Teaching Lessons from Engineering Feedback Model for New Educators

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Abstract:[*]
The Shannon s communication model is often used as a presentation vehicle in a teaching and learning environment. The model includes an input, an output, and a receiver or a transmitter. In engineering, we view this model as a open loop system. A classroom lecture by itself is primarily an open loop system, and many educational researchers suggest that the classroom lecture is less than 10% effective in learning. However, we as educators focus our efforts primarily on the lecture mode.

Now there is a body of educational research that suggests that the learning takes place primarily in the corrective feedback path. In electrical engineering systems we call this a negative feedback. The negative feedback is an appropriate term in electrical engineering systems, but in social systems, we can simply use the term feedback. In teaching, this feedback includes such items as classroom interaction, personal interaction of students and faculty members, homework, quizzes, and tests. In a learning environment, this feedback path is the most effective, and we as educators need to focus more on this path.

This paper identifies similarities between student learning and the engineering feedback model and discusses teaching techniques, suggestions, and behaviors that are most conducive to student learning.

Introduction:

The traditional feedback model of an engineering system can be viewed as a good representation of our classroom teaching and learning processes. Shannon s communication model is often used to represent classroom teaching. In terms of engineering terminology, it is an open loop model, and it can represent one aspect of teaching - namely, the lecture. However, the presently accepted concept of teaching involves assessment of learning. If learning does not take place, there is no teaching. If we include learning is an integral part of teaching, Shannon s model falls short in representing the teaching. However, Shannon s model with feedback, known as the Shannon-Weaver model, can represent the teaching-learning process, and this model is very similar to the model of an engineering system. This paper describes both the Shannon s original model and modified model with feedback and compares the modified model with the engineering systems model. It draws analogies between the engineering model and classroom activities and student activities and suggests various lessons that can be learned from the engineering model to improve teaching and learning.

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Communication Model and Engineering Open Loop Model:
Figure 1 shows the Shannon s original communication model. It was designed to represent technical communication such as radio transmission. It has five blocks: 1) information source, 2) transmitter, 3) receiver, 4) destination, and 5) noise. The mathematical version of this model was used to calculate such parameters as channel capacity and signal to noise ratio. The Noise Source represents any external signal picked up while transmitting the signal. In the later version of this model, the first four terms were replaced by the terms: sender, encoder, decoder, and receiver. This is similar to an open loop engineering system model that includes input, output, and process (gain).

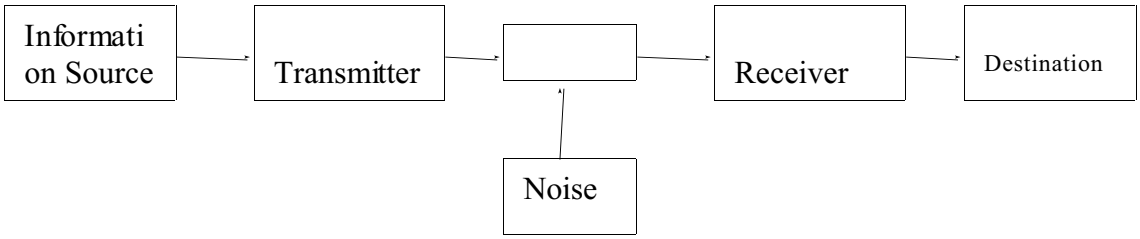

Figure 1: Shannon s Communication Model

To apply this model to the teaching process, we need to define what teaching is. Over the years, the definition of teaching has changed considerably from teacher-centered lecturing to student-centered learning. The transition of definitions is as follows. Teaching is:

1. An activity of transmitting knowledge to students (lecturing or making a group presentation)
2. Facilitating student learning.

The transmission of knowledge can take place through lectures, videotapes, handouts, and printed materials. According to the first definition, teaching can be effective when an excellent dissemination of knowledge occurs. The effectiveness depends upon the quality of knowledge transmitted and how it is transmitted. The communication model or our open loop engineering model can represent this type of teaching, especially, a large classroom lecture. However, if we take the second definition, commonly accepted at the present time, effective teaching is determined by student learning. In this definition, the focus shifts from teaching to learning, from what teacher does to what student learns. Let us examine what a teacher does in a typical teaching situation. A teacher:

1. Lectures.
2. Interacts with students while lecturing by questioning students, answering students questions, and inviting other students to answer questions.
3. Encourages interaction among students through discussion.

4. Tests student learning through homework, quizzes, and tests.
5. Assesses and evaluates student performance.

In these activities, there is a lot of communication from students to the teacher, from receivers to the sender. The limitations of the Shannon s model are:

- it is one way.
- there is no feedback between the sender and the receiver.
- it is not interactive or does not account for multiple sources of input.

By examining the teaching activities listed above, all of them except the first one require feedback from students to the teacher. Therefore, the model must include a feedback path from the receiver back to the sender. If the feedback path is added to the Shannon s original model, the model will be similar to an engineering system as shown in Figure 2 and described in the next paragraph.

Engineering Model with Feedback:
This is a simple input-output model in which a certain portion of the output is fed back to the input. The algebraic sum of these signals is processed (amplified) again. The direction of the signal flow from the input to the output is called the forward path and the direction of the signal fed back from the output to the input is called the feedback path.

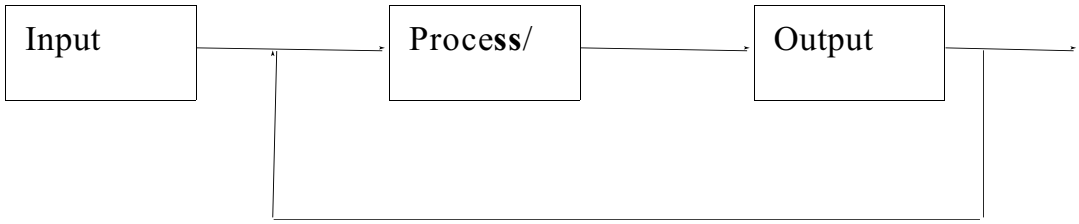

Figure 2: Engineering System Model With feedback

The objective of the feedback is to keep the desired output constant under changing conditions. If for some reason the output decreases, the feedback signal decreases, and the combined input is adjusted to keep the output constant and vice versa. In engineering terms, this is called negative feedback which has a negative connotation in social systems. Therefore, we will replace the term negative feedback with corrective feedback. Nobert Weiner, father of cybernetics, defines feedback in the simplest form as a behavior that is tested with reference to its expected result and success or failure of this result influences the future behavior.

Engineering System with Feedback and Teaching & Learning:
There are many similarities in these two systems. The forward path can be viewed as a lecture - from a teacher to students. The feedback path is primarily what the teacher receives from students or what students do. Even in the lecture mode, when a teacher senses glazed eyes, he or she is likely to go into feedback mode by asking questions. Based on the feedback received , the teacher may provide an additional explanation with an example or an analogy. Glazed eyes or faces with lost looks are the feedback signals that would provide corrective feedback to the

lecturer and a good lecturer is likely to change the flow and nature of the signal that is being transmitted.

In addition to asking questions during the lecture, there are many commonly practiced methods of eliciting feedback including home work, quizzes, tests, and exams. These feedback methods can be used for assessment as well as for evaluation. Now let us examine what we understand by the term good teaching.

Seven Principles of Good Teaching Practice:
To derive lessons or conclusions from our engineering feedback model, we need to examine the practices of good teaching. As discussed earlier, the second definition of teaching focuses on facilitating learning. Chickering and Gamson described the following seven practices that promote learning, first published in 1987 in the AAHE Bulletin. James Eison elaborated these practices in his article, *Teaching Strategies for the Twenty-First Century*.[5] Good teaching practice:

1. Encourages contact between students and faculty.
2. Develops reciprocity and cooperation among students.
3. Encourages active learning.
4. Gives prompt feedback.
5. Emphasizes time on task.
6. Communicates high expectations.
7. Respects diverse talents and ways of learning.

Engineering Feedback Model and Principles of Good Teaching
These seven principles and activities related to teaching do not even include lecturing - the forward path in our system model. That does not mean good lecturing is not valued. On the contrary, it is an integral part of the model. Without the forward path, there will not be any feedback path.

Forward Path and Lecture. Dynamic, well-organized, and enthusiastic lectures can be very motivational to students, but its effectiveness in terms of learning is less than 20%. After ten or fifteen minutes of listening to a lecture, the attention span of an audience begins to drift. Trenaman[8] discovered that with an increase in the duration of talk the amount remembered begins to decline. He experimented with an astronomy class by playing a lecture by Professor Fred Hoyle in three different time segments to various groups of students: 15 minutes, 30 minutes, and 45 minutes. Students those who listened for 15 minutes were able to recall 41% of the material; students who listened for 45 minutes could recall only 20% of the material. Trenaman stated that hardly a single listener grasped the essential features of the last 15 minutes. We find a similar description in Nilson s Teaching at its Best[11]: a lecture begins with a five-minute settling-in period during which students are fairly attentive. This attentiveness extends another five to ten minutes, after which students become increasingly bored, restless, and confused. Even medical students display a similar pattern of concentration levels: an increase over about 15 minutes, followed by sharp decrease. The decline in attention can occur even

earlier if the information being sent does not fit into 90% of what the audience already knows labeled as, prerequisite in academia. The receiver is no longer in tune with the frequency of the sender and noise level begins to dominate. In spite of many drawbacks of the lecture method, it is the most commonly practiced. Now the question is how it can be made more effective.

Johnson, in his Systematic Instruction Model (SIM)[6] has described various steps and techniques that combine lecture with the feedback mode. His first two steps include: an advance organizer and listing of specific objectives of a lecture. An advance organizer tells the students what to expect and objectives specify the details and the assessment criteria. This is followed by an interactive lecture. The lecture mode can be very effective in implementing three of the principles (# 5, #6, and #7) of good teaching: setting high expectations, providing suggestions for time on task, and encouraging different ways of thinking.

A good teacher must keep current in one s field and find creative ways to make that knowledge accessible to students. To make knowledge easily accessible to students, the teacher should be aware of what students already know. Learning is the result of mental construction, meaning students learn by fitting new information together with what they already know. Wilbur Schramm, the founder of Communications as a field of study, asserts that communication (learning) cannot occur unless the field of experience of the sender and receiver overlap. To teach new and unfamiliar concepts, use of analogy is a very effective teaching technique. Students must be able to relate lecture material to their knowledge and experience. In a given course, many teachers devote 60% to 75% of their time to preparing and giving lectures. To tune to the same frequency of students, the teacher must use such feedback techniques as pausing, asking and answering questions. If the concepts discussed in the lecture are not followed by homework or a quiz, students are likely to forget what the lecture was about.

In summary, the lecture mode can be made more effective by using techniques such as an advance organizer, specifying objectives and setting high expectations, using analogies to place new materials in the context of what students already know, and using several feedback methods through interactive lectures.

Feedback Path and Learning. If teaching effectiveness is to be evaluated or judged by learning, we should focus primarily in the feedback path. In the list of seven principles of good teaching practice, the first four belong in the feedback path.

1. **Encourages contact between students and faculty.** This contact can be in the classroom (during lecture or at the end of the class) or outside the classroom (during office hours, in hallways, or through electronic media). Tinto[12] asserts that interaction between faculty and students is the most important factor in student persistence during college years. Faculty contact is a particularly critical factor in determining dropout rate in given programs for students at risk and students who are not sure of their career path.

2. **Develops reciprocity and cooperation among students.** Theses interactions among students are mini feedback paths, and they can help students in two ways: learning from each other and social integration. Tinto[12] argues that individuals are more likely to persist when they are either academically or socially integrated and even more likely to persist when both forms of integration occur. This type of feedback provides both types of integration.

3. **Encourages active learning.** In this type of learning, students participate in the learning process; they are not just observers. They listen to lectures, think seriously about what is being taught, and provides essential feedback to instructors by completing assignments. They become an integral part of the learning process. Techniques used in lectures such as one muddy point or one-minute paper are excellent illustrations of getting regular feedback and promote active learning.

4. **Gives prompt feedback.** The timing of this corrective feedback is critical to student learning. When students complete an assignment or take a quiz, they need a feedback as soon as possible. Ideally, it should be instantaneous. To cite an analogy, a skidding car should get a corrective ABS feedback before the car gets into a ditch or hit some object or someone. If one of the objectives of a quiz is to assist student learning, feedback should be given as soon as possible. Now days it is possible to provide instantaneous feedback though electronic communication such as e-mail, user list, instants messenger, net meeting, or web-based blackboard.

Summary:

If one examines the principles of good teaching practices, one must come to the conclusion that activities in the feedback path account for most of the learning. And if good teaching is to be judged by learning, we as teachers should focus more on the feedback path than on the forward path. Our feedback path in the model very well represents the old saying:

" If you tell me, I forget.
" If you show me, I remember.
" If you let me do it, I understand.

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