Enhancing Learning by Improving Process Skills in STEM

Implementation Guide

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What are Process Skills?

In many STEM classrooms, teaching pedagogies are being initiated that can lead to the development of crucial process skills (also known as professional skills, lifelong learning skills, workplace skills, transferrable skills or soft skills). Employers note the importance of key skills like communication, teamwork, critical thinking, and problem solving as being necessary for workplace success. Assessing process skill development and providing feedback to students and instructors is a key component for enhancing these skills in STEM programs. The ELIPSS project focuses specifically on the process skills listed in Table 1.

Table 1: Process Skills definitions

ORAL & WRITTEN COMMUNICATION	Oral Communication: Exchanging information and understanding through speaking, listening, and non-verbal behaviors. Written Communication: Conveying information and understanding to an intended audience through written materials (paper, electronic, etc).
TEAMWORK	Interacting with others and building on each other's individual strengths and skills, working toward a common goal.
PROBLEM SOLVING	Identifying, planning, and executing a strategy that goes beyond routine action to find a solution to a situation or question
CRITICAL THINKING	Analyzing, evaluating, or synthesizing relevant information to form an argument or reach a conclusion supported with evidence.
MANAGEMENT	Planning, organizing, directing, and coordinating one's own and others' efforts to accomplish a goal.
INFORMATION PROCESSING	Evaluating, interpreting, and manipulating or transforming information
ASSESSMENT (Self Assessment and Metacognition)	Self and Peer Assessment: Gathering information and reflecting on experiences to improve subsequent learning and performance. Metacognition: Thinking/reflecting about one's thinking and how one learns, and being aware of one's knowledge.

To heighten awareness and understanding (for both instructors and students) of the centrality of process skill development to the overall educational experience of undergraduates, it is important to identify, elicit, and assess process skills in a classroom. To help with this goal, the ELIPSS project has developed rubrics to assess process skills in the classroom during student interactions and in student written work. Each rubric is tested for validity, reliability, and utility using a variety of tasks that are appropriate to test each type of rubric.

Getting started: Try a rubric!

In the active learning classroom, process skills are often *implicitly* built into course activities and assignments, but how does one *explicitly* identify these points? To do this, instructors must first isolate places in their existing classroom activities or assignments, where the rubrics could be used to provide feedback and enhance student learning. A specific classroom activity or assignment may help develop multiple process skills. However, when assessing these skills, it is best to keep the focus on one or two skills at a time. Below are some suggestions for helping instructors become more familiar with assessing process skills.

Activity Annotation

Select a classroom activity that you plan to use in your course. Identify one or two process skills that are relevant to that activity. For each question or series of questions, identify the process skill being used. Then, using the categories on the rubric, annotate (map/label) the activity to indicate which category is being exhibited. Figure 1 shows an example of an annotated engineering activity using the Information Processing rubric. Annotation can also be useful when using the product rubric to assess student written work.

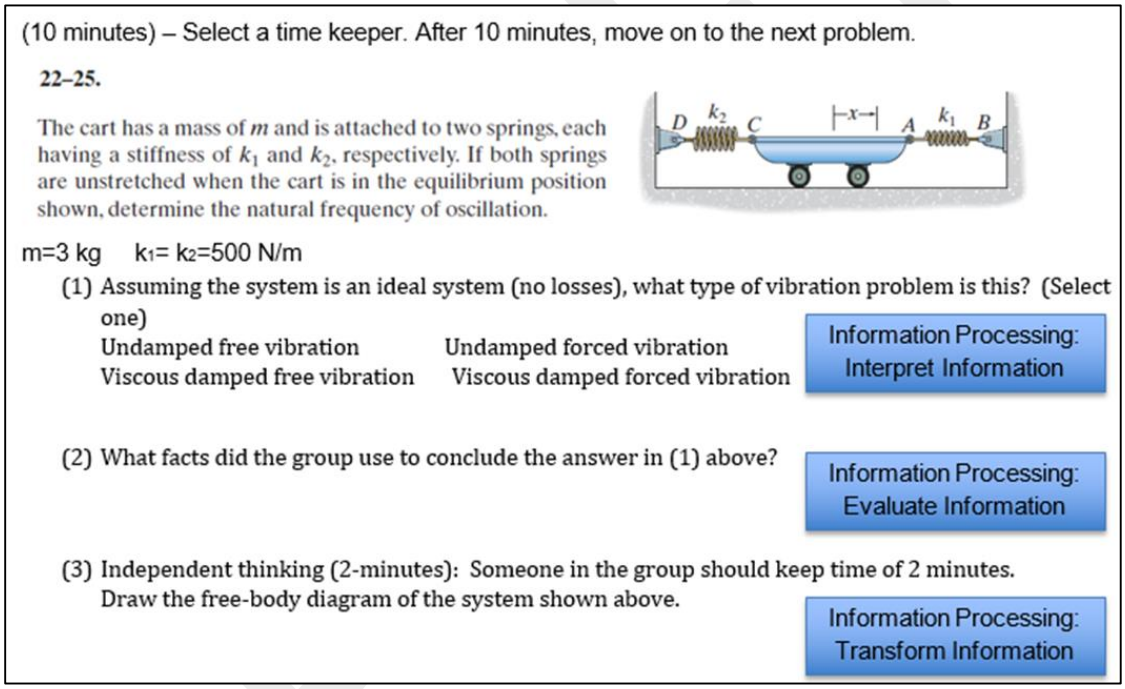

Figure 1: Example of annotation of an activity using the Information Processing rubric. Excerpt from an Engineering Measurements - Mechanical Engineering Case Study submitted by Eunice Yang

Evidence of Process Skills

Once you have identified and annotated a process rich activity, think about what you, as the instructor, would expect to see as evidence for the process skills of interest. What do you expect to see as students work through an activity? What do you expect students to write down as they work through problems? Keep in mind that evidence will vary depending on the process skill, content and type of activity you are assessing (interaction rubric vs product rubric).

To help you think about what evidence might look like for a given process skill, first create a list of general behaviors that you would expect to see. Some find it useful to think of behaviors on both ends of the rubric scale. Table 2 identifies behaviors related to student's information processing at the high level and at the low level.

Table 2: Examples of behaviors indicating the display or lack thereof of information processing

Information Processing	
Ideal Behaviors	**Poor Behaviors**
Performing a calculation	Answering questions without examining the model or provided information
Analyzing a graph and verbalizing what the graph is representing	Looking up the answers
Identifying trends and patterns	Asking for help without attempting to answer the questions as a group first

Referring back to your annotated activity, attempt to identify ideal behaviors that you would be able to observe as students complete the activity. Figure 2 shows the engineering activity with comments about ideal behaviors to look for. For example, question 1 had previously been identified as Information Processing in the interpret category. Now the focus is on what the students should be doing as they interpret the information in the model.

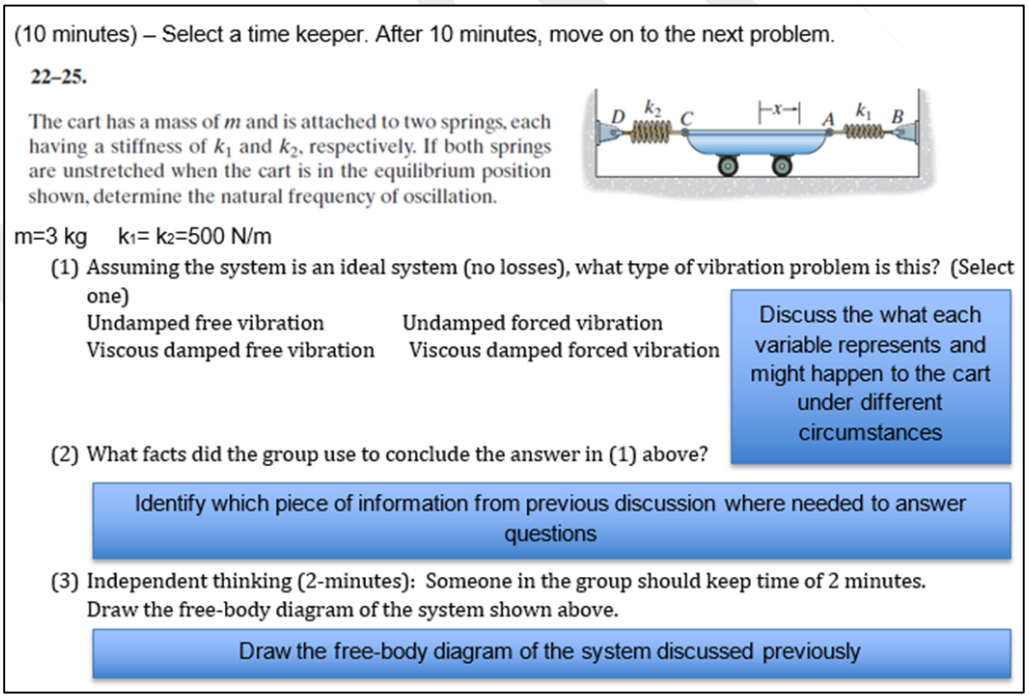

Figure 2: Example of observable behaviors information process for an activity. Excerpted from an Engineering Measurements - Mechanical Engineering Case Study submitted by Eunice Yang

Keep in mind, if you plan to use an interaction rubric during a classroom activity, you should also think about how you might facilitate the activity in order to help elicit that process skill. Brainstorm questions you could ask students or different facilitation strategies you could use to help them with a specific skill.

For additional practice on recognizing behaviors you might observe for a given process skill, the ELIPSS project has videos of students working in a group. While watching the video, complete the rubric to assess the relevant process skills. After completing the training video you can compare your rubric to a completed key.

As a reminder, don't try to do too much at once. Focus on one or two process skills for each activity or assignment. It can be challenging for students and instructors alike to keep track of many different categories and skills at the same time.

Mechanics of rubric use/implementation

The rubrics are designed to be flexible enough to be implemented in a variety of ways. When using a rubric, it is important to consider who will do the assessing:

- Student teams (self-assess or peer assess)
- Teaching assistants
- Colleagues
- Instructor

Students can be given a copy of the rubric to self-assess the team during an in-class activity. Alternatively, students could use the rubrics on a peer group or with examples of their own or a peer's written work. Many students, especially younger students, many have little experience in understanding process skills and how to assess these skills. Thus it is helpful to give examples during classwork or when going over problems on the strategy used to work through the problem, and clearly tie these strategies to various process skills. For example, when going over an example of a problem the students have worked through, the instructor could point out the steps used in problem solving that they should be paying attention to while working on the task. Once students get familiar with the terminology, they can be given the rubrics to score themselves on the process. Students should be reminded that scoring themselves or classmates with the rubrics will not affect their grade, but should result in feedback to improve their performance in the future.

Teaching assistants and/or colleagues can be used to help assess process skills as the instructor focuses on facilitating the activity. If you have the opportunity to use TAs or to ask for colleagues to help assess students, it is beneficial to provide these people with some training to improve the reliability of their assessments. Information on how an instructor could train TAs is discussed in detail in the **Using the rubrics with TAs** section. Similar training could be used with a colleague depending on their level of experience with active learning and process skill assessment.

Finally, the instructor can use the interaction rubrics to assess student groups while also facilitating the class. Keep in mind that doing both facilitation and assessment with the rubrics can be overwhelming unless the instructor is well prepared in advance. Alternatively, the instructor could videotape or audiotape several groups to watch/listen to outside of class. This would allow the instructor to provide whole class feedback. Listed below are a number of strategies to help with the logistics when using the rubrics to assess process skills and to provide feedback to a number of students:

- Use a clipboard to keep the rubrics organized; it provides a hard surface for you to write on as you walk around the room.
- Have one rubric ready for each group. Pre-label the rubrics with team names or student names. Consider ordering them by how the teams sit in your classroom.
- Move to an electronic platform, such as a course management system, as a way of collecting your rubric data and displaying it to students.
- To assess multiple groups at once, bring one rubric and a separate sheet of paper that includes an empty table where information can be recorded for all teams on one page. Here is an example of a simplified version of the rubric to fill in during class.

Group	Rubric Rating (Score/Category)	Comments
1	3A, 4B, 3C	
2	5A, 5B, 4C	
3	3A, 2B, 4C	

Giving feedback to students

When? How soon after scoring?

It is important to give feedback to students as soon as possible. If you are using interaction rubrics it is best to give the feedback at the end of class or at the beginning of the next class so they can recall the details of how they interacted. More global observations can be discussed with the whole class, pointing out skills that were effective and others that need improvement. For written work, the feedback on process skills can be provided at the same time as the assignment is returned with the content grade.

How to introduce the rubric to students?

If students will be asked to complete the rubrics, it is beneficial to distribute rubrics to students ahead of time, so they can become familiar with the rubrics prior to the class where they will be used This allows students to reflect on the different aspects of a process skill and the categories in each rubric. It is also helpful to briefly go over the terminology and what a category from a rubric would look like in your classroom or on a specific assignment.

How to deliver interaction rubric to students? (email, printed, one rubric per group or one per person)

There are multiple ways in which you can return the rubrics as feedback to students including:

- Filling out the printed rubric during class and handing it to each group.
- Creating a rubric in a course management system where students can view the rubric.
- Creating a google doc for each group.
- Providing whole class summary of process skills after using rubrics on multiple groups.

How to debrief the use of rubrics?

Ultimately, rubrics should be used in order to provide feedback to students on their process skills. Thus, simply handing back the scored rubrics may not be enough. Help students reflect and be metacognitive about how they did by talking with students about their experience. In this discussion, be sure to get feedback from students on the use of the rubric – what are the strengths and areas of improvements for the feedback they received. This can help you as the instructor implement the rubrics later in your course, but this process also encourages the students to consider the rubrics/feedback they received. If you are using the interaction rubrics, giving feedback while observing can be beneficial to students specifically in relation to the positive or negative behaviors that are observable.

Using the rubrics with TAs

In large classrooms it is impossible for the instructor to get to every group of students during each class. Using teaching assistants (TAs) to help facilitate an active learning classroom is one way to get feedback to all teams. We have found undergraduate TAs are particularly effective as peer leaders in active learning classrooms. Students who have previously taken a course that engages active learning have a good understanding of the pedagogy used in class. However, they are typically not as familiar with process skills and how to assess these skills as part of facilitation. Prior to asking TAs to assess student process skills, it is beneficial to provide them with some training. Below is listed a number of suggestions for instructors to prepare TAs facilitate and assess process skills in the classroom, in addition to reviewing course content.

- Have TAs complete the activity for content, then annotate the activity with respect to process skills.
- Have TAs discuss what information students need in order to effectively perform an aspect of a process skill.
- Have TAs identify what behaviors they might observe for different process skills in the activity.
- Discuss with TAs the potential problems they might encounter within an activity and how to facilitate and elicit the process skills by asking students questions.

It is important that TAs also have an opportunity to learn from their experience of being a teaching assistant. As TAs assist with the classroom facilitation, feedback can be provided to TAs in terms of how they are using process skills. Two process skills that TAs regularly use when facilitating active learning classrooms are oral communication and management. It is beneficial to reflect upon what behaviors are expected of TAs when managing multiple groups of students. Having TAs complete the rubrics on their performance as facilitators can be a useful exercise. Alternatively, asking a colleague to use the rubrics on the TAs is another option.

Working with colleagues

The value of helping students gain proficiency with process skills is becoming widely accepted, however, student's process skills in addition to content material can be challenging for instructors. By working with your colleagues, you can help each other to assess process skills in your classrooms.

Departmental level

Does your department need to assess particular skills on a programmatic level? Could a member of your department apply a rubric in a first year, sophomore, junior, or senior level course? At the departmental level, there are several ways in which a department could incorporate these rubrics:

- Partnering with colleagues for observations
- Coordinating across courses to document student growth through the curriculum
- Find a colleague who is also using active learning strategies. Apply a rubric in their classroom and provide feedback.

Institutional level

At an institutional level, you can look at skills across departments (biology vs chemistry, etc.) or through a general education program.

Regional level

At a regional level, you can reach out to other local schools to observe and request observation.

Questions about integrating the rubrics into your course curriculum

How early do I start using rubrics?
It is best to start discussing process skills and using rubrics as early as possible! Starting early helps emphasize the importance of identification, assessment, and feedback on process skills. Starting early also helps make the use of the rubrics a classroom norm.

How often do I use them?
You can use the rubrics as often as you are able or as you would like. Most of the time, instructors have tried to use a particular rubric at least twice to give students the ability to see their growth within a course. Generally it is best to focus on one or two process skills per class period.

How many different rubrics can be used in a semester?
How many rubrics per semester is dependent on the type of course you are teaching, and the level of experience of both students and instructor. Use as many rubrics as you can use *effectively*.

Generally we have found that there a progression of skills as the semester progresses. Process skills tend to overlap, so you may find that when students are discovering new concepts, they typically use information processing followed by critical thinking. As they start doing more complex problems, information processing and problem solving fit together. A good place to start in a semester is to encourage teamwork and communication as students get comfortable working in teams.

Is there a sequence I should use? And why?
The sequence will vary depending on your course content and level of your students. Below is listed some sequences that the leadership team has used.

- Written communication either before or after other rubrics
- Oral Communication > Teamwork
- Teamwork > Information Processing > Critical Thinking > Problem Solving

Our instructors used these sequences of process skills because oral communication is important and necessary for good teamwork. Teamwork is also a skill easily incorporated at the beginning of a semester when you are structuring the class to work in groups.

Once students are established in their groups, have learned to work as a team, and communicate effectively, our instructors began to look at process skills that are more closely related to content. Information processing is necessary for all critical thinking and problem solving activities, so giving students feedback on information processing early on is important. Critical thinking helps students look at the information that they processed and use it to construct an argument. Problem solving is fairly complex and, in some courses, we get to problem solving late in the semester so the rubrics for it are typically used last.

How to write questions that incorporate the various process skills
Try using a rubric on existing student work. This is the best way to get an idea of how a question should be structured to elicit the skill you're interested in. Once the rubric is used on student work, then you may want to modify the question to better fit the rubric. Keep in mind, some categories may not be applicable to every problem or work.