2.4.14 Designing Process-Oriented Guided-Inquiry Activities

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Research in the cognitive sciences, contemporary learning theory, and classroom research contribute 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 accessing prior knowledge and experiences; following a learning cycle that consists of exploration, concept formation, and application; discussing and interacting with others; reflecting on progress in learning; and assessing performance (Bransford, Brown, & Cocking, 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, called the "Learning Cycle," was originally proposed by Karplus as part of SCIS, the Science Curriculum Improvement Study (Atkin & Karplus, 1962; Karplus & Thier, 1967). 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; Abraham & Renner, 1986; Abraham, 1988; Lawson, Abraham, & Renner, 1989).

Orientation

The orientation stage 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. As a result, learning is enhanced because the learner feels that the topic is important and worthwhile, the learner has some understanding of what is being learned, and the learner 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 a set of tasks to follow that embody what is to be learned and that 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.

Conceptual Formation

As a result of the exploration, concepts are invented, introduced, or formed. Rather than presenting information in texts or lectures, educators engage students in guided inquiry or discovery to develop their conceptual understanding. 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 contexts. *Problems* require the learner to transfer the new knowledge to unfamiliar contexts, synthesize 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 to the instructor to get feedback 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, what they need to improve, and what strategies they need to develop in order to achieve these improvements, they are both encouraged and motivated to work toward their 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 will usually 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 so 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 preferred learning styles and since 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 ***2.4.13 Overview of Learning Activities***. Also, any single activity can be composed of a combination of activity types. The activity should be at the appropriate level for the students and should support the learning objectives and success criteria.

3. **Choose an appropriate title—**Use a short sentence or phrase rather than a word or two. The title should be clear and inspiring, and should convey a sense of the content.

4. **Create the "Why" for the activity—**Begin each activity with a section titled "Why." 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 of the activity and describes how it 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, i.e., not overlapping, and should relate to the "*Why"* statement. Compound objectives need to be separated. The objectives should be written in a clear, concise style that is easy for students to understand, so both students and faculty know when they are achieved. The most important objectives should be listed first and the least important last. Finally, objectives should include learning process skills, not just mastery of content.

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. Good success criteria are understandable, measurable, realistic, and relevant to the learning objectives. Generally, 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. More than two criteria can confound students and cause them to lose their focus. If students know what is expected and how they will be assessed, their accountability and performance level increase dramatically.

7. **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.

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 itself, by outside resources that are referenced for students, or by sources that they need to find or research for themselves.

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. A process-oriented course is likely to be a new experience for the students, so at the beginning of the course, the plan should be explicit, thorough, and complete. As the course progresses, it should become less structured, providing 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. **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 question.

Directed questions require that students process and recall information. The answer can be found by examining the model, information, resources, or by 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 upon 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 they may have more than one correct answer. The level of difficulty should progress with the questions, and the questions should 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 it 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.

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

13. **Design problems—**These 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. The 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.

    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.

14. **Determine how closure will be accomplished—**Students must have some means for validating their results, and they need to be encouraged to self-assess their performance and identify ways they can improve. Their learning will also 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.

Activity Template

The components in the Activity Design Template in Table 1 (on the following page) 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.

Concluding Thoughts

While the focus of this module has been the design of *guided-discovery* learning activities, the same principles and methodology also apply to the design of other types of learning activities. The learning objectives of an activity should either contribute to or match the learning outcomes of the course. Activities are where student learning occurs in support of the learning outcomes for a course. It is important to use several different activity types during a course both for variety's sake and to support the varying learning styles of students. A learning activity should always be assessed by students to identify opportunities for refinement and improvement.

Table 1

Activity Design Template

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 and 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." List essential references related to the activity.
Glossary	Provide key terminology
Plan and/or Tasks	List the plan and/or tasks for meeting the learning objectives
Key Questions	Pose questions that guide the execution of the plan and/or tasks, the exploration of the model, and processing of the information and resources in order to stimulate thought, introduce or form concepts, and construct understanding
Skill Exercises	Apply the new knowledge in simple situations and familiar contexts
Problems	Use the knowledge in new or real-world contexts requiring transference, synthesis, and integration of concepts
Validation	Share results with peers and assess
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 and develop strategies for improvement

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