feedback observations categorized by type and strength or weakness.

The mentors sifted through the feedback forms each week and wrote from one to three scripted responses. Most of the scripts fit into the three distinct categories shown in Table 5. Some scripts originated from the mentor's observations, some from the observer's observations, and some jointly from both.

Type of scripted response	Percent of total scripts written	Average time followed	Example of typical cue/response
Reorient the mentee when the mentee has lost his or her direction.	40%	75%	The next time I notice we are stuck I could respond with, "Do you have any ideas?"
Correcting misconceptions and errors	30%	50%	The next time I notice an incorrect application of a concept I could respond with, "Why is that so?"
Mentor is resisting an urge to work from his or her own representation	20%	80%	The next time I notice myself taking the pencil I could respond with giving the pencil back.

Table 5. Mentor scripted responses classified according to type of cue/response.

The mentee feedback form consisted of three questions. Responses to these questions fell into a few broad categories. Statistics of these responses are listed in Table 6.

Question 1: "What actions did the mentor take to understand the problem from your perspective?"

- Mentor was exploring the mentee's representation……..23 total, 85%
- Other responses…….4 total, 15%
- Mentees reported that 85% of the time mentors understood problem from their perspective.

Question 2: "What actions did the mentor take to help you understand the problem better?"

- Mentor was enabling within mentee's representation……19 total, 70%
- Mentor was enabling, but not certain who's representation……8 total, 30%
- Mentees reported that 90% of the mentors' attempts to help actually helped.

Question 3: "What actions did the mentor take to establish and build rapport with you?"
• Mentor directly building rapport……..…..10 total, 40% • Working at the mentee's level equated to strong rapport……...10 total, 40% • Maintaining level of challenge equated to strong rapport……5 total, 20% • Mentees reported that 95% of the time they felt comfortable to ask any question.

Table 6. Mentee weekly responses classified by response type and tallied.

The general questions in the mentor exit surveys showed a wide variety of opinions about relative value of feedback source and script writing. However, all mentors indicated that improvement would be greatly slowed without their most important feedback source. The mentors were also asked to choose their most important cue/response. Five of the six cue/responses share three common features. Table 7 shows the responses by category.

Mentor perceived most important source of feedback: • Mentor's self-feedback…….……..1 mentor • Observer's feedback……...2 mentors • Self and observer feedback equal…….……..2 mentors • Self and mentee feedback…….……..1 mentor
Mentor perceived value of writing scripted responses: • >90% of improvements related to writing cues/scripts……..1 mentor • 75% of improvements related to writing cues/scripts……2 mentors • 50% of improvements related to writing cues/scripts……1 mentor • <25% of improvements related to writing cues/scripts……..2 mentors
Average perceived increase in time to improve the same amount if did not have the most important source of feedback and/or the writing of scripted responses: • Twice as long……..1 mentor • Four times as long……...2 mentors • Impossible to improve as much…..……..……...2 mentors
Commonality between the mentor rated "most important scripts." • The cue/responses would work equally well for exploring and enabling the mentee's representation. • The cue/response was written in a question form. • The cue/response asked the mentee to examine what they were working on from a more global viewpoint.

Table 7. Mentor exit survey responses to general questions.

The mentee exit survey asked, "What things did the mentor do that were especially helpful and why were they helpful?" The mentee response are categorized and tallied in Table 8.

Actions reported by mentees as helpful by category:

- Mentor explored mentee's representation……..10 total, 48%
- Mentor enabled mentee within mentee's representation……..……4 total, 19%
- Mentor directly build rapport……..…….1 total, 5%
- Mentor provided missing information or method……..……..6 total, 28%

Table 8. Mentee exit survey responses classifying helpful actions of mentors.

The mentee exit survey asked how the mentor had helped them. The mentor exit surveys asked the mentors in what way they had improved. Mentor growth areas could be matched to actions the mentees identified as helpful. Table 9 compares these responses.

- Mentoring skills improvement areas cited by mentors…….…….14
- Skills improvement areas with corresponding scripted responses…..……12
- Skills improvement areas independently cited as helpful actions by mentees……7
- Total number of helpful mentoring actions cited by mentees…..…….…….15

Table 9. Comparison of mentor exit survey responses, mentee exit survey responses, and scripts written by mentors.

7. Discussion

7.1. Mentoring Actions that led to Mentee Learning

At the end of the study the mentees were asked, "What things did the mentor do that were especially helpful and why were they helpful?" A full one half of the responses were that the mentors asked them to explain what they were thinking (Table 8). The mentees gave various reasons why this simple action was helpful.

One mentee wrote, "He would ask me to explain the problem the way I saw it so he knew what I knew. This let him explain things I was having problems with easier." The mentor could enable the mentee to refine his representation of knowledge because he knew what it was. The mentor knew where to target his help. Another mentee echoed this thought, "(He) asked questions (so that he) could check my understanding before beginning."

Another mentee gave a different reason, "She asked me to review the problem and explain it to her. This made me rethink the problem and determine if I understood the problem." In this case the mentee's representation of knowledge was surfaced to the mentee herself. Simply clarifying what she was thinking helped her to solve the problem.

Another reason is expressed in this comment, "He had me explain why I was using what I was using (so that) I looked for better answers, this led to more efficient solution paths." Here the mentee was able to evaluate and improve his representation of knowledge after the mentor had surfaced it.

The second most frequently cited (28%) helpful action of the mentors was to provide missing information or method. When the mentees would get stuck, the mentors would simply give

enough information to continue working. Again the mentees gave various explanations how the mentors giving them information help.

"(He) modeled how the problem was in a physical realm. This let me see the problem in a different aspect."
"(He) explained (the problem). That provided direction and somewhere to start."
"She set up a helpful format to solving problems which helped me organize my thoughts."

These quotes could indicate that the mentors are asking the mentees to work from their (mentor's) representation of knowledge. However since the mentor began by exploring what the mentee knew, even when the mentor gave information, the telling was shaped to fit the mentee's representation of knowledge.

The third most frequently cited (19%) helpful action of the mentors was to enable the mentees to refine their representation of knowledge. In each of the following quotes note how the learning is specifically within the mentee's representation of knowledge.

> "(She) found a graphical method to solving problems. I am a visual person and she helped me visualize the problem."
> "(He) asked me where I thought to go next. It was helpful because I thought through the problem and tried to figure it out."
> "(He) helped me to look for what the outcome should be. This helped me to visualize what was going on."

The mentees also cited the same actions as helpful in their weekly feedback comments. The following quote illustrates the strength of exploring and enabling within the mentee's representation of knowledge.

> "He walked me through what I was doing, and he helped me to check my concepts. He also had me make predictions and when they turned out to be wrong, he helped me to know why."

The mentee makes joint references to exploring and enabling in this quote. What the mentee ***didn't say*** is also important:

"He walked me through what I was doing," rather than, "He showed me a way to do it,"
"He helped me to check my concepts," rather than, "He showed me how to check my concepts."
"He also had me make predictions and when they turned out to be wrong…" rather than "He had me make predictions and then told me which ones were wrong."

7.2. Mentoring Skills Growth

The mentors and observers recorded 417 interactions between the mentors and mentees during the study. These tallies (Table 4) show that the mentors were following our mentoring model most of the time with occasional missed opportunities. The mentors and observers cited exploring, enabling and rapport building with approximately the same frequently. However, the mentors cited missed opportunities about twice as frequently as the observers.

The mentee comments throughout the study also indicate that the mentors were following our mentoring model. Eighty five percent of the mentee responses indicate the mentors were exploring their representation. Seventy percent of the mentee responses indicate the mentors were enabling the mentee within the mentee's representation (Table 6). The mentees also rated the mentors as understanding the problem from their perspective 85% of the time. Additionally the mentee comments contain several specific examples of strong mentoring: "Asked me to explain to her what was going on in the problem" and, "He made me explain the problem so he made sure I understood it."

The scripted responses written by the mentors indicate that the mentors were focusing effort on improving their performance. Table 5 tallies the scripts by function. Interestingly the mentors wrote 20% of these scripts to help them resist the urge to work from their own representation. Corresponding, the mentees' cited that the mentors were helpful because they understood and helped the mentee do the problem from the mentee's perspective.

Comparing the mentee exit comments with the mentor cited growth areas gives the strongest indication of mentor skills growth. The mentors were asked in what areas their skills had improved during the pilot study. Correspondingly, the mentees were asked in what way their mentors had been helpful and had changed during the pilot study. Surprisingly half of the growth areas cited by the mentors were also cited by the mentees (Table 9). For example one mentor felt she had improved her ability to ask leading questions. Her mentee independently stated that he found it helpful when the mentor asked him to review or explain something. Another mentor felt she had grown in showing how concepts relate and her mentee independently stated that going over concepts was helpful. Furthermore, of the 14 mentor cited growth areas, 12 of them had corresponding scripts written.

7.3. Self-Mentoring to Grow Skills

When the mentors reviewed the weekly feedback they were exploring their own understanding and performance of mentoring. The review surfaced relevant characteristics of their performance. Below are a few mentor quotes showing exploration of their own mentoring.

> "(Mentee said) I'm pretty much stumped; (I) suggested the drawing of more detailed diagram because it helps the mentee learn the skills to get 'unstumped.'"
> "(I asked) What if this happened? (this allowed me to) checked understanding and basic transfer of concept. This let me see if the mentee got it."
> "(I) jumped the gun to help with concepts and left out the set up (so this) disconnected with the mentee."

The writing of scripted responses was equivalent to self-enabling their skills growth. Notice the focus on improved performance in each of these cue/responses from Table 5.

"The next time I notice we are stuck I could respond with, 'Do you have any ideas?'"
"The next time I notice an incorrect application of a concept I could respond with, 'Why is that so?'"
"The next time I notice myself taking the pencil I could respond with giving the pencil back."

7.4. Individuality and commonality of growth

The mentors' opinions varied widely on which feedback source was most useful and on the usefulness of writing scripts. However, there was a strong commonality on what type of script was most useful.

When asked which feedback source most important, the group of six mentors was almost evenly split between the sources. One of the six felt his own insights were the most important feedback while another mentor listed his own insight as least important. Two of the mentors felt the observers' feedback was most important. Two felt their own insights and the observers' insights were equal in value (Table 7). Though the mentors were individual about which feedback source was most important, all mentors indicated that it would take at least twice as long to achieve the same amount of improvement without it.

The mentors were nearly evenly split on the usefulness of writing scripts. One mentor said it was fundamental to his improvement. Another mentor said that reviewing feedback and making written comments was important, but that writing scripts was not. The other mentors were evenly spread between the two extremes.

Five of the six scripts chosen by the mentors to be most important had three similar traits. First, the scripts were written as questions. Second, they could be used equally well to explore a mentee's representation as well as build upon it. For example, "What concept is that? Or how does that work," certainly explores the mentee's representation, but also asks the mentee to build upon it. Third, the scripts asked the mentees to examine their thinking from a more global perspective.

7.5. Environment of Respect and Challenge

The mentors and observers recorded very few times that the mentors actively built rapport (Table 4). Only 5% of the scripts were aimed at building rapport. Yet each mentor/mentee pair seemed to develop strong rapport.

The mentees identified three ways in which rapport was built. First, the mentor built rapport by being polite and personable. This happened primarily when the mentee was having difficulty. In these situations, respect of the individual was the primary essence of the mentee comments:

"She always was understanding when I did not understand."
"He didn't do anything to make me feel stupid or not know what is going on."
"She helped influence where I go in my solution path. Never felt stupid."

In all of these comments there is a basic statement of respect directed toward the mentee. Forty percent of the mentee comments were of this nature (Table 6).

Second, when the mentor worked at the mentee's level rapport was built. The mentees reported this action as building rapport as often as they reported the mentors being polite and personable.

> "(He) was real personable and tried to teach at the same level as I was at. He knew a way to do the problem but it was above my level so he didn't teach that way."

The mentee ties rapport to working at his level. Note that the mentor stayed within the mentee's representation of knowledge, "…at the same level as I was as."

Third, twenty percent of the mentee comments indicated that maintaining the level of challenge built rapport (Table 6).

> "He does a good job of making me feel like an intelligent person instead of just doing the problem for me."

Note that this mentee couples feeling intelligent with doing the problem herself. Reinforcing the challenge reinforced the feeling of intelligence. Apparently, this person felt that too much "help" from the mentor would be demeaning. A different mentee echoed the same sentiment:

"He was very helpful, and still assumed that I knew what I was doing."

7.6. Synergy between exploring, enabling, trust, and challenge

The most striking characteristic of the mentee comments is the synergy between exploring and enabling, and respect and challenge. Exploring the mentees' representation of knowledge prepared the mentors to help at the mentees' level. Helping at the mentees' level was viewed as respect and hence built rapport. Enabling the mentee to refine their representations maintained the level of challenge and was also viewed as respect. The comments suggest that exploring, enabling, respect, and challenge all happen simultaneously.

8. Conclusions

The following underlying principles seemed to emerge as we trained our mentors.

1. The simple formula of exploring what a mentee knows and then collaboratively enabling the mentee to refine his or her understanding appears to produce strong mentee learning. The mentees indicated this process was fundamental to their learning. A full half of the help the mentees' reported receiving was from their mentor asking them leading questions to explain what they knew. In contrast, people often equate "telling" or "explaining" with helping a person learn. Our mentors certainly did some explaining. However, since the mentors focused on exploring what the mentees know, even the "telling" was grounded in the mentees' framework.

2. Collecting, processing, and incorporating self and observer feedback appears to enable our mentors to quickly and effectively develop their skills. This skills growth process followed the same pattern as our mentoring process. Collecting self and observer feedback is simply the mentor exploring his or her understanding and performance of mentoring. Processing and incorporating feedback enabled each mentor to improve his or her understanding and performance of mentoring. The mentors' opinions about which feedback source was most important and the value of our specific approach to writing improvement plans varied greatly.

We suggest providing at least self and peer feedback and some form of structured writing of improvement plans.

3. Maintaining the level of challenge and the development of healthy rapport appear to be synergistic with exploring what a mentee knows and enabling the mentee to refine his or her understanding. The mentees' reported that their mentors respected their intelligence, and hence built rapport, by asking them to explain the problems from their (mentees') perspective. Furthermore, the mentees' reported that the mentors respected them by *not* doing the problems for them, but rather by enabling them to do the problems themselves. The comments suggest that exploring, enabling, respect, and challenge happen simultaneously and synergistically.

While the data strongly supports these conclusions, they could be further strengthened by directly measuring the mentee learning. We believe that such a study would be valuable. However, measuring the mentee learning was beyond the scope of this pilot study.

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Biographical Information

STEVEN C. ZEMKE is a PhD student in the Mechanical Engineering Department at University of Idaho. His research area is teaching methods for engineering. Prior to coming to University of Idaho he taught two years at Eastern Washington University in the Engineering Technology and Multimedia Design Department. Prior to teaching Steven was a design engineer for 23 years.

DONALD F. ELGER, a Professor of Mechanical Engineering at the University of Idaho in Moscow, has been actively involved with traditional research and pedagogy for the past 15 years. Research interests include the design of enriched learning environments, meaningful learning, mentoring, the design process, fluid dynamics, and heat transfer. Dr. Elger teaches courses in design and in fluid mechanics.