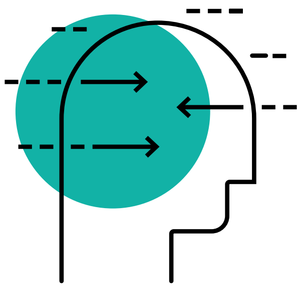
Learning Design Principles
Minds in Mind

Desirable Difficulty & Scaffolding



Summary

What are Pearson's Learning Design Principles?

Our Learning Foundations describe the optimal conditions for learning and reflect the learner experience we hope our products will create. We do this by incorporating our Learning Design Principles.

Each of our Learning Design Principles goes into detail about a key principle, supporting product design and marketing by describing:

- the research that informs the principle
- why it matters in learning
- how we can apply it in practice

Our portfolio of Learning Design Principles will continue to grow over time.

Welcoming Experience
- Motivation & Mindset
- Social & Collaborative Learning

Minds in Mind
- Developing Understanding
- Attention & Cognitive Load
- Active Learning, Memory & Practice
- Desirable Difficulty & Scaffolding
- Feedback for Learning

Learning Behavior
- Self-Regulated Learning & Metacognition

Purposeful Design
- Objective Design
- Assessment & Evidence-Centered Design
- Personalized Learning & Adaptive Systems
- Authentic Learning

Learn Anywhere
- English Performance Standards
- Digital & Virtual Learning

Desirable Difficulty & Scaffolding

Learning happens best when there is a balance of challenge and support.

Desirable difficulty is the idea that learning is most effective when it is challenging — but not too difficult. Desirable difficulty is characterized by activities that require effort, focus, and active engagement and effort from the learner (e.g., practice testing, spacing out learning).

Scaffolding is what others do to support learners through appropriately challenging tasks. It supports individuals as they 'climb' from one stage of learning to the next. This can look like hints, worked examples, just-in-time instruction, or resources.

Scaffolding should adapt to the learner's needs as they change, so it doesn't provide too much or too little help. Thus, scaffolding is often characterized by initially high levels of structure and support that adaptively fade out as the learner is able to do more of the task independently.

The sweet spot where learning is challenging, but not too challenging, is the **Zone of Proximal Development (ZPD)**. A task in the ZPD is one that the learner can't complete by themselves, but can complete with appropriate support.

The ZPD represents the level of **optimal challenge** for the learner, providing the right level of support and challenge to help them progress. Designing for optimal challenge helps to keep learners engaged and motivated, and leads to improved learning outcomes, as learners are challenged to push past their current abilities. By identifying the ZPD, educators can provide scaffolding, such as hints, worked examples or corrective feedback, that can help the learner to progress towards more advanced tasks.

More knowledgeable others such as instructors, peers, or even learning systems, can also support desirable difficulty by providing hints, modeling effective strategies, or correcting errors. This centers learning in the ZPD.

In more social and cultural contexts, scaffolding can look like **guided participation**. This is when learners jointly participate in learning with more knowledgeable others, the experience is viewed as central to acquiring knowledge, and is adapted or contextualized for the specific learner's life circumstances.

Why it matters

Research suggests that learning within one's desirable difficulty can result in more efficient, durable, flexible, transferable learning than staying in one's comfort zone.

Scaffolding can support increased task fluency, mastery, learning, metacognition or even development.

When you get optimal challenge right, individuals can experience **flow**: the enjoyment experienced when a person's skills match the perceived challenges of the activity. Learners in flow can become totally absorbed in the material, lose their sense of self-awareness and time, and engage in the task for the joy of it. People do some of their best work when experiencing flow.

Impact

When we successfully incorporate this principle into learning experiences, we can have an impact on these learner outcomes:

- learners feel supported in their learning and can find help when they need it, because scaffolding imparts new problem-solving procedures, provides just-in-time guidance, and/or connects to prior knowledge
- learners experience flow and persist because the content is at the optimal challenge level
- learners are prepared for challenging content because they have engaged in exploratory problem solving in a supportive environment
- learners gain independence and confidence as scaffolding is faded
- learners attain proficiency efficiently because the learning is tailored to their ability level
- learners transfer their conceptual knowledge because they can identify deep structural similarities in problems

The big ideas

1

Learning should be appropriately challenging and take appropriate effort.

It's difficult but I can do it.

I need some help to get started.

2

At first, learners benefit from a scaffolded learning environment with high levels of structure and support.

3

As learners progress, fading out the supports is beneficial for learning.

As I get better, I need less help.

4

Sometimes exploratory problem-solving before instruction can be an effective way to induce desirable difficulty.

Grappling with a too-hard problem first prepares me for future learning.

Desirable difficulty

Learning should be appropriately challenging and take appropriate effort.

What it feels like for learners

It's difficult but I can do it.

To create desirable difficulty, it is important to provide both the right type and the right amount of challenge for the learner.

- Right **type** of challenge:
  the knowledge, objectives, and procedures the learner will need to be able to apply in future. Think about how learners might apply their knowledge or what barriers they might experience in the future, and design the task with the right challenges to prepare them (e.g., if a learner will ultimately need to decide when to conduct certain types of medical exams, they should practice making those judgements during learning)
- Right **amount** of challenge:
  the difficulty of the task: challenging enough to promote learning but not so difficult that the learner can't complete the task or understand why they are failing (the ZPD). The sweet spot is roughly 85% success, 15% failure. Learning thrives here: learners can strengthen their skills and grow and build new ones, discover what works and what does not.
- Digital advantage:
  Desirable difficulty may slow progress during the formative stages of learning and make learners feel like it takes more effort, but it ultimately produces more durable and flexible learning. Keeping learners engaged is key. Digital learning environments are particularly well-suited to identifying and personalizing experiences to the learners' desirable zone.
- Effort:
  High-quality learning takes effort.
  If learning feels hard, that is a good sign that it's working. Some learners find putting in effort enjoyable and lean in, while others are fatigued and disengage. Some interpret difficulty as a signal of failure and misunderstanding. Frame effort and struggle as a natural part of learning, and encourage a growth mindset.

See this Learning Design Principle:
Motivation & Mindset

See these Learning Design Principles:
Assessment & ECD
Authentic Learning

What it means for designing learning experiences

- Identify the learner's prior knowledge level
- Design challenging, effortful activities just beyond what learners can do on their own
  - Choose difficulty intentionally and with application contexts in mind.
  - Focus on generative activities, e.g., retrieval practice, spaced practice
- Target the right balance of success and challenge (85% success rate)
- Provide scaffolding and support so they can succeed at those learning activities
- Embed formative assessment to monitor learner knowledge level
- Monitor both success rate and indicators of affective state to calibrate learning activities within the flow zone
- Monitor how the learner is feeling and provide encouragement and emotional reframing as needed. Support perceptions of competence after success
- Reinforce the idea that effort is a positive sign of learning
- Normalize struggle and support a growth mindset

Big Idea 2

Start with support

At first, learners benefit from a scaffolded learning environment with high levels of **structure and support.**

What it feels like for learners

I need some help to get started.

Novice learners lack the networks of information and mental models that experts have, making it difficult for them to understand and retain new information. Novices knowledge is context-dependent, focused on individual cases and surface-level features.

Experts think in terms of systems and underlying concepts. They can fluently categorize new information according to their existing mental models and understand how a discipline is organized, anchoring around the big ideas of the field.

See this Learning Design Principle:
Developing Understanding

Scaffolding helps novices think like experts.

Key features of scaffolding include:

- learner ownership of the activity
- appropriateness of task to the student's current knowledge
- real-time adjustments to level of support based on learner's understanding
- collaboration between instructor and student
- internalization of knowledge or processes as scaffolds are removed

Scaffolding can be used to support conceptual, metacognitive, strategic, and motivational outcomes — so it is crucial to reflect on its purpose and use before incorporating it into learning.

There are a few common scaffolding strategies that have been studied extensively and are proven to be effective:

- **Worked examples** consist of a problem formulation, solution steps, and the final solution. They help learners learn flexible problem-solving procedures by providing novices with strategies for solving new and complex problems, and reducing the cognitive load associated with solving complex problems. Worked examples can reduce instruction time, improve performance, and guide schema development.
- **Instructional explanations**, also known as hints, are a form of just-in-time knowledge or assistance provided when learners get stuck. They have been shown to improve efficiency in learning, but they have less impact on learning gains. Hints can range from low-information cues to

more specific and detailed suggestions. with studies suggesting that the amount of time spent on low-to-intermediate hints (rather than those that give the student the answer), may be more predictive of learning. Self-explanation prompts improve self-efficacy and performance.

- **Advanced organizers** are teaching tools that help learners leverage prior experiences and knowledge to learn new information. They establish a framework to anchor new information and facilitate integrating new and existing knowledge. They can be expository or comparative, and can include graphic organizers and digital games. Research shows that advanced organizers have a small to medium effect on retention and learning, are most effective when combined with concepts and processes, and when used for science and mathematics and fact-based exams.

See this Learning Design Principle:
Developing Understanding

See these Learning Design Principles:
Personalized Learning & Adaptive Systems
Feedback for Learning

What it means for designing learning experiences

- Consider scaffolding a type of instruction embedded within problem-solving
- Provide novices with thoughtfully designed scaffolds at the start of new learning
- Minimize any split attention effects and reduce cognitive load by integrating modalities into a unified experience
- Worked examples:
  - Vary intra- and inter-example features.
  - Alternate worked examples with practice problems.
- Instructional explanations:
  - Use hints when learners are stuck.
  - Provide low-to-intermediate information level hints.
  - Consider prompting learners to self-explain before offering an instructional explanation.
- Advanced organizers:
  - Design to activate and integrate with prior knowledge.
  - Support schema development and knowledge organization around underlying concepts or processes.
  - Use for science, math, and fact-based domains.

Big Idea 3

Fade out support

As learners progress, fading out the supports is beneficial for learning.

What it feels like for learners

As I get better, I need less help.

Fading means gradually reducing the level of support provided.

As learners gain knowledge and skill in a particular learning context or for a specific learning task, scaffolding should be faded out to facilitate continued learning.

Just like training wheels on a bicycle or bumpers on a bowling lane, as the learner progresses, these additional supports become redundant as the learner gains relevant skills.

- **Maintaining support is not only unnecessary, but can harm learning**
  The expertise reversal effect is where support that is helpful for novices can become a hindrance for more advanced learners. This is because experienced learners have developed their own problem-solving strategies, and the additional support takes up unnecessary cognitive load. As learners gain expertise, they no longer need models on how to think like an expert — they can do that on their own.
- **Fading out scaffolding maintains optimal challenge**
  Just as scaffolding is often added to ensure that learning is not too hard, fading out can ensure that learning does not become too easy. When a task becomes too easy, learners lose out on the valuable information offered by failures. The learning task and amount of scaffolding can be adjusted to maintain optimal challenge as the learner increases in their ability level.
- **Fading promotes better cognitive outcomes**
  Research has shown that learners benefit from progressing from fully-worked examples to partial or completion examples as expertise increases.
  - Fading is more effective when the final steps of the worked example are faded out first.
  - Customized scaffolding, which incorporates both fading and adding support back in when needed, leads to better cognitive outcomes for learners doing problem-based STEM learning.
- **Fading out can aid in the transition to independent performance**
  Scaffolding is intended to be a bridge to independent performance. Transferring responsibility for learning to the learner is key. Fading out scaffolding can support self-regulated learning.

See this Learning Design Principle:
Active Learning, Memory & Practice

See these Learning Design Principles:
Personalized Learning & Adaptive Systems

What it means for designing learning experiences

- Measure prior knowledge to determine appropriate level of scaffolding
- Gradually fade or adaptively remove scaffolding once a learner can achieve some success on their own
- Embed formative assessment to monitor learner knowledge level
- Keep learning at the optimal level of challenge
- Adaptively add scaffolding back in if needed
- Providing scaffolding to learners who don't need it actually impedes learning

Big Idea 4

Exploratory problem-solving, sometimes

Sometimes **exploratory problem-solving** before instruction can be an effective way to induce desirable difficulty.

What it feels like for learners

Grappling with a too-hard problem first prepares me for future learning.

Productive failure is a form of guided discovery where learners work to solve an open-ended, complex problem. The goal is not for them to achieve the right answer, but for the instructor to build off learner-generated solutions and offer additional instruction on the key concepts involved in the task.

Productive failure can prime learners to learn from subsequent instruction and guided problem-solving. It is better for promoting conceptual understanding than procedural knowledge.

Note that guided discovery should be differentiated from experiential or discovery-based learning, which have been shown to provide little benefit or even harm to student learning outcomes.

Productive failure promotes beneficial cognitive processing by:

- activating relevant adjacent schemas
- highlighting gaps in knowledge
- motivating search for deep structure
- inducing cognitive disequilibrium to motivate curiosity and attention to instruction
- prompting positive affect and engagement

To be effective, productive failure experiences must include:

1. instruction that builds on learners' solutions
2. group work as the participation structure in the problem-solving phase
3. generation of multiple representations and solutions
4. dialogue-dominant social surround facilitation in the instruction phase

Despite the name, it is not necessary for a learner to experience failure themselves in order to learn from it. Vicarious failure, where a learner studies others' incorrect solutions, can also lead to better conceptual knowledge acquisition than direct instruction.

See this Learning Design Principle:
Authentic Learning

See these Learning Design Principles:
Social & Collaborative Learning

What it means for designing learning experiences

- Determine whether exploratory problem-solving is appropriate given the learning goals, domain, and instructional context
- Make sure all conditions of effectiveness are met:
  - build on learner solutions
  - group work during problem solving
  - multiple representations and solutions
  - social and dialog-infused instruction
- Support beneficial cognitive processing by:
  - providing remediation and correction of initial mental models
  - highlighting gaps in knowledge
  - sparking curiosity or confusion
  - highlighting where analogies transfer fully, where they break down, and where understanding needs to be updated
- Support a positive affective environment
- Learners do not need to fail for instruction to be effective

Authors

Megan Imundo, Ph.Dc

Megan Imundo examines the features of educational settings which promote long-term learning and transfer of learning. She earned her bachelor's degree in psychology and cognitive science from Northwestern University. Currently, she is a Ph.D. candidate in cognitive psychology at the University of California, Los Angeles advised by Drs. Robert and Elizabeth Bjork. Megan strives to connect academic research and real-world practice and regularly collaborates with organizations who seek to leverage the science of learning in authentic learning contexts.

Katherine McEldoon, Ph.D.

Katherine McEldoon is a research-to-practice connector. After earning her Ph.D. in cognitive and learning sciences at Vanderbilt University and a post at Arizona State University's Learning Sciences Institute, she has worked in academia, government, and industry to ensure the best scientific insights support student learning, no matter the context. Katherine has most recently worked as Lead Learning Scientist on Pearson's Efficacy & Learning team, bringing evidence-based insights to Pearson's world of learners.

Reviewers

Sara Finnigan, M.A.
Principal Learning Designer

Amy Wood, M.A.
Director, Learning Research and Design

Matthew Ventura, Ph.D.
Director, Advanced Technology Research and Design

Emily Lai, Ph.D.
Vice President, Learning Impact Measurement

Muireann Kelly, Ph.D.
Senior Research Scientist

Autumn Westphal, M.A.
Learning Designer

Tanya Churaman, M.S.
Researcher

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