Designing Process-Oriented Guided-Inquiry Activities

David M. Hanson, Department of Chemistry
Stony Brook University, Stony Brook, NY 11794-3400

Research in the cognitive sciences, contemporary learning theory, and classroom research lead to a design for classroom activities or lessons that is based on how people learn. This design recognizes that people learn by constructing their own understanding in a process that involves prior knowledge and experiences; following a learning cycle consisting of exploration, concept formation, and application; discussing and interacting with others; reflecting on their progress in learning; and assessing their performance (Bransford et al., 2000). In this design, each activity consists of five stages: *Orientation*, *Exploration*, *Concept Formation*, *Application*, and *Closure*. These activities are most effective when teams of students work on them together with much discussion both within and between teams. The sequence of exploration, concept formation, and application lies at the heart of this design. This sequence, which originally was proposed by Karplus as part of SCIS, the Science Curriculum Improvement Study (Atkin & Karplus, 1962; Karplus & Thier, 1967) is called the *Learning Cycle*. A discussion of the Learning Cycle is provided by Lawson (1995), and studies have documented that most students learn best when this sequence is followed. Specifically, students exhibit improved attitudes, higher achievement, better understanding and retention of concepts, and the development of learning process skills (Raghubir, 1979; Lott, 1983; Renner et al., 1985; Abraham & Renner, 1986; Abraham, 1988; Lawson et al., 1989).

Orientation

The *Orientation* prepares students for learning. It provides motivation for the activity and creates interest, generates curiosity, and makes connections to prior knowledge. Learning objectives and criteria for success are identified. Learning is enhanced as a result because the learner feels that the topic is important and worthwhile, has some understanding of what is being learned, and can build understanding from explicit prior knowledge. The identification of learning objectives and success criteria focuses the learner's efforts on essential issues and sets the expected level of mastery. Background, vocabulary terms, prerequisites, and references to resources provide the learner with the necessary information to begin learning something new.

Exploration

Each activity gives students a plan or set of tasks to follow that embody what is to me learn and leads to meeting the learning objectives. In the *exploration* stage, students have the opportunity to make observations; design experiments; collect, examine, and analyze data or information; investigate relationships; and propose, question, and test hypotheses.

Concept Formation

As a result of the exploration, concepts are invented, introduced, or formed. Rather than presenting information as in texts or lectures, conceptual understanding is developed by engaging students in guided inquiry or discovery. This process is structured by supplying questions that compel students to think critically and analytically as they engage in the exploration. These questions, which are called guided-inquiry, critical-thinking, or key questions, guide the learner in the exploration. They can help define the task, direct the learner to information, lead the learner to appropriate connections and conclusions, and help the learner construct understanding of the concept being learned.

Application

Once the concept is identified, it is reinforced and extended. *Application* involves using the new knowledge in exercises, problems, and even research situations. *Exercises* give the learner the opportunity to build confidence in simple situations and familiar context. True understanding and learning is exhibited in *problems* that require the learner to transfer the new knowledge to unfamiliar contexts, synthesis it with other knowledge, and use it in new and different ways to solve real-world problems. *Research questions* identify opportunities for the learner to extend learning by raising new issues, questions, or hypotheses.

Closure

Each activity ends with the students validating their results, reflecting on what they have learned, and assessing their performance. Validation can be obtained by reporting results to peers and the instructor to obtain their perspectives regarding the content and the quality. When students are asked to reflect on what they have learned, their knowledge is consolidated, and they see that they have been rewarded for their hard work. Self-assessment is the key to improving performance. When students recognize what they have done well, where they need to improve, and develop strategies to achieve these improvements, they are both encouraged and motivated to work toward that goal. Self-assessment is the key to success in courses, college, and careers because it produces continual improvement.

An Activity Design Methodology

1. Identify the focus of the activity. An activity usually will involve one of the following: learning a concept, developing proficiency with a process or use of a tool, or increasing understanding within a context of a discipline. The focus should be sufficiently sharp that each activity can be completed in 20 to 40 minutes.

2. Select and develop the principal activity type. Since students have a variety of learning styles and learning takes place in many different forms and disciplines, it is useful to have many tools, techniques, and processes to support learning. A productive learning environment will incorporate a diversity of activity types. A list of possibilities is provided in Table 1. Also, any single activity can be composed of a combination of activity types. A popular activity is exploration of a model. A model is anything that contains or represents the new knowledge or concepts. Models have a variety of forms as shown by the listing in the Table 2. Models include methodologies. Methodologies are listings of steps in processes and should be viewed as guides rather than sets of rules. The activity should be at the appropriate level for the students and support the learning objectives and success criteria.

Table 1. Activity Types

Laboratory experiment
Demonstration
Exploration of a model
Writing assignment
Reading assignment
Problem-solving session
Mini-lecture
Student teaching
Individual project or paper
Team project or paper
Research project
Group discussion
Debate
Student presentation
Interview
Self-assessment
Peer-assessment
Reflection on learning
Use of learning teams
Use of technology
Problem-based learning
Case studies

3. Choose an appropriate title. Use a short sentence or phrase rather than a word or two. Should be clear, inspiring, and reflect a sense of the content.

4. Create the "Why?" for the activity. Begin each activity with a section with this title. This section should put the activity in context for the learner by addressing three

questions: What will the student learn? Why is it relevant to the subject? Why is it relevant to the learner? The first sentence clarifies the title and further defines the content of the activity. The second sentence defines the general importance and describes how the activity fits into the course. The third sentence provides justification for the activity from the perspective of the individual learner.

5. Identify the learning objectives. A learning objective identifies what is to be learned or understood as a result of completing the activity. An activity should have two or three objectives. Activities with only a single objective may not be very interesting to the learner while those with many objectives may be too formidable. Objectives should be orthogonal, ie. not overlapping, and relate to the *Why* statement. Separate compound objectives. The objectives should be written in a clear, concise style that is easy for students to understand, and so both students and faculty know when they are attained. List the most important first and the least important last. Include learning process skills not just mastery of content as objectives.

Table 2. Models
Figure
Graph
Table of data
Written relationships
Methodology
Discussion
Demonstration
Laboratory activity
Student lecture notes
Student reading notes
Interactive computer simulation
Lecture or mini-lecture
Reading assignment

6. Define the success or performance criteria. Success criteria are the measurable outcomes of the activity. They describe what the learner should be able to do after completing the activity. Exam questions should be easily formulated from the success criteria. An activity should have one or two success criteria. Without any criteria, students can easily lose accountability for their outcomes and the tendency is to coast through the activity with minimal effort. If students know what is expected and how they will be assessed, their accountability and performance level increase dramatically. More than two criteria can confound students and cause them to lose their focus. The better students will use the criteria to use the limited time resource most effectively. Be clear, understandable, measurable, realistic, and relevant to the learning objectives.

7. Create key questions. Critical-thinking questions are the heart of a guided-inquiry learning environment in which students are actively working to learn new content and develop process skills. This form of learning is most effective when it involves the use of three types of questions: *directed*, *convergent*, and *divergent*. Each activity should require students to answer five to ten key questions: two or three directed questions, two to six convergent questions, and one divergent questions. *Directed questions* require that students process and recall information. The answer can be found by examining the model, information, resources, or drawing on personal experience and prior knowledge. Such questions have a definite answer and build the foundation for more challenging questions. *Convergent questions* require that students make connections and reach conclusions that are not obvious at first examination. Convergent questions have answers that are not directly available in the model, information, or resources. They require students to analyze and synthesize and may have more than one correct answer. The level of difficulty should progress with the questions. They drive students to develop and understand the concepts presented in the activity. *Divergent questions* send students in different directions. This type of question may have no right or wrong answer but requires students to ponder, explore, generalize, and expand upon their current knowledge. Divergent questions require the highest level of thinking and produce outcomes and conclusions that vary among teams and individuals. Divergent questions have no readily available solution, are open-ended, provide significant challenges, do not need to relate directly to the learning

objectives, and are beyond the stated success criteria for the activity. They may even launch research ideas.

8. Identify necessary information and resources. The information and resources should help students answer the key questions and complete the activity. Information can be provided within the activity or by outside resources that are referenced for the students or that they need to find or research.

9. Create a glossary of relevant terms. List the new important terms and vocabulary required to complete the activity. Definitions may accompany the terms, or you may require students to find and write definitions in the glossary in their own words.

10. Write a plan for the activity. The plan is a numbered list of tasks or steps that detail what is to be done in the activity. At the beginning of a process-oriented course that most likely is a new experience for the students, the plan should be explicit, thorough, and complete. As the course progresses, it should become less structured, giving broad guidance, and challenging the students to devise the specifics. After the students have gained experience, the plan may be implicit, or the students can be asked explicitly to develop their own plan in order to achieve the stated objectives and meet the success criteria.

11. Develop skill exercises. Students apply their new knowledge in simple situations and familiar contexts to build confidence and strengthen understanding. Typically an activity should have two to five exercises. They often repeat the key questions in an identical or similar context as the model.

12. Design problems. Problems present new situations that require students to transfer, synthesize, and integrate what they have learned. The purpose is to move them to the problem-solving level of knowledge. Problems often have a real-world context, contain superfluous or missing information, have multiple parts, do not contain overt clues about the concepts needed to arrive at a solution, and may not have a right answer.

13. Determine how closure will be accomplished. Students must have some means for validating their results and need to be encouraged to self-assess their performance and identify ways they can improve. Their learning also will improve if they are given the opportunity to reflect on what they have learned. Self-assessment and reflection should be done in a meaningful and interesting way consistent with the learning objectives and success criteria.

14. Provide a research project. A research project requires extensive synthesis either through discovery or further exploration and usually requires much time to complete. Students or teams of students could select one or possibly two projects from among all the activities for a one-semester course.

15. Identify prerequisites. Students and others, who may use your activity, need to know what prior knowledge and skills are needed to complete the activity, and whether any reading assignments need to be completed in advance.

16. Equalize team progress (Graduated Key Questions and Problems): In a process-oriented classroom, student teams will work at different rates and will not complete sections of the activity at the same time. The differences are made easier for faculty to manage by using different levels of key questions and problems. An open-ended or divergent key question at the end serves as an equalizer for faster teams who reach this question ahead of others. Such questions can take up considerable time, especially with added facilitation and intervention by the instructor, allowing other teams to catch up. Not all teams will get as far on such questions, and it is important to reward

or acknowledge the efforts of the faster teams for their additional work, especially if it is of high quality. Problems of varying difficulty also serve the purpose of pacing the class. The most difficult problems should be at the end. Also, note that the amount of blank space left between questions, exercises, or problems on a work sheet sends a message to the students about your expectations for their response. There should not be equal amounts of space between every question.

Activity Template

The components in the Activity Template below contribute to high-quality process-oriented guided-inquiry activities. While all enhance learning, not every one is needed in each activity. For example, while learning objectives and success criteria definitely should be part of the instructor's planning, it may be desirable for students to work on the exploration and concept formation without this information.

Title	Label the activity.
Why?	Explain and identify the reasons for learning.
Learning Objectives	List what is to be learned.
Success Criteria	Determine the desired outcomes and abilities that will be used to measure performance and achievement.
Prerequisites	Identify the prior skills and knowledge that are needed.
Resources	List essential references related to the activity.
Vocabulary	Provide key terminology.
Information	Provide information needed for the activity. Additional information can be provided to help students consolidate their learning after they have completed the Key Questions.
Plan and/or Tasks	List plan and/or tasks for meeting the learning objectives.
Model	Include representations or methodologies of what is to be learned.
Key Questions	Pose questions that guide the execution of the plan and/or tasks, exploration of the model, and processing of the information and resources in order to stimulate thought, introduce or form of concepts, and construct understanding.
Skill Exercises	Apply the new knowledge in simple situations and familiar contexts.
Problems	Use the knowledge in new contexts or real-world contexts requiring transference, synthesis, and integration of concepts.
Research	Identify opportunities for the learner to extend the learning to new situations and create knowledge that is unique or new.
Validation	Results are shared with peers and assessed.
Reflection on Learning	Have students think about what has been learned and assess how well the material has been mastered.
Self Assessment	Have students identify what has been done well, how they could improve, and strategies for improvement.

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