PBEA
PLANT BREEDING E-LEARNING IN AFRICA

Other Materials

Introduction to Applied Learning Activities in Plant Breeding

START

Administrative Information

COURSE OVERVIEW

The first part of this course covers fundamental concepts for creating applied learning activities. These concepts include thoughts on expertise, mental schemas, cognitive load, the Revised Bloom's Taxonomy, Gagné's Nine Events of Learning, and the relationship between real-world tasks and learning-world tasks. In addition, the importance of designing and implementing applied learning activities in a way that models real-world tasks is discussed, as well as the use of general and guiding frameworks to assist learning. And finally, the importance of aligning learning objectives with teaching activities and assessments will be discussed.

The second part of this course covers the design and development of text-based applied learning activities. By the end of this course, educators will be able to design and develop multiple types of applied learning activities. These activities can include:

- drill and practice multiple choice or short answer questions
- partially solved real-world learning tasks
- learning tasks with and without guidance
- case studies
- capstone activities such as creating a plant breeding program

Administrative Information

Several templates for building applied learning activities will be presented, along with strategies for their use in various educational settings.

For those who wish to add an interactive component to their applied learning activities, the Applied Learning Platform is available after the Appendix as well as at http://WhenKnowingMatters.com.

OPTIONAL READINGS

The following textbooks and resources are not required, but offer comprehensive explanations of many concepts in this course.

- J. J. G. Van Merriënboer and P. A. Kirschner, Ten Steps to Complex Learning: A systematic Approach to Four-Component Instructional Design, New York: Routledge, 2013
- R. Clark, F. Nguyen and J. Sweller, Efficiency in learning: evidence-based guidelines to manage cognitive load, San Francisco: Pfeiffer, 2006.

KEYS TO SUCCESS IN THIS COURSE

- Keep your specific domain of expertise and educational setting in mind as you work through the course. Examples are not intended to be prescriptive or applicable in all settings. Rather, their purpose is to stimulate your own creative thinking and strategies for application.

Administrative Information

- An applied learning activity will only be as effective as the pedagogical principles employed in its design, its contextual setting, and the appropriate cognitive load that it places on learners. Invest time in reflecting upon each section of this document so these factors will become second nature to your thinking.
- The only way to learn any skill is to use it. After reading the first section of this document, get started making applied learning activities as soon as possible.
- Work with a colleague and discuss the material in this course. Give each other regular feedback on your applied learning activities and strategies for implementation.

OBJECTIVE

At the completion of this course, you will be able to design and develop engaging and effective applied learning activities based on sound pedagogical principles. In addition, you will be able to help your colleagues do the same.

LEARNING MAP

There are no shortcuts for developing expertise.

This manual was written for you to work through at your own pace. Read each section and reflect on how it may be appropriate for your particular learning environment. A key theme is how to design applied learning activities that facilitate the learning process and respect the challenges faced by learners.

Administrative Information

Team up with a colleague with whom you can collaborate and give one another feedback. Remember, creating applied learning activities is a functional form of art with a purpose.

After getting comfortable creating text-based applied learning activities, you may wish to explore the possibility of adding an interactive component. If so, you may want to consider exploring the Applied Learning Platform that is included after the Appendix. A free version has been made available to the collaborators on this plant breeding proposal. It takes about 3 hours to view the demonstration videos adding another 3 hours for pausing and working along in a separate browser. The exercises should take another 2-3 hours. After that, it takes about 30 minutes to create each activity.

MEDIA AND RESOURCES

This document and related materials can be distributed by and accessed from a USB device, a CD, or a DVD. These materials can also be transferred to the local hard drive of a computer.

These files run best locally when using the Firefox browser or Internet Explorer.

There are two formats of this document, Microsoft Word and pdf. I suggest that you use the pdf formatted document to avoid unintentional changes in the content. The Microsoft Word version is useful if you want to use any of its text in your own course.

The **TextBasedActivities directory** contains text-based activities in directories denoted by specific faculty members. Some activities are included in the body of this document.

Administrative Information

The **Resources directory** contains text materials that are used with permission of the authors. You should seek permission from them directly if you wish to reuse them in your work beyond the scope of this document.

HOW TO UPDATE THESE MATERIALS

This manual and the Applied Learning Platform will be updated regularly. Each new version will be distributed as a zip file that can be extracted and copied to a USB drive or local files on a computer. CD/DVDs will be reissued as needed. In addition, resources may be downloaded. <site and process to be determined>.

STRUCTURE AND TERMINOLOGY FOR PLANT BREEDING E-LEARNING IN AFRICA

1. A **Repository** contains the **Content Modules** and **Applied Learning Activities** that can be selected and uniquely assembled by educators in Africa to form a specific **Course**. As such, the same **Content Module** may be used by different educators in different **Courses**.

2. A **Course** consists of a **Content Component** and an **Applied Learning Component**.
   The **Content Component** of a **Course** consists of **Content Modules**, which are used to convey course material, and can include self-study and review questions, as well as self-assessment quizzes. The same Content Module can be used in multiple courses.

Administrative Information

3. The **Applied Learning Component** of a **Course** consists of **Applied Learning Activities** that can be exercises, case studies, situations, learning tasks, scenarios, etc., which are used by educators to model expertise to learners, and by learners to develop competence in applying course content. New content should not be introduced in an Applied Learning Activity because if other educators substitute that activity with their own, there may be an **inadvertent loss of the content** from the **Repository**.

4. A **Content Module** can be associated with **multiple Applied Learning Activities**, and an **Applied Learning Activity** can be associated with more than one **Content Module**.

5. **Content Learning Objectives** pertain to the understanding of course material such that learners can successfully pass a written or oral examination, while **Applied Learning Objectives** on the other hand pertain to the application of course content to solve authentic real-world problems.

6. **Content Modules** and **Applied Learning Activities** should include **Educator Notes** that state the goals, design, scope, use, and limitations of the Module or Activity.

Introduction

THREE IMPORTANT QUESTIONS FOR PRODUCING PLANT BREEDERS *FOR TODAY*

What do plant breeders do?
How do plant breeders think?
What do plant breeders know?

THREE IMPORTANT QUESTIONS FOR PRODUCING PLANT BREEDERS *FOR THE FUTURE*

What will plant breeders do?
How will plant breeders think?
What will plant breeders know?

CONTENT COVERAGE AS A STRATEGY TO BUILD COMPETENCE

Content coverage as the main driver of course development can become a disservice to all involved. Educators cannot effectively dispense as much content as is available to learners, and learners cannot possibly integrate such a massive amount of fact-based material into their understanding. In the final analysis, **if student learning is the priority**, it really does not matter how much course material is presented or even responded to correctly on an examination if, after the course, learners are unable to remember and apply it appropriately.

Introduction

DO, THINK, AND LEARN AS A STRATEGY TO BUILD COMPETENCE

A better strategy for building competence in learners is a do, think, and learn approach to course content that *begins at the end* with the answers to three questions.

1. What should learners be able to do?
   - Translation: What real-world tasks and skills are performed by plant breeders?

2. What thinking skills should learners have?
   - Translation: What cognitive strategies are used by plant breeders?

3. What content must be learned to support the thinking and doing?
   - Translation: What knowledge should plant breeders possess to support the cognitive strategies needed to perform real-world tasks?

COMPETENCE AND APPLIED LEARNING ACTIVITIES

Competence begins with a foundation that is only noticed when it fails. Each interaction among learners and educators as well as each learning activity should build upon the previous, and each stage must solidify before adding the next. Otherwise, the final product will be unstable and collapse when applied to real-world plant breeding challenges. This foundation can be built and tested using applied learning activities that can be designed not only for today's challenges, but also for those in the future. In essence, applied learning activities allow students to gain experience and make mistakes when the consequences are not starvation.

Introduction

Applied learning activities are the ideal mechanism for communicating expertise and building competence when the context of learning situations are carefully defined, the data is provided, the constraints are established, and the learning objectives are clear. Once these simpler activities are mastered, learners can progress to less well-defined challenges that more closely match the competencies required for success in the plant breeding domain.

A key element in developing competency is that there should be continuity among learning objectives, teaching and applied learning activities, and assessments. In essence, be clear about what is expected, organize teaching and applied learning activities around those objectives, and then assess those objectives using the same competencies that have been modeled and practiced. More will be discussed about how to align objectives, activities, and assessment in the sections on the Revised Bloom's Taxonomy and Gagné's Events of Instruction.

INPUT/OUTPUT CHALLENGES FOR A TRAINING PROGRAM IN PLANT BREEDING

Building plant breeders can be viewed as an input/output manufacturing process where each course receives learners as input. The task is to add educational value during the course, and then output the learners to the next stage of their development, which can be anything from another course, to a new program of study, or a position in industry.

Introduction

For a manufacturing system to produce a consistently high quality product, it requires consistently high quality input materials that are acted upon by consistently high quality processes. In this way, people, materials, methods, equipment, and environments are all brought together to transform input into the desired output. Success requires that quality and consistency be maximized and variation be minimized. **Educators of plant breeders must contend with far more variability than a controlled manufacturing process.**

VARIATION IN LEARNERS

Learning styles, background, motivation, and beginning ability can vary widely within and among learners in a plant breeding training program. In addition, the presence or absence of abilities such as using a computer or previous skills in using the Internet or other resources and technologies can also vary. As such, educators must be proactive in identifying any *as-yet-not-mastered skills* that learners need to address. The mastery of these skills must either become part of the training program, or learners should be directed to available resources to acquire these skills on their own. **Either way, self-directed applied learning activities can be used to surface and address many of these initial variations in learner ability.**

VARIATION IN PURPOSE FOR GRADUATE PLANT BREEDERS

The variety of plants used for food and/or industry is wide-ranging. The challenge for any plant breeding training program is choosing which ones to focus on, and to what level of detail. **Applied learning activities can be used by educators to address this variation by 1) emphasizing core principles in plant breeding that pertain to categories of plants and, 2) focusing on relevant region-specific needs.**

Introduction

VARIATION IN PLANT BREEDING CONTEXT

Plant breeding objectives and constraints within the same category can differ widely depending upon factors such as variety, region, and availability of natural resources. Once again, core similarities can be emphasized, with local distinctions addressed by local educators through adjustments to content presented in an appropriate context. **Applied learning activities can be used to address this variability when designed to include the context of locally relevant scenarios.**

VARIATION IN LEARNING ENVIRONMENT

Every learning environment is unique with regard to access to technology; social and cultural norms; political influence; expectations of administrators, educators, and learners; etc. While many of these factors are beyond the control of educators, when it comes to learning, educators are left with the challenge of helping learners build competence. **Applied learning activities created with the Applied Learning Platform can help address this variability because they can run locally on a user's computer, and educators can create activities without the need for information technology personnel or a centrally maintained database.**

OPTIMIZATION OF A SYSTEM

Optimization of any system requires that the parameters you wish to optimize are visible through some sort of measure, and are controllable through some sort of action. The measure needs to be of sufficient detail to detect meaningful differences, and the control needs to be fine-tuned enough to correct those differences.

Introduction

Optimizing an educational system is no different in its requirement that student learning and performance be measured with a meaningful level of detail, and that people and processes influencing learning outcome can at the very least be influenced if not controlled. Otherwise, the system will drift with spasmodic starts and stops waiting for an irresistible personal or financial wave to give it direction. Even so, waves can never accomplish what only swimmers can do.

Competence, Expertise and Novice Learners

COMPETENCE

Evaluating competence always begs the question, "**Competent for what?**" A physician's assistant may be competent for diagnosing some conditions, but incompetent when it comes to more complex problems or performing surgery. Competence as a plant breeder can be just as situational when it comes to such variability as working with an unfamiliar crop, or working with a familiar crop in an unfamiliar environment. For this reason, novice learners and even experts who take on the challenge of an unfamiliar area of study will repeatedly pass through four stages of competence.

FOUR STAGES OF COMPETENCE (WIKIPEDIA.ORG)

- Unconscious incompetence
- Conscious incompetence
- Conscious competence
- Unconscious competence

Unconscious incompetence is when learners have no idea of just how incompetent they are. My experience with this was on a family trip when I drove past a factory with white smoke billowing from several stacks. My wife asked me, "What do you think is made in that factory?" Before I could offer a guess, our four-year-old said with absolute confidence, "**Clouds.**" I looked at our nine year-old daughter and we both shook our heads slowly. We both knew the effort to convince her otherwise would have been in vain, especially since all of the evidence was in her favor. The four year-old was unconscious of her incompetence.

Competence, Expertise and Novice Learners

Conscious incompetence is when learners have learned enough to realize there is much that they do not know. In this phase, learners are faced with the choice of either **working hard to develop competence**, or **working even harder to conceal their incompetence**. In the *Cloud Factory* above, my *nine-year-old* did not know what the factory produced, though she was absolutely certain it was not clouds.

Conscious competence is the **reward of hard work and successful practice**, and is not based on false confidence, nor is it contaminated with groundless pride and arrogance. This competence is founded on personal ability with an appreciation of its current limitations.

Unconscious competence is the result of hard work and successful practice to the point that **performance has become automated** below awareness. Someone with this level of competence does not have to "think" about a cognitive task when it is performed. That does not mean that their brain is not working, it just means it does not have to consult the much slower language and awareness sections. Problems arise however when an expert is asked **to explain how the cognitive task was accomplished**. Educators who are *unconsciously competent* are routinely confronted with the **challenge of transferring their own expertise to learners** who are *consciously incompetent*.

Competence, Expertise and Novice Learners

Moving a learner from *conscious incompetence* to *conscious competence* is a gradual process that requires a series of incremental steps. Applied learning activities can be used to advance this process. Early activities should focus on remembering and understanding facts and concepts, while subsequent activities build upon this competence and focus on **applying that understanding to real-world scenarios**. As such, each learning activity should take into account its targeted learner's current level of competence with regard to knowledge and thinking skills. From this beginning point, the activity can then be designed to move learners to the next level of competence. As I will discuss later in the section on Cognitive Load Theory, each activity should impose a manageable amount of mental work because cognitive demands that are unmanageable by learners only bring about frustration, and detract from learning.

Mental Schemas

When experts are presented with a familiar problem or situation, they often respond quickly with an appropriate decision. If however, novice learners are presented with the same problem, they either do not have a response, or offer a weak solution based on a limited understanding and lack of experience. The difference between these two performances is that an expert possesses a rich network of related facts, concepts and cognitive processes that was built over time with practice and experience. In addition, this network is activated appropriately when presented with a problem to solve. I will refer to this network as a *mental schema*.

> Note: There is disagreement as to whether an individual has a single mental schema of life, or uses multiple schemas to represent anything from a single object to an area of expertise. I will use the term schema in the latter sense realizing that it is a purely conceptual distinction. I will also use the term *mental model* to denote the more knowledge-based facts, concepts, and procedures of a particular domain.

INSIDE WORLD AND THE OUTSIDE WORLD

A mental schema is an inner representation of the outer world. Each *known* object in the outer world has a corresponding representation in an individual's mental schema. In this way, a schema includes objects and their properties, an understanding of how objects (concrete and abstract) interact with one another, and how those interactions can be analyzed, evaluated, and predicted. At its essence, a mental schema is an individual's inner functional image of his or her outer world.

Mental Schemas

Mental schemas are always an incomplete and inaccurate representation of reality. For example, if I ask ten students to picture a stalk of corn in their mind and think about what they know about corn, there would be considerable variation due to their previous experiences with corn. Their mental schemas are not aligned. For alignment to occur, each learner must assimilate new material and experiences into their schema in a way that existing areas can accommodate. These existing areas need to be refined or perhaps even pruned when it is discovered that a *known fact* is not, such as when it was determined that the earth is in fact…not flat.

SCHEMA CONSTRUCTION TAKES TIME

Construction of mental schemas takes time and requires the commitment and participation of both educators and learners. It is critical to reinforce what has been learned by asking learners to repeatedly explain even basic concepts, and to use those explanations in applied learning activities. These activities should also be used by educators to model expertise to learners because giving learners the *opportunity to think* does not teach them *how to think*. They experience great benefit in first listening to an expert on how to solve a problem, then watching how the expert solves the problem, followed by an opportunity to practice the same. This should not seem strange because no one would expect a student to learn how to play a piano without first being permitted to watch and hear the teacher perform.

Mental Schemas

COVERAGE OR LEARNING

Even though contact time with learners is limited and there is much to be understood, the choice is often between *content coverage* as the driving force, or a commitment to learning. As stated previously, it does not really matter what is covered if it is also forgotten. The real value of educators that cannot be contained in a learning module is not in the content delivered, rather, it is the judgment and decision-making skills that are modeled and passed on. That is why schema construction requires much of the contact time with learners to be devoted to discussion and approaches to problem solving with opportunities to perform the skill and receive feedback.

PROBLEM-SOLVING

Solving a problem requires an adequate schema that is appropriately activated. One explanation for how experts solve a problem is that relevant features of the problem which also includes any constraints, are identified and considered in light of their mental schema. Various mental simulations are thought through until one is selected and implemented. When the results of the implementation are available and perceived, experts use that feedback to enhance their understanding which will improve their problem-solving abilities in the future. The main downside of this process for acquiring expertise is that it takes a considerable amount of time, and one's experiences are limited by circumstances. **Applied learning activities address this weakness by providing timely, directed, and focused cognitive practice that is not dependent upon circumstances.**

Mental Schemas

THE SCHEMA CHALLENGE FOR NOVICE LEARNERS

With the help of educators, novice learners are faced with the challenge of transforming themselves from a state of *incompetence* to one of *competence* by building and refining their own mental schemas. In addition, they need to learn how to **appropriately activate relevant portions of their schemas** when trying to solve a problem. Unfortunately, while their goals are large, their schemas are small. To make matters worse, novice learners often see the results of expert thinking, but have no clue about how that ability was acquired or performed. And asking experts for an explanation is often unfruitful because of their *unconscious competence*. They can easily provide a solution, but often find it difficult to explain how it came to them. **Applied learning activities with feedback can make those explanations easier.**

THE SCHEMA CHALLENGE FOR EDUCATORS

Educators face a challenge that extends well beyond that of experts. Not only must educators maintain expertise in their domain of interest, they must also have educational expertise in how to help learners build and use their own mental schemas. Educators often accomplish this by **modeling their expertise to learners** by demonstrating solutions to authentic real-world problems. They also answer questions from learners as to how those solutions were determined, and why other solutions were less acceptable.

After modeling their expertise to learners, the next step for educators is to give learners similar applied learning activities to solve with the educator and peers providing feedback on their solutions. **Applied learning activities used in this way assist learners in schema building, and provide both educators and learners with evidence of knowing.**

Mental Schemas

Helping learners build their own mental schemas is a **creative artistry that uniquely sets one educator apart from another**. Each educator has a distinct understanding of the subject domain along with an understanding of individual learners. **Applied learning activities allow educators to express their unique understanding of their discipline and their learners.**

THE CLASS SCHEMA

Any *meaningful* discussion requires that participants have a shared understanding of what each other is saying. Obviously, this understanding does not necessarily mean agreement. Since the mental schemas of a group of learners will vary, it is the educator's challenge to bring them into enough of an alignment for meaningful discussions to occur. I will refer to this shared baseline understanding as the *class schema*.

The concept of a *class schema* is illustrated by the expressions, "Everybody needs to be on the same page" and "Everyone needs to get up to speed." These expressions capture the need for members of a class to be at a common point of understanding.

Many courses begin with an Introduction and Review session to identify *schema deficits*. In addition, these sessions serve to reactivate and reinforce cognitive processes that may not have been accessed recently. For some, these review sessions at the beginning of a course can seem tedious, or be viewed as an activity that should not be necessary, but their benefit cannot be overestimated. Even if the review of *individual topics* is only necessary for a small segments of the class, all learners benefit from the augmentation and reinforcement of their mental schemas. **Applied learning activities at the beginning of a course can surface these schema deficits.**

Mental Schemas

While it is important that members of a class begin at a common point of understanding, it is just as important that they continue to maintain and develop common milestones of understanding throughout a course. Obviously, this does not mean that their individual understandings (mental schemas) will not vary widely based on background, experience, and effort, rather, it means each class member's minimal understanding should encompass the relevant features of the course for continued learning and meaningful discussions to occur. **Applied learning activities throughout a course can surface developing schema deficits in individual learners in time for effective remediation.**

COURSE SCHEMA

I will use the term, *course schema*, to represent facts, concepts, and procedures that an educator expects learners to remember, understand, and be able to apply at the end of a course. Thus, at the beginning of a course there is a gap between the *class schema* and the *course schema*. Once the initial *class schema* is established, the remainder of the course is about narrowing that gap until the *course schema* becomes part of each learner's *mental schema*.

Course schemas are not static because educators learn year after year what needs to be improved. New material can be included and existing material may no longer be relevant. In addition, learners will contribute to the *class schema* from their personal schemas in ways that extend beyond the initial *course schema*. These contributions may even rise to the level of being incorporated into the formal *course schema* for subsequent offerings. This continuous enhancement and improvement requires an intentional, pragmatic, and responsive stance by educators.

Mental Schemas

Capturing augmentations to the course schema from learners by educators in real-time during class is extremely difficult. In addition, learners who are participants find it difficult as well. The problem is cognitive load (which will be described shortly) that exceeds working memory. Listening and thinking creates an intrinsic cognitive load, from which transcribing notes adds to. One solution is to record the class, and have a team of learners review the recording for additional relevant material, and take notes that can be distributed to the rest of the class.

As course schemas evolve, applied learning activities support this evolution by being easily adapted as course requirements change and areas needing improvement are discovered.

COURSE SCHEMAS AND A PROGRAM SCHEMA

The only way to reliably improve a program of study is to be explicit and intentional about the expected knowledge and cognitive competencies to be achieved in each course, with the ultimate goal that all of the *course schemas* be coherently integrated into an overall *program schema*. For this to occur, each course cannot be viewed by its educators as a single silo unto itself. As such, a Plant Breeding Program should have an established program schema that each educator understands, and knows the contribution of his or her efforts.

Mental Schemas

One challenge to developing an effective *program schema* is that while the understanding of learners for a particular course is frequently assessed, understanding across multiple courses is not. This lack of **comprehensive assessment** places a great deal of responsibility on learners to integrate sections of their mental schemas from multiple courses when they are the least experienced and capable of doing so. This should not be surprising because expert educators also find this challenging. A step in the right direction is for program material to be reinforced throughout multiple courses in order for it to become a permanent part of a learners schema. **Applied learning activities in a course can help address this when designed to include material from previous courses.**

Context Applied Learning

Context Applied Learning emphasizes two types of contexts for presenting course material and modeling expert thinking skills: *content context* and *situational context*.

CONTENT CONTEXT

Content context provides that new material be presented in the context of previously learned material. This approach enables learners to progressively extend their existing mental schema without having to manage a myriad of fragmented and disconnected islands of thought. This approach is similar to assembling a puzzle in which new pieces are added to previously completed sections. The puzzle metaphor has at least one glaring deficiency when it comes to schema building. Puzzles usually come with a picture of the final product on the box, whereas learners have no such luxury.

SITUATIONAL CONTEXT

Situational context provides that new content is presented, modeled, and practiced in the context of an authentic real-world setting that is likely to be encountered after training. This goes a long way is satisfying a learner's BDSW Factor. (**Big Deal So What?**) Learner's should never be asking themselves, "Why am I learning this?" because the situational context of presented material already answered the question.

Context Applied Learning

Almost any learning activity can be framed to some degree in the context of a real-world setting, which as indicated previously automatically answers the question of relevance. Of course, it should not be an absolute requirement that all content be applied in a context, but if it is not, it should at least be scrutinized for its continued relevance given the ever-increasing amount of information that learners must understand, and the rapidly changing competencies in the various plant breeding settings.

Applied learning activities can satisfy context considerations by incrementally introducing new material with material that has already been learned, and by doing so using authentic real-world scenarios.

Cognitive Load Theory

Cognitive Load Theory addresses the amount of mental work required of a learner, and makes a distinction between *working memory* and *long-term memory*. Working memory refers to one's capacity for processing information at any given moment, while long-term memory refers to what can be recalled for use in working memory. The capacity of working memory and its duration of storage is very limited compared to long-term memory.

Cognitive Load Theory identifies three types of cognitive load that are additive in their overall cognitive demand placed on a learner. These loads are referred to as Intrinsic, Extraneous, and Germane.

INTRINSIC COGNITIVE LOAD

Intrinsic cognitive load is the mental work that working memory must do that is inherent in the learning activity. The amount of work is determined by such characteristics as the number, complexity, and interactions of the elements in the activity. The experience of intrinsic load for a new activity is relative to a learner's preexisting cognitive ability. A new more complex problem will have a greater intrinsic load than a previously mastered one.

EXTRANEOUS COGNITIVE LOAD

Extraneous cognitive load is any mental work that is not directly related to the learning activity. Examples include unclear directions, missing resources, contention within a learning group, or inaccurate or incomplete data. Of course, for advanced learners an applied learning activity may intentionally include many of these real-world distractions.

Cognative Load Theory

GERMANE COGNITIVE LOAD

Germane cognitive load is the mental work of learning, which is not the same as the intrinsic cognitive load for completing a learning activity. Germane cognitive load is the useful mental work of extending and refining one's schema and reflecting on the general principles of the learning activity. This reflection includes relating the learning activity to other activities, and refining the cognitive processes and strategies that were used in the activity.

For learning to occur, the additive work of an applied learning activity's intrinsic, extraneous, and germane cognitive loads cannot exceed a learner's working memory. The limitation of working memory was clearly articulated by George Miller in 1956.[1] He asserted that in general, people could hold seven items plus or minus two in their working memory at one time. These items can be discreet such as a grocery list, or complex such as a set of courses in a curriculum. With complex items, *chunking* is required, in that the details are contained in the overall course as an item. When the specifics of that course are considered, all other courses must leave working memory for the moment. This has relevance for applied learning activities when considering how many active items a learner must manipulate, and what is the learner's capacity for and experience with *chunking*.

Cognative Load Theory

EFFECTIVE APPLIED LEARNING ACTIVITIES FROM A COGNITIVE LOAD PERSPECTIVE

Effective applied learning activities 1) impose a manageable intrinsic cognitive load, 2) minimize extraneous cognitive load, 3) provide adequate time for the germane cognitive load of reflection and incorporation, and 4) are presented in a relevant real-world context. This means that a single activity should be challenging, but not defeating. It also means that a series of activities should incrementally increase in complexity at a rate that is manageable by learners.

Learning is also enhanced when unintentional extraneous cognitive load is minimized, and a learning activity provides additional guidance on its relevance to learners. This guidance emphasizes why the learning objectives of the activity are valuable enough for learners to invest the time and energy incorporating them into their mental schemas.

SURVIVAL MODE

Unfortunately, the use of applied learning activities does not end well when the limits of cognitive load are not considered. One can easily predict a disastrous learning outcome when learners are presented with an activity that has an intrinsic cognitive load that 1) vastly exceeds their mental model and cognitive strategies, 2) is unclear in its requirements or relevance, and 3) leaves no time for reflection and incorporation into their mental schema. When this occurs, learning stops and surviving begins.

Cognative Load Theory

When learners fall back into survival mode they generate enough of a "solution" to an applied learning activity to receive an acceptable grade. Of course, this behavior is completely understandable because regardless of the authentic real-world learning activity that learners are presented with, they are always functioning within their own larger authentic real-world task of completing the program of study. After all, the question of "What will learners be able to do when they graduate?" is only relevant for those who do. And for those learners who survive their way to graduation the question remains, "How much better could they have been prepared to address the world's plant breeding challenges if issues such as cognitive load had been considered?"

Survival mode in an educational setting is not limited to learners. Educators and administrators must contend with numerous competing priorities with often conflicting reward structures. Just as quality learning takes time and effort that should be rewarded with competence, quality teaching takes time and effort as well, and should be rewarded accordingly.

Revised Bloom's Taxonomy

Effective applied learning activities should be intentionally designed to address specific learning objectives. In addition, authors of learning activities should know what cognitive processes are being exercised along with what prior cognitive skill and knowledge is required. The Revised Bloom's Taxonomy (RBT) provides a framework for educators to communicate about these ideas within a course or a curriculum.

The Revised Bloom's Taxonomy is an update of the original, and was developed to be more understandable and complete than its predecessor. The Taxonomy shown in Table 1 consists of Cognitive Processes dimension and a Knowledge dimension.

The Cognitive Process Dimension includes six categories that increase in cognitive complexity which are: Remember, Understand, Apply, Analyze, Evaluate, and Create (many authors use the verb forms which are Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating). The assertion is that each level is a fundamental component of the next, and must be mastered before the next can be performed. For example, in order to Understand, one must Remember. In order to Apply, one must Understand and so on.

The Knowledge Dimension, also shown in Table 1 consists of four categories: Factual Knowledge, Conceptual Knowledge, Procedural Knowledge, and Metacognitive Knowledge.

Factual Knowledge pertains to the basic elements of a discipline that learners must know such as the terminology for objects and the specific details about those objects.

Revised Bloom's Taxonomy

Conceptual Knowledge pertains to ideas and the interrelationships among basic elements that enable them to function together such as classifications, categories, principles, generalizations, theories, models, and structures.

Procedural Knowledge pertains to processes and how they are performed, methods of inquiry, and judgment for which skills should be used, and which algorithms, techniques, and methods are indicated.

Metacognitive Knowledge pertains to one's awareness and understanding of one's own cognition and strategies for learning.

These dimensions are consistent with a learn, think, and do approach to building competence. What learners should be able to do is represented by Applying, Analyzing, Evaluating, and Creating. These competencies require higher-order thinking skills, and also build upon the lower-order thinking skills of Remembering and Understanding. The content in terms of facts, concepts, procedures, and strategies that need to be learned to do these activities is represented by the Knowledge dimension.

Let's consider a learning activity that is a quiz on definitions. What position would it occupy in the taxonomy table? The objective of the quiz would be to Remember Factual Knowledge so it would be positioned at the intersection of those two dimensions in the table. What about providing extension advice to farmers? Depending on the advice, it would likely be at the intersection of Apply and Conceptual Knowledge. What about an applied learning activity to create a plant breeding program for a crop? It would be at or near the intersection of Create and Procedural Knowledge.

Revised Bloom's Taxonomy

While using the Revised Bloom's Taxonomy to classify an applied learning activity is helpful, its greatest value is that it informs educators to consider the subsumed intersections of knowledge and cognitive processes for a particular activity. These intersections identify the constituent skills and knowledge required to successfully complete the activity.

For example, before learners are given an applied learning activity to design a plant breeding program, an educator should consider whether or not learners have mastered the requisite constituent skills and knowledge so as to impose a manageable cognitive load. While considering the activity an educator should ask,

- What procedures, concepts, and knowledge will learners need to know and be able to apply?
- Have learners developed sufficient analytical and evaluation skills for this task?
- Have I modeled the cognitive processes that I want them to use?
- Do learners know where to find any additional knowledge they will need?
- Have I formulated the applied learning activity in such a way that learners know what I am asking them to create?

Revised Bloom's Taxonomy

	The Cognitive Process Dimension					
The Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	Quiz					
Conceptual Knowledge			Advice to farmers			
Procedural Knowledge						Create a breeding program
Metacognative Knowledge						How I solve problems

Table 1.

Revised Bloom's Taxonomy

IMPLEMENTING THE REVISED BLOOM'S TAXONOMY

To aid in classification, the taxonomy includes nineteen sub-categories of the Cognitive Processes with terms to clarify each. They are summarized as follows.

Remember

- Recognizing
  - Identifying
- Recalling
  - Retrieving

Understand

- Interpreting
  - Clarifying
  - Paraphrasing
  - Representing
  - Translating
- Exemplifying
  - Illustrating
  - Instantiating
- Classifying
  - Categorizing
  - Subsuming

Revised Bloom’s Taxonomy

- Summarizing
  - Abstracting
  - Generalizing
- Inferring
  - Concluding
  - Extrapolating
  - Interpolating
  - Predicting
- Comparing
  - Contrasting
  - Mapping
  - Matching
- Explaining
  - Constructing models

Apply

- Executing
  - Carrying out
- Implementing
  - Using

Revised Bloom's Taxonomy

Analyze

- Differentiating
  - Discriminating
  - Distinguishing
  - Focusing
  - Selecting
- Organizing
  - Finding coherence
  - Integrating
  - Outlining
  - Parsing
  - Structuring
- Attributing
  - Deconstructing

Evaluate

- Checking
  - Coordinating
  - Detecting
  - Monitoring
  - Testing

Revised Bloom's Taxonomy

- Critiquing
  - Judging

Create

- Generating
  - Hypothesizing
- Planning
  - Designing
- Producing
  - Constructing

ALIGNMENT OF A CURRICULUM USING THE REVISED BLOOM'S TAXONOMY

Alignment within a curriculum occurs when learning objectives, instructional activities and materials, and assessments are consistent with one another. In essence, what learners are told to learn is consistent with what is taught or assigned, which is consistent with what is assessed. Misalignment is indicated by statements from learners such as, "I didn't know what I was supposed to learn." to "Why are you talking about that when we aren't expected to know it?" to "Why did the test have questions that we never talked about in class and were not in the readings?"

Revised Bloom's Taxonomy

The Revised Bloom's Taxonomy can be used bring about alignment by plotting learning objectives, instructional activities, and quiz/tests/applied learning activities on the same table. Intersections of cognitive processes and knowledge that have no entries may indicate gaps that can be identified and filled, while areas of over-learning can be reduced. Sections that have an objective and an assessment without intentional instruction activities should be identified. In addition, applied learning activities should be plotted on the same grid to ensure that course material is being applied in an authentic real-world context.

BLOOM'S COGNITIVE PROCESSES, VERBS, AND POTENTIAL ACTIVITIES

An additional resource, **Revised Bloom's Handout**, has been made available to this project by Rex Heer at Iowa State University Center for Excellence in Learning and Teaching, and is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. It further explains the intersections of Knowledge and Cognitive Processes with examples of learning activities for each. For additional resources, see: **www.celt.iastate.edu/teaching/RevisedBlooms1.html**.

A **pdf copy of "Quick Flip Questions for the Revised Bloom's Taxonomy"** provided by Edupress has been made available to this project. It contains key words and stems of questions that are characteristic of each level of the Revised Bloom's Taxonomy. It was scanned by, and used with permission of, Edupress™, a trademark of Highsmith, LLC.

Revised Bloom's Taxonomy

For example, questions that start with "What is…" or "Recall…" are characteristic of learning activities at the Remembering level, whereas questions such as, "What approach would you use…" or "How would you use…" are typically used at the Applying level. And finally, questions such as, "How would you improve…" or "What way would you design…" are associated with the Creating level.

What follows is a Bloom's Taxonomy Guide used with permission: Copyright © 2012 Northern Illinois University Faculty Development and Instructional Design Center. Bloom's Taxonomy, in *Instructional Guide for University Faculty and Teaching Assistants*. Retrieved from **http://www.niu.edu/facdev/resources/guide**.
This site has many other resources that educators will find useful.

A copy of their guide to **Bloom's Taxonomy** is also included in the materials distributed with this document. Table 2 provides helpful suggestions for terms used to design applied learning activities for each level of thinking, and Tables 3, 4, and 5 provide stem questions for each activity.

Revised Bloom's Taxonomy

Verbs and Products/Outcomes Based on the Six Levels of Bloom's Revised Taxonomy
Adapted from —Bloom's Bakery, An Illustration of Bloom's Taxonomy || by Argiro, Forehand, Osteen, & Taylor (2007)

Verbs	Level of Thinking	Potential activities, products or outcomes
change, combine, compare, compose, construct, create, design, devise, formulate, generate, hypothesize, imagine, improve, invent, plan, predict, propose	**Creating** **Creating something new**	algorithm, framework, haiku, multimedia, presentation, game, poem, story, theorem, treatment
argue, appraise, assess, check, debate, decide, defend, determine, dispute, editorialize, judge, justify, prioritize, rate, recommend, select, support, verify	**Evaluating** **Defending a concept or idea**	critique, judgment, opinion, recommendation, report, self-evaluation
advertise, analyze, appraise, attribute, categorize, compare, contrast, differentiate, distinguish, examine, identify, infer, investigate, organize, outline, separate, sequence, test	**Analyzing** **Distinguishing different parts of a whole**	chart, plan, questionnaire, spreadsheet, summary, survey
classify, construct, complete, demonstrate, dramatize, examine, execute, illustrate, implement, practice, show, solve, use	**Applying** **Using information in new way**	collection, interview, model, building, presentation, role, playing, scrapbook, simulation
calculate, compare, describe, discuss, distinguish, expand, explain, identify, interpret, locate, outline, predict, report, restate, translate, define	**Understanding** **Explaining information and concepts**	drawing, paraphrasing, peer teaching, show & tell, story, problems, summary
describe, duplicate, find, list, locate, name, recall, recognize, reproduce, state, tell, underline, write	**Remembering** **Recalling information**	definitions, fact charts, lists, recitations, work-sheets

Table 2.

Revised Bloom's Taxonomy

Verbs	Sample question/ statement stems	Potential activities, products or outcomes
Verbs and Products/Outcomes Based on the Six Levels of Bloom's Revised Taxonomy Adapted from *Good Questions are the Key to Good Research* by Dalton (1986)		
Verbs	**Sample question/ statement stems**	**Potential activities, products or outcomes**
Creating		
change combine compare compose construct create design devise formulate generate hypothesize imagine improve invent plan predict propose	— Design a... to...? — How would you improve...? — Formulate a theory for...? — Predict the outcome of...? — How would you test...? — How would you estimate the results for...? — If you had access to all resources how would you deal with...? — What would happen if...? — How many ways can you...? — Develop a new proposal which would... — Create new and unusual uses for... — Construct a new model that would change...	— Invent a machine to do a specific task — Design a computer lab for your program — Create a new product and plan a marketing campaign — Design a cover for a DVD — Sell a product — Write a musical score for ... — Write about your feelings in relation to...
Evaluating		
argue appraise assess check debate decide defend determine dispute editorialize judge justify prioritize rate recommend select support verify	— What is your opinion of...? — How would you prove or disprove...? — Would it be better if...? — What would you recommend...? — How would you rate the...? — What would you cite to defend the actions...? — How could you determine...? — How would you prioritize...? — Based on what you know, how would you explain...? — What data were used to make the conclusion? — How would you compare the ideas...? — How would you compare the people...? — How would you justify...?	— Prepare a brief — Form a panel to discuss views — Write a letter to... expressing your views on ... — Write an end of the year report — Write a job aid for... — Explain and justify a proposal — Select the most useful products for...

Table 3.

Revised Bloom's Taxonomy

Analyzing		
advertise analyze appraise attribute categorize compare contrast differentiate distinguish examine identify infer investigate organize outline separate sequence test	— What are the parts of features of …? — How is ___ related to …? — What is the theme …? — List the parts …? — What inferences can you make …? — How would you classify …? — How would you categorize …? — What evidence can you find …? — What is the relationship between …? — What is the function of …? — What motive is there …? — Identify the different parts …?	— Gather data and analyze them according to … — Troubleshoot problems with lab equipment — Design a survey — Write a story about an interviewee — Arrange a conference and all necessary steps — Make an organizational chart of your unit or department — Write a ad campaign for your organization — Construct a flow chart which illustrates a system
Applying		
classify construct complete demonstrate dramatize examine execute illustrate implement practice show solve use	— How would you use…? — What examples can you find to…? — How would you solve ___ using what you've learned? — What approach would you use to…? — What would result if…? — What elements would you choose to change …? — What questions would you ask in an interview with …?	— Make a model of an activity — Paint a wall poster to advertise a special event — Design a marketing strategy for your organization — Design a store window for homecoming — Develop a storyboard of digital images to demonstrate a process — Use a set of standards to evaluate performance

Table 4.

Revised Bloom's Taxonomy

Understanding		
calculate compare describe discuss distinguish expand explain identify interpret locate outline predict report restate translate	— How would you classify the type of...? — How would you compare or contrast...? — How would you rephrase the meaning...? — What facts or ideas show...? — Which statements support...? — What can you say about...? — Which is the best answer...? — How would you summarize...?	— Illustrate what you think the main idea was — Write and perform a play based on the story — Retell the story in your own words — Paint a picture of some aspect you like — Write a critique of a presentation — Prepare a flow chart to illustrate the sequence of events
Remembering		
define describe duplicate find list locate name recall recognize reproduce state tell underline write	— What is...? — Where is ? — How did ___ happen? — How would you describe...? — Who was...? — Who were the main...? — When did...? — Recall...?	— Make a list of the main events — Make a timeline of events... — Make a facts chart — Recite a poem — List all the ___ in the story. — Write a list of any pieces of information you can remember

Table 5.

Gagne’s 9 Events of Instruction

Cognitive Load Theory informs the importance of not overwhelming a learner’s working memory, and the Revised Bloom’s Taxonomy informs as to what types of cognitive processes and knowledge are required for the various levels of thinking from lower-order to higher-order. What neither addresses however is clear and pragmatic guidance on what to do in a classroom setting.

Gagné’s 9 Events of Instruction (some authors use Steps) provides educators with a consistent successful approach to working with learners in a classroom setting. These events are also helpful when designing an applied learning activity. The steps in order of occurrence are:

1. Gain attention—clears learners’ minds of competing and distracting priorities.
2. Inform learners of objectives—signals which areas of their schemas will be exercised.
3. Stimulate recall of prior learning—activates a learner’s mental schema in the area that will be addressed. In essence, it helps learners pick up where they left off at the previous session. This sets the *content context* for learning.
4. Present the content—in a flipped classroom this may be discussing content that learners acquired on their own prior to class.
5. Provide learning guidance—includes modeling of performance by an educator along with instructions, tips, and pitfalls to avoid. Key concepts are also clarified.
6. Elicit performance (practice)—occurs when students work through applied learning activities.
7. Provide feedback—feedback on their practice either from an educator or peers.

Gagne's 9 Events of Instruction

8. Assess performance—can occur with applied learning activity outputs or conventional testing methods.
9. Enhance retention and transfer to the job—is reinforced with situational context in an applied learning activity.

These events will not occur in every classroom meeting, but imagine a scenario where an educator walks into the room and begins presenting content until the end of the period, leaving two minutes for questions and walks out. And after that, he or she may still be surprised that his or her learners are not ready for the next course in their program or to be productive in the workforce.

An excellent article, Gagne's Nine Events of Instruction is included with this document courtesy of the Northern Illinois University Faculty Development and Instructional Design Center.

Gagne's 9 Events of Instruction

INTEGRATING COGNITIVE LOAD THEORY, BLOOM'S, AND GAGNE

The Revised Bloom's Taxonomy informs author's of applied learning activities as to what knowledge and cognitive processes are being exercised, which translates directly into cognitive load depending upon the current proficiency of learners and exposure to prior modeling of the activity's solution. Several points of consideration motivated by Bloom's include:

1. What level of competence is the applied learning activity directed towards?
2. Where is the activity oriented in the Revised Bloom's Taxonomy table?
3. What are the prerequisite knowledge and cognitive processes?
4. What is the targeted learner's level of expertise/competence?
5. Does this activity make sense incrementally, given the targeted learner's level of competence?
6. Is the intrinsic cognitive load manageable?
7. Has extraneous cognitive load been minimized?
8. Are there distracters and if so, are they intentional to the activity?
9. Will the learner have time for the germane cognitive load of reflection and incorporation of the new material into the mental schema?
10. Is this applied learning activity in alignment with learning objectives, teaching activities, and learner assessment.

Gagne's 9 Events of Instruction

Gagné's work more specifically informs the design of an applied learning activity. Several points of consideration include:

1. Is the activity engaging?
2. Are the objectives of the activity clear to learners?
3. Does the activity provide *content* context?
4. Is the activity presented in a relevant *situational* context?
5. Is adequate background information provided to orient learners to the activity?
6. Is the learning task stated appropriately, which can range from clear to intentionally ambiguous?
7. Are any constraints on the situation/activity clear?
8. Is the outcome/deliverable that is expected from learners clear?
9. Has the performance of this activity been modeled to learners previously?
10. Does the activity provide sufficient guidance to learners?
11. Are adequate supporting resources either made available or identified?
12. How will learners received feedback on their performance to assist in schema building/remodeling?

An Example of Schema Management in a Quantitative Genetics Course

Recall that learners arrive in class with their own mental schemas that have some overlap and vary considerably from one another. The educational goal is to quickly establish an initial shared schema that will, by the end of the course, grow into an approximation of the desired course schema, which will serve them well when they enter the next course or join the workforce. Recall also that this course schema is not defined solely by what learners *know*, rather, it also includes what learners can *do* when the course is completed.

This discussion emerged from observations of Dr. William Beavis's course, Introduction to Quantitative Genetics for Plant Breeding. As such, it is not a summary of the course and is limited to useful practices that can be widely implemented regardless of specific course content.

APPLIED LEARNING ACTIVITY ON SIGNIFICANT CONTRIBUTORS TO QUANTITATIVE GENETICS

In the first applied learning activity, learners were divided into groups with each group assigned the name of an individual who had made significant contributions to quantitative genetics. The individuals were Ronald A. Fisher, Sewall Wright, C.R. Henderson, Shizhong Xu, and Mark Cooper. The assignment was to report on each individual's contribution to quantitative genetics. Reports needed to be a succinct synthesis, not *plagiarized,* copied and pasted text of random facts such as career path, associates, students, awards, or positions. See **Significant Contributors to Quantitative Genetics**.

An Example of Schema Management in a Quantitative Genetics Course

Dr. Beavis **modeled his expertise in this activity** by providing an example using Alan Robertson. The bolded selections show his conceptual framework for the presentation.

Alan Robertson's first contributions to QG showed how the genetic gain per year resulting from mass selection depended on the relative selection differentials applied to bulls and cows. **He decided to work on this problem because** there was an Operations Research question about trade-offs between testing few bulls with many daughters, thus obtaining reliable estimates of breeding value, or many bulls with fewer daughters, thus giving greater selection differential. **Specifically he showed** that without progeny testing of bulls, genetic improvement depended on performance of the cows, with an expected maximum rate of 1% per year in a small herd. **On the other hand**, with progeny testing enabled by artificial insemination, the herd size could be increased 20-fold, which in turn enabled progeny testing of bulls, when combined with performance testing of cows could result in progress of 1.7% per year. **He further showed** that this is true if the estimated breeding values for bulls are not affected by genotype environment interactions. **Progeny testing has become the foundation** for genetic improvement in most domesticated species.

Robertson's **next contribution to QG** was **based on his concern** about the impact of selection resulting in a "yield plateau". **He realized that** this potential problem would be difficult to investigate using dairy animals, or any organism with a long life span.

An Example of Schema Management in a Quantitative Genetics Course

So he established D. melanogaster (Drosophila) as a model system for studying population and quantitative genetics in animals. **In 1960 Robertson published** a theoretical manuscript that showed for a simple additive model, the expected limit to artificial selection is equal to the expected response in the first generation of selection multiplied by twice the effective population size, with a half-life of 1.4 times the effective population size. **These predictions were found to be true** in Drosophila, other model organisms and in many domesticated animal and plant species. **He and his graduate students** extended the theory of limits to artificial selection to include the effects of linkage through initial investigations using computer simulation.

This activity gave learners an appreciation for the people and ideas that influenced their discipline, which put these contributions in a *person-context*. This helped bring learners to a shared understanding within their class (the class schema), within their cohort, and with others in the plant breeding community (the discipline schema).

Note: African educators using this activity will no doubt have a list of individuals that will be similar, yet have differences based on specific contributions to plant breeding in Africa.

The important point of this learning activity is that learners arrive at a shared understanding with their cohort of the heritage and the accomplishments of others. This same type of shared understanding must continue throughout the course.

An Example of Schema Management in a Quantitative Genetics Course

THE PRESENTATIONS

It became clear during the presentations that learners often speak about concepts they can identify (Revised Bloom's cognitive process of Recall), but do not fully understand. That is why a significant source of value from the learning activity was the feedback during the presentations in the form of questioning from Dr. Beavis, his explanations, and class discussion. He would ask in a non-threatening tone, "What does that mean?" or "How was that applied?" This is an example of Gagné's stimulating recall, and providing guidance and feedback. These questions and answers resulted in the individual's schema augmentation, as well as the establishment of a common class schema. The questioning and discussion also set the tone of the course in that it would be *safe* for students to admit they did not understand something, and their questions could be asked without receiving ridicule and would be answered with respect.

Occasionally, Dr. Beavis would interrupt a presentation that was completely accurate in order to explain it more clearly for learners who appeared somewhat confused. The benefit for those who did understand was that it reinforced their learning from the added perspective.

THE CHALLENGE WHEN ASKING QUESTIONS

Asking a question that a learner cannot answer begs a higher question, "Does the learner *not know* the answer, or does the learner *know* the answer and the question fails to activate the relevant areas of his or her schema to respond correctly?" Either way, learners must not only *know* the material, they must *know how to access it appropriately*. This becomes evident when upon hearing the answer a learner replies, "Oh, that's what you meant."

An Example of Schema Management in a Quantitative Genetics Course

When asking a question of the class that students cannot answer, asking them repeatedly or giving them more an extended period of time will not help. It is often helpful to break the question down into its constituent parts that will hopefully activate partial schemas, which can then be expanded upon during discussion. This approach by Dr. Beavis helped manage *intrinsic cognitive load* and provided for incremental challenges to learners that were not overwhelming. He also managed the potential for *extraneous cognitive load* in the form of stress by not acting like a face-to-face demanding and demeaning interrogator who was in complete control of their future. Rigor is about the challenge of the material, not the challenging behavior of people.

ASKING QUESTIONS MODELS THE SKILL OF ASKING QUESTIONS

Dr. Beavis repeatedly tells learners to question everything. Examples include, "Always question the validity of the data you are given. Does it make sense?" "What goes on inside the *black box* that spit this data out to you?" "What was happening in the environments where these data were generated?"

Asking questions when it comes to applied learning activities also includes being explicit about assumptions. Dr. Beavis would frequently ask, "What are your assumptions for this situation?" or for example, "Can we assume that all of the spilled seeds will germinate?" or "Did all of the farmer's seeds germinate?" Another question would be, "What is your breeding population size and why is this important?" As a result, student answers to many applied learning activities would begin with, "To solve this problem I am going to assume…"

An Example of Schema Management in a Quantitative Genetics Course

Another use of questions is to begin a class period by asking students to explain concepts from the previous meeting or assigned readings/videos. This addresses Gagné's steps of *get attention* and *stimulate recall*. Another approach to get student's attention is to begin a class period with an *unannounced quiz*, and then discuss the answers once the quiz has been collected. This helped some students enter subsequent class periods a little more alert and prepared.

LEARNER CONTACT SESSIONS WITH THE EDUCATOR

Each session if possible should be contextually connected to the previous, so learners can reactivate their mental schemas where the previous session ended. Once again, this is consistent with Gagné's *stimulate recall* and provided an opportunity for the *germane cognitive load* of learning.

The use of metaphors can also be helpful. One that Dr. Beavis used to illustrate the rapidly increasing changes in quantitative genetics was to compare them to a rifle that was first equipped with open sights, and then a scope, and then a laser scope, and then a laser to replace the bullet. This illustrated that the *marksmanship* of genetics was the issue, not the specific tools being used today. The principles are foundational; the tools are temporary.

Dr. Beavis also invested some contact time with students discussing a seminar that most of the class attended. This tied learning in a classroom to a non-classroom activity, which created a cross-link in their schemas between information in the classroom and its relevance in the outside world.

An Example of Schema Management in a Quantitative Genetics Course

During learner contact time it is also helpful to incorporate when possible the specific expertise of a student along with clarification and subtle guidance. This helps the student who is contributing, it gains the attention of the other students, and reinforces the relevance of their current expertise and experience.

When completing a learning session it is helpful to ask students to reflect on what is important to remember and to tell them what will be covered in the next meeting. This strengthens their understanding (germane cognitive load) and orients them to the *recall and relevance* of what will covered next.

EXAMINATIONS

An unusual approach to examinations is to provide learners with the midterm at the beginning of the course, and the final at midterm. Dr. Beavis did this with the final and it helped provide learners with the context for, and relevance of, what was to be learned thereafter. This also meant that the competencies developed from the applied learning activities during the course would be used on this examination, though in a somewhat different context. After all, the goal of the course is to develop competence in learners that is demonstrated on examinations, not surprise them with examinations whose competences for success have not been modeled to them, nor have they been practiced by them.

An Example of Schema Management in a Quantitative Genetics Course

Dr. Beavis also administered his final examination in stages by having learners first submit their conceptual approach to the problem so they could receive feedback prior to proceeding. This helped catch misconceptions and errors early in the process before students wasted valuable learning time, and also made the final examination somewhat easier to grade. This highlights the fact that examinations are not only an assessment tool, but a learning one as well.

CONCLUSION

The evolution of a course to employ applied learning activities takes time and effort with a considerable amount of trial and error. As such, it takes several offerings of the same course for an educator to finally identify which material should be required, and how that material should be presented, modeled, and practiced. In addition, it takes time to assess the effectiveness of a series of applied learning activities with regard to the cognitive load that each requires along with the prerequisite knowledge. The work is worth it when you see learners gradually progress through these activities from intellectual crawling, to standing, to walking, and then to running. These students are not limited to remembering and understanding facts and concepts, but also can apply, analyze, evaluate, and create.

Real-World Tasks and Applied Learning Activities

The following sections on real-world tasks and applied learning activities characterize these ideas and describe how they are related and will be used in the remainder of this document. The main point is that real-world tasks have analogous counterparts in applied learning activities that should mirror as closely as possible their real-world counterparts.

REAL-WORLD TASKS

- Real-world tasks are performed by plant breeders.
- Real-world tasks vary along several dimensions such as context and complexity.
- Real-world tasks consist of constituent skills.
- Performance of real-world tasks and constituent skills demonstrates competence.

APPLIED LEARNING ACTIVITIES

- Applied learning activities are models of real-world tasks.
- Applied learning activities vary along the same dimensions as their corresponding real-world counterparts, such as in context and complexity.
- Applied learning activities consist of constituent skills that are similar to the constituent skills used to complete real-world tasks.
- Performance of applied learning activities and their constituent skills demonstrates competence and provides *evidence of knowing*.

Real-World Tasks and Applied Learning Activities

WHOLE-TASK AND PART-TASK LEARNING ACTIVITIES

Whole-task refers to a comprehensive applied learning activity that corresponds to a real-world competency. An example would be to design a plant breeding program. Whole-tasks consist of **part-tasks** that typically represent **constituent skills** that are often used in multiple whole-task learning activities. An example would be to decide on methods for advancing progeny. Of course, depending on perspective this part-task could be considered as a whole-task with its own constituent skills.

Whole-task mastery focuses on complex real-world tasks that demonstrate overall competency. Applied learning activities for this type of comprehensive task should be characterized by content and situation context, and require previous mastery of constituent skills that are needed for task performance. The Revised Bloom's Taxonomy levels for these tasks would be Applying, Analyzing, Evaluating, and Creating.

Constituent skill mastery focuses on an independent unit of ability that is required to perform an overall competency. Constituent skill learning activities should also be characterized by *content context* and *situational context*, and more often than not, represent a skill that is used in multiple competencies. Examples include the ability to identify relevant features of a problem, how to select an appropriate statistical test, or how to construct a Punnett square. The Revised Bloom's Taxonomy levels for these skills would generally be Remember, Understand, and Apply. Note that I have included Apply in both categories, which emphasizes the relative nature and perspective of these levels. The important point is not that you assign an activity to a specific level, rather, it is that you think carefully about what you are trying to achieve and what methods you are employing to do so.

General Approach to Creating Applied Learning Activities

SURVEY THE DOMAIN

To avoid a piecemeal approach to developing content modules and applied learning activities, an educator should first survey the real-world domain of interest and decide which competencies learners should develop. The next step is to identify which real-world tasks and constituent skills characterize each competency. And finally, identify the relevant variability in context and complexity that occurs within each type of task. This survey is used to establish *task classes*, which are specific types of real-world tasks that are defined for each level of complexity along with their relevant variability and context.

CREATE APPLIED LEARNING ACTIVITIES FOR INDIVIDUAL TASK CLASSES

The next step is to develop several applied learning activities for each task class. Some of the activities will be used to model the solution process in-class or by video, while others will be assigned to learners. Some of the activities assigned to learners may included partial solutions with guidance, while other activities from the same task class may provide no solution or guidance. This approach provides a scaffolding in the form of partial solutions and guidance that is gradually reduced/removed as learners demonstrate competence. In the ideal, when all solutions and guidance are removed, the learning objective(s) of the activity will have become internalized as part of a learner’s mental schema.

General Approach to Creating Applied Learning Activities

All of the applied learning tasks *within the same task class* should require the same mental model and cognitive strategies to solve. As learners work through the learning activities within a task class, each should require a manageable intrinsic cognitive load with a minimum of extraneous cognitive load. In addition, learners should be given enough time to address the germane cognitive load of building and elaborating their mental schemas. Recall that for learning to occur, the total cognitive load cannot exceed a learners working memory. After receiving feedback, learners can reflect more on their performance which is used to further build, elaborate, and/or prune and refine their mental model and cognitive strategies.

Once a task class is mastered, then learners can progress to the next more complex task class, which in order to solve requires an even more robust mental schema with additional cognitive strategies. Once again, the demand of the intrinsic cognitive load must be manageable based on a learner's increased ability. Note that even though in an absolute sense, the task is more difficult than the tasks in the previous task class, it is just as manageable because of the increased competency of the learner.

Task classes will be augmented and refined as educators reflect upon overall learner performance and the relationship between competencies and applied learning activities.

GENERAL APPROACH TO DESIGNING AN APPLIED LEARNING ACTIVITY

When deciding on the content of an applied learning activity, an educator should ask, "What portion of my mental schema with its facts, relationships, and cognitive processes do I want my learners to acquire and/or practice?" Notice the word "portion."

General Approach to Creating Applied Learning Activities

From Cognitive Load Theory, it is clear that it does no good to stress vast sections of a learner's schema when it is first being constructed. Avoiding this approach is not only merciful to learners by keeping the complexity of an applied learning activity manageable, it is merciful to educators by keeping learning activities focused and relatively simple to assess and provide feedback.

The next decision is what *situational context* of a real-world task will be used. Creating a context for an applied learning activity is educational art, and the real challenge is to deconstruct one's expertise into discrete units of knowledge and skills and present them in a context that is sufficiently engaging without becoming distracting or overwhelming. Unfortunately, this deconstruction goes against a brain's natural tendency because it is in one sense, a regression to surface the automated subconscious processes of its schema.

While deconstructing one's expertise is difficult, it should not be thought of as a regression in the ultimate sense because no dismantling actually occurs. In fact, the ability to deconstruct and communicate one's expertise is a further elaboration and strengthening of the same, which results in the acquisition of even more expertise. Recall the Schema Challenge for Educators from earlier in the lesson.

Deconstructing one's expertise is not unlike an artist who must reduce a painting into brushstrokes or a novelist who must reduce a bestselling novel into its themes and individual sentences. As difficult as this can be, an expert must never lose sight of the fact that learners are trying to create expertise in their own minds, and such a deconstruction is required for them to manage the complexity of the task.

General Approach to Creating Applied Learning Activities

The next decision is which dimensions of variability in context and complexity of the real-world task will be modeled in the activity. This decision should be based on the current ability of the intended learners. As mentioned previously, applied learning activities that require substantially more schema than learners have or can activate will result in their frustration and falling back into survival mode.

IN SUMMARY

An applied learning activity should be thought of as a single conceptual step in a series of steps that begin with relatively simple contexts and exercises that focus on relatively simple tasks and subtasks. As learners increase in competency, activities should increase in complexity with new challenges introduced in the context of previously mastered knowledge and cognitive skills. As learners build competence and confidence, increasingly complex of activities can be introduced until overall mastery of an applied learning objective is achieved. Recall that the ideal is that every activity is perceived by learners as equally difficult because as each additional activity increases in complexity, the competency of learners will have previously increased accordingly.

Frameworks

Recall that steps five and six of Gagné's Nine Events of Instruction call for guidance and practice. Frameworks are an effective mechanism for providing this guidance in an applied learning activity. There are two main types of frameworks that assist schema building and enhance cognitive strategies: **General** and **Guided**.

GENERAL FRAMEWORK

A general framework is a consistent and systematic approach (cognitive strategy) for performing a specific type of competency. It enhances learning and should be internalized for use in similar situations in the future. For example, the following five element framework is a general framework for analyzing a plant breeding operation or understanding a plant registration.

FIVE ELEMENTS OF PLANT BREEDING

A framework for analyzing a plant breeding operation could consist of the following five elements:

1. Establish objective(s)
2. Create variability
3. Evaluate progeny
4. Select progeny
5. Increase progeny

Frameworks

These elements represent the five general steps involved in any plant breeding operation, and thereby create a framework for identifying, analyzing, and evaluating the strengths and weaknesses of a specific operation. These steps are represented in the higher-order cognitive processes of the Revised Bloom's Taxonomy. Of course, these higher order processes subsume the lower-order processes of Remember, Understand, and Apply.

To demonstrate competency in using the five-element framework, an applied learning activity might require learners to perform the learning task of identifying these five elements in a plant registration. One rationale for this competency is that real-world registrations vary in organization, and plant breeders need an internalized consistent to analyze and critically assess the processes described in each.

To reinforce the learning of this framework, a series of registrations could be presented in applied learning activities that gradually increase in complexity based on either the specifics of the plant breeding operation, or the organization of elements in the registration. In addition, these more complex applied learning activities might ask learners to analyze and evaluate how these elements were performed, and to suggest an alternative approach (a create cognitive process). This gradual approach of increasing complexity is consistent with the goal of schema building and elaboration without creating an excessive intrinsic cognitive load that overwhelms working memory.

Frameworks

Another use of the *five-element framework* by an educator could be to organize course material according to its elements. As such, various methods for establishing objectives, creating variability, evaluating progeny, selecting progeny, and increasing progeny would be categorized and addressed under their respective element. An applied learning activity for students in this context could be to **design** a plant breeding program from the options in each element category along with the rationale for each choice.

GUIDING FRAMEWORK

A guiding framework differs from a general framework in that it provides a step-by-step process for learners to use when working through a specific learning activity. These steps would be a series of questions or statements that direct a learner's attention to important considerations, such as:

1. What relevant considerations are important in this situation?

2. For each consideration, explain why it is important?

3. Do these data appear to be accurate? Justify your answer.
   (or with even more guidance provided)
4. These data are not accurate. What problems do you see?

5. What do you know from the Chi Square test results?
   (or with even less guidance provided)
6. What test(s) would you use to analyze these data? Justify your answer.

Frameworks

FRAMEWORKS CAN BE TEMPORARY OR PERMANENT

Few people memorize all of the menu options on their word processor because the menu is relied upon to assist in the search for a seldom used feature. In this sense, the menu is not a scaffolding to eventually be removed, it is a tool to be used. Such is an educator's decision when using frameworks. Is the framework intended as an **intermediate and temporary** scaffolding to assist learners in developing their mental schemas and cognitive strategies, or is it meant to be a **permanently internalized** portion of their mental schema for performance of real-world tasks in the future?

FRAMEWORKS CAN BE DISCIPLINE-WIDE OR EDUCATOR-DEFINED

Some frameworks are accepted throughout a domain, such as the SOAP approach used in human and veterinary medicine for considering and communicating the status of a patient. (Subjective information, Objective information, Assessment, and a Plan). Students are expected to give their report in that order addressing specific elements in each category. These elements also serve as prompts when thinking about a patient.

Other frameworks are defined or modified by an educator to accomplish a specific learning objective. For example, an educator could decide that the previous five-element framework should be four by combining *Evaluate progeny* and *Select progeny* into a single step of *Evaluate and select progeny*. Another educator might consider the Evaluation and Selection processes as two subcategories under the heading, *Evaluate and select progeny*, which would result in six entries with five elements. The point is that frameworks are scaffolding that serves the schema building work of both educators and learners, and should be used accordingly as needed.

Frameworks

EXAMPLE OF USING GUIDING FRAMEWORKS

What follows is a series of applied learning activities for the same scenario that vary in the comprehensiveness of the learning task and the level of guidance provided to learners. The activity is content derived from Fei et al. MSc Program in Agronomy, Iowa State University and has to do with the effect of the herbicide Imazamox on two types of barley.

Each activity is introduced, presented, and followed by a discussion.

The first example is the whole-task Imazomox and Barley activity without a solution and without guidance.

The second activity is the same activity with a fully worked solution to be studied by learners.

The third and fourth activities are part-task activities created from the original whole-task activity that provide varying levels of guidance.

The purpose of this series is to demonstrate how a whole-task activity can be decomposed into more cognitively manageable steps that will not exceed a learner's working memory. The whole-task activity without guidance begins on the next page.

Frameworks

WHOLE-TASK WITH NO FRAMEWORK AND NO SOLUTION

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

Table 1 shows the number of plants that either survived (healthy or injured) or dead after herbicide treatment, and the Chi-square test results.

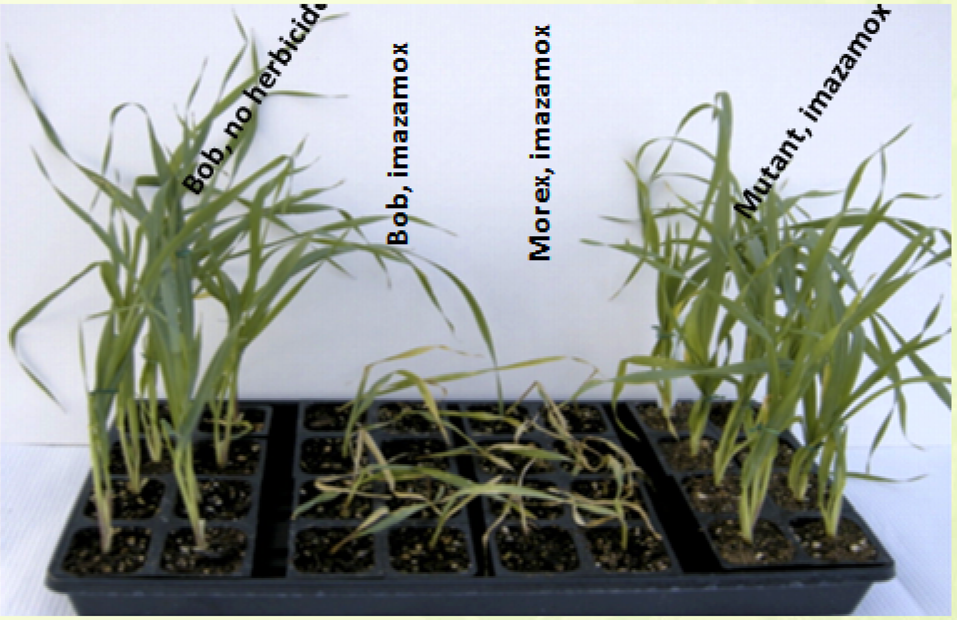

Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Frameworks

Crosses	Plants tested	Survived: Healthy†	Survived: Injured‡	Survived: Total	Dead	x^2*: Value	x^2*: Probability
Mutant x Bob							
Mutant x Bob 1	121	69	20	89	32	0.135	0.7133
Mutant x Bob 2	129	91	10	101	28	0.747	0.3875
Mutant x Bob 3	211	157	2	159	52	0.014	0.9051
Pooled total	461	317	32	349	112	0.122	0.7266
Bob x mutant							
Bob x Mutant 1	85	56	5	61	24	0.475	0.4909
Bob x Mutant 2	135	75	22	97	38	0.757	0.3843
Bob x Mutant 3	144	101	4	105	39	0.333	0.5637
Pooled total	364	232	31	263	101	1.465	0.2261

x^2 test for a single dominant nuclear gene model was performed.
* x^2 test at the 0.05 level against survived (healthy and injured F_2 plant combined); dead = 3:1 ratio model with 1 degree of freedom. x^2 probabilities greater than 0.05 indicate that observed values were not significantly different from expected values, and the proposed 3:1 ratio model was accepted.

Table S1. Phenotypic evaluation for imazamox resistance in six F_2 populations obtained from the reciprocal crosses between mutant and progenitor Bob. Data from Lee et al., 2011.

a. Based on Table 1, is the trait of herbicide resistance controlled by a single gene or multiple genes? Justify your answer.

b. Is the gene action for the herbicide resistance gene dominant, incompletely (partially) dominant or overdominant? Justify your answer.

c. You advance the generations for one of the six populations by selfing, what fraction or percentage of plants at F_4 would be killed if sprayed by the herbicide Imazamox? Justify your answer.

Frameworks

Discussion

This learning activity represents a whole-task competency that learners should master, and no guidance is offered in the form of a guiding framework. This activity could impose too great of a cognitive load on some learners. What follows is the same activity with a fully worked solution that can either be modeled in class by the educator, or studied by learners in preparation to work through a similar activity.

Frameworks

WHOLE-TASK WITH NO FRAMEWORK AND WITH SOLUTION

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

Table 1 shows the number of plants that either survived (healthy or injured) or dead after herbicide treatment, and the Chi-square test results.

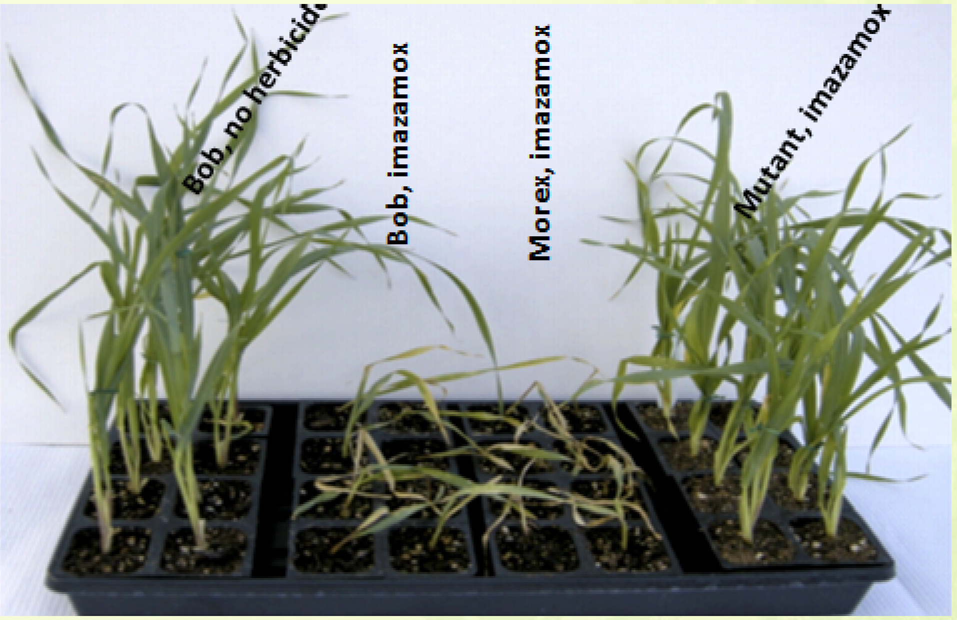

Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Frameworks

Crosses	Plants tested	Survived			Dead	x^2*	
		Healthy†	Injured‡	Total		Value	Probability
Mutant x Bob							
Mutant x Bob 1	121	69	20	89	32	0.135	0.7133
Mutant x Bob 2	129	91	10	101	28	0.747	0.3875
Mutant x Bob 3	211	157	2	159	52	0.014	0.9051
Pooled total	461	317	32	349	112	0.122	0.7266
Bob x mutant							
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Pooled total	364	232	31	263	101	1.465	0.2261

x^2 test for a single dominant nuclear gene model was performed.
* x^2 test at the 0.05 level against survived (healthy and injured F_2 plant combined); dead = 3:1 ratio model with 1 degree of freedom. x^2 probabilities greater than 0.05 indicate that observed values were not significantly different from expected values, and the proposed 3:1 ratio model was accepted.

Table 1. Phenotypic evaluation for imazamox resistance in six F_2 populations obtained from the reciprocal crosses between mutant and progenitor Bob. Data from Lee et al., 2011.

a. Based on Table 1, is the trait of herbicide resistance controlled by a single gene or multiple genes? Justify your answer.

Based on the table, we can conclude that the herbicide tolerance trait is controlled by a single gene because Chi-square tests conducted on all six populations support the null hypothesis. Lack of difference between a cross and reciprocal cross indicates that the trait is controlled by a nuclear gene and not maternally inherited.

Frameworks

b. Is the gene action for the herbicide resistance gene dominant, incompletely (partially) dominant or overdominant? Justify your answer.

The gene action is incomplete dominance because both injured and healthy plants were observed in the surviving plants. The healthy plants are likely homozygous for the mutant allele whereas the injured plants are heterozygous carrying one normal allele and one mutant allele.

There would be no injured plants if the gene action were complete dominance.

c. You advance the generations for one of the six populations by selfing, what fraction or percentage of plants at F_4 would be killed if sprayed by the herbicide Imazamox? Justify your answer.

Assume we work with one of the F_2 populations after the spray of herbicide. The proportion of the surviving plants in F_2 is 1AA (homozygous mutant): 2Aa (heterozygous). The proportion of heterozygous plants is reduced by one half every generation. Therefore the percentage of plants that will be killed (aa) is 25% (1/6 + 1/12).

	AA	**Aa**	**aa**
F_2 generation	1/3	2/3	
F_3 generation	(1/3)+(1/6)	1/3	1/6
F_4 generation	(1/3)+(1/6)+(1/12)	1/6	(1/6)+(1/12)

Frameworks

Discussion

Once again, seeing a completed whole-task activity such as this and working through a similar activity may still impose too great of a cognitive load for some learners. In addition, when given the full solution, learners may not have thought through the schema-building process in a way that generalizes to other less similar problems. To address this, the whole-task activity could be divided into less cognitively demanding part-task applied learning activities that can be worked through before attempting the original whole-task version.

Notice that the following part-task activity is much reduced in scope and has three questions that serve as a guiding framework.

Frameworks

PART-TASK WITH GUIDING FRAMEWORK

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

What are the relevant observations in this situation, and why are they relevant?
What does the image reveal about the effect of Imazamox on Bob?
What does the image reveal about the effect of Imazamox on the Mutant?

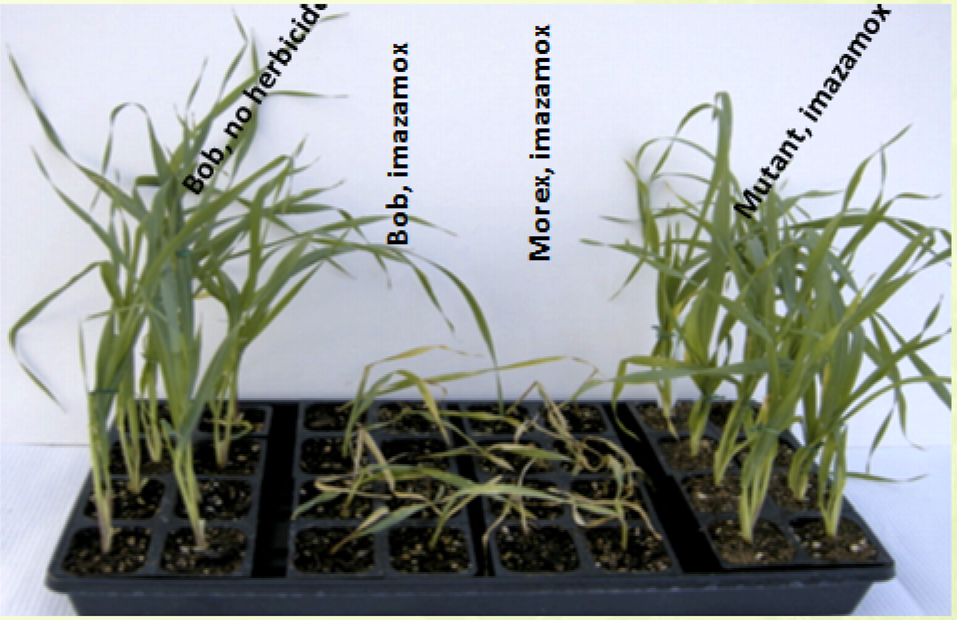

Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Frameworks

Discussion about this activity

In this part-task activity, learners are practicing a constituent skill that is used with any problem, which is to identify the important considerations in a situation. This constituent skill represents the Revised Bloom's Taxonomy cognitive processes of Apply, Analyze, and Evaluate. A follow up activity would build upon this skill by presenting a similar situation, with the additional question, "Which test(s) could be used to analyze the data you generate from these crosses?" This additional question continues to build constituent skills towards the competence required for the whole-task activity.

While this part-task activity provides guidance, learners may need even more guidance as demonstrated by the following part-task version. Notice that now there are seven questions in the guiding framework with the last three pertaining to knowledge that is even more basic in nature.

Frameworks

PART-TASK WITH A DETAILED GUIDING FRAMEWORK AND NO ANSWERS

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

What does the image reveal about the effect of Imazamox on Bob?
What does the image reveal about the effect of Imazamox on the Mutant?
What is a homozygous mutant plant and why is that relevant?
Why is resistance to herbicides important?
What does mutagenesis mean?
What is unique about a self-pollinated diploid species?
What is a progenitor cultivar?

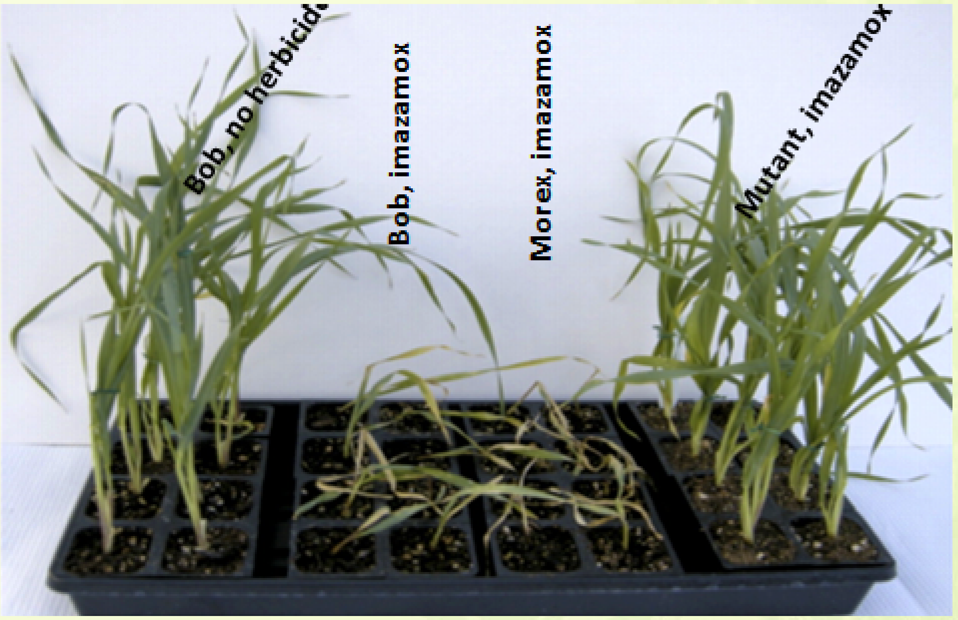

Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Frameworks

Discussion about this activity

As before, learners are given a part-task constituent skill to identify important considerations in a situation. They are also provided with a more robust framework of additional guiding questions that represent the Revised Bloom's Taxonomy cognitive processes of Remember and Understand Facts, Concepts, and Processes. This activity also provides situational context to help students learn these definitions.

Frameworks

RECAP DISCUSSION ON THE SERIES OF IMAZAMOX AND BARLEY ACTIVITIES

Recall that the original whole-task version of this activity without guidance or a solution assumed that the skills prompted by the guiding questions in the subsequent activities were already mastered by learners. In addition, it assumed that learners could access these skills appropriately.

The part-task series of activities that followed provided guidance incrementally, which focused learner attention on specific aspects of the problem, and this made learning more cognitively manageable (intrinsic load) than the larger whole-task.

One approach to using a series of activities such as this is for learners to first be exposed to the whole-task activity to give them and idea of what competency they are working toward. Then have them work through part-task activities that decrease in guidance, followed by studying the whole-task version again with a solution. Some educators elect to provide a fully worked solution at the beginning, and use it to model their thought processes on how the solution was achieved.

Once learners are comfortable with the series of part-task constituent skills of the whole-task activity, they would be prepared to work through a very similar whole-task activity that perhaps differed in the herbicide used and/or the crop. It is important to note that these "similar" activities are all members of the same **task class** that requires the same knowledge and cognitive processes to solve.

Frameworks

While it may seem arduous at first to develop a large number of learning activities a given task class, in reality once the general structure of the activity is established, derivative activities can be generated rather quickly.

IN SUMMARY

Frameworks are dynamic and can reflect a widely held conceptualization of a domain, or a particular educator's perspective. Frameworks can be used as temporary scaffolding in a learning activity to assist learners with the task of schema building and selecting cognitive strategies, or they can be a permanently internalized guide for performing real-world tasks in the future.

Generate Learning Activities From Course Material

In most circumstances, course content has already been established and an educator is creating applied learning activities to enhance learning.

One approach to generating learning activities from content is to **begin at the beginning**, and look for core terms and concepts that learners need to Remember and Understand to perform higher-order cognitive processes such as Apply, Analyze, Evaluate, and Create. As additional course material is processed, look for situations where the understanding of previous material is required to master the new material. This will give you an idea of how and when terms and concepts should be introduced in the series of applied learning activities.

Another approach to generating applied learning activities from an existing course is to **begin at the end** by looking at final examinations and capstone projects. Each of these can be deconstructed into their supporting knowledge and cognitive processes. The Revised Bloom's Taxonomy can be used to examine the use of *Evaluating* in capstone projects, which can be examined for the use of *Analyzing*, which can be examined for use of *Appling*, which can be examined for *Understanding* and *Remembering*.

The Knowledge can be examined for *Metacognitive knowledge* on the approach to the solution. The *procedural knowledge* can be examined for *conceptual* and *factual knowledge*. Once this deconstruction has occurred, applied learning activities can be generated to systematically build the mental schemas necessary to solve the original examinations and capstone projects.

Generate Learning Activities From Course Material

With either approach or a combination of the two, recall that alignment of curriculum can be informed by plotting learning objectives, teaching activities, and assessments on the same Revised Bloom's Taxonomy table.

GENERATING LEARNING ACTIVITIES AMONG COURSES

No single course represents a real-world position of employment for plant breeders. As such, *what learners should be able to do* requires integration of many skills and competencies from many courses. Learners ultimately should master the competencies of a *program of study*, not simply those of a course within a program. For this reason, applied learning activities in one course should reinforce learning objectives from previous courses. In addition, these activities should prepare learners for the courses that follow.

Recall that from an engineering perspective, learners emerge as *output* from one course, and are *input* to the next, until they eventually enter the plant breeding workforce. For this reason, applied learning activities should be created accordingly and shared among educators. In an ideal situation, an activity would be created for one course and reused in a subsequent course with increased complexity and further elaboration of the scenario to more and more closely match its real-world whole-task counterpart.

Resources

[Quick Flip Questions for the Revised Bloom's Taxonomy from Edupress]
[Revised Bloom's Taxonomy guide from Northern Illinois University]
[Revised Bloom's Handout from Iowa State University Center for Excellence in Learning and Teaching]
[Cat hit by car activity]
[Gagnes_Nine_Events_Instruction.pdf]

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R. Clark, F. Nguyen and J. Sweller, Efficiency in learing: evidence-based guidelines to manage cognitive load, San Francisco: Pfeiffer, 2006.

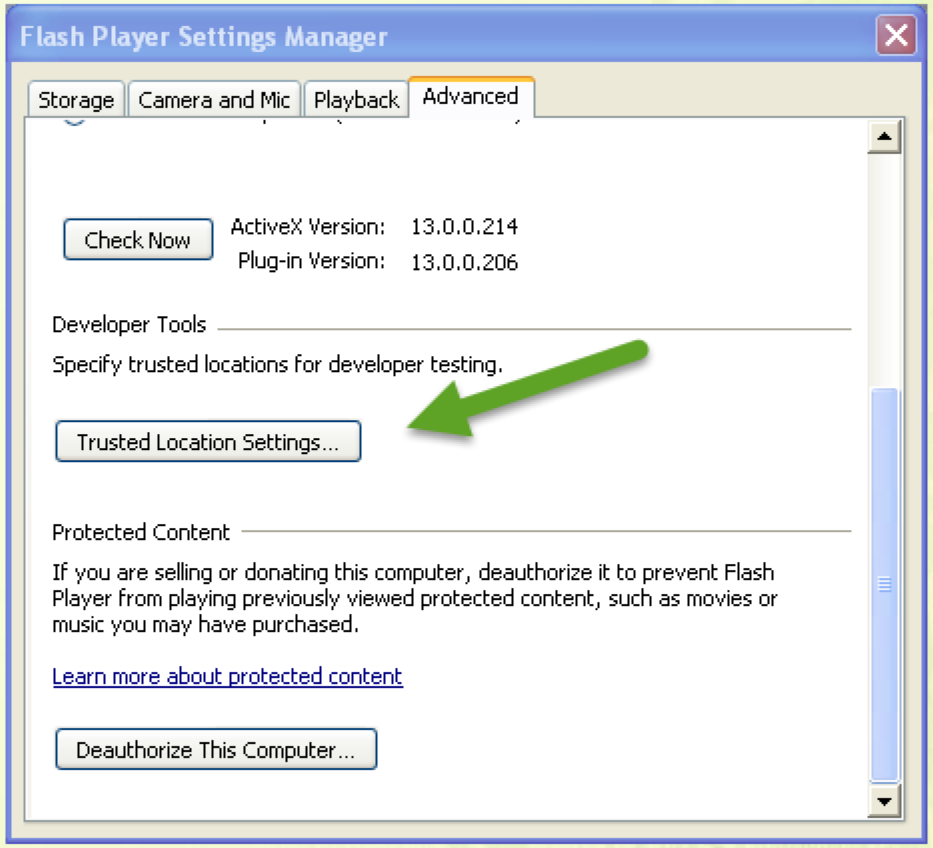
J. J. G. Van Merriënboer and P. A. Kirschner, Ten Steps to Complex Learning: A systematic Approach to Four-Component Instructional Design, New York: Routledge, 2013.

Appendix

BROWSER SETTINGS

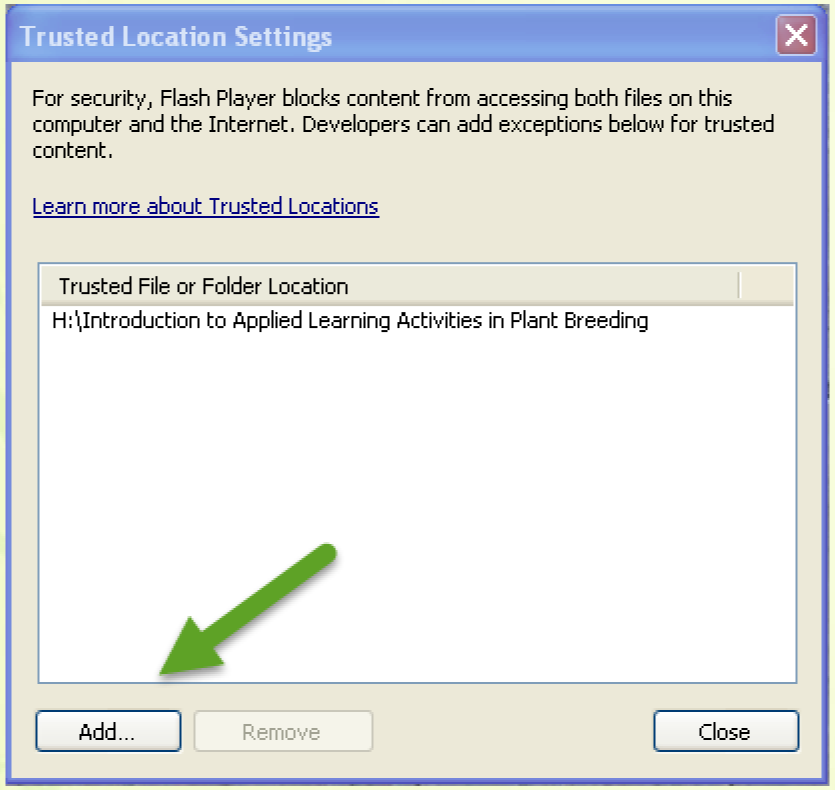
Firefox is the preferred browser for using the Applied Learning Platform for accessing local files on a USB drive or on a hard disk. Other browsers will have varying levels of success. If clicking on the ALP.html file to start the Applied Learning Platform does not work, you may need to change your Flash Player settings in the control panel on a Windows machine or a Mac.

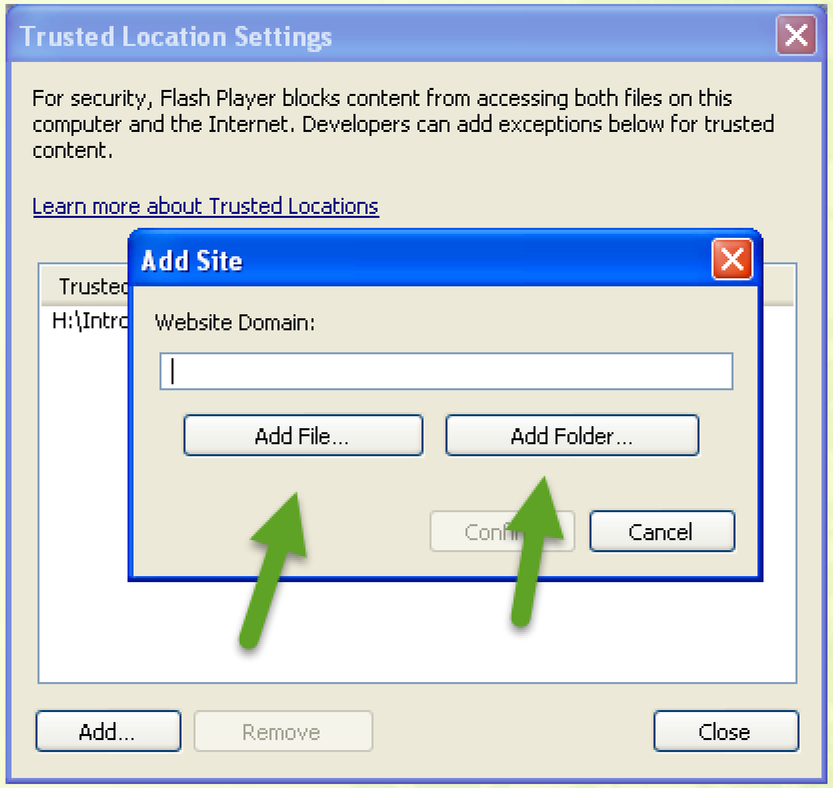
Changing the Flash Player settings is done by double-clicking the Flash Player icon and selecting the “Advanced” tab. Scroll to the bottom and select “Trusted location Settings” under Developer Tools and Add…



Appendix

On Windows you can add either a file or a folder. On the Mac, you will see a plus sign in the lower left and can only add a specific swf file. Select the ALP.swf file and click open. This gives browsers permission to open the ALP.swf file which is opened by the ALP.html when it is double-clicked.





Applied Learning Platform

OVERVIEW

The Applied Learning Platform takes a **desktop publishing approach** to creating, distributing, and peer-evaluating **interactive applied learning activities**. It does not require a database, the assistance of information technology personnel, or the installation of a course management system.

The Applied Learning Platform is the exact opposite of an expert system. An expert system provides expertise to its users; the Applied Learning Platform is used by educators to build expertise in its users.

Applied learning activities can be designed to elicit responses from learners that range from answers to simple questions, to a complex assessment of an authentic real-world scenario. Such an assessment by learners would be in the form of a drag and drop outline that integrates the relevant observations of the scenario with the knowledge that explains those observations. In this way, an assessment enables learners and educators to see what one another is thinking along with the evidence for those thoughts.

Examples of drill and practice simple question activities with markup tags for loading are found at Types of applied learning activities using the Applied Learning Platform, and an evidence-based assessment can be viewed at Completed full assessment.

Applied Learning Platform

The applied learning activities created with the Platform can be used to facilitate learning in a traditional recitation section of a course, in a flipped classroom, with team-based learning, or with blended courses and distance education. These activities are used by educators to model expert thinking skills to learners, and by learners to develop and practice their own. In addition, assessments by learners can be submitted prior to class as evidence of preparation, or brought to class for discussion.

LEARNING MAP FOR THE APPLIED LEARNING PLATFORM

This manual was written for you to work through at your own pace. Read each section and reflect on how it may be appropriate for your particular learning environment. There are no shortcuts to developing expertise.

Read the previous sections of this manual to get a solid foundation on how to design applied learning activities that facilitate the learning process and respect the challenges faced by learners.

Team up with a colleague with whom you can collaborate and give one another feedback. Remember, creating applied learning activities is a functional form of art with a purpose.

After that, work along with the Applied Learning Platform **demonstration videos**. The only way to learn to use a software application is to use the software application. It is imperative that you make as many mistakes as quickly as possible and keep backup copies of your work.

Applied Learning Platform

It is also important to work the exercises for practice and review the section on types of applied learning activities to give you ideas that you can use in your own activities. There is also a section, Example of using guiding frameworks with the Applied Learning Platform that demonstrates how to implement scaffolding that you will find helpful. These guiding frameworks are the same as those presented previously at Example of guiding frameworks, though they differ in that the Applied Learning Platform markup tags are provided for creating interactive versions. Links are provided to three file types of the same markup tags if you wish to practice or modify the activities. I encourage you to do so, because the best way to learn how to use any software program is to use it.

Three types of files containing markup tags for using the Applied Learning Platform are provided for your use depending on the technology available to you: a Microsoft Word document, a text file, and a pdf. The Microsoft Word document and text file are the quickest for copying and pasting, while the pdf version is considerably slower. **Note: The pdf Select all and Copy will only work for the entire document if a viewing mode with scrolling is enabled. Otherwise, it will only select the current page.**

And my last piece of encouragement, please do not forget to have fun!

Applied Learning Platform

MEDIA AND RESOURCES

This document and related materials can be distributed by and accessed from a USB device, a CD, or a DVD. These materials can also be transferred to the local hard drive of a computer. If you wish to open these files with any browser other than Firefox, you may need to change the Flash Player settings to allow local files to be opened. See **Browser settings**. The reason is that browsers are designed for accessing files over the Internet and not on a local machine. For this reason their capabilities vary widely. So far, I have not been able to open these files with Google Chrome regardless of the settings.

There are two formats of this document, Microsoft Word and pdf. I suggest that you use the pdf formatted document to avoid unintentional changes. The Microsoft Word version is useful if you want to use any of its text in your own course.

The **Videos directory** contains the demonstration videos. Videos may be started directly by double clicking on the video name that ends with an "html" extension.

The **ALP directory** contains the files for the Applied Learning Platform that can be run by clicking on this link **ALP.html**, or by using your file system to navigating directly to the ALP directory and double clicking on the same. *Do not mistake this file for the ALP.swf* file which will not respond as you would like.

Applied Learning Platform

The **ALPActivities directory** and subdirectories contain the XML markup documents for use with the Applied Learning Platform available with this document or at www.WhenKnowingMatters.com. You are free to copy and or modify applied learning activities as you choose.

The **TextBasedActivities directory** contains text-based activities in directories denoted by specific faculty members.

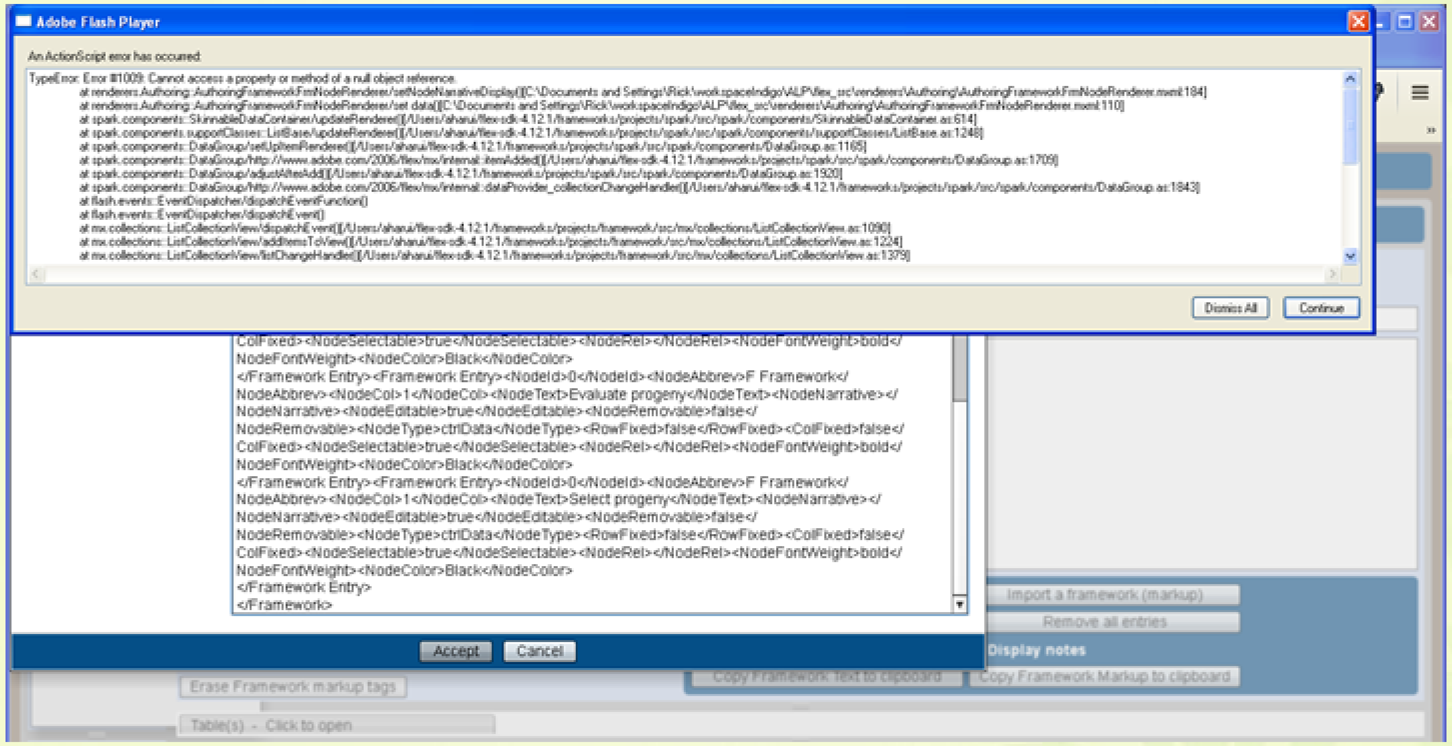
The **Resources directory** contains text materials that are used with permission of the authors. You should seek permission from them directly if you wish to reuse them in your work beyond the scope of this document.

Feedback

Your feedback is essential to improving this document, its supporting materials, and the Applied Learning Platform. Please do not hesitate to send me your suggestions. It matters not whether it is a typographical error or a misinterpretation of a foundational concept. I encourage you to view your suggestions as a way of helping your colleagues that just happens to pass through me.

Applied Learning Platform

When using the Applied Learning Platform, if you see an error screen like the one below, please copy the obscure text, paste it into an email, and send it to me. If you can tell me what you were trying to accomplish, that would help as well.



Applied Learning Platform

THE PROCESS FOR CREATING AND DISTRIBUTING APPLIED LEARNING ACTIVITIES

Internet access

1. Educators navigate to the www.WhenKnowingMatters.com website where they start the Applied Learning Platform, and select "Create an activity."
2. When finished creating an activity, they copy the XML markup tags of the activity to their clipboard and save them in a word processing document (Activity document) that is distributed to learners.
3. Learners receive the document and copy its entire contents to their clipboard.
4. Learners navigate to the www.WhenKnowingMatters.com website where they start the Applied Learning Platform, and select "Begin an activity."
5. Learners paste the contents of their clipboard into the software, work through the activity and save it in a separate word processing document.

USB, CD, DVD or local file access

1. Educators locate and double-click the ALP.html file on the media they are using to start the Applied Learning Platform (USB, CD, DVD, or local files), and select "Create an activity."
2. When finished creating an activity, they copy the XML markup tags of the activity to their clipboard and save them in a word processing document (Activity document) that is distributed to learners.
3. Learners receive the document and copy its entire contents to their clipboard
4. Learners locate and double-click the ALP.html file on the media they are using to start the Applied Learning Platform (USB, CD, DVD, or local files), and select "Begin an activity."
5. Learners paste the contents of their clipboard into the software, work through the activity and save it in a separate word processing document.

Applied Learning Platform

ACTIVITY DOCUMENT

An activity document is the word processing document that contains the XML markup tags of an activity that is authored using the Applied Learning Platform. The document can include any additional resources such as links, images, videos, etc. The only limit on the types of resources included in the document is the document's inherent native capabilities, such as differences among Microsoft Word, WordPad, Notepad, TextEdit, or a pdf.

An example of an **activity document from veterinary medicine** is provided by David Coleman and Duncan C. Ferguson. It contains images of radiographs for learners to analyze along with a guiding framework of questions for learners to consider. The document also contains the Applied Learning Platform XML markup tags.

BUILDING COMPETENCE WITH THE APPLIED LEARNING PLATFORM REQUIRES PRACTICE

Since competence emerges from doing, the Applied Learning Platform will be of no value to you if you do not develop the skill of using it. Acquiring this skill by educators and learners takes time and effort, which should not be a surprise to educators because that is exactly what they desire and require from their students. For this reason, it is absolutely essential that you work through each of the tutorials on your own. The most convenient way to do this is to have a copy of the platform open in a separate browser, and work along with each exercise pausing the video when needed. A learning map is also available to help you organize and prioritize your efforts.

Applied Learning Platform

What follows are demonstration videos, practice exercises, and examples of applied learning. I encourage you to work through these sections in this order because each increases in complexity and builds upon information acquired from previous videos. This approach helps manage cognitive load. While you are working, think about how your own applied learning activities would look if you were using them rather than the demonstration activities.

Most videos have closed captioning, which can be accessed by placing your cursor over the video, and clicking on the CC that appears at the bottom. Videos can be searched for text by placing your cursor over the video, and clicking on the Table of contents button that appears at the bottom. This will reveal a column to the left that has a search box at the top. Enter the term or phrase you are interested in, and a list of its occurrences will appear below the box. Clicking on each occurrence will take you to that portion of the video.

DEMONSTRATION VIDEOS

How to receive, begin and save an applied learning activity
Click on the following link to view.
A brief overview of starting and saving a drag and drop applied learning activity.
(6 minutes 25 seconds)

Applied Learning Platform

How to author a learning activity with CreatorBasic

In this video, I will cover the introductory-level features of CreatorBasic by demonstrating how to create the applied learning activity that was used in the previous video. These introductory features are used with virtually all applied learning activities that are created with the Platform. Subsequent videos will assume this level of competency, and build upon it by introducing you to the more advanced features.

This video will cover how to start CreatorBasic, create a learning activity, and save it for distribution to learners. It also demonstrates a framework that is preloaded into a learner's classification. Click on the following link to view.
How to author a drag and drop learning activity (24 minutes 29 seconds)

Creating, modifying, sharing, and using frameworks

This video demonstrates how to create a learning activity that includes a framework for you to use when assessing a consultant's performance. It also shows how to modify and share frameworks with others. The context of the activity is a consultant who is responsible for developing an introductory course on applied learning activities in plant breeding.
Click on the following link to view. **Frameworks** (35 minutes)

Applied Learning Platform

The mechanics of building an assessment

This video demonstrates the mechanics of adding, editing, and moving entries. In addition, it demonstrates how to collapse and expand sections of an assessment in order to reduce cognitive load when building an assessment. And finally, it demonstrates the ability to specify relationships between entries in an assessment. The set of allowable relationships is author defined for each activity.

Even though the video is an adaptation of a veterinary medical case, understanding of medical concepts is not necessary to understand the mechanics of building an assessment. This video will be replaced when a similar activity is available for plant breeding.
Click on the following link to view. **Formulation mechanics foal demonstration** (7 minutes)

Creating, modifying, sharing, and using tables

This video demonstrates how to create a learning activity that includes a simple table of a complete blood cell count from veterinary medicine. It also shows how to modify and share tables with others. I should note in advance that complex tables are best captured as an image and placed in the activity document as a resource, rather than created as a table using markup tags. Click on the following link to view.
Table builder in foal demonstration (7 minutes 45 seconds)

Applied Learning Platform

Peer Evaluator

This video demonstrates how to use the Peer Evaluator to evaluate a learner's activity. Click the following link to view.
Peer evaluator (7 minutes)

Change display settings

This video demonstrates how to change the display settings for projection in the classroom, or for one's personal preferences. Changes are saved with the activity.
Click on the following link to view. Change display settings (4 minutes 11 seconds)

Advanced authoring features of CreatorBasic

This video demonstrates advanced authoring features of CreatorBasic such as changing the default assessment and relevant observations terminology to an author's preference. In addition, it covers the ability to add author-defined abbreviations and the use of explicit relationships between assessment entries. The demonstration also shows how to save a learning activity from the Example activities included with Presenter, modify the activity, and save it as a separate activity. This is particularly helpful when creating partially solved activities for learners to complete. You should have already viewed the videos, A brief overview of starting and saving a drag and drop applied learning activity and How to author a drag and drop learning activity prior to working along with this one. Click on the following link to view Advanced authoring features of CreatorBasic (15 minutes 35 seconds)

Applied Learning Platform

Example learning activities included with activity Presenter

Click on the Examples button in the activity Presenter to load and explore various activities from plant breeding and veterinary medicine. You may save each activity, load it into CreatorBasic, and modify it if you choose. There are no videos associated with example activities.

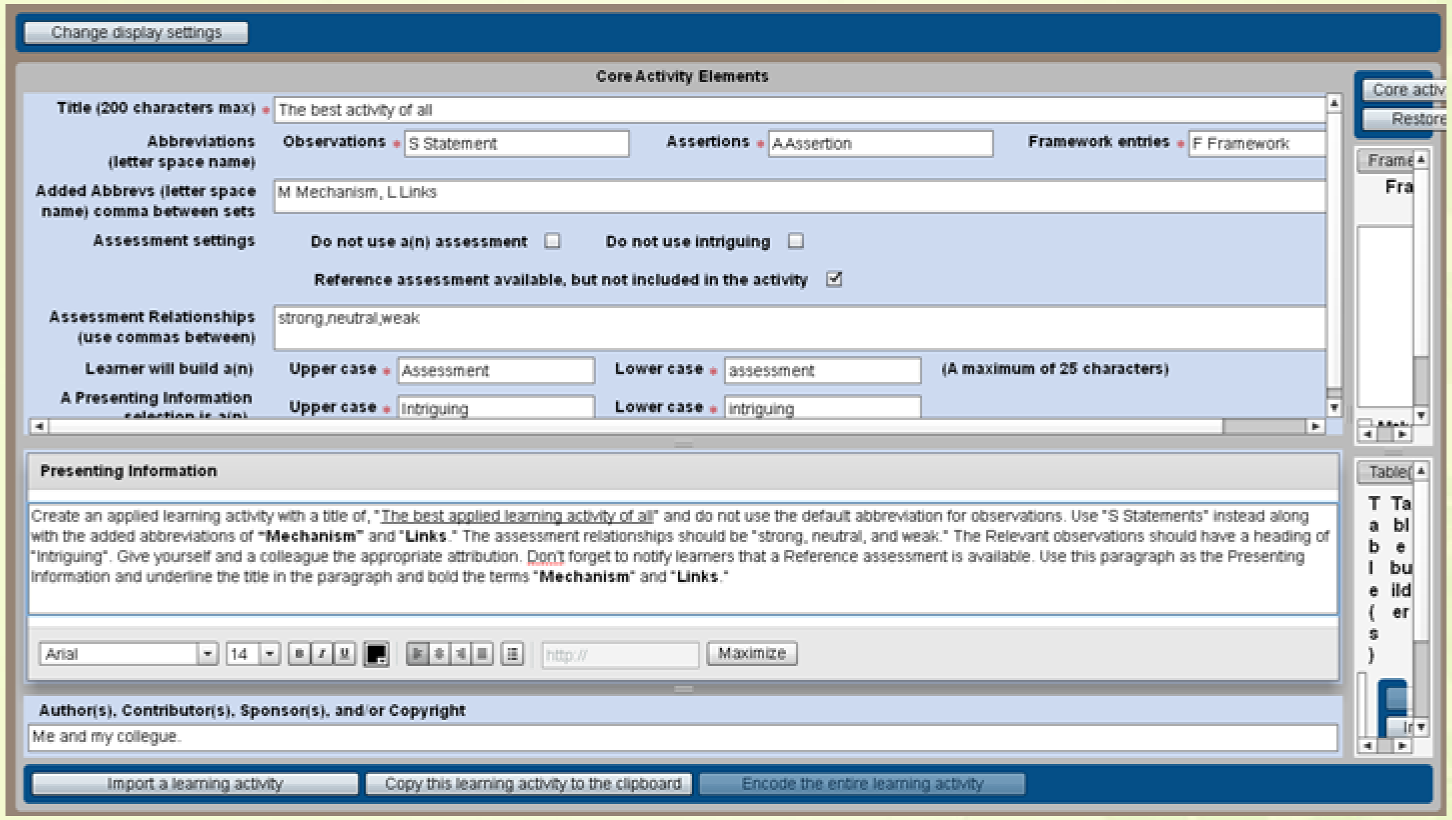
EXERCISES FOR PRACTICE

Basic elements exercise

Create an applied learning activity with a title of, "The best applied learning activity of all" and do not use the default abbreviation for observations. Use "S Statements" instead along with the added abbreviations of "M Mechanism" and "L Links." The assessment relationships should be "strong, neutral, and weak." The Relevant observations should have a heading of "Intriguing". Give yourself and a colleague the appropriate attribution. Don't forget to notify learners that a Reference assessment is available. Use this paragraph as the Presenting Information and underline the title in the paragraph and bold the terms "Mechanism" and "Links."

Applied Learning Platform

When you are finished your CreatorBasic should look like this.



Applied Learning Platform

Cognitive load theory framework exercise

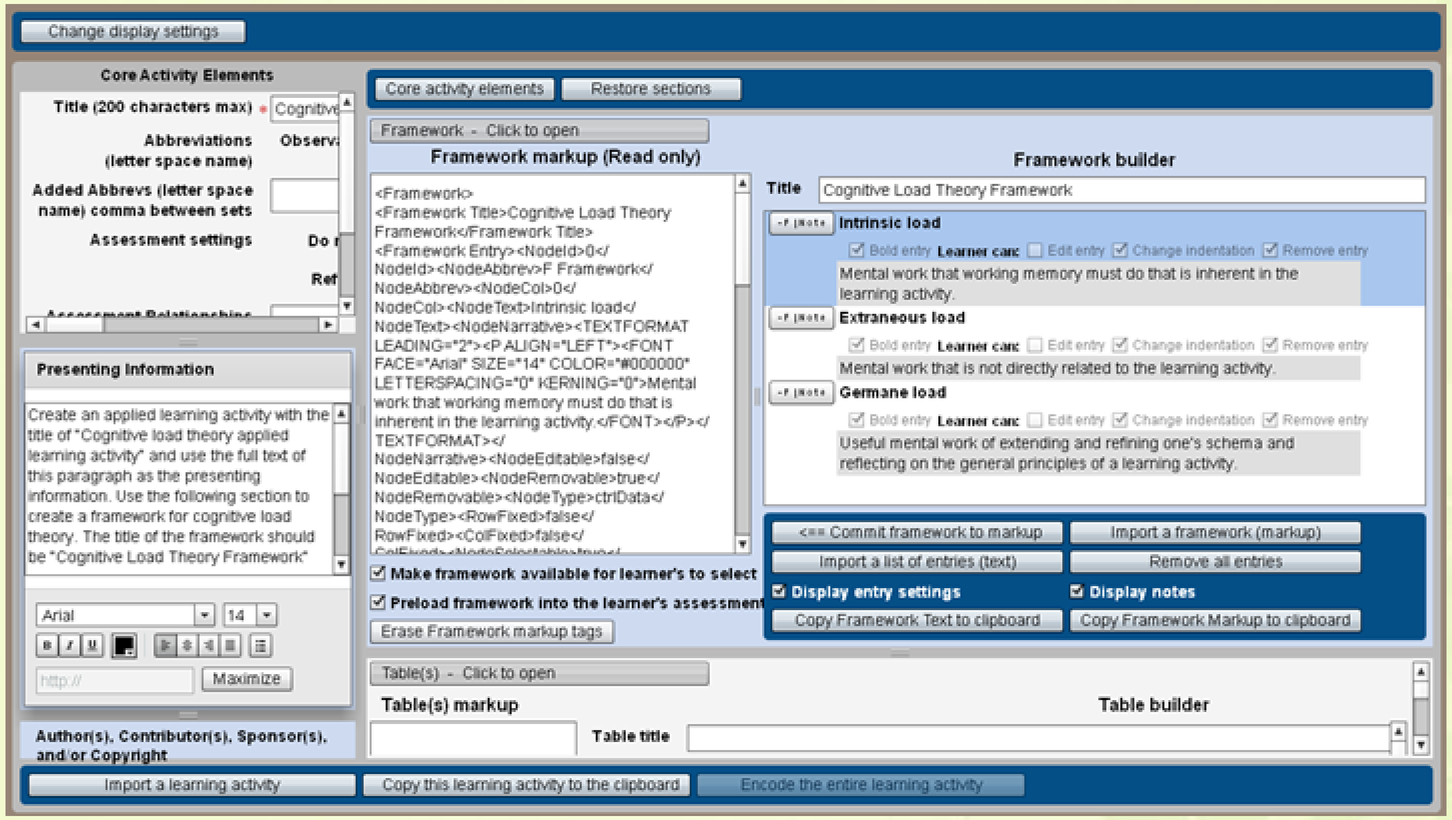
Create an applied learning activity with the title of "Cognitive load theory applied learning activity" and use the full text of this paragraph as the presenting information. Use the following section to create a framework for cognitive load theory. The title of the framework should be "Cognitive Load Theory Framework" and there should be three entries left justified, one for each type of load. The learner should also be allowed to change the indentation and remove the entry from their assessment. Enter a definition of each in the Note. Use the following section as a resource.

> *Intrinsic cognitive load* is the mental work that working memory must do that is inherent in the learning activity.
>
> *Extraneous cognitive load* is any mental work that is not directly related to the learning activity.
>
> *Germane cognitive load* is the useful mental work of extending and refining one's schema and reflecting on the general principles of a learning activity.

*** Do not forget to commit the framework to markup and make sure it is preloaded and also available for learner selection.***

Applied Learning Platform

When you are finished your CreatorBasic should look like the following.



Applied Learning Platform

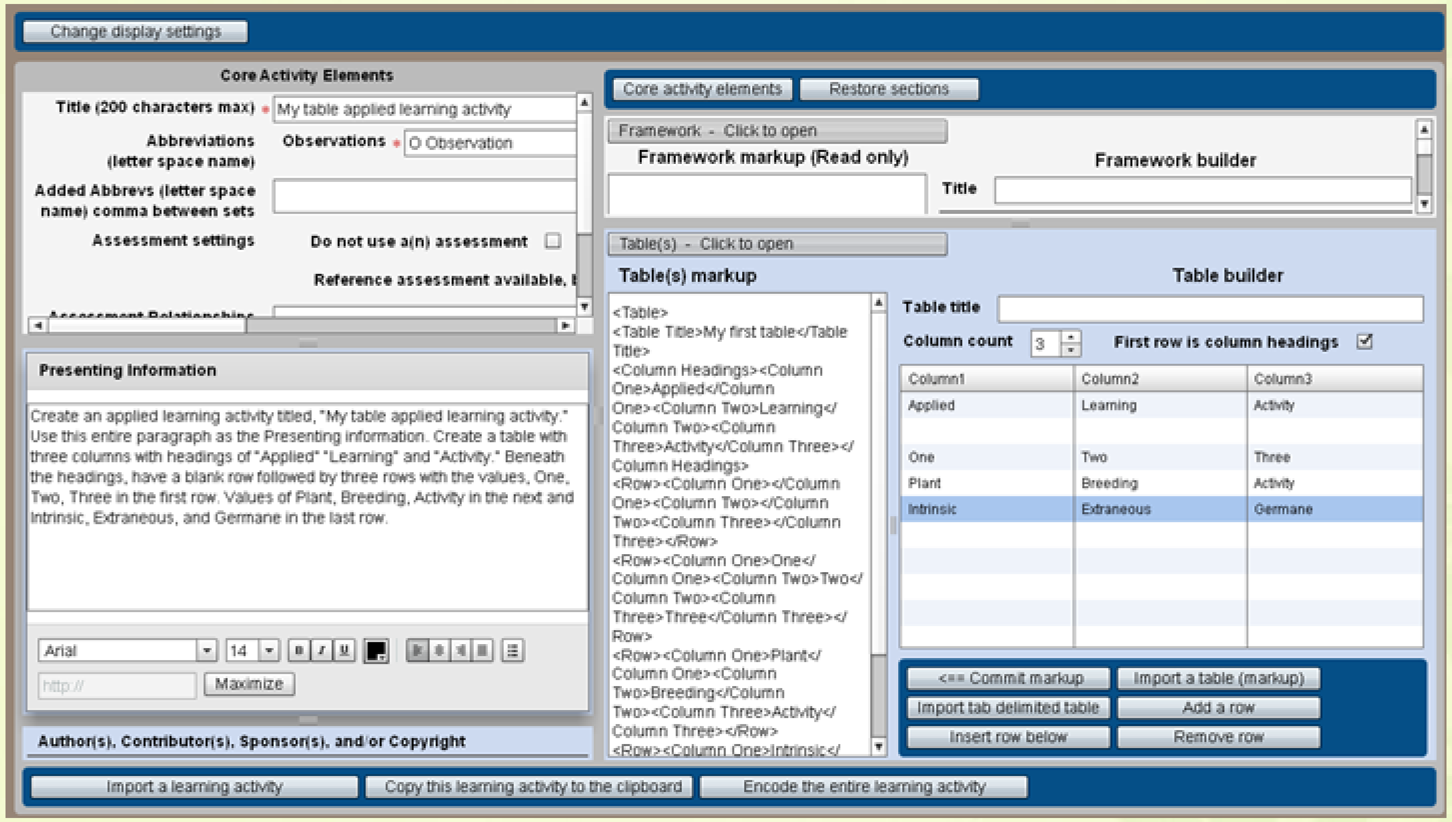
Table builder exercise

Create an applied learning activity titled, "My table applied learning activity." Use this entire paragraph as the Presenting information. Create a table with three columns with headings of "Applied" "Learning" and "Activity." Beneath the headings, have a blank row followed by three rows with the values, "One" "Two" and "Three" in the first row. Values of "Plant" "Breeding" and "Activity" in the next, and "Intrinsic" "Extraneous" and "Germane" in the last row.

Don't forget to commit your table to markup

Applied Learning Platform

When you are finished your CreatorBasic should look like the following.



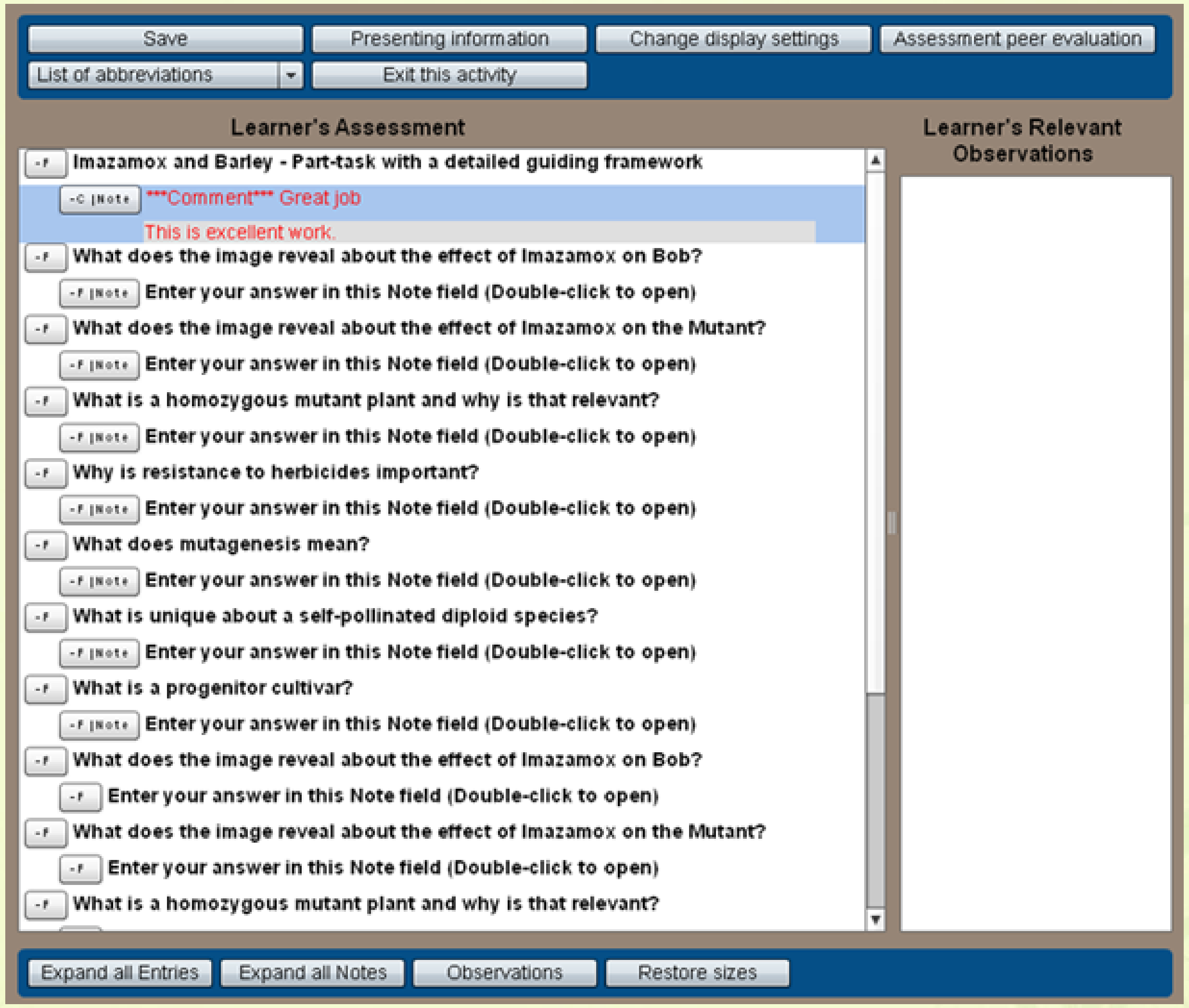
Applied Learning Platform

Peer assessment exercise

Start Presenter and open the Example activity, "Imazamox and Barley Part-task with answers for a detailed guiding framework." Save the learning activity. Restart the Applied Learning Platform by doing a Refresh on your browser, or navigating to the ALP.html file in the ALP directory and double-clicking on it. Then select, Peer evaluate an activity, and Import the activity that is on your clipboard. Click on "Build your assessment" and under the first entry, which is the same as the title, add an indented comment that says, "Great job" along with a Note that says, "This is excellent work."

Applied Learning Platform

When you are finished your Peer evaluator screen should look like this.



Types of Applied Learning Activities Using the Applied Learning Platform

Applied learning activities as discussed for the purposes of this document should begin with, and not be limited to the lower-order cognitive processes. Recall that the Revised Bloom's Taxonomy begins with Remembering and Understanding of Factual and Conceptual Knowledge. As such, mastery of the higher-order cognitive processes first requires mastery of these lower-order processes.

Remembering and understanding of facts and concepts can be implemented any number of ways from paper-based methods to computer-based. The following lower-order thinking activity examples are implemented using the Applied Learning Platform, which has the following advantages over traditional eLearning platforms.

- Interactive drill and practice activities can be authored easily.
- Activities can be modified quickly without the need of an IT department.
- Activities can be distributed electronically without the need of an IT department.
- Early experience using the software for less complex activities leads to proficiency when using it for more complex activities that require higher-order thinking skills.

Three types of files containing the same markup tags used in the activity are provided for your use depending on the technology available to you: a Microsoft Word document, a text file, and a pdf. The Word document and text file are the quickest for copying and pasting, while the pdf format is considerably slower. **Note: The pdf Select all and Copy will only work for the entire document if a viewing mode with scrolling is enabled. Otherwise, it will only select the current page.**

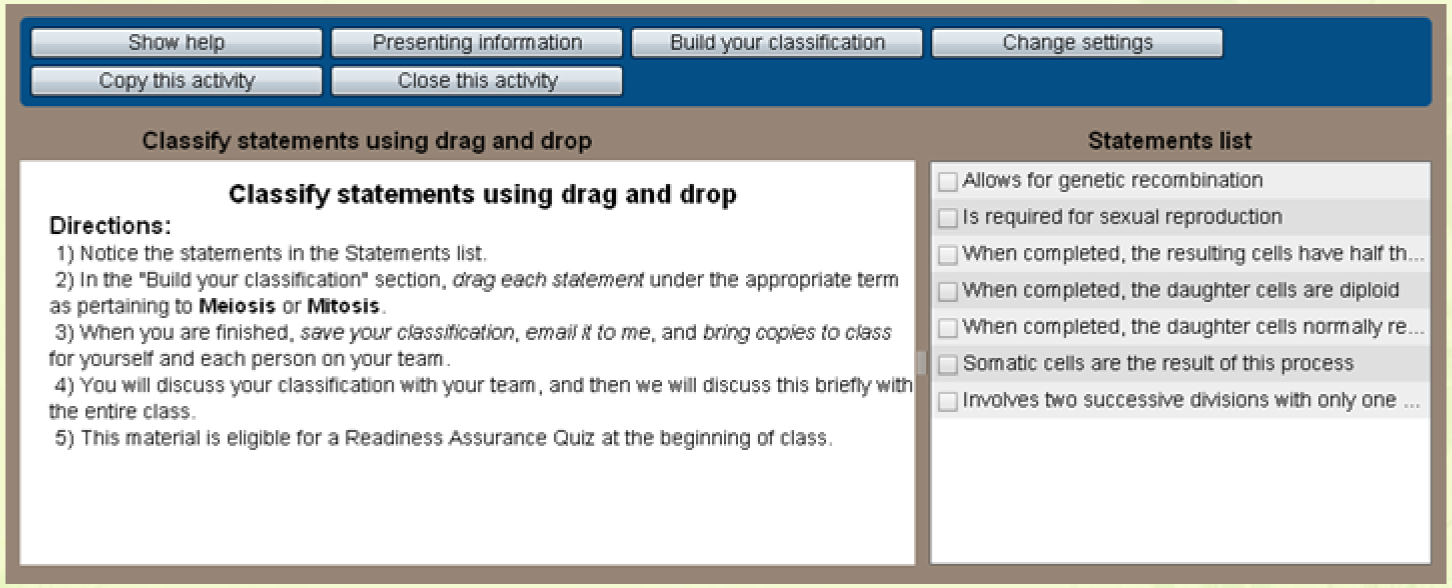
Types of Applied Learning Activities Using the Applied Learning Platform

See the demonstration videos for how to use these files with CreatorBasic and Presenter. Remember, the best way to learn how to use any software program…is to use it.

CLASSIFY STATEMENTS USING DRAG AND DROP

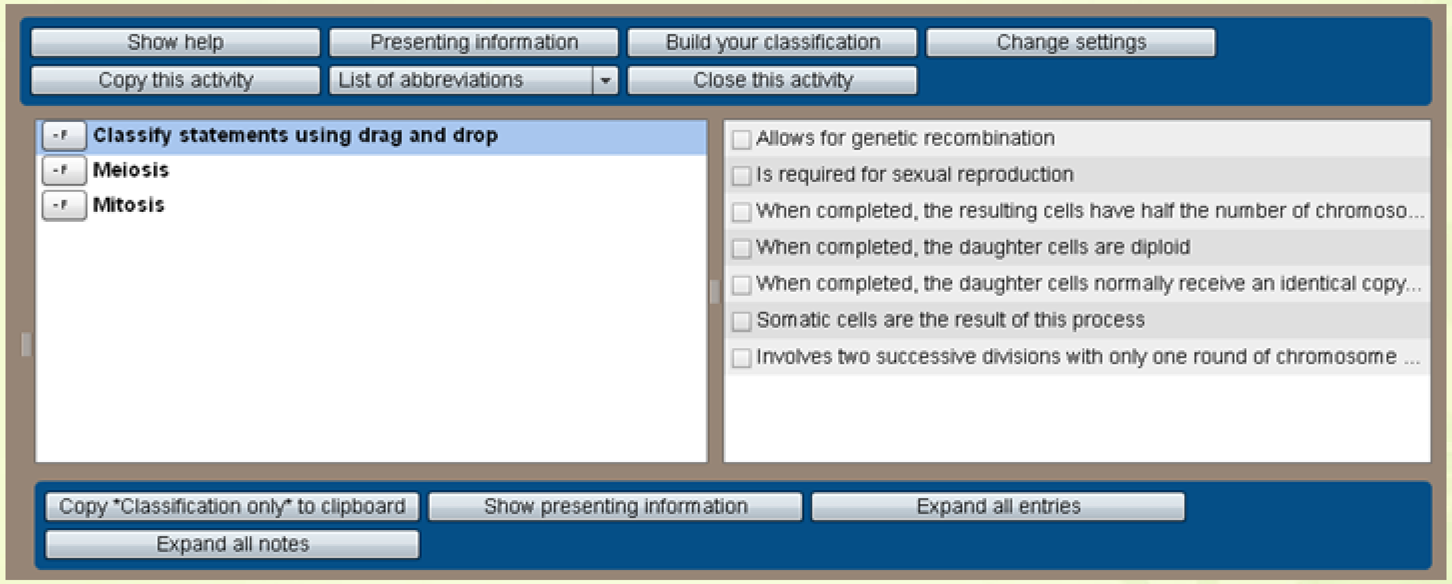
In this activity learners will drag statements from the Statement list and drop them under the appropriate term (shown in the next screen). After reading the Presenting information, learners switch to the Build your classification screen by clicking on the corresponding button in the top menu.

Presenting Information



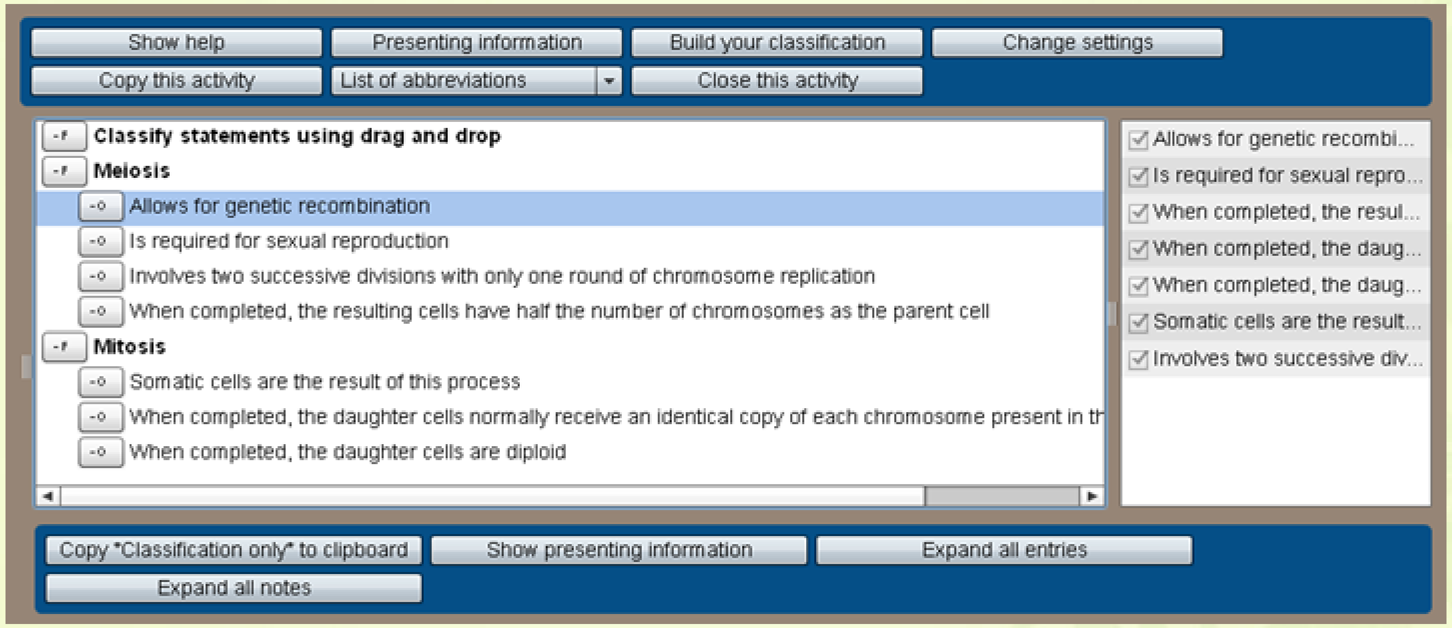
Types of Applied Learning Activities Using the Applied Learning Platform

Classification screen before processing by the learner



Types of Applied Learning Activities Using the Applied Learning Platform

Classification screen after processing by the learner



Discussion

Notice that the statements have been placed under the appropriate term, and the boxes on the right have checkmarks signifying they have been classified.

Applied Learning Platform Markup for this activity (Word, txt, pdf)

Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

IDENTIFY STRUCTURES IN AN IMAGE

Figure 2 is included in the Activity document and is used for reference in this activity. Learners will drag names of structures from the Structures list and drop them under the number that corresponds to the structure in the image. After reading the Presenting information, learners switch to the Build your identification screen by clicking on the corresponding button in the top menu.

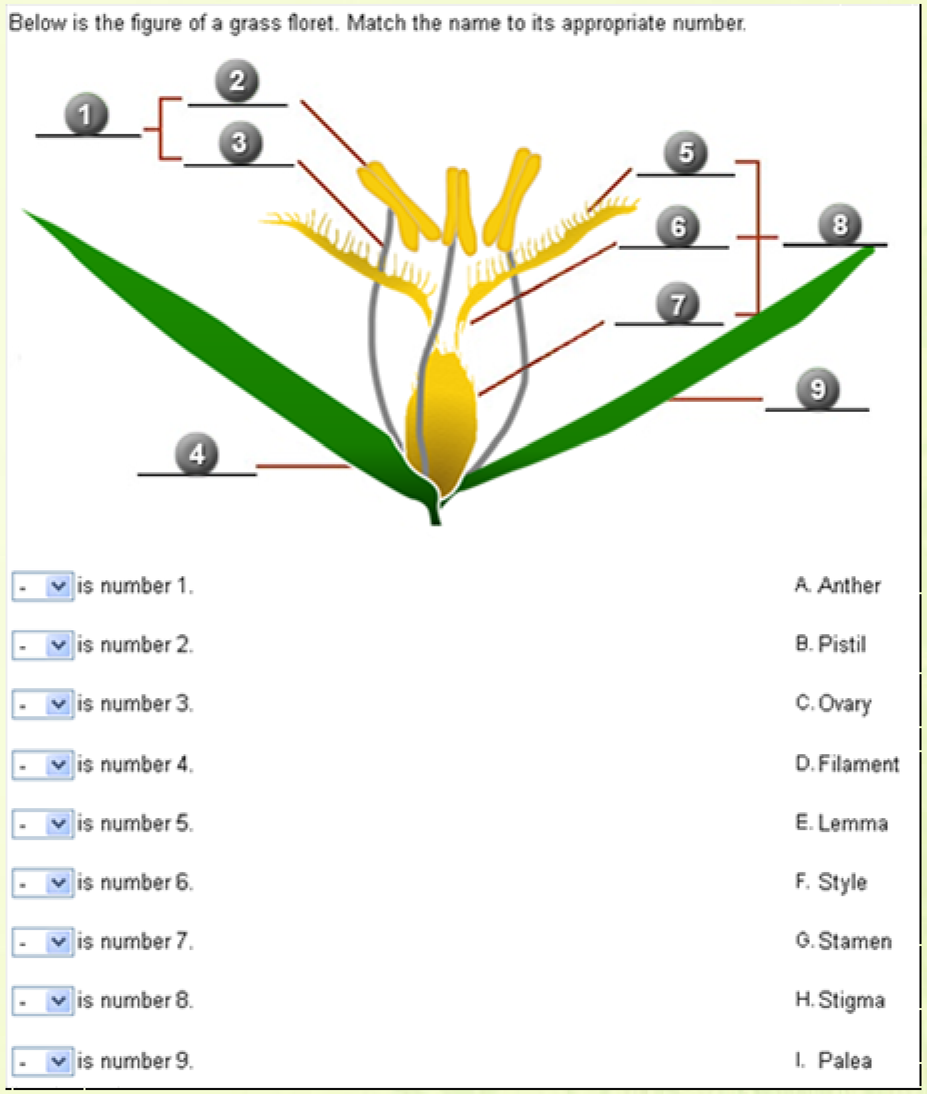
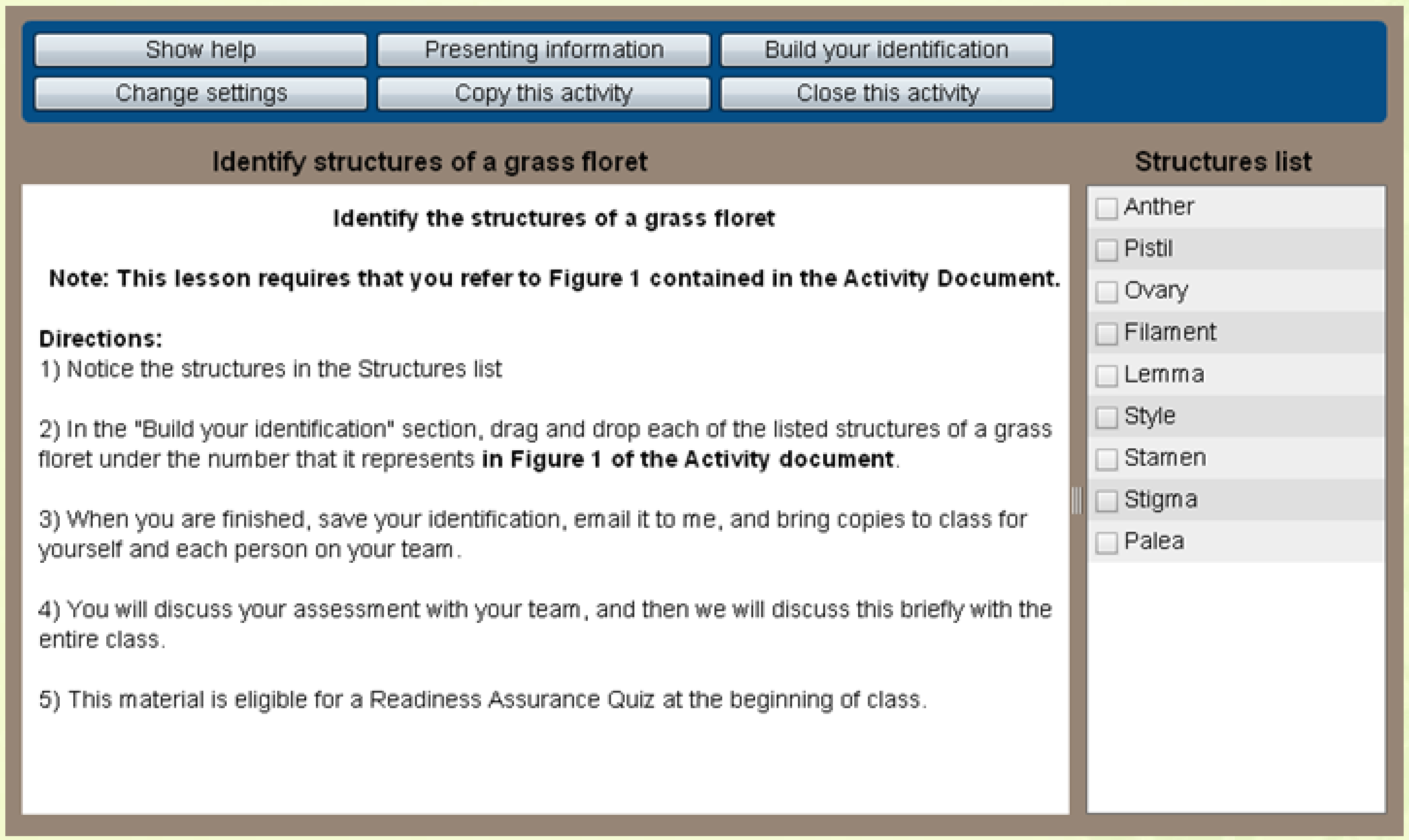


Fig. 2

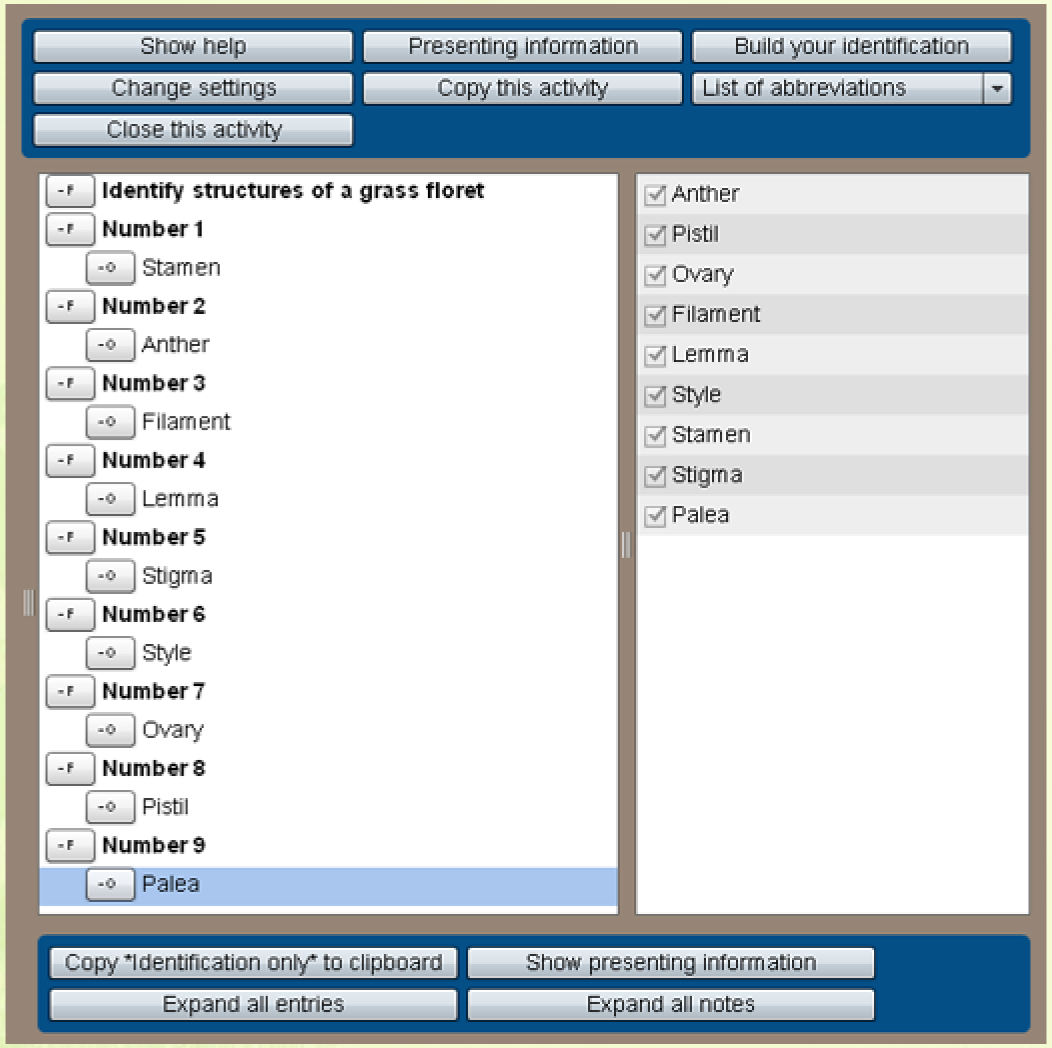
Types of Applied Learning Activities Using the Applied Learning Platform

Presenting Information



Types of Applied Learning Activities Using the Applied Learning Platform

Identification screen



Discussion

Notice that the structure names have been placed under the appropriate number as indicated in Fig. 2, and the checkmarks signifying each name has been identified. This activity could be modified from year to year by changing the numbers associated with each structure in the image.

Applied Learning Platform Markup for this activity (Word, txt, pdf)

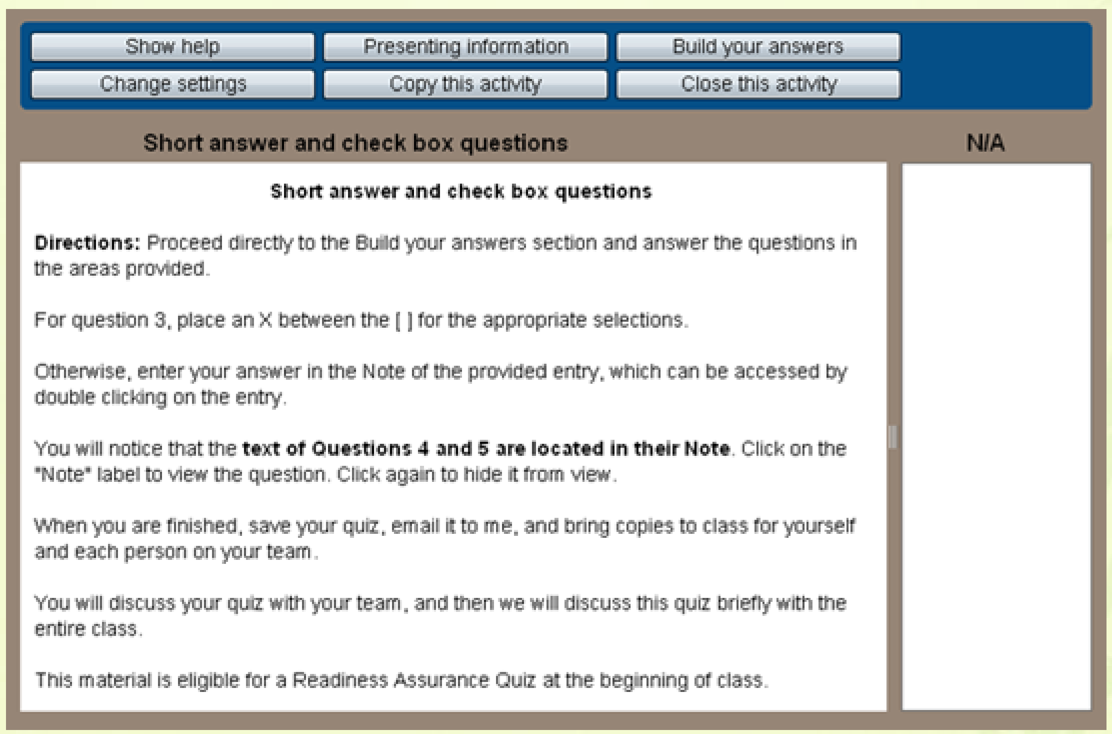
Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

Short answer and check box questions

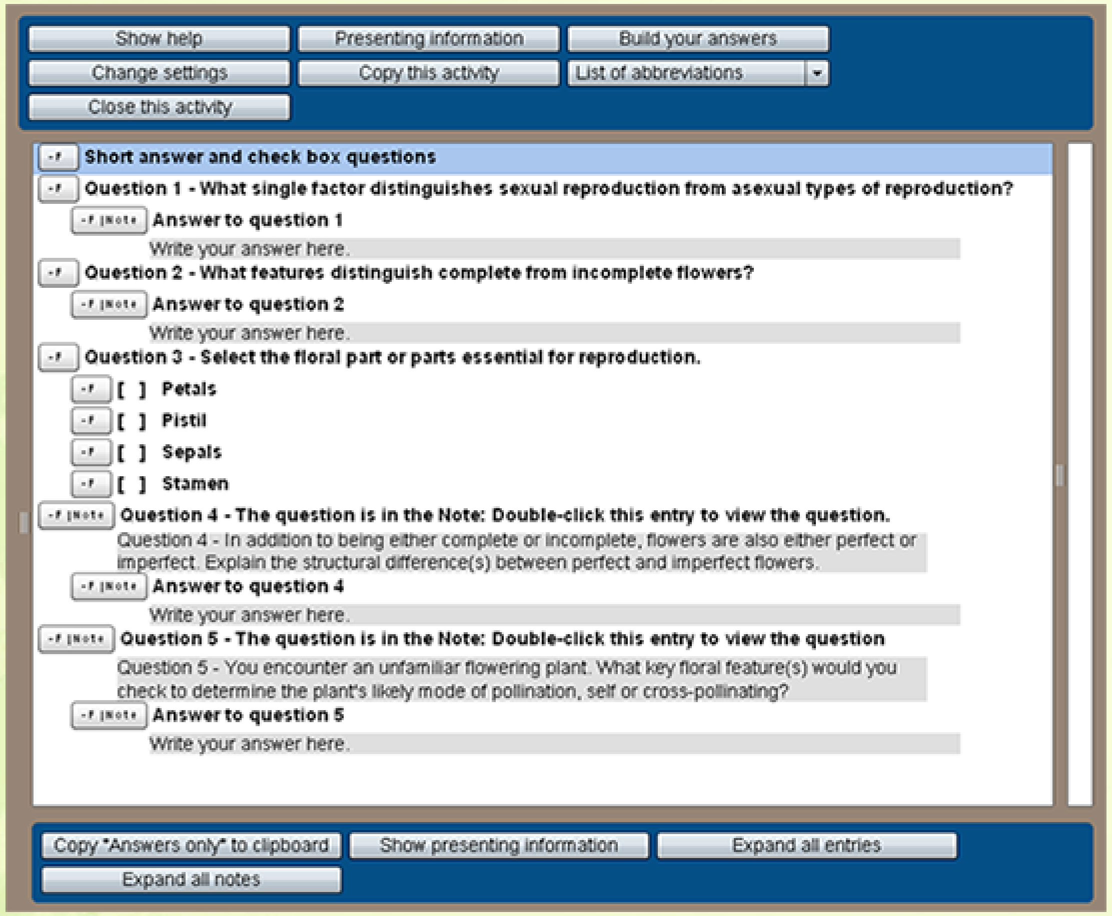
In this activity learners will provide short answers to questions, and mark check boxes for selections. What is unique about this activity is that questions 4 and 5 are contained in their Note field, which will open when a learner left mouse clicks on the Note label. Clicking again will hide it from view.

Presenting Information



Types of Applied Learning Activities Using the Applied Learning Platform

Answers screen



Discussion

This activity uses the Note field for questions and answers that require longer responses. Short responses can be placed in the main section of an entry above the Note as in, “Answer to question 4 above.”

Applied Learning Platform Markup for this activity (Word, txt, pdf)

Start the Applied Learning Platform

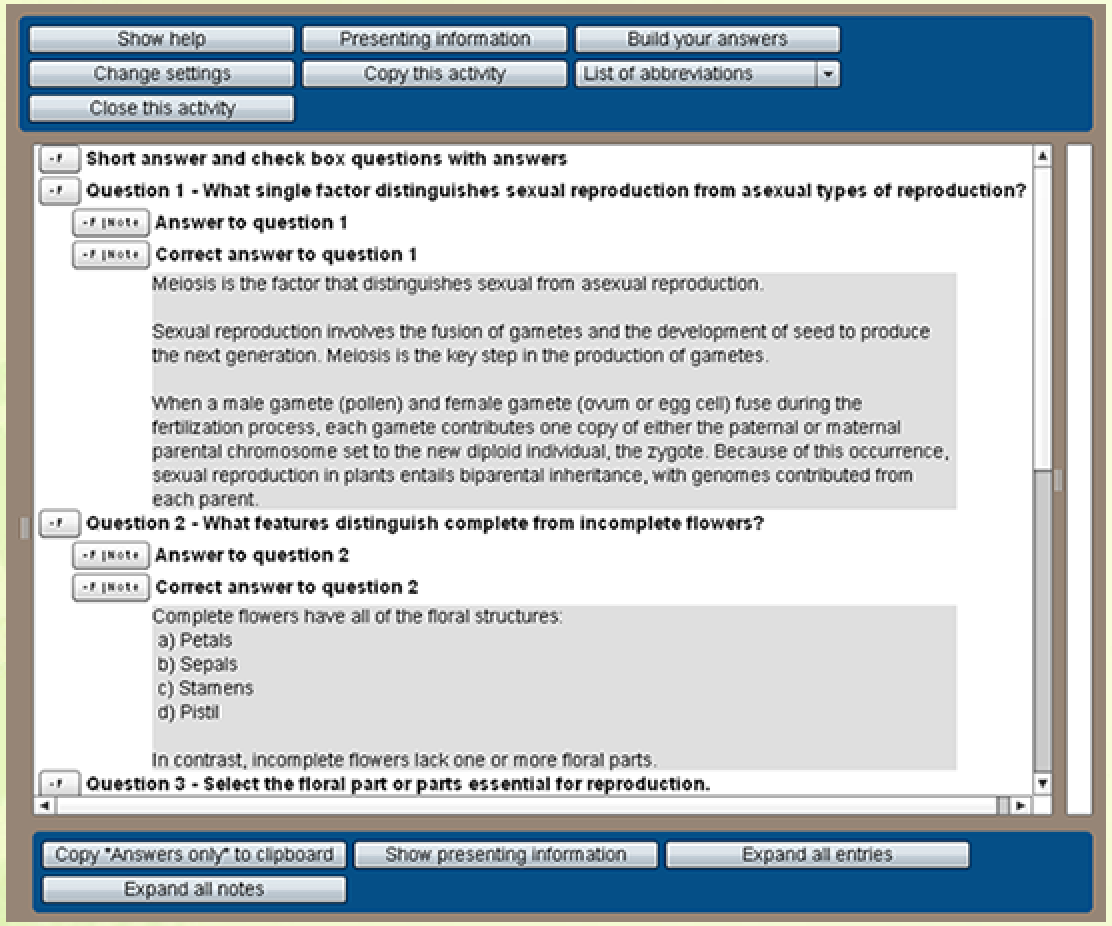
Types of Applied Learning Activities Using the Applied Learning Platform

Short answer and check box questions with answers

This activity differs only slightly from the previous in that the author has provided the answers for learners to look at after they attempt to answer the question on their own. Obviously, learners can choose to look immediately at the author's answers, but recall that the purpose of this activity is for learning, not assessment. You can lead students to knowledge but you can't make them learn.

Types of Applied Learning Activities Using the Applied Learning Platform

The presenting information screen is identical to the previous, except that the answers screen is shown.



Applied Learning Platform Markup for this activity (Word, txt, pdf)

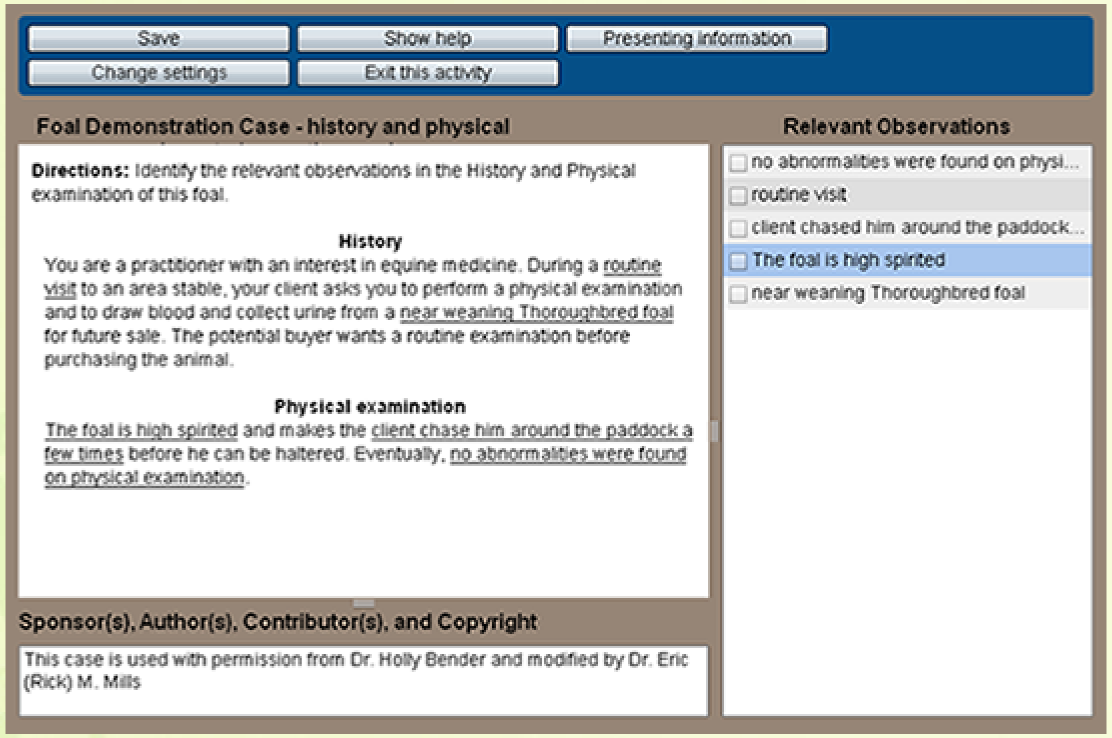
Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

Prioritize observations

What follows is the first in a series of applied learning activities from veterinary medicine that demonstrate an incremental increase in cognitive load that begins with the tasks of identifying and prioritizing abnormalities. Notice that the relevant observations are ranked from top to bottom on their relevance in determining the status of the foal. The first being that no abnormalities were found on physical examination, and the second being that it was a routine visit, so the client had not noticed anything wrong either.

Types of Applied Learning Activities Using the Applied Learning Platform



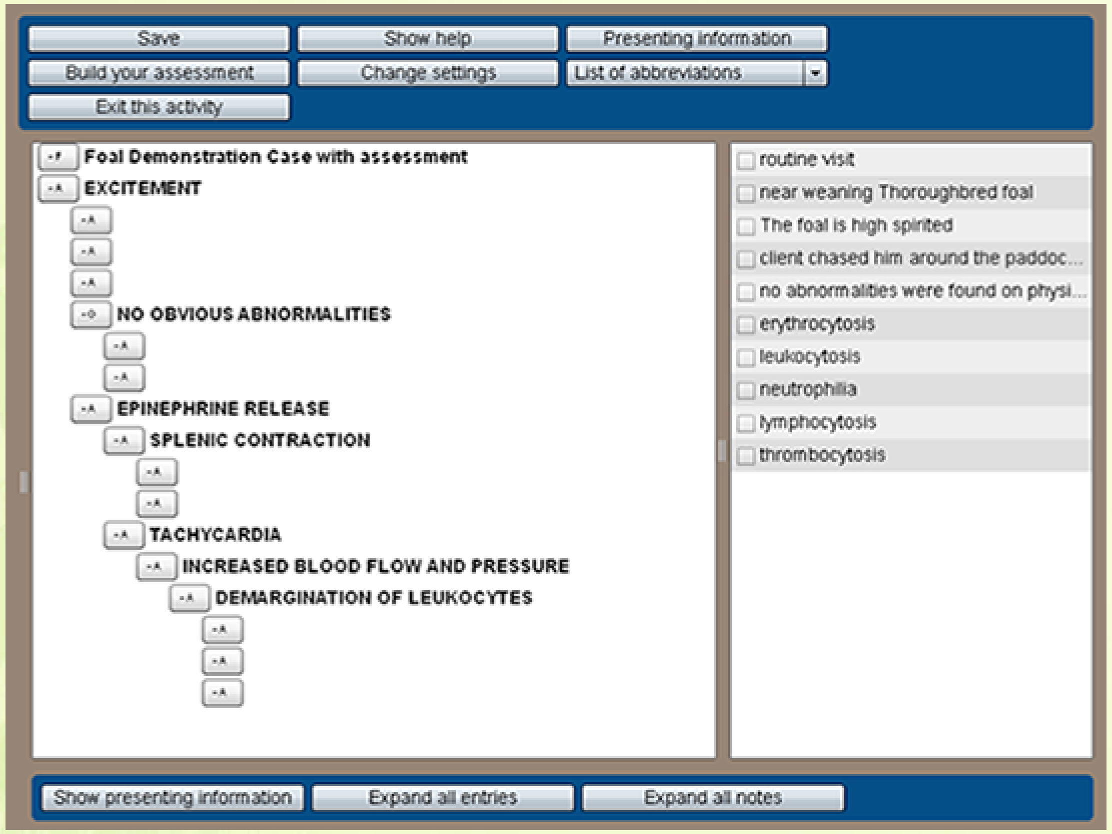
Applied Learning Platform Markup for this activity (**Word**, **txt**, **pdf**)

Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

FILL IN THE BLANKS OF AN ASSESSMENT

In this applied learning activity the learner is asked to provide the evidence in the form of observations for the rationale that is already represented in the assessment. This partial solution provides scaffolding to assist the learner in schema development.



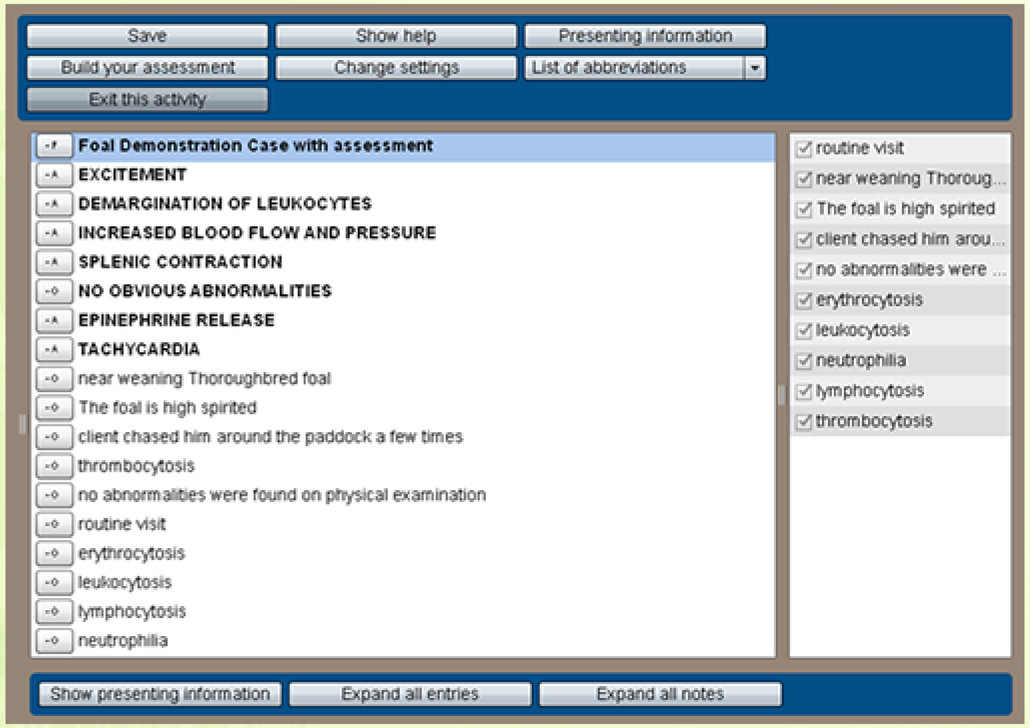
Applied Learning Platform Markup for this activity (**Word**, **txt**, **pdf**)

Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

REARRANGE AN ASSESSMENT

In this applied learning activity the relevant observations have already been made along with the appropriate assertions, though the assertions have not be arranged in the appropriate order as in the previous example. The learner is asked to rearrange the assertions and observations into a logical explanation of this foal's abnormalities. This activity provides less scaffolding than the previous. A correct arrangement is on the following page.



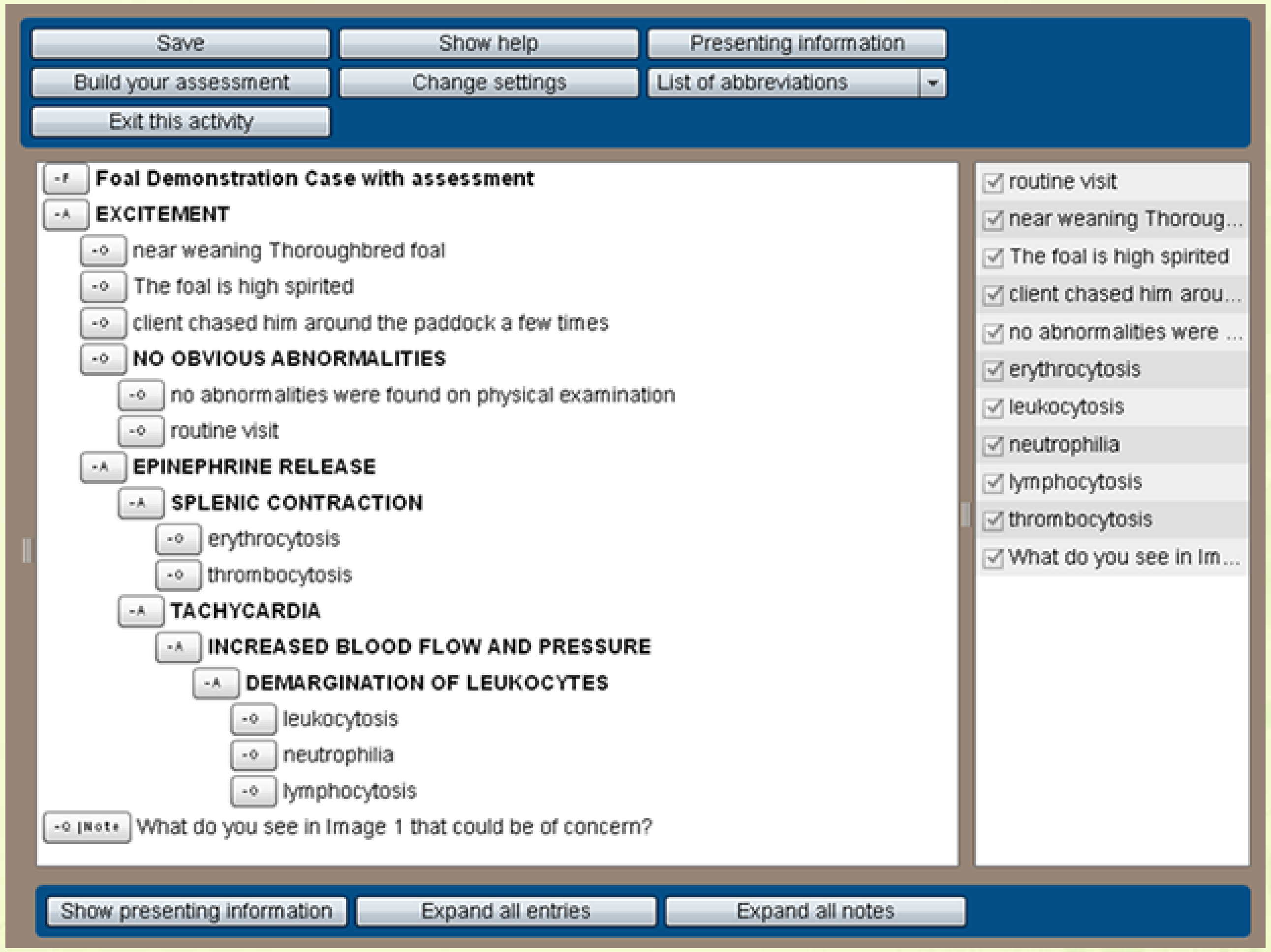
Applied Learning Platform Markup for this activity (Word, txt, pdf)

Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

Reference assessment for the previous Rearrange assessment activity

A solution to the previous applied learning activity.



Types of Applied Learning Activities Using the Applied Learning Platform

EXAMPLE OF USING GUIDING FRAMEWORKS WITH THE APPLIED LEARNING PLATFORM

What follows is a series of applied learning activities that are interactive versions of the previously presented paper-based activities on guiding frameworks. These activities use the Applied Learning Platform. As mentioned previously these activities are a series for the same scenario that vary in the comprehensiveness of the learning task and the level of guidance provided to learners. The activity is content derived from Fei et al. MSc Program in Agronomy, Iowa State University and has to do with the effect of the herbicide Imazamox on two types of Barley.

Each activity is introduced, presented, and followed by a discussion. Links are provided to three file types of the same markup tags if you wish to practice or modify the activities using the Applied Learning Platform that is distributed with this document. I encourage you to do so, because the best way to learn how to use any software program is to use it.

The three types of files provided for your use depending on the technology available to you: a Microsoft Word document, a text file, and a pdf. The Microsoft Word document and text file are the quickest for copying and pasting, while the pdf version is considerably slower.

Note: The pdf Select all and Copy will only work for the entire document if a viewing mode with scrolling is enabled. Otherwise, it will only select the current page.

Types of Applied Learning Activities Using the Applied Learning Platform

The first example is the whole-task Imazamox and Barley activity without a solution and without guidance.

The second activity is the same activity with a fully worked solution to be studied by learners.

The third and fourth activities are part-task activities created from the original whole-task activity that provide varying levels of guidance.

The purpose of this series is to demonstrate how a whole-task activity can be decomposed into more cognitively manageable steps that will not exceed a learner's working memory. The whole-task activity without guidance begins on the next page.

Types of Applied Learning Activities Using the Applied Learning Platform

WHOLE-TASK WITH NO FRAMEWORK AND NO SOLUTION

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

Table 1 shows the number of plants that either survived (healthy or injured) or dead after herbicide treatment, and the Chi-square test results.

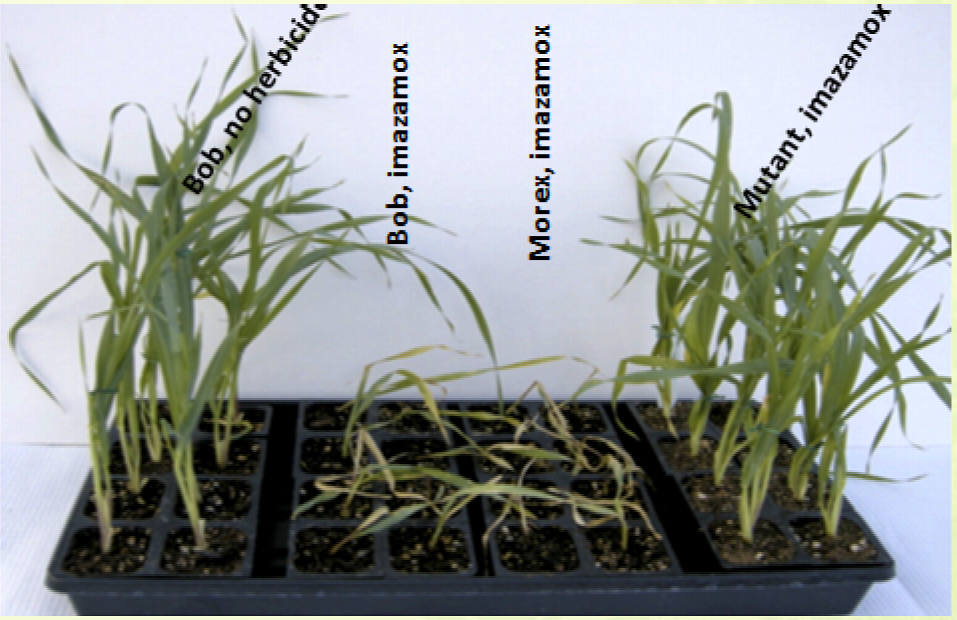


Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Types of Applied Learning Activities Using the Applied Learning Platform

		Survived				x^{2*}	
Crosses	Plants tested	Healthy†	Injured‡	Total	Dead	Value	Probability
Mutant x Bob							
Mutant x Bob 1	121	69	20	89	32	0.135	0.7133
Mutant x Bob 2	129	91	10	101	28	0.747	0.3875
Mutant x Bob 3	211	157	2	159	52	0.014	0.9051
Pooled total	461	317	32	349	112	0.122	0.7266
Bob x mutant							
Bob x Mutant 1	85	56	5	61	24	0.475	0.4909
Bob x Mutant 2	135	75	22	97	38	0.757	0.3843
Bob x Mutant 3	144	101	4	105	39	0.333	0.5637
Pooled total	364	232	31	263	101	1.465	0.2261

x^2 test for a single dominant nuclear gene model was performed.
* x^2 test at the 0.05 level against survived (healthy and injured F_2 plant combined); dead = 3:1 ratio model with 1 degree of freedom. x^2 probabilities greater than 0.05 indicate that observed values were not significantly different from expected values, and the proposed 3:1 ratio model was accepted.

Table 1. Phenotypic evaluation for imazamox resistance in six F_2 populations obtained from the reciprocal crosses between mutant and progenitor Bob. Data from Lee et al., 2011.

a. Based on Table 1, is the trait of herbicide resistance controlled by a single gene or multiple genes? Justify your answer.

b. Is the gene action for the herbicide resistance gene dominant, incompletely (partially) dominant or overdominant? Justify your answer.

c. You advance the generations for one of the six populations by selfing, what fraction or percentage of plants at F_4 would be killed if sprayed by the herbicide Imazamox? Justify your answer.

Types of Applied Learning Activities Using the Applied Learning Platform

Discussion

This learning activity represents a whole-task competency that learners should master, and no guidance is offered in the form of a guiding framework. This activity could impose too great of a cognitive load on some learners. What follows is the same activity with a fully worked solution that can either be modeled in class by the educator, or studied by learners in preparation to work through a similar activity.

Applied Learning Platform Markup for this activity (**Word**, **txt**, **pdf**)

Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

WHOLE-TASK WITH NO FRAMEWORK AND WITH SOLUTION

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

Table 1 shows the number of plants that either survived (healthy or injured) or dead after herbicide treatment, and the Chi-square test results.

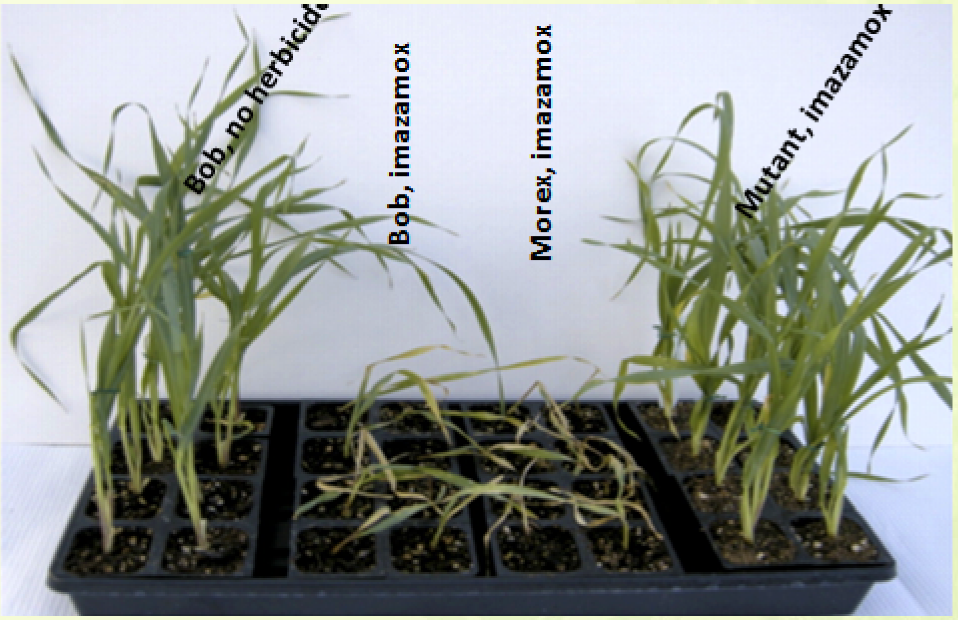


Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Types of Applied Learning Activities Using the Applied Learning Platform

Crosses	Plants tested	Survived			Dead	x^{2*}	
		Healthy†	Injured‡	Total		Value	Probability
Mutant x Bob							
Mutant x Bob 1	121	69	20	89	32	0.135	0.7133
Mutant x Bob 2	129	91	10	101	28	0.747	0.3875
Mutant x Bob 3	211	157	2	159	52	0.014	0.9051
Pooled total	461	317	32	349	112	0.122	0.7266
Bob x mutant							
Bob x Mutant 1	85	56	5	61	24	0.475	0.4909
Bob x Mutant 2	135	75	22	97	38	0.757	0.3843
Bob x Mutant 3	144	101	4	105	39	0.333	0.5637
Pooled total	364	232	31	263	101	1.465	0.2261

x^2 test for a single dominant nuclear gene model was performed.
* x^2 test at the 0.05 level against survived (healthy and injured F_2 plant combined); dead = 3:1 ratio model with 1 degree of freedom. x^2 probabilities greater than 0.05 indicate that observed values were not significantly different from expected values, and the proposed 3:1 ratio model was accepted.

Table S1. Phenotypic evaluation for imazamox resistance in six F_2 populations obtained from the reciprocal crosses between mutant and progenitor Bob. Data from Lee et al., 2011.

a. Based on Table 1, is the trait of herbicide resistance controlled by a single gene or multiple genes? Justify your answer.

Based on the table, we can conclude that the herbicide tolerance trait is controlled by a single gene because Chi-square tests conducted on all six populations support the null hypothesis. Lack of difference between a cross and reciprocal cross indicates that the trait is controlled by a nuclear gene and not maternally inherited.

Types of Applied Learning Activities Using the Applied Learning Platform

b. Is the gene action for the herbicide resistance gene dominant, incompletely (partially) dominant or overdominant? Justify your answer.

The gene action is incomplete dominance because both injured and healthy plants were observed in the surviving plants. The healthy plants are likely homozygous for the mutant allele whereas the injured plants are heterozygous carrying one normal allele and one mutant allele.

There would be no injured plants if the gene action were complete dominance.

c. You advance the generations for one of the six populations by selfing, what fraction or percentage of plants at F_4 would be killed if sprayed by the herbicide Imazamox? Justify your answer.

Assume we work with one of the F_2 populations after the spray of herbicide. The proportion of the surviving plants in F_2 is 1AA (homozygous mutant): 2Aa (heterozygous). The proportion of heterozygous plants is reduced by one half every generation. Therefore the percentage of plants that will be killed (aa) is 25% (1/6 + 1/12).

	AA	**Aa**	**aa**
F_2 generation	1/3	2/3	
F_3 generation	(1/3)+(1/6)	1/3	1/6
F_4 generation	(1/3)+(1/6)+(1/12)	1/6	(1/6)+(1/12)

Types of Applied Learning Activities Using the Applied Learning Platform

Discussion

Once again, seeing a completed whole-task activity such as this and working through a similar activity may still have imposed too great of a cognitive load for some learners. In addition, when given the full solution, learners may not have thought through the schema building process in a way that generalizes to other less similar problems. To address this, the whole-task activity could be divided into less cognitively demanding part-task applied learning activities that can be worked through before attempting the original whole-task version.

Applied Learning Platform Markup for this activity (**Word**, **txt**, **pdf**)

Start the Applied Learning Platform

Notice that the following part-task activity is much reduced in scope and has three questions that serve as a guiding framework.

Types of Applied Learning Activities Using the Applied Learning Platform

PART-TASK WITH GUIDING FRAMEWORK

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

What are the relevant observations in this situation, and why are they relevant?
What does the image reveal about the effect of Imazamox on Bob?
What does the image reveal about the effect of Imazamox on the Mutant?

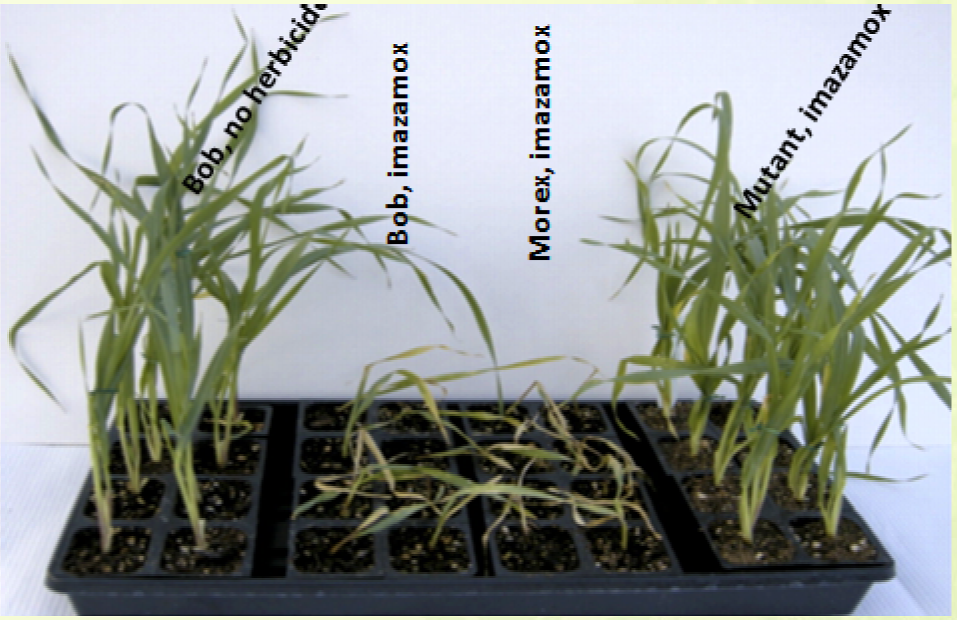


Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Types of Applied Learning Activities Using the Applied Learning Platform

Discussion about this activity
In this part-task activity, learners are practicing a constituent skill that is used with any problem, which is to identify the important considerations in a situation. This constituent skill represents the Revised Bloom's Taxonomy cognitive processes of Apply, Analyze, and Evaluate. A follow up activity would build upon this skill by presenting a similar situation, with the additional question, "Which test(s) could be used to analyze the data you generate from these crosses?" This additional question continues to build constituent skills towards the competence required for the whole-task activity.

Applied Learning Platform Markup for this activity (Word, txt, pdf)

Start the Applied Learning Platform

While this part-task activity provides guidance, learners may need even more guidance as demonstrated by the following part-task version. Notice that now there are seven questions in the guiding framework with the last three pertaining to knowledge that is even more basic in nature.

Types of Applied Learning Activities Using the Applied Learning Platform

PART-TASK WITH A DETAILED GUIDING FRAMEWORK AND NO ANSWERS

Imazamox and Barley

A homozygous mutant plant resistant to the herbicide Imazamox was obtained by mutagenesis for barley, a self-pollinated diploid species.

Reciprocal crosses between the mutant plant and its progenitor cultivar, Bob were made and a total of six F_2 populations were obtained.

They were treated with the herbicide Imazamox.

What does the image reveal about the effect of Imazamox on Bob?
What does the image reveal about the effect of Imazamox on the Mutant?
What is a homozygous mutant plant and why is that relevant?
Why is resistance to herbicides important?
What does mutagenesis mean?
What is unique about a self-pollinated diploid species?
What is a progenitor cultivar?

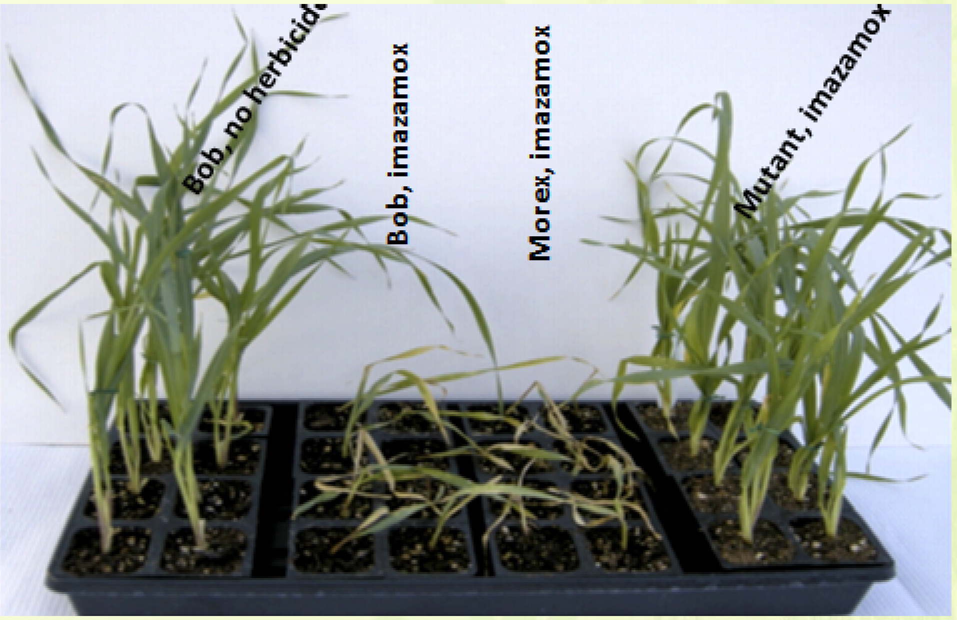


Fig. 1 Mutagenesis of barley seed confers resistance to imidazolinone herbicides. Lee et al., 2011.

Types of Applied Learning Activities Using the Applied Learning Platform

Discussion about this activity

As before, learners are given a part-task constituent skill to identify important considerations in a situation. They are also provided with a more robust framework of additional guiding questions that represent the Revised Bloom's Taxonomy cognitive processes of Remember and Understand Facts, Concepts, and Processes. This activity also provides situational context to help students learn these definitions.

Applied Learning Platform Markup for this activity (**Word**, **txt**, **pdf**)

Start the Applied Learning Platform

Types of Applied Learning Activities Using the Applied Learning Platform

RECAP DISCUSSION ON THE SERIES OF IMAZAMOX AND BARLEY ACTIVITIES

Recall that the original whole-task version of this activity without guidance or a solution assumed that the skills prompted by the guiding questions in the subsequent activities were already mastered by learners. In addition, it assumed that these skills could be accessed appropriately.

The part-task series of activities provided guidance incrementally, which focused learner attention on specific aspects of the problem, and this made learning more cognitively manageable than the larger whole-task.

One approach to using a series of activities such as this is for learners to first be exposed to the whole-task activity to give them an idea of what they are working toward. Then have them work through the part-task activities, followed by studying the whole-task version again with a solution. The educator would employ modeling of the solutions as needed.

Once learners were comfortable with the part-task constituent skills of the whole-task activity, they would be prepared to work through a very similar whole-task activity that perhaps differed in the herbicide used and/or the crop. It is important to note that these “similar” activities are all members of the same *task class* that requires the same knowledge and cognitive processes to solve.

Types of Applied Learning Activities Using the Applied Learning Platform

While it may seem arduous at first to develop a large number of learning activities for a given task class, in reality once the general structure of the activity is established, derivative activities can be generated rather quickly.

IN SUMMARY

Frameworks are dynamic and can reflect a widely held conceptualization of a domain, or a particular educator's perspective. Frameworks can be used as temporary scaffolding in a learning activity to assist learners with the task of schema building and selecting cognitive strategies, or they can be a permanently internalized guide for performing real-world tasks in the future.

Other Materials

Introduction to Applied Learning Activities in Plant Breeding

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